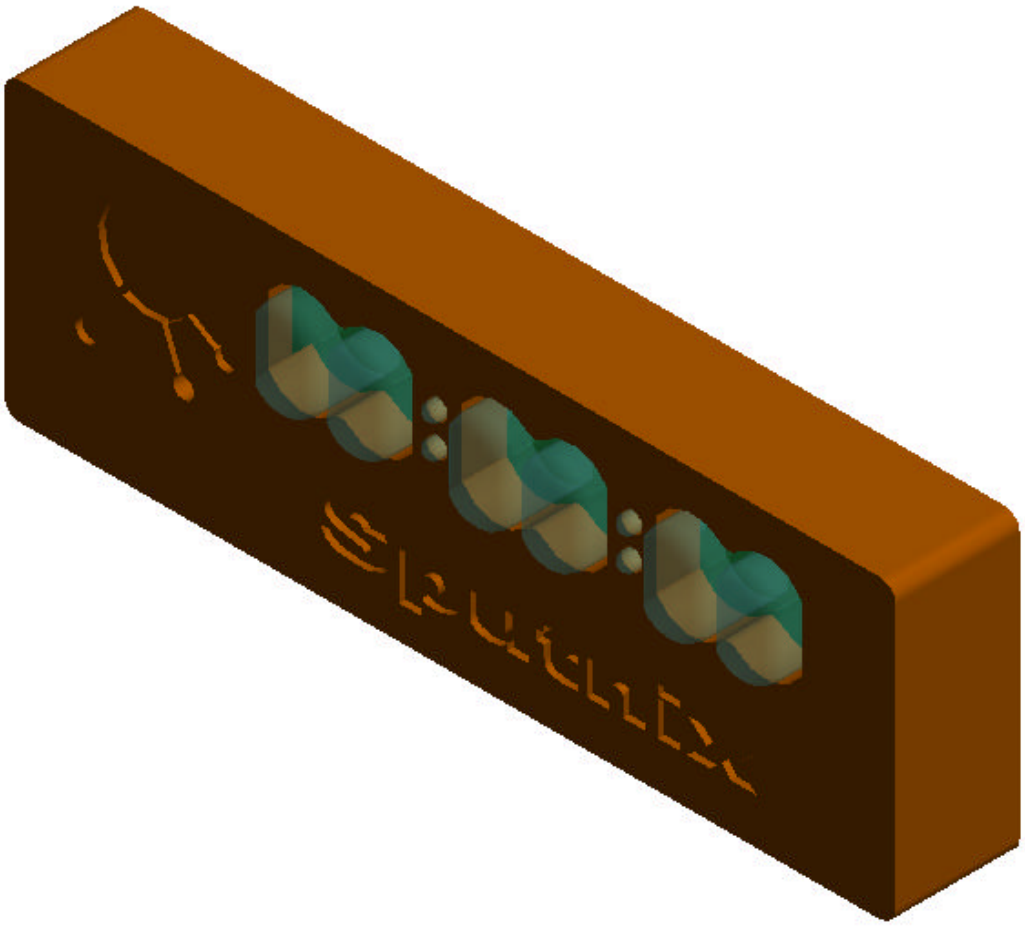
Sputnix Specification



SPUTNIXIE.COM
by Greg Powell

ABSTRACT

This document provides hardware and firmware specifications in order to supplement the understanding of the source code and schematic diagrams. The clock is a 3rd generation design.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 Hardware

1.1 Printed Circuit Board

This document describes Sputnix hardware revision D issue 1.

1.2 Display

The time display consists of 6 IN-12b Russian Nixie tubes and 4 neon bulbs as colons. All numerals and colons are individually controllable with 5-bit brightness resolution. The 64-bit display is directly driven via 8 shift registers connected in series. The display draws the most current, 200V 16mA (3.2W). The PCB features socketed pins so that the tubes can be replaced or interchanged.

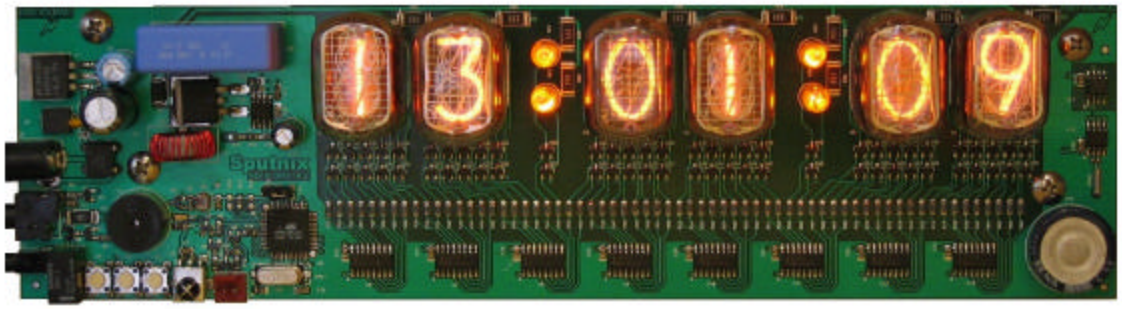


Figure 1: Nixie Tube Display.

1.3 I/O

1.3.1 Power Input

Input voltage range is 10 to 13 volts. Refer to Table 1 for actual power consumption. A bridge rectifier on in power input means that the input is polarity insensitive. A transient voltage suppressor preceded by a thermistor protects the supply input. The TVS minimum conduction voltage is 13.3V. The voltage available to the external trigger output will vary with the input voltage and is equal to the input voltage minus a 1.4V drop across the input rectifier.

Table 1: Power Consumption

Clock State	Input Voltage	Current Draw*
Display off/Relay off	13V Max	20mA
Display 100% /relay on	10V Min	580mA

* Relay draws 30mA

1.3.2 Relay

A 2.5mm mono connector provides a dry contact relay output rated to 1A 24VDC. De-rated to 50mA, 24VDC.

1.3.3 Trigger Input/Power

A 3.5mm stereo connection is provided typically for a PIR motion sensor. Dry contact between tip and ring will trigger input. The input RC time constant is 5ms; Contact bounce is normally up to 50ms and should be taken into account. A supply of 10V, 10mA (refer to section 1.3.1) is available from ring (-) and sleeve (+) connections to power a PIR motion sensor. Refer to Figure 2 for pinout details. Refer to section 2.10 for firmware functionality.

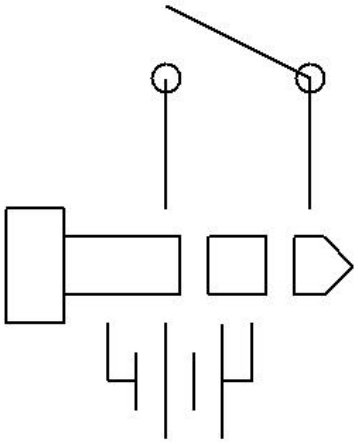


Figure 2: 3.5mm External Trigger Pinout.

1.3.4 Buttons

Three buttons are provided for clock setting and functions.

1.3.5 IR Input

A 38KHz infra red input allows the use of a universal remote control. The remote provides a keypad and expanded button set for ease of feature programming. An RCA SystemLink remote control such as the RCU403 is recommended to control the clock. To configure the remote to work with the clock follow the remote control programming instructions and use the TV code “062”.

1.3.6 Serial Input

A serial transmit and receive connection is provided for RS-232 connection. The voltage level of serial transmit is 0 to 5V. The receive input is tolerant of RS232 voltage levels. The serial connection also allows for upgrading the firmware when in boot mode (refer to).

1.3.7 Nixie Tubes

The IN-12b tubes have a maximum ionization voltage of 170V. All tubes will operate properly at or above the ionization voltage. The minimum supply voltage must exceed the maximum ionization voltage in order to ensure that all tubes ionize and operate within current limits.

1.3.8 Display Power

The power supply for the tubes generates a supply voltage of 200V and is capable of supplying 16mA. Each tube requires 2mA for optimal maximum brightness and tube life. A boost topology switch mode power supply is used to boost the input 12V up to 200V. The output ripple is 34KHz and less than 1Vpp at.

1.4 Audio

A buzzer provides audible feedback of button entry and alarm capability.

1.5 Time Keeping

A real time clock keeps the time with capacitor backup for long-term power outage. The clock will keep time up to 20 days (1F capacitor) or 2 days (0.1F capacitor) without external power.

1.6 Temperature Sensor

A temperature sensor is built onto the board for sensing ambient temperature.

1.7 Light Sensor

A light sensor on board allows detection of ambient light for automatic adjustment of element brightness.

2 Firmware

2.1 User Interface

2.1.1 Remote Control

There are two levels of clock control. The first are one-button commands and second are two-button commands. One-button commands are shown in Table 2. Two-button commands are shown in Table 3.

Table 2: One-button commands.

Remote Control Button	Function
“Power”	Toggle power on and off
“Volume”	Adjust brightness
“4”	Toggle 12hr and 24hr display mode
“5”	Toggle relay on and off
“6”	Show alarm time for 2 seconds
“8”	Show firmware version for 2 seconds
“MUTE”	15 minute snooze

Table 3: Two-button commands.

Remote Control Button	Function
“Enter” + “0”	Enter boot mode*
“Enter” + “1”	Set time
“Enter” + “2”	Set alarm
“Enter” + “3”	Toggle Alarm Enable
	Enable Auto brightness adjust

* only if program jumper is installed on J5.

2.1.2 Buttons

To be implemented.

2.2 Interrupts

2.2.1 IR Receive

Modulated 38KHz infrared signals will be demodulated by the Photo IC and generate an external interrupt. The protocol was based on an Atmel application note “AVR410: RC5 IR Remote Control Receiver”. The IR data is sampled based on the RC5 bi-phase encoded protocol. A flag is set indicating an IR command has been received. RC5 commands are repeated every 114ms thus a timer is set to expire in 120ms to avoid receiving the same command more than once. The flag is checked in the main loop where a parsing subroutine is called to handle the command inputs.

2.2.2 Timer Interrupt

A 10ms timer interrupt is used as a multi-purpose timer. The timer is used for element fading. Elements are updated at 100Hz. A flag is set every 10ms and allows for 1 second digit cross fade. The timer is also used for menu button timing; an 8-bit counter allows for up to 2.5 seconds of delay between pressing the menu button and subsequent mode button. The time is used for IR receive blocking. Since IR messages are repeated every 114ms while a button is pressed the IR is blocked for 120ms after each IR message is received to avoid receiving a message twice. The timer is also used for the display colon-blinking cadence.

2.3 Element Display

2.3.1 RAM

Elements are controller via RAM. All 64 elements are organized in RAM according to the schematic connections of the shift registers. To turn an element on a value between 0 and 32 is written to a RAM location corresponding to the element. The brightness is 5-bit PWM controlled; a value of 32 will correspond to 100% brightness while 16 will correspond to 50% brightness. A value of zero is used to turn the elements off.

2.3.2 Time

To enter set time mode a combination of button presses is required. “ENTER” + “1” will put the clock in set time mode. The colons will blink at a cadence of 0.5 seconds. Time is entered from left to right. In both 12 and 24-hour mode all 6 numbers are entered sequentially. In 12-hour mode the 6 digits are followed by

"1" for pm or "0" for am. The time is kept by the real time clock (refer to section 5).

2.3.3 Time Display Modes

The clock supports both 12 and 24-hour time display. When in 24-hour mode all 6 digits will be on. In 12-hour mode the leading zero is turned off. In 12-hour mode the top right hand colon is the PM indicator and will be off during AM.

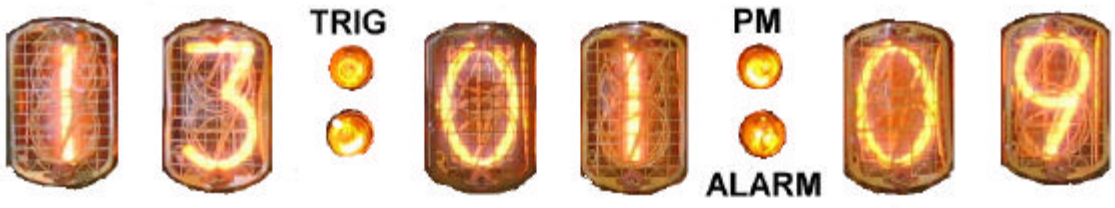


Figure 3: Display.

2.3.4 Temperature

[To be implemented]. Temperature is displayed in the hours and minutes positions with the lower colon in-between representing a period and the upper colon on the end representing the degrees indicator.

2.4 Settings Backup

User settings are backed up to RAM provided on the real time clock. The RTC RAM is non-volatile battery-backed (refer to section 5). The state of the clock such as relay, power and brightness are stored. The settings are restored upon power-up.

2.5 Alarm

An alarm can be set in the alarm set mode. The alarm setting can be momentarily displayed for 2.5 seconds. The alarm can be enabled or disabled. The lower right hand colon blinks if the alarm is enabled (Refer to Figure 3). When the alarm is enabled and the current time matches the alarm set time the buzzer will sound and the relay will toggle. The buzzer will silence when any IR input is received. The relay can be toggled with the relay toggle button.

2.6 Snooze

If the mute button is pressed at any time the buzzer will be set to go off 15 minutes later. The buzzer will automatically shut off 1 minute later or if any IR input is received.

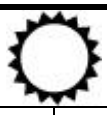
2.7 Brightness Setting

Brightness is controlled by the volume up/down buttons on the remote control. There are 6 brightness levels: 100%, 50%, 25%, 12.5%, 6.25% and 3.125%. Brightness can be adjusted for both bright and dim ambient light conditions (refer to section 2.8).

2.8 Auto Dimming

The display will automatically adjust to the ambient light level. The brightness can be set for both light and dark ambient light levels; the display will automatically adjust to the set levels when the ambient light level crosses the bright/dim threshold. The brightness levels are selected by placing the clock in the prospective ambient levels and adjusting the brightness to the desired level using the volume control buttons. There are thus 36 possible brightness configurations.

Table 4: Display Brightness.

	Ambient Light											
												
Display Brightness	100%	50%	25%	12.5%	6.25%	3.125%	100%	50%	25%	12.5%	6.25%	3.125%

2.9 Auto De-Sputter

[To be implemented]. The display will automatically exercise the elements randomly in order to preserve un-used digits.

2.10 External Trigger

The external trigger will turn clock power on when an input edge is detected. The input detects rising or falling edges on external trigger input and will therefore

work with normally open or normally closed relay contacts. An edge trigger event is displayed by the upper left colon turning off for 2.5 seconds (refer to Figure 3). Upon power-up the external input is assumed to have an open contact and will not trigger. If a closed contact is applied at power-up then the external input will trigger a one-hour auto shut down of the display.

2.11 Boot Upgrade

The clock application code can only be upgraded if the micro controller has been programmed with boot code. To enter boot mode the clock can be re-powered with the boot jumper, J5, installed. Or by pressing the “ENTER” + “0” button combo on the remote with the boot jumper installed. To upgrade the clock firmware enter boot mode and execute AVRprog.exe. AVRprog will scan the serial ports for a supported device. If the clock is properly connected to a serial port and is in boot mode the following screen will appear:

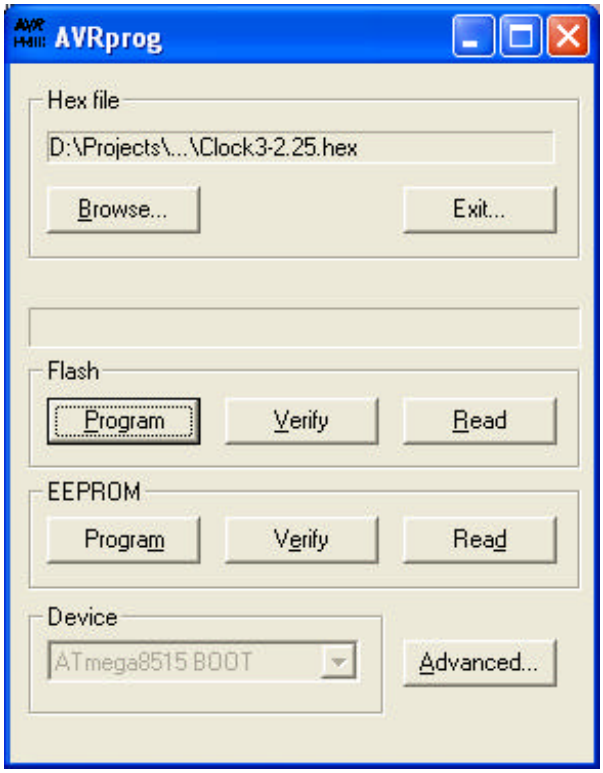


Figure 4: AVRprog Boot Upgrade.

Browse for the desired HEX file and click on Program. When the upgrade is complete the Exit button can be clicked for the clock to exit boot mode or the clock can be re-powered without the boot jumper installed.

If the clock is not in boot mode or the serial port is in use then the following screen will appear:

Figure 5: AVRprog Fail.

2.12 Serial Cable

The serial cable, that connects to J3, for boot upgrade (or RS232 interface) pinout is as follows:

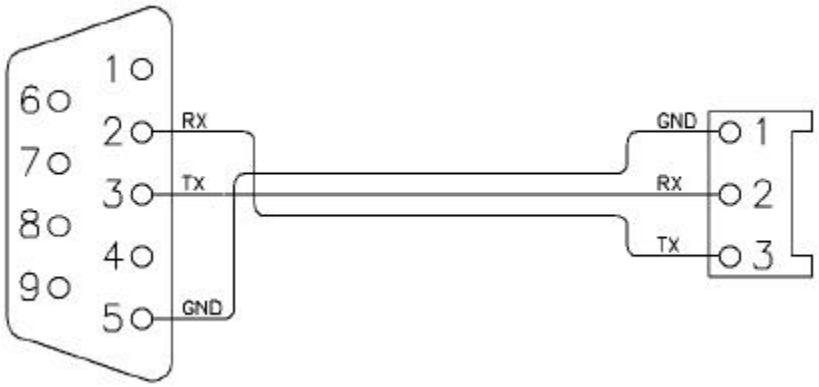


Figure 6: Serial Cable.

2.13 Programmer

To program the micro controller with boot code initially the Atmel ATAVRISP or ATAVRISP2 is recommended (both available from Digikey). Once the boot code has been programmed the programmer will no longer be required.

The ATAVRISP connects to the programming header on the bottom side of the board as follows (I used pogo pins for temporary connection):

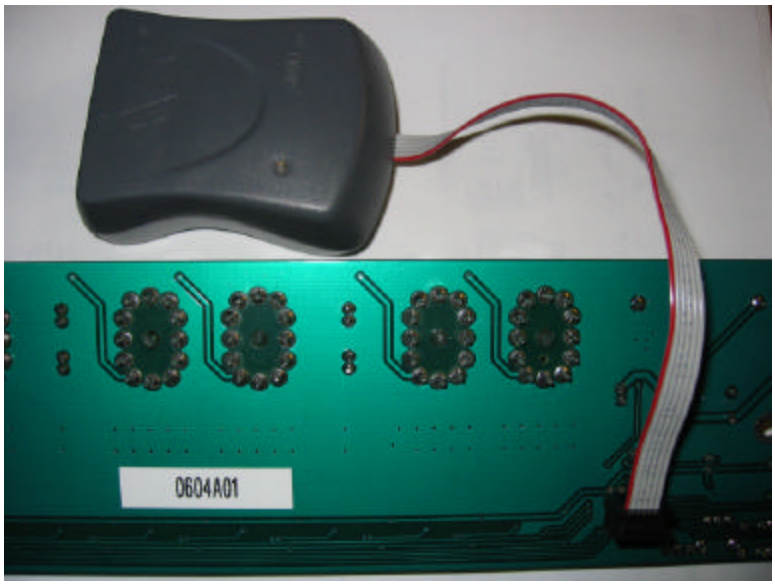


Figure 7: Programmer Connection.

When programming the boot code using Atmel AVR Studio, set the fuse bits as follows:

1. Boot Flash section set to 512 words.
2. Boot reset vector enabled.
3. Internal RC oscillator 8MHz, startup time 6 CK + 64ms.

Fuses should read as follows: $DAE4

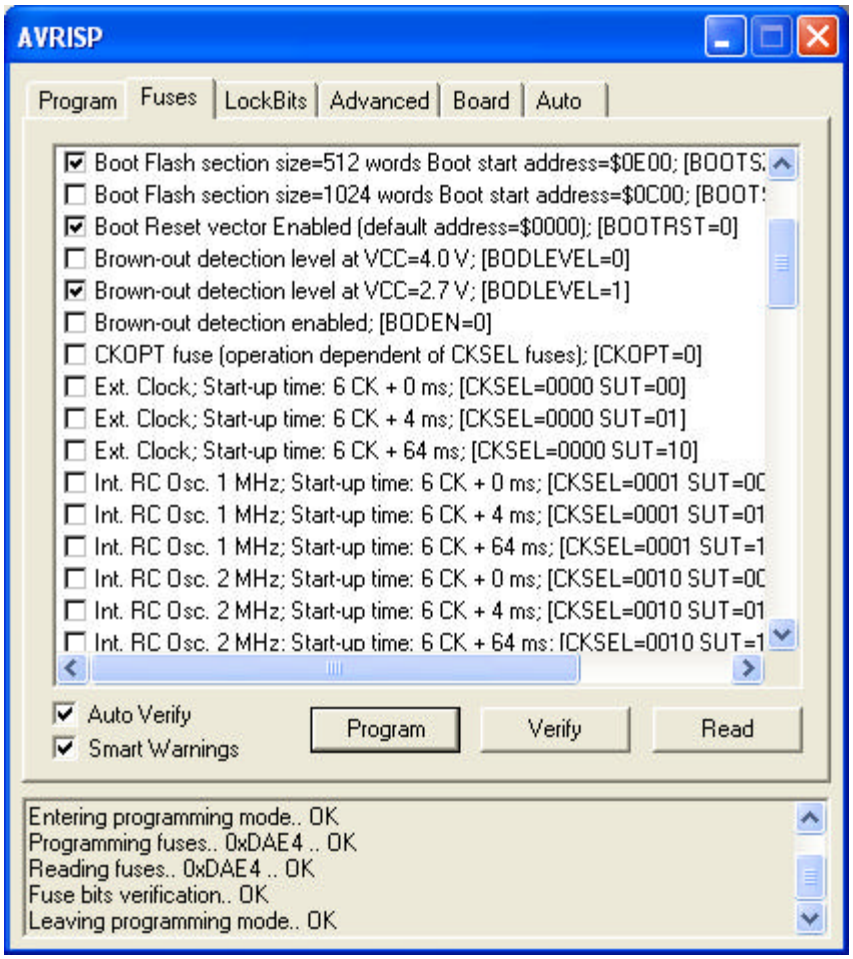


Figure 8: Atmel AVR Studio - AVRISP.

APPENDIX A

Schematic

APPENDIX B

Layout

APPENDIX C

Bill of Materials

APPENDIX D

Source Code