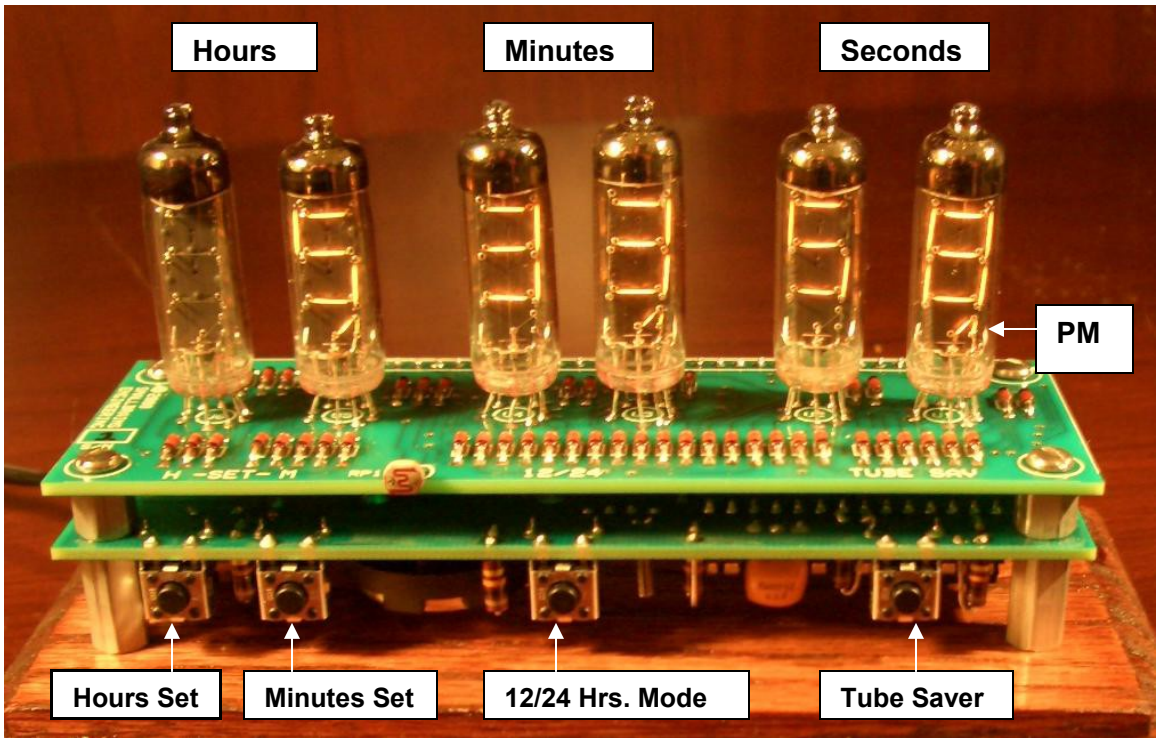
Small Brains Engineering's Numitron Clock User's Manual

This handmade digital desk clock uses six NOS (new, old stock) Russian surplus IV-9 Numitron display tubes to display the time with glowing metal filaments suspended in glass vacuum tubes.

What is a Numitron?

Numitrons are an obsolete digital display technology introduced in the early 1970's. Essentially a specialized version of Edison's original electric light, Numitrons glow with a warmth unlike any modern display. Built like vacuum tubes, yet driven directly by low voltage logic, Numitrons were a transitional technology bridging the eras of radio tubes and digital logic. Numitrons competed with the older and more common Nixie tubes, but were quickly made obsolete by the introduction of the modern LED display. As a result Numitron displays are quite rare today.

Operation:



The Display

Your Numitron Clock displays the time using six IV-9 Numitron display tubes. Each tube can display a single digit and a digit separator mark. The digit separators in the ones-of-hours and ones-of-minutes tubes flash once per second. The separator marks are lit during the second half of each second. The digit separator mark in the ones-of-seconds tube is used as a PM indicator when the clock is set for 12-hour mode.

Your clock will automatically dim and brighten the display tubes to match the ambient light level. For best appearance and tube life you should avoid direct sunlight.

12 Hour and 24 Hour modes

The clock can be set to display the time in either 12-Hour or 24-Hour format by pressing the **12/24** button.

Tube Saver Mode

You can put the clock into or out of a tube saver mode to conserve power and extend the lifetime of the Numitron tubes by pressing the **TUBE SAV** button. The digit separator marks will flash in sequence like the swinging pendulum of a mechanical clock to show the clock is powered up and running. Tube Saver mode is ideal if you're away for the weekend or on a short vacation. If your clock is not going to be used for an extended time it should be unplugged.

Setting the Clock

When the **H-SET** button is pressed the hours value will increase. The value will increase slowly at first, and then speed up if the button is held down. When the **M-SET** button is pressed the minutes value will increase, and the seconds value will be set to zero. The value will increase slowly at first, then speed up if the button is held down. If the minutes value wraps around from 59 to 00, the hours value will not be incremented.

To set the clock accurately, set the minutes value to the current minute. As your reference clock wraps around from 59 to 00 seconds, click the **M-SET** button to increment the minutes value to the current time and reset the seconds value to 00.

The hours value may be set before or after setting the minutes value. The digit separator in the one-of-seconds tube will be lit when the clock is set for 12-hour mode and the time is past mid-day.

The clock may be set in either 12-hour or 24-hour modes.

Care and Cleaning

The Numitron clock is designed for indoor use, away from direct sunlight. It should not be subjected to weather, or high levels of shock or vibration.

Acrylic cover

Acrylic should never be cleaned with any cleaner containing ammonia, such as common cleaners like Windex™ or Formula 409™. Also, never clean the acrylic cover with a dry cloth or with your hand, as this simply rubs dust and dirt into the plastic. First blow off any dust, then use a soft cloth with a diluted solution of mild dish detergent and warm water. It is even better to use a cleaner specifically recommended for acrylic, such as Novus #1™ or Brillianize™ plastic cleaners.

Base and Electronics

The acrylic cover should be used to keep dust out of the base and electronics section, as well as to protect the Numitron tubes from damage.

Should the electronics section need cleaning, great care must be used to prevent damage to the Numitron tubes and the clock's time base crystal, which is located just to the right of and behind the 12/24 button. It is the slender vertical silver tube, and it is quite sensitive. Any shock or damage may effect the accuracy of your clock.

If the base and electronics become contaminated, we recommend you contact us for service.

Customizing your clock

There are several ways you might like to customize your clock. Photographs or colored backgrounds may be placed on the inside of the acrylic case behind the tubes. Window tinting films or colored filters could be used to enhance contrast and give your clock an even more unique appearance.

For the hard-core techie, the Technical Information and Specifications sections provide information on how to drive the Numitrons with custom microprocessor firmware. Custom firmware could be used to display the date stored in the RTC chip, or other information.

Service

Each Small Brains Engineering Numitron Clock is a hand-made, individually serialized piece of electronic art, and we will service these clocks as long as we are physically able to do so. For service information please email:

SmallBrainsLabs@comcast.net

Numitron Replacement

Numitrons may last over 100,000 hours of operation (over 11 years!). This clock drives the tubes conservatively, especially in lower lighting levels, for an even longer life. Eventually a segment will fail, but this is not a major problem. Small Brains Engineering stocks a large number of spare Numitron tubes. We can replace failed tubes, or provide replacement tubes to competent electronics technicians to service our clocks.

Backup Battery Replacement

This clock uses a CR-2032 coin-cell battery to maintain timekeeping without external power. This battery will drive the DS1307 time-keeping chip for over 10 years without external power.

The backup battery may be replaced by a competent electronic technician by following this procedure:

1. Disconnect external power, and carefully remove and store the acrylic cover.
2. Carefully lift the base of the clock, and remove the four screws and washers mounting the electronics to the base. The Numitron tubes must be protected from any shock or impact.
3. Lift the electronics from the base a few inches by letting the power cable slide through the hole in the base. You can now see the CR-2032 coin cell in its battery holder on the bottom of the electronics module.
4. Remove the old battery, and inspect the contacts for any leakage. If your battery has leaked, please contact us for service.
5. Install a fresh battery into the holder plus side facing away from the socket, and place the electronics module back onto the base and replace the mounting screws and washers.
6. Reconnect the external power and reset the clock. Verify that the clock will continue to keep time while the external power is disconnected. If all is well, replace the acrylic cover.

Specifications

Size:	5 ¾ “ wide, 4 “ tall, 3 ¼” deep (inches)
Numitron type:	Russian type **ИВ-9** (IV-9), multiplex drive @ 8.5V
Digit Size:	Approx. 0.45” tall, 0.26” wide
Microprocessor:	Microchip PIC @ 20 MHz, in 28-pin DIP socket
RTC:	Dallas DS1307 I^2C RTC with CR-2032 cell
Time-base:	32.768 KHz crystal, Epson C-2 Type, +/- 20 PPM.
Power consumption:	Approx. 0.180 to 0.220 A @ 12 VDC input
Power connection:	2.1 mm, 12 VDC, center positive (reverse protected)

Technical Information

This section is for people who wish to customize their clocks by replacing the stock microprocessor with one containing their own firmware.

The stock microprocessor is a PIC16F876A-I/SP using a 20 MHz ceramic resonator. Pin 2 is used as an analog input for the light level sensor, all other pins are configured for digital I/O. Any pin-compatible PIC may be used.

<u>I/O Assignments</u>

PORTA, analog and digital inputs:
A.0 – Light level sensor ADC input. Lower = darker, higher = brighter.
A.1 – H-SET button, 0 = pressed, 1 = not pressed.
A.2 – M-SET button, 0 = pressed, 1 = not pressed.
A.3 – 12/24 button, 0 = pressed, 1 = not pressed.
A.4 – SWQ signal input from DS1307, 10 K ohm pull up to +5V.

PORTB, segment driver outputs:
B.0 – DP Segment, 0 = dark, 1 = lit.
B.1 – Segment A, 0 = dark, 1 = lit.
B.2 – Segment B, 0 = dark, 1 = lit.
B.3 – Segment C, 0 = dark, 1 = lit.
B.4 – Segment D, 0 = dark, 1 = lit.
B.5 – Segment E, 0 = dark, 1 = lit.
B.6 – Segment F, 0 = dark, 1 = lit.
B.7 – Segment G, 0 = dark, 1 = lit.

PORTC, digit driver outputs and I^2C bus:
C.0 – ones-of-seconds drive, 0 = dark, 1 = lit.
C.1 – tens-of-seconds drive, 0 = dark, 1 = lit.
C.2 – ones-of-minutes drive, 0 = dark, 1 = lit.
C.3 – I2C bus SCL, 4.7 K Ohm pull up to +5V.
C.4 – I2C bus SDA, 4.7 K Ohm pull up to +5V.
C.5 - tens-of-minutes drive, 0 = dark, 1 = lit.
C.6 – ones-of-hours drive, 0 = dark, 1 = lit.
C.7 – tens-of-hours drive, 0 = dark, 1 – lit.

Recommended Multiplexing Timing

The display tubes are multiplexed so that only a single tube has its drive signal (PORTC) on for a 4 millisecond window out of every 24 milliseconds. This yields a refresh rate of about 41.6 Hz. Each tube has a maximum duty cycle of16.6% for full brightness and a 8.3% duty cycle at full dimming.

To give a reasonable brightness at this duty cycle the Numitron drive voltage is regulated to about 8.5 volts.

Any custom firmware must ensure that the tubes are not over-driven (duty cycle too high) to prevent premature tube failure. Also the power supply is designed to drive a single tube at a time. Enabling more than one digit drive signal at a time may cause excessive current demand and heat.

To drive the display the microprocessor must set PORTB to select the desired pattern of segments, and then pulse the desired digit drive output high. Current will now flow through the Numitron tube and the filaments will glow. The longer the digit drive signal remains high, the brighter the filaments will glow. Turn off the digit drive signal and begin the process on the next tube to be driven.

For best tube life each tube should be driven with the duty cycle between 8.3% and 16.6%. IV-9 and other Numitrons may be subject to mechanical resonances in the filaments that can drastically shorten the tubes life. We recommend using the 8.3% to 16.6% duty cycles with the stock refresh rate of ~ 41.6 Hz.