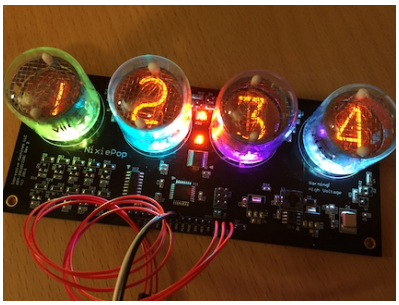
Impressive Machines

NixiePop 4-Digit Nixie Tube Controller

The NixiePop controller is a general-purpose 4-digit Nixie tube controller with programmable colon and backlighting.



Features

- High quality gold plated surface mount PCB
- Four-digit Nixie display
- RGB LED back-lighting on each tube independently programmable to generate multiple colors
- The colon indicator can also be turned on and off
- Modules can be stacked next to each other for more digits
- Runs from 9-12V, with on-board 180V power supply
- Easily controlled by a serial line from the Arduino or any micro-controller or laptop to display any digits
- The board can also function as a stand-alone voltmeter
- Based on the familiar ATMega328P
- Comes pre-programmed with open source display software
- Easily customized via the ISP port using standard tools
- Most spare micro-controller pins are accessible at the connector
- Based on plug-in IN-4 Nixies which are easily replaced
- Schematics and code are available for easy hacking

WARNING – SHOCK HAZARD!

During normal operation this unit generates a high voltage, and this can give you an electric shock if you handle the wrong part of the board. The current is not very high but a shock from the unit is unpleasant. Do not handle the board unnecessarily while it is turned on, or if you do hold it, hold only the corners of the board and avoid touching the copper traces or Nixie pins.

It is normal for the high voltage supply to produce a whistling noise.

The Nixie tubes are fragile glass objects. In particular it can be easy to snap off the bottom sharp ends of the tubes that protrude through the board. Be careful when placing the board down on a surface. If the ends crack then the gas is lost and the tubes will no longer function.

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Operational Modes

The NixiePop unit comes pre-programmed with software that provides two modes of operation:

In the serial mode the unit is entirely controlled by the serial port of another computer (e.g. an Arduino board). Commands can be used to set the digits to be displayed, control the backlighting, or turn the colon on and off. Digits can range from 0 through 9, or optionally can be turned off. If all the digits are turned off then the display powers down the high voltage supply to reduce power consumption, electrical noise, and acoustic noise.

In the voltmeter mode the unit reads the analog voltage on a port pin in the range 0-5V. This is converted to a digital readout of millivolts in the range 0-5000. This mode does not require a connection to an external computer. In this mode the display always has a white backlight.

Connector Pinout

All digital signals use 5V logic levels.

Pin	Name	Function
1	5V	Regulated 5V output. This output has a limited current capability. Check the specifications at the end of this document.
2	GND	Ground.
3	ADC6	In voltmeter mode this input should be an analog voltage in the range 0-5V and will be converted to a number to display in the range 0-5000. In serial mode this input is unused.
4	ADC7	Spare analog input to the CPU. Not used by the current software.
5	PD2	Spare port connected to the CPU. Not used by the current software.
6	PD3	If this input is tied to ground while the unit is powered up then the display will enter voltmeter mode and will display the voltage on ADC6. If this input is left floating or tied to 5V then the display will enter serial mode and wait for commands on RXD.
7	VIN	Input voltage in the range 9-12V.
8	GND	Ground.
9	MISO	SPI master in slave out (PB4) of the CPU. Not used by the current software.
10	MOSI	SPI master out slave in (PB3) of the CPU. Not used by the current software.
11	SCK	SPI serial clock (PB5) on the CPU. Not used by the current software.
12	RES	Active low reset line to the CPU. This is pulled high through a 10K resistor on the board. Grounding this line will reset the CPU.
13	SS	SPI slave select (PB2) of the CPU. Not used by the current software.
14	RXD	Serial data into the display. Send commands to the display using this pin.
15	TXD	Serial data out from the display unit. The display uses this line to acknowledge commands that are sent on RXD. Connecting this line is optional.
16	GND	Ground.

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Serial Protocol

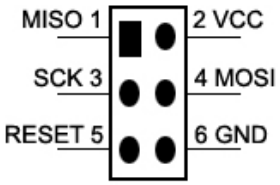
The unit receives serial data on RXD and acknowledges serial data using TXD. The serial protocol is 19200 baud with 8 bits, 1 stop bit and no parity. The commands are described in the following table:

Command	Description
:	Turn the colon on. (colon)
;	Turn the colon off. (semicolon)
$nnnn	Displays the digits nnnn. Here n can range from 0-9 and also the "-" character can be used to indicate a blank (non-displaying) digit. The display can be turned off completely by sending "$----".
#rgbrgbrgbrgb	This command is used to set the color of the backlighting for each of the digits independently. The order of the components is from left to right on the display. The values of r, g, and b can be 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, a, b, c, d, e, f, representing 16 levels of brightness. So for example sending the command "#888f000f000f" sets the first (leftmost) digit to a middle grey, the second digit to full red, the third digit to full green, and the last (rightmost) digit to full blue. The backlight can be turned off by sending "#000000000000".

It is not necessary to insert carriage returns in the command sequence. The acknowledgment response from the unit is to echo the command as it is sent, unless an error is detected, in which case a "?" character is returned.

ISP Port

The ISP port can be used to erase the existing software and re-program the CPU with user software for novel functionality. The port is a standard 6 pin programming port:



Pin 1 of the ISP port is the pin closest to R29. Conventional Atmel programming tools can be used to re-program the CPU. We recommend using the AVR JTAGICE3 interface unit and Atmel Studio development environment.

Hardware Description

The design is based around the Atmel ATMega328P microcontroller. This is a common type that is also used on some Arduino boards. It has 32K flash ROM and 2K RAM. The CPU is programmed via the 6-pin ISP port that is built into the board. A 16MHz crystal is provided for generating the CPU clock. Spare port lines for the CPU are brought out to the connector to allow for greater flexibility.

The power supply generates 5V for the logic and 180V to drive the Nixies. The 5V comes from a fixed linear voltage regulator. The 180V supply is generated by a switching boost converter

based around the MAX1771. This design uses a transformer rather than an inductor to increase the stability and lengthens the on-time of the MOSFET.

The Nixie tubes are multiplexed and switched at both the anodes and the cathodes. During normal operation each digit anode is turned on one by one. The cathode corresponding to the desired digit is connected to ground. The anodes are switched though a level shifter involving NPN and PNP high voltage transistors. A four-bit code from the CPU is decoded using an MC14028 IC to give one-of-ten active high outputs. These drive the cathode transistors.

The cathodes are also connected to ground via 51V zener diodes. This is done to prevent ghosting between digits, because otherwise the voltage differential between cathodes that are on and cathodes that are off can rise high enough to energize digits in the tubes that are intended to be off. However the addition of these zeners causes tubes to partially illuminate if the cathodes are all turned off while the anode is on, and so the software must turn both the anode and the cathode off for digits that are intended to be blank.

The LEDs are driven by a TLC5971, which is employed to PWM control four channels of RGB LEDs using constant current drive.

Software Description

On start-up the software configures the ports and configures the timer for the interrupt service routine (ISR). It also sets the backlight to a mid white. The code then checks the logic value on PD3 and if low, the system enters voltmeter mode, otherwise it enters serial command mode.

The digits are multiplexed by an ISR that is called when Timer0 expires. On every interrupt the next digit is selected. The code reads the current desired number from a global variable. Values 0-9 indicate the digit, and 0xf is reserved to indicate a blank digit. If an active digit is on, the interrupt routine energizes the Nixie anode and turns on the correct cathode. If the digit is blank, the routine turns off both the anode and the cathode. The ISR also is responsible for incrementing a timer variable that is used by the voltmeter mode.

In serial mode the serial port is programmed for 19200 baud. The code waits for serial command bytes and echoes these back to the user. When each command is validated it is then used to change the state of the display. The “$” command changes the global variables that are read by the ISR. If the digits are all commanded to be off then the power supply disable control bit is set in order to turn off the HV supply, otherwise this supply is enabled. If the color of the backlight LEDs is changed then the code serializes the new color data into the TLC5971 chip.

In analog voltmeter mode the code initializes the ADC module. Using the timer byte which is incremented by the ISR, the voltmeter code regularly does an ADC conversion of the voltage on ADC6 and converts this reading into a value which is suitable for display on the Nixie digits. The code handles leading zero suppression. It is recommended to place a capacitor across the analog input to stabilize the display reading.

The CPU is intended to run from the on-board 16MHz crystal. For this reason the fuse bytes are set to Ext=FF, High=D9, Low=DE, although they can be changed by the user via the ISP port for other applications.

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Specifications

Dimensions	153 x 64 x 41 mm
Weight	105 g
Mounting holes	6-32
Nixie tube type	IN-4
CPU	ATMega328P
Supply voltage	9 – 12V
Supply current (typical)	230mA
5V supply output current (maximum)	200mA
Nixie voltage	180V

Further Information

Software, the latest updates, and a high-resolution schematic can be found at https://github.com/impressivemachines/NixiePop

Contact

http://impressivemachines.com

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