Arduino IN-14 Nixie Clock v45

"All-In-One" Clock

Operating Instructions
&
Construction Manual

Contact Information

If you want to get in contact with us, please email to:

nixie@protonmail.ch

We'll usually get back to you right away. We can help you with kits or construction.

We also offer discounts for direct purchases, we save the Ebay fees, and share this with you.

http://www.open-rate.com/Store.html

Software

The software is open source and is available on GitHub at the address:

https://github.com/isparkes/ArdunixNix6/releases

This board works with Release "Revision 4 boards" under the "Releases" tab.

Troubleshooting

If everything does not work as you expect, please carefully look at the tests in the construction steps, and the troubleshooting tips.

At the end of the manual, there is a troubleshooting section, which goes through some of the common problems. If you can't work it out, please get in contact with us. **We guarantee that you will get going.**

Description

The Arduino Nixie Clock is a beautiful mix of old and new, resulting in a high accuracy, low power clock which will be a talking point in your home.

The clock has the following features:
- Latest technology, highly reliable and accurate.
- Tried and tested design, with many hundreds of clocks sold.
- Based on the Arduino micro-controller: Easy to program an well documented.
- Open source hardware and software. Nothing is hidden in this clock. (You may modify and load the software).
- Low power consumption.
- Long tube life: Anti Cathode Poisoning (ACP) and configurable blanking makes sure that the tubes will stay healthy for many years with no intervention from you.
- The multiplexed display and automatic dimming used in this design extends the life of the tubes indefinitely. Some other designs run the tubes too "hard", and this causes a rapid degradation in the useful life of the tube.
- All settings are stored in non-volatile memory. Once they are set, they are remembered forever, or until you change them again.
- RGB back lighting allows you to set the the color of the back lighting to practically any color you desire.
- Ambient light sensing, with automatic tube dimming, which sets the tube and LED brightness according to the light conditions. This also increases tube life.
- Absolutely silent operation. Some Nixie clocks emit an irritating "buzz" or "hiss" which is especially annoying if you keep the clock in a bedroom.
- Automatic week day or weekend blanking, extends the life of tubes even further
- Automatic time of day blanking, can blank between a start hour and an end hour, on week days, weekends or every day
- Configurable suppression of Anti Cathode Poisoning when the clock is fully dimmed. In the middle of the night, all the digits lighting up at full brightness could be disturbing. You can choose to stop ACP when the clock is fully dimmed
- The High Voltage Generator auto-calibrates itself to match your tubes and power supply, meaning that the power consumption is the lowest possible. (Usually 2W when fully bright, 0.4W when blanked).
- Highly accurate when using RTC module:
  - Battery backed, temperature compensated, high accuracy clock. The accuracy is Accuracy ±2ppm from 0°C to +40°C. (Maximum 1 minute per year).
  - The battery life should be 3 years in normal use.
  - Retains the date and time even when turned off (not just for a few minutes, but for as long as the battery lasts)
  - Leap Year Compensation Valid Up to the year 2100
- Extremely accurate when using the optional Wifi module:
  - The time never drifts, is always right to within 1 second.
  - Automatically compensates for Daylight Savings Time changes, leap years and seconds.

General

The clock has different modes of operation, which you select using the pushbutton. When you start the clock up th very first time, it will start in "Time Display Mode". We set it up to be the right time for where the clock is being shipped to, so in the best case you will not even need to set the clock the first time!

The other modes of operation are described in the following sections.

Safety

The voltages produced in the High Voltage circuit can reach peaks of 400V! Take precautions not to electrocute yourself! If you are not sure what this means, please do not use this clock and return it for a full refund.

A shock from the clock high voltage circuit is at least a nasty bite. At worst it can kill you.

We decline any responsibility in the case of injury or death.

REPEAT: If you are not sure, please do not use the clock.

Powering Up

When you power the unit up, it will display "88:88:88" for several seconds. This is for the calibration of the High Voltage Generator to match the power adapter you have attached. During this time you might hear some faint crackling noises from the generator. This is normal.

After finishing the calibration, the version number ("00:42:07") will be displayed for about a second. The clock will then go into normal operating mode.

Time Providers

Real Time Clock (standard)

By default, the clock comes with a Real Time Clock (RTC) module which provides a battery backed time source that remembers the time even when the clock is not powered up.

WiFi Time Providers (optional)

More up to date is a WiFi real time provider, which logs into your home WiFi network and periodically retrieves the time from Internet time sources. These are accurate to 1 second, and auto adjust for Daylight Savings Time. You configure once, and then the module remembers the configuration forever.

Additionally, the WiFi time module gives you a easy to configure interface, which you can use to set up the clock using a tablet, phone or computer.

Time Display Mode

Normally, the clock will show the time. To show additional information press the button with a "short" press. Each press cycles through the following information. After 5 seconds, the display will revert to the normal time display.

Mode	Description	Values
Date	**Date.** The current date will be shown.	
Temp	**Temperature.** The current internal temperature inside the clock case will be shown in degrees Celsius. If this goes above 40, you should consider ventilating the case, because the temperature compensation is not able to work at such high voltages, and the clock life may be reduced, and the time may drift.	
Light	**Ambient Light Reading.** This shows the current ambient light reading from the LDR (light dependent resistor). It is a normalized value, and goes between 100 (dark) to 999 (bright). This controls the dimming of the tubes.	100: darkest 999: brightest
Version	Display the version number. The format will be :"VV vv 07", where major version is "VV", minor version is "vv" and the "21" is the id for the version display.	00:42:07

Setting Mode

To enter setting mode, press the button for more than 1 second ("medium press"). The "RGB back light" LEDs will start to flash white. The number of consecutive flashes indicates the mode you are in.

Each medium press of more than 1 second will move the setting mode onto the next. When you finish the setting modes, the clock returns to normal time display mode.

To exit the setting mode before going through all the options, press the button for more than 2 seconds ("long press"). The "RGB back light" LEDs will return back to their normal operation. Another way of exiting is to cycle through all of the setting options, after which you will return to time mode.

To change a setting, pgress the button for less than one second, and then release it ("short press").

Mode	Description	Values
	Time mode. This is the normal mode and displays the time. It is the normal start up mode of the clock. If you do nothing. The clock is in this mode. In this mode a short press cycles through the values given in "Time Display Mode", but always returns to the standard time display after 5 seconds.	
Time and Date Settings		
	Set minutes. Each short press will advance the minute. The minutes roll over back to 0 ffter reaching 59 minutes. Each time you set the minute, the seconds is reset to 0.	
	Set Hours. Each short press will advance the hour. The hours roll over back to zero after reaching 12 or 24 (depending on the 12/24 hours mode).	
	Set Day. Each short press will advance the day. The day roll over back to one after reaching the maximum number of days in the month.	
	Set Month. Each short press will advance the month. The month roll over back to zero after reaching 12.	
	Set Year. Each short press will advance the year. The year roll over back to 2015 after reaching 2099.	
Basic Settings		
"00" flashing	**12 or 24 hour time.** The hours are displayed in 12 or 24 hour mode.	"1" = 12 hour "0" = 24 hour default: 0
"01" flashing	**Blank leading "0".** Blank out the leading "0" from single digit hours.	"1" = blank "0" = don't blank default: 0
"02" flashing	**Scroll back.** Use the scroll back (rapid count down) effect when changing from "9" to "0".	"1" = enable "0" = disable default: 1
"03" flashing	**Date format.** Set the format that the date is displayed in.	"0" = YY.MM.DD "1" = MM.DD.YY "2" = DD.MM.YY default: 2
"04" flashing	**Display blanking.** To preserve the tubes, you can set the display to be blanked. Options: • "4" = "hours": Blanks between the start and end hour every day. • "5" = "H or weekends": This blanks all day during the weekends and between the start and end hour every other day. • "6" = "H or week days": This blanks all day during the week days and between the start and end hour every other day. • "7" = "H on weekends": This blanks between the start and end hour on weekends. • "8" = "H on week days": This blanks between the start and end hour on week days.	"0" = Don't blank "1" = Weekends "2" = Week days "3" = Always "4" = Hours "5" = H **or** weekends "6" = H **or** week days "7" = H **on** weekends "8" = H **on** week days default: 0
"05" flashing	**Blanking Hour Start.** Hour blanking will start at this hour, on the days set by the Display Blanking Mode. If the display blanking mode does not use hours, this setting is not shown.	Default: 00

"06" flashing	**Blanking Hour End.** Hour blanking will end at this hour, on the days set by the Display Blanking Mode. If the display blanking mode does not use hours, this setting is not shown.	Default: 07
"07" flashing	**Anti Cathode Poisoning night suppression.** The ACP which runs during the night lights the digits up at full brightness, and some people might find this disturbing. Using this setting, you can stop ACP happening when the display is fully dimmed (e.g. at night).	"1" = don't do ACP when dimmed "0" = do ACP always default: 0

Special Effects Settings

"08" flashing	**Fade Speed Slower**. Each short press will make the fade speed between digits slower.	Default: 50 Max: 200 Min: 20
"09" flashing	**Fade Speed Faster**. Each short press will make the fade speed between digits faster.	Default: 50 Max: 200 Min: 20
"10" flashing	**Scroll-back Speed Slower.** Each short press will make the "scroll-back" speed slower.	Default: 4 Max: 40 Min: 1
"11" flashing	**Scroll-back Speed Faster.** Each short press will make the "scroll-back" speed faster.	Default: 4 Max: 40 Min: 1

Back Light Settings

"12" flashing	**Back Light Mode.** This sets the mode of the back light. "Fixed" mode will show the back light color according to the Red, Green and Blue channel intensities. "Pulse" will make the intensity of the back light "pulse", brightening for a second and then darkening for a second, but always respecting the relative intensities set by the Red, Green and Blue channel intensities. "Cycle" fades the back lighting randomly, and does not use the Red, Green and Blue channel intensities. These settings will be skipped if cycle mode is selected. Options "0", "1" and "2", do not dim with the bulbs. Options "3", "4" and "5" do.	"0" = Fixed "1" = Pulse "2" = Cycle "3" = Fixed/Dim "4" = Pulse/Dim "5" = Cycle/Dim default: 0
"13" flashing	**Red Channel Intensity.** Sets the maximum intensity of the red channel back light. This will be dimmed according to the display dimming. If you are in cycle mode, this setting will be skipped.	Default: 15 Max: 15 Min: 0
"14" flashing	**Green Channel Intensity.** Sets the maximum intensity of the green channel back light. This will be dimmed according to the display dimming. If you are in cycle mode, this setting will be skipped.	Default: 15 Max: 15 Min: 0
"15" flashing	**Blue Channel Intensity.** Sets the maximum intensity of the blue channel back light. This will be dimmed according to the display dimming. If you are in cycle mode, this setting will be skipped.	Default: 15 Max: 15 Min: 0
"16" flashing	**Cycle Speed.** If you are in cycle mode, this controls the speed at which the colors cycle. The higher the number, the slower the colors will change.	Default: 10 Max: 64 Min: 4

HV Generation Settings (See "HV Settings" note)

"17" flashing	**HV Target Voltage Higher.** Each press sets the HV target voltage higher by 5V.	Default: 180 Max: 200 Min: 150

"18" flashing	**HV Target Voltage Lower.** Each press sets the HV target voltage lower by 5V.	Default: 180 Max: 200 Min: 150
"19" flashing	**PWM On Time Longer.** This setting controls how long the PWM On pulse is. Normally you should not have to change this, but you can try changing this is the HV generation is noisy or you have unusual tubes.	Default: 150 Max: 50 Min: 500
"20" flashing	**PWM On Time Shorter.** This setting controls how long the PWM On pulse is. Normally you should not have to change this, but you can try changing this is the HV generation is noisy or you have unusual tubes.	Default: 150 Max: 50 Min: 500
"21" flashing	**Increase Minimum dim.** This setting allows you to increase the minimum brightness you want to have when the clock is fully dimmed.	Default: 100 Max: 500 Min: 100
"22" flashing	**Decrease Minimum dim.** This setting allows you to decrease the minimum brightness you want to have when the clock is fully dimmed.	Default: 100 Max: 500 Min: 100
"23" flashing	**Increase Anti-ghosting.** This setting reduces "ghosting" (the number on the right shows faintly on the digit on the left). This is due to transients when switching.	Default: 0 Max: 50 Min: 0
"24" flashing	**Decrease Anti-ghosting.** This setting reduces "ghosting" (the number on the right shows faintly on the digit on the left). This is due to transients when switching.	Default: 0 Max: 50 Min: 0
Information Settings		
"25" flashing	**Current case temperature.** Show the current temperature inside the case (used as part of the temperature compensation for the clock crystal).	
"26" flashing	**Clock version.** Show the clock software version.	
	Digit Test. Will roll through all digits on all locations to check that the display is healthy.	

Note "HV Settings": Before leaving the clock for long periods with a new "HV Generation" setting, check that neither the MOSFET nor the 7805 voltage regulator is running too hot. If either of these components gets too hot, either adjust the high voltage settings or add a heat sink.

Display Blanking Mode

During display blanking mode the tubes will be off depending on the display blanking settings, but the LEDs will continue to work as usual, telling you that the clock is still running.

You can configure the display to blank at weekends, during week days, always or never (the default). Also you are able to define hours during which to blank. For example I have a setting saying that the clock is blanked on weekdays between 7am and 4 pm, while I am out at work. At weekends, the display runs all the time.

You are also able to override the blanking. Press the button while the clock is blanked, and the display will come on again. Pressing the button will display the time for about a minute (60 seconds, but the display is only blanked on the minute change).

If you press the button multiple times within 5 seconds, the blanking will stay off for longer periods:

- 1 Press: 60 seconds
- 2 Presses: 1 hour
- 3 Presses: 4 hours

Tube Healing Mode

After a long period of time, tube filaments which are not often used (e.g. the "9" on the tens of hours or minutes) can get dim, despite the ACP that is regularly done.

If you make a "super-long" press of the button (more than 8 seconds), the clock will enter filament healing mode. All the power will be placed through a single filament of a single digit to clean it. A short press will change the selected filament. Another super-long press or cycling through all the filaments will return the clock to normal.

Warning!

Caution! Don't leave a single filament in this state for an extended period of time. It is a harsh process, and may damage the tube if you leave it in this mode for too long. Normally a few minutes will restore the cathode digit.

Warning!

Be careful using tube healing mode!

It is an extremely harsh process, and should only be used if you see dark spots or "shadows" on digit filaments. Normally, the ACP should take care of your tubes and only in exceptional cases do you "need tube healing".

Factory Reset

To reset the clock back to initial settings, hold down the button while powering on. The "tick" LED will flash 10 times to signal that the reset has been done.

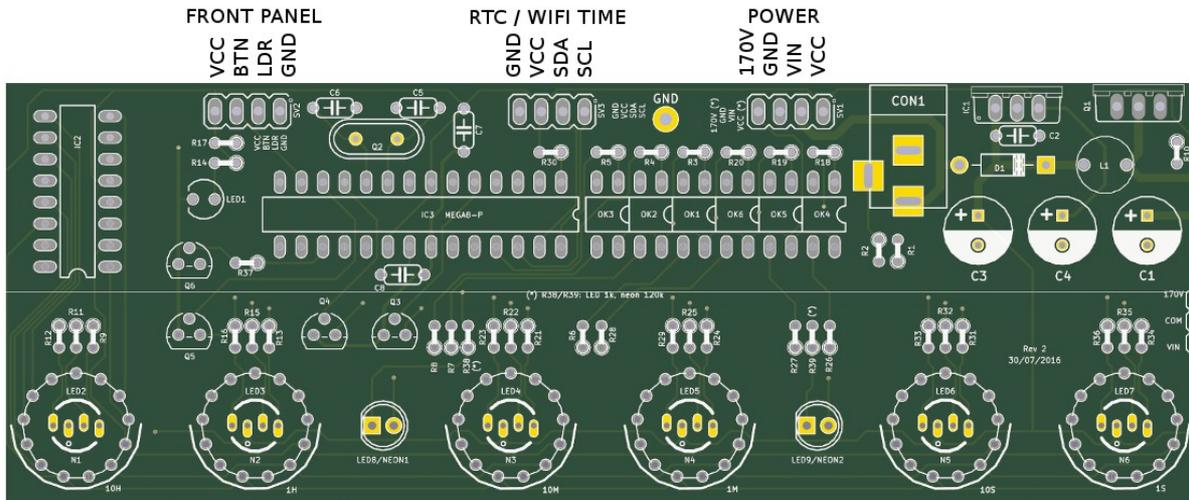Everything will be reset back to the factory default state.

External power supply

The perfect voltage for the external power supply is 7.5V or 9V DC. You can use 12V DC. If you use more than 12V be aware that you might have to provide a heat sink for the power components and adjust the HV voltage generation. It is not advised to use more than 12V.

The absolute maximum permissible is 24V DC. Higher voltages than this will surely damage the clock.

Board layout

For reference, the board layout is as shown (viewed from the top):

The connections are:

Connector	Description	Values
POWER	External power should be applied to the board with this connector. Any DC input source is possible, from 7.5V – 12V. Higher voltages may be possible, but could cause the digits to flicker if the voltage is too high, and you might have to provide a heat sink for the the MOSFET and voltage regulator. The absolute maximum input voltage is 24V. Any higher voltage than this will damage the board within a few seconds! The input VIN is protected against the input being connected reversed. The input current ranges from 300mA to 1A depending on the size of the tubes and the number of LEDs you are driving. **170V: Output** of high voltage for driving external neons etc. **GND:** The negative side of the input supply **VIN:** The positive side of the input supply **VCC: Output** of regulated 5V, which can be used to drive auxiliary circuitry.	
FRONT	These are the controls that go on the front panel: The input button and the Light Dependent Resistor to detect ambient light. **GND:** The "ground". One lead of the button and one lead of the LDR and one lead of the button are connected to this. **BTN1:** The other lead of the button is connected to this input **DLS:** "Dimming LDR Sense": The other lead of the LDR is connected to this **VCC:** Regulated 5V output to drive any LEDs or lighting. Note that you can also connect the LEDs to the VIN if you want to reduce the load of the regulator.	
RTC / WIFI	The connection for the RTC (Real Time Clock) or WiFi time provider module. Connect this to the appropriately marked terminals on the RTC / WIFI module.	

Schematic

Below is the schematic for the clock.

And for the LDR and button:

Construction

Preparation:

You should have a small tipped soldering iron, some thin (< 1mm, ideally 0.6mm) solder, and electronic side cutters.

Components:

You should find the following contents as listed in the BOM (Bill of Materials). It is best to check the contents before you start.

Please see the appendix to help you identify individual components.

Low Voltage Circuit:

Parts List:

D1	UF4007
C2	100nF
C3	220uF
C4	220uF
IC1	7805TV
R14	3k
LED1	LED3MM
SV1	CONN_POWER

The Low Voltage circuit is a very traditional voltage regulator using a linear regulator. It's job is to reduce the external voltage from the power adapter down to a known and stable 5V to drive the micro-controller and the 74141/K155ID.

Put the parts on the board in the marked locations in the order they appear on the list.

Notes:

- See the section on "Component Identification" for help with identifying the components.

- D1 should be placed so that the white stripe on the body lines up with the white stripe on the board.

- C3 and C4 must go the right way round. The negative side is marked with a stripe. (See hint)

- The LED must go with the right polarity. The side which has the shorter lead goes nearest the diode. (See hint)

- Put IC1 so that the metal tab lines up with the white stripe on the board. The metal side faces to the *outside* of the board.

Test Step

Once all the components are on the board, hook up the power, and check that the power LED comes on.

Check also that the voltage is 5V between the "GND" test point and the "VCC" test point and at the power connector.

Trouble shooting

If the LED does not come on, turn off immediately to avoid damage to the components. Check your soldering and the polarity of the components.

If the components are in the right way, connect the power again, and check that the 7805 voltage regulator does not get hot. If it does not, measure the voltages in the low voltage circuit.

Measure the voltage at the input ("Vin") and at the cathode side of D1 (nearest the centre of the board). This should measure 0.7V less than the input voltage.

If all is well, proceed to the next step. If not, check carefully the orientation of the components and the power leads. Diode D1 protects the board from having the power connected inverted.

If the LED comes on, check for a few seconds that the 7805 does not heat up. It should stay almost cold.

Hint: The 220 uF capacitor

The electrolytic capacitor has a stripe on it to denote the **negative** side of the capacitor. The positive side of the capacitor (which goes into the "+" on the board) is the other one!
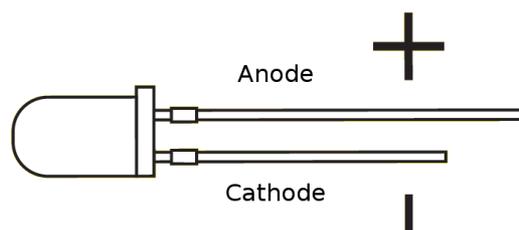

Hint: The LED orientation

The LED has one lead longer than the other, and a flat on one side. The side with the **shorter** lead (the cathode) goes into the hole on the board nearest the diode.
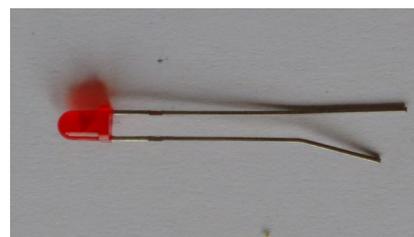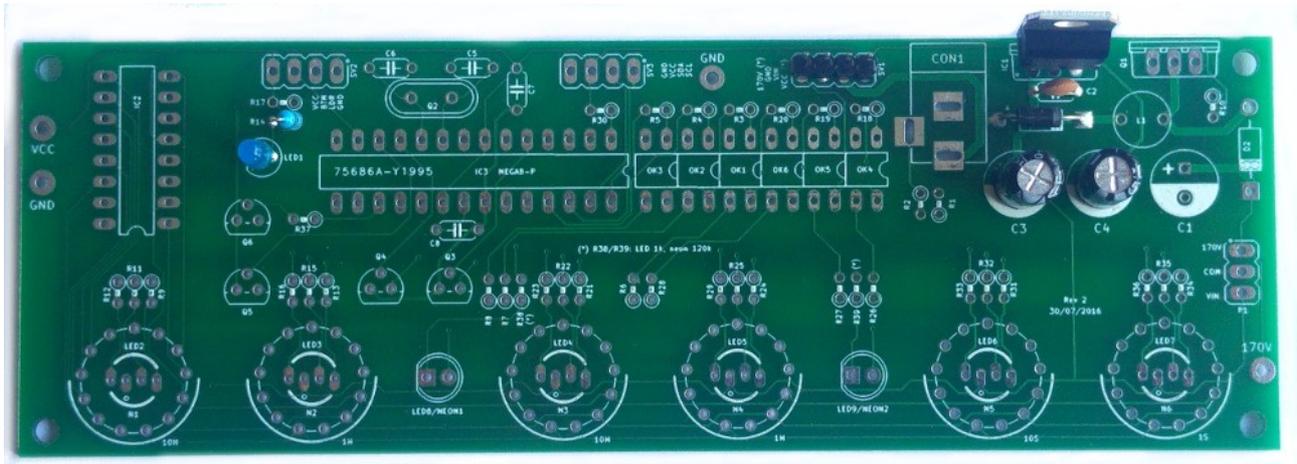

The LED

The LED should look something like this:

At the end of the low voltage circuit build, your board should look like this:

Low Voltage Circuit

High Voltage Circuit:

Parts List:

C5	22pF
C6	22pF
C1	2.2uF 400V
C7	100nF
C8	100nF
D2	UF4007
S28	SOCKET 28
Q2	16MHz
L1	100uH
R10	3k
Q1	IRF840
R1	390k
R2	4.7k
R30	10k
IC3	MEGA8-P

The high voltage circuit uses the micro-controller to drive the boost circuit with a high frequency square wave, and has a feedback loop in which the controller reads the voltage produced via an analogue input, and regulates the brightness of the tubes so that there is no flickering or unwanted dimming.

Notes:

- See the section on "Component Identification" for help with identifying the components.

- C1 must go the right way round. The negative side is marked with a stripe (see hint).

- Put Q1 so that the metal portion lines up with the white stripe on the board. The metal side faces to the outside of the board.

- D2 should be placed so that the white stripe on the body lines up with the white stripe on the board.

- Put the micro-controller socket in first and solder it. Make sure that the depression on the end of the socket lines up with the marking on the board. When you put the chip in, the chip should go in with the depression matching the silk screen on the board.

Double check the orientation/location of the components before you proceed!

Especially check that R1 and R2 are in the right positions, and that the electrolytic capacitor C1 is the right way round. If you switch R1 and R2, you will put 170V into the micro-controller, and this will destroy it.

Warning!

Once all the components are on the board, hook up the power. Give your work a careful check to make sure that the orientation of the components is right. Especially check that the stripe on C1 is facing the marking on the board.

Warning!

Be careful, we are dealing with high voltages now!

The voltage may be <u>significantly</u> higher than 170V at the moment, because the high voltage generator is powerful and the output is not loaded. Once you add a load, (by connecting the tubes), the voltage should oscillate around 170V – 190V, and might have a slight "sawtooth" appearance if you view it with an oscilloscope.

Test Step

Apply power to the board again. Listen for any stressed sounding buzzing or humming, and check that neither the 7805 nor the MOSFET get excessively hot.

Check that the power LED still lights.

Trouble shooting

If you hear any angry sounding buzzing turn the power off immediately and check the orientation of C1! The circuit should run almost silently, with only a very faint "crackling" sound.

If you can't reach the target voltage, turn off and check the polarity of your components, especially C1. If you have an oscilloscope, you can check the voltage at the gate of the MOSFET, and it should show pulses of high frequency square wave: this is the driver waveform to the HV generator, which is being turned off and on by the voltage detection, trying to achieve the target voltage (180V default).

Warning!

Note also that the "Power" header also has high voltage exposed on it!

This is for if you want to drive neons instead of LEDs for the colons. Be careful handling the board, it is easy to touch the "Power" header by mistake. If you are sure you won't be needing it, you can snap the extra pin off and populate only the bottom 3 pins on the connector.

Test Step

Check the voltage at the 170V test point. You should read a voltage in excess of 170V.

You can also test using an old neon lamp if you have one. Temporarily connect the neon lamp between the "GND" test point and the "170V" test point with an appropriate ballast resistor (turn the power off first). Turn the power on and the neon lamp should come on.

Trouble shooting

Q1 can get warm, **but should not get too hot to touch**. If it gets hot, you need to check the orientation of the components and that there are no solder bridges.

If you don't get the expected voltage reading:

- Check your soldering that there are no bridges or dry joints.
- Check that the external power supply is able to supply the power needed to achieve the high voltage: check that the VIN voltage is stable and not fluctuating.
- Temporarily connect the LDR and re-test.
- Temporarily connect the button and do a factory reset

Hint: Mounting the 28 pin socket

Mounting the 28 pin socket can be a little difficult. A good trick is to fix it in place with a small piece of tape, and the solder one leg in place. You can hold the socket firm while you "wet" the solder again, which will hold the socket firmly enough to solder the remaining pins. One leg is usually enough to hold the socket in place while you solder the others.
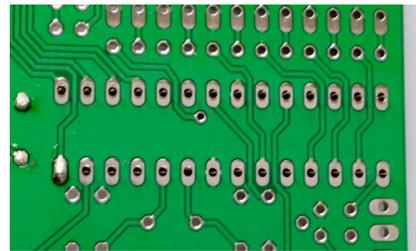
Mounting 28 pin socket

At the end of the high voltage circuit build, your board should look like this:
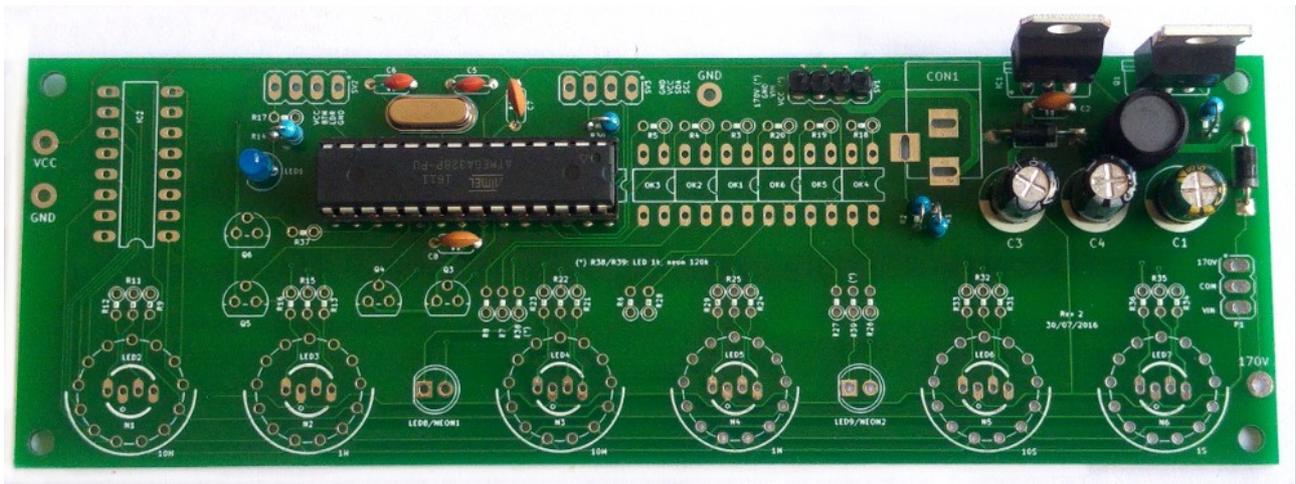
High Voltage Circuit

LEDs/neons

Parts List:

RTC	RTC (see note)
WiFi	WiFi Module (see note)
SV3	CONN_RTC (see note)
R37	1k
R38	1k or 120k (see note)
R39	1k or 120k (see note)
Q3,Q4,Q5	2N7000
Q6	MPSA42
LED8/NEON1	LED 5mm or neon (see note)
LED9/NEON2	LED 5mm (see note)
Neon1	Neon indicator lamp
Neon2	Neon indicator lamp
R17	10k
R9,R11,R12	1k
LED2	RGB Common Anode
R13,R15,R16	1k
LED3	RGB Common Anode
R21,R22,R23	1k
LED4	RGB Common Anode
R24,R25,R29	1k
LED5	RGB Common Anode
R31,R32,R33	1k
LED6	RGB Common Anode
R34,R35,R36	1k
LED7	RGB Common Anode
P1	Connect COM to HV or VCC

This step installs and checks the LEDs (and neons if you chose that option). We install the "tick" of "colon" indicators and all of the RGB back light LEDs. We do this now, because the RGB LEDs are mounted under the tubes.

You might want to test after you install each RGB LED. The startup pattern should slowly turn on and then off the colons, the Red channel of the RGB LEDs, then the Green channel and then the Blue channel.

⚠️ **Warning!**

The startup procedure only runs once, and then the clock goes into normal mode.

You should power off the clock before the Blue phase ends. If you don't do this, and the startup test sequence completes, you can reset it by doing a "factory reset". To do this, connect the button and hold it down while powering on.

**If any of the channels does not go out completely:**

Sometimes the LEDs don't go out completely (especially the Blue channel, because the blue LED is very sensitive). If this happens, carefully clean the flux residue from around Q3-6 (of course with the power off) using a cotton bud and pure alcohol. The FETs are very sensitive to being partially turned on due to tracking over the flux. Let the board dry completely before re-testing.

Trouble shooting

Notes:

- You can install either LEDs or neons as the colon indicators. There is a minor change to the components depending on which you choose.

- **For LEDs**: You need to connect P1 "VIN" to "COM" and choose 1k values for R38 and R39. You need to take care of the polarity of the LEDs, following what is marked on the board.

- **For neons**: You need to connect "170V" to "COM" and choose 120k values for R38 and R39. The polarity of the neons does not matter.

- Q3 - Q6 should be orientated with the flat side as shown on the board. Some FETs come with the leads in a row rather than in a triangle. If this is the case, bend the middle lead slightly so that it fits the holes in the board (see hint).

- R17 is needed to bias the LDR ambient light detection circuit, to make sure that the LED lights up reliably.

- Mount the RGB LEDs close to the board, but be careful not to strain the LED too much. Normally it is best to mount the LEDs until the "lump" in the leads (about 3 – 4mm proud of the board). If you mount the LEDs too high, the tubes have to be mounted much too high from the board.

- The "colon" LEDs need to be mounted proud of the board, on moderately rigid extension wires. It is not easy to estimate the height they should be mounted at yet (it will become clear once you mount the tubes), so for the moment, make the leads longer than you will need.

- Be careful to adequately insulate the LED leads using some heat shrink or excess plastic sleeving.

The Pin-out

5mm LED

red cathode
common anode
green cathode
blue cathode
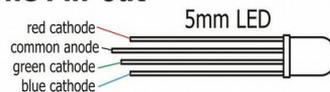
- The RGB LEDs have a tiny "o" on the board to indicate where the common anode goes. The anode is the **longest** lead of the RGB LED.

Hint: MPSA42/2N7000 mounting

To mount the MSPA 42 transistor or the 2N7000 FETs, bend the middle lead back slightly. It will then fit in the PCB without problems.

Anode Control Circuit:

Parts List:

S24	SOCKET 24
OK1	EL817
OK2	EL817
OK3	EL817
OK4	EL817
OK5	EL817
OK6	EL817
R3	1k
R4	1k
R5	1k
R18	1k
R19	1k
R20	1k
R6	3k
R7	3k
R8	3k
R26	3k
R27	3k
R28	3k

This circuit controls passing the HV to the anodes of the tubes. The micro-controller multiplexes the anodes by turning each of them on it turn for a very short period of time. The software controls the rate of the multiplexing and the order in which the anodes are activated.

Notes:

• The Opto-isolators fit into the 24 pin socket snugly. Be careful to put them in the right way round. The dot denotes pin 1 and should be on the side closest to the edge of the board. All 6 should fit perfectly into the 24 pin socket.

• The Opto-isolators are socketed because they are sensitive to heat and are easily destroyed if you apply too much heat to them. Putting them in a socket means that we don't run the risk of destroying them while soldering.

Hint: Putting the resistors in

A trick that can speed assembly up is to use a piece of normal sticky tape to hold things in place while you solder them. This makes is easier to solder and gives a better result.

Place the components, and then temporarily tape them into place.

Using tape to hold resistors in place

Cathode Control Circuit:

Parts List:

IC2	74141N/K155
S16	SOCKET 16

This part of the circuit controls which cathode will be lit. The cathode lit changes rapidly during normal operation, because the display is multiplexed.

Notes:
- Instead of the 74141, you might have the Russian equivalent "K155ID1".
- Be careful to orient the 74141 correctly

Place the 16 pin socket and the connector, and then put the cathode driver chip on the board in the socket.

Mounting the tubes

The tubes are the last components on the board. They must be mounted carefully so that they sit neatly over the top of the RGB LEDs, and so that they are upright and parallel.

|	
⚠️ Important!	**Install the tubes one at a time and test after each tube is installed!** It is very hard to locate where an error is if a tube is faulty or you make a solder bridge by mistake, because all the tubes share the cathode control lines. To help in locating a bad tube or a construction error, test the display after you install each tube, and deal with any issues that appear before moving on. Start with the seconds tube and move to the hours tube, and let the test run for about 30 seconds each time, so each cathode is tested.

The **pin out diagram is viewed from the bottom of the tubes**. Pins 2 and 13 are decimal points, and are often removed on the tubes. The other pins are given below.

Pin	Connection
1	Anode
2	Left decimal point
3	Digit 1
4	Digit 2
5	Digit 3
6	Digit 4
7	Digit 5
8	Digit 6
9	Digit 7
10	Digit 8
11	Digit 9
12	Digit 0
13	Right decimal point
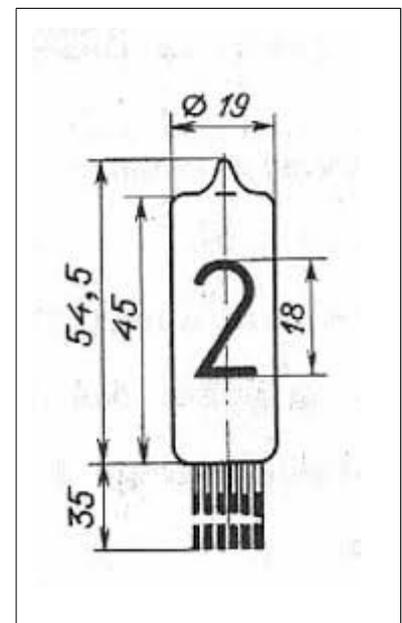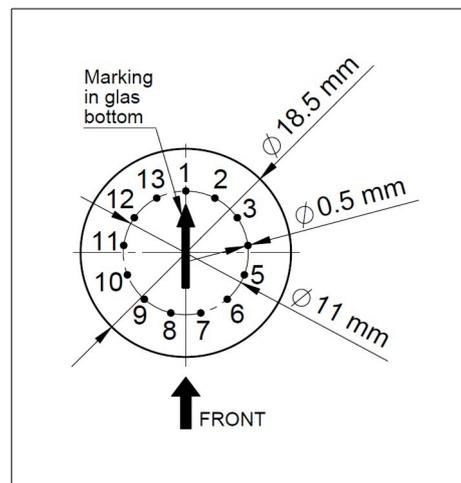
- It is best to carefully spread the legs of the tube out. If you have long enough leads, a trick is to trim the leads to different lengths so they get shorter by 0.5mm as you go round the tube. This means that pin 3 is shorter than pin 1 by 0.5mm. Pin 4 is shorter than pin3 by 0.5mm and so on. Pin12 is shorter than pin 3 by 5mm at the end. This means that you can thread the leads into the holes more easily.
- You can remove the decimal point leads on each side of the anode (pins 2 and 13) if you want – they are not used. Remember to leave an unpopulated hole on the board on each side of the anode in this case. Be careful to trim the right leads if you want to remove them!
- Place the tube base against the top of the LED, without leaving a gap.
- To make the tube stand upright, solder just three leads at the beginning (e.g. pin 1, pin6 and pin 10). You can then easily align the tube so that it is perfectly upright by reheating only one of the pins. Once the tubes are upright and aligned, you can solder the remaining pins.
- For last resort, final, small adjustments, you can force the tube slightly so the leads give. It is best to align the tubes without force. IN-14 tubes are robust, but they are made of glass and must be treated with care.
- Once the tubes are mounted, you can trim the colon LEDs to match the height of the tubes.

Front Panel components

When all the components are installed, you are finished with the board.

SV2	4 pin connector
LDR	LDR
S1	SWITCH

The switch connects to ground when closed. It uses the internal pull-up resistor provided by the Atmega on the input pin to pull the input to VCC when the switch is not closed.

The switch is de-bounced in software, so practically any switch you want to use is suitable. A simple switch is provided in the kit, but you might want to substitute this switch with one that suits you case.

The LDR should be mounted in such a way that the flat face of the LDR is exposed to the ambient light. This will allow it to detect the ambient light and adjust the brightness for it.

RTC or WiFi module

The clock needs to know the time. To do this, an RTC or WiFi module is supplied with the kit, (depending on the option you chose). You can mount these modules directly on the board, or as a separate board connected by flying leads.

The markings on the board need to match up with the markings on the module. In particular, the VCC and GND need to be in the right orientation.

The WiFi module has it's own instruction manual. Please refer to that if you have the WiFi option.

- The RTC module has two sets of contacts on it. You can use either the side with the pins on it or wire up the other side with flying wires. If you use the side with pins, you should carefully remove the two unused pins (see hint). If you use the contacts on the module, you should leave CONN_RTC off the board.

- If you receive the connector header as a single strip, break off 4 pins for SV3.

Hint: Trimming the extra pins on the RTC module

ONLY if you want to mount the RTC module directly onto the main board (you can also do it via flying leads), trim off the pins "32K" and "SQW" using a pair of precision side cutters.

If you want to mount using flying leads, you can skip this step and use the four holes on the other side of the board.
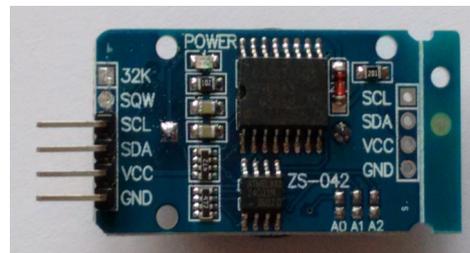
RTC Module with pins removed

Troubleshooting

If not everything goes as you expect, please refer to the test steps during the construction and the associated troubleshooting tips. If that does not cover the problem you have, please see below. If you still can't find the answer, contact us!

Trouble shooting

The tubes flash (or blink) on and off.

This could be a symptom that the external power supply can't deliver the power needed to drive the circuit.

On start up, the High Voltage generator needs to draw significantly more power than when it is running normally, and in some cases this might overload the external power supply.

Try a different external power supply and see if the problem persists.

Trouble shooting

The tube display brightness is not constant, and appears to "pulse" rapidly.

This is a symptom that the High Voltage generator or the external power supply is overloaded.

First perform a factory reset to make sure that no strange values have been left in the EEPROM.

Next, check the value of the **PWM On Time** configuration. Try increasing this until the brightness is constant, but be careful not to set the value too high. The longer the On Time, the more the MOSFET has to conduct current, and this will cause it to heat up. A good value for small tubes is 120-150, larger tubes may require 150-200.

Trouble shooting

The display is too dim.

Check if the auto-dimming is working. If the display does not change in low or high ambient light, your LDR does not appear to be working. Check the connections to the LDR.

If the LDR is correct, perform a factory reset to make sure that no strange values have been left in the EEPROM.

Check the LDR reading by pressing the button three times in quick succession when the clock is on. You should see a value between "01 00 00" and "09 99 00". Changing the light conditions should change this value. It is normal that the value is not stable when it is in the middle of the range. We read the LDR many times a second, and it is unusual that two readings are identical.

Trouble shooting

The display does not come on, but I do have a high voltage.

Try pressing the button. If the display comes on, you probably have display blanking mode set. Check the configuration.

Check the orientation of the opto-couplers.

Check the LDR connection. In some cases, the dimming algorithm does not start up as expected when no LDR is present. Shine a bright light on the LDR.

In some cases, a factory reset can help.

Trouble shooting

One or more of the RGB LEDs will not go out completely

One of the LEDs (either one of the R, G or B channels, or the TICK LED) does not go out completely when it is configured to be dark or at the darkest point of the "pulse" flash.

The FETs which drive the LEDs are very sensitive, and can pick up the stray voltages which are carried by excess flux on the board. **Carefully** clean with a non-scratching instrument between the three pins on the FET of the affected channel. Alternatively, use a solvent to remove excess flux.

Trouble shooting

The MOSFET gets really hot.

Try a factory reset. There is a setting about how hard the IRF740 should be driven "PWM On Time". Perhaps the value has not been set properly. The default value should be OK most of the time, but depending on the tubes and power supply, this might need adjustment. The lower the value, the less power will be used and the less hot the MOSFET will run, but also the less power will be available to drive the tubes.

Check the power supply. If the power supply is too "strong" (too much voltage or too much current capacity), the MOSFET will have to carry high currents. Try a different power supply. 9V and 500mA is ideal.

Change the settings for the "PWM On Time". Adjust it to be as small as possible without a loss of brightness. This also reduces the power consumption of the module: normally it should not consume more than 3W.

Trouble shooting

I can see some "ghosting".

"Ghosting" is where you can see a very faint image of another number at the same time as the one that should be shown. Some tubes are more sensitive than others, and depending on the construction and components, it might show up more.

If you see ghosting, increase the "anti-ghosting" setting, but only to the point where the ghosting is no longer visible or irritating.

The "anti-ghosting" setting decreases the overall brightness of the display slightly, and not all tubes (even of the same sort) need it, so anti-ghosting should only be used when there is a real need to use it.

Programming the micro-controller

The micro-controller comes preprogrammed. You don't **need** to program it, but you might want to.

You can update the micro-controller with a newer version of the software, or even create your own software, and load it onto the chip. We have gone to a lot of trouble to make this as easy as possible.

Programming with an Arduino Uno

We supply the 328P micro-controller chips with a standard Arduino boot loader, so you don't need to have a special programmer in order to update the software, a standard Arduino UNO is enough.

To program the 328P, simply remove it from the clock board, and place it in the Arduino UNO. Then you will be able to program the controller as you would any other Arduino UNO, simply upload the software onto the controller. Put the 328P back into the clock board and you are done.

You can also program the 328P micro-controller with a programmer, but you will lose the possibility to program in the Arduino UNO, unless you remember to burn the boot loader again.

That's it!

One last thing: The controller used in the IN-14 All-In-One clock Rev is completely compatible with the Classic Nixie Clock module Rev2, Rev3 and Rev4. They can be interchanged without danger.
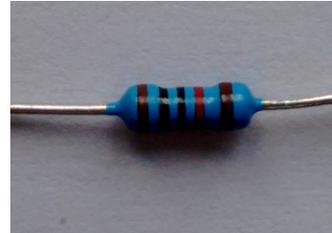
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Component Identification

We can't always guarantee to get exactly the the same components. Where we have alternatives, they are listed separately under the same heading.

10k resistor

The color code for the 10k resistor is:

BROWN = 1
BLACK = 0
BLACK = 0
RED = 2 (2 zeros in this case)
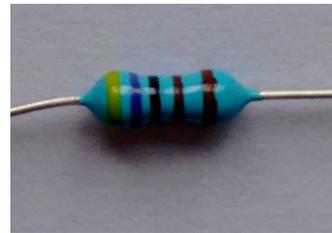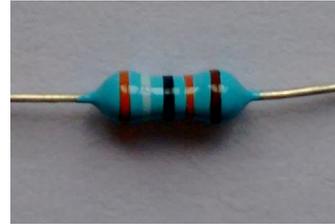BROWN = 1 (1% Tolerance)
= 1 0 0 0 0 with 1% tolerance

10k resistor

4.7k resistor

The color code for the 4.7k resistor is:

YELLOW = 4
VIOLET = 7
BLACK = 0
BROWN = 1 (1 zero in this case)
BROWN = 1 (1% Tolerance)
= 4 7 0 0 with 1% tolerance

4.7k resistor

390k resistor

The color code for the 390k resistor is:

ORANGE = 3
WHITE = 9
BLACK = 0
ORANGE = 3 (3 zeros in this case)
BROWN = 1 (1% Tolerance)
= 3 9 0 0 0 0 with 1% tolerance

390k resistor

3k resistor

The color code for the 3k resistor is:

ORANGE = 3
BLACK = 0
BLACK = 0
BROWN = 1 (1 zero in this case)
BROWN = 1 (1% Tolerance)
= 3 0 0 0 with 1% tolerance

3k resistor

100nF capacitor

The coding on the 100nF capactor is "104". It does not matter which way round it goes.

This is decoded as:

= "1" then a "0" and then 4 more zeros
= 100000 pF
= 100 nF (1 nF = 1000 pF)

100nF capacitor

22pF capacitor

The coding on the 22pF capactor is simply "22". It does not matter which way round it goes.
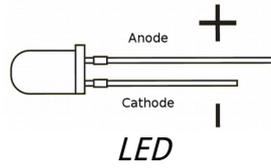

22pF capacitor

RGB LED

The RGB LED has one pin longer than the rest. This longer pin is the common anode.

The Pin-out
5mm LED
red cathode
common anode
green cathode
blue cathode

RGB LED
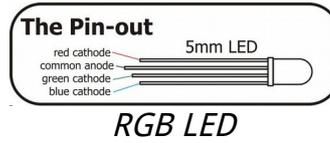
LED

The LED has one pin longer than the other. The long pin is the anode, the short pin the cathode.

Anode

Cathode

+

—

LED

Parts list / BOM

Here is the list of the parts needed:

#	ID	Qty	Value
1	C5,C6	2	22pF
2	LED9,LED8	2	LED 5mm
3	C1	1	2.2uF
4	C3,C4	2	220uF
5	LED2,LED7,LED6,LED5,LED4,LED3	6	LED RAGB (common anode)
6	Q2	1	16MHz
7	D1,D2	2	UF4007
8	IC2	1	74141N
9	R2	1	4.7k
10	R1	1	390k
11	R14,R7,R8,R28,R27,R26,R6,R10	8	3k
12	R13,R12,R9,R11,R3,R19,R18,R23,R20,R21,R22,R24,R25,R29,R31,R32, R33,R34,R35,R36,R37,R4,R5,R15,R16	27	1k
13	R38,R39	2	1k for LEDs, 120k for neons
14	R30,R17	2	10k
15	IC3	1	MEGA8-P 328P
16	OK1,OK2,OK3,OK4,OK5,OK6	6	EL817
17	SV1,SV2,SV3	3	4 pin header
18	Q3,Q4,Q5	3	2N7000
19	Q6	1	MPSA42
20	C7,C2,C8	3	100nF
21	LED1	1	LED 3mm
22	L1	1	100uH
23	IC1	1	7805
24	Q1	1	IRF840
25	N2,N5,N4,N3,N6,N1	6	IN-14
26	RTC module (optional)	1	DS3231
27	WiFi module (optional)	1	WiFi Provider
28	CON_1	1	Barrel Jack

Revisions:

Rev1V42: 16Jul2016: First version
Rev2V42: 11Aug2016: Update for Rev2 boards
Rev2V42: 23Aug2016: 450V capacitor downgraded to 400V
Rev2V42: 05Sep2016: remove reference to SV6, update BOM
Rev2V44: 26Sep2016: Add off board components schematic
Rev2V45: 17Dec2016: Remove reference to 1N4001
Rev2V45: 17Feb2017: Add hint about installing tubes one at a time and testing after each tube.
Rev2V45: 24Feb2017: Update photos
Rev2V45: 26Mar2017: Correct text about orientation of opto isolators