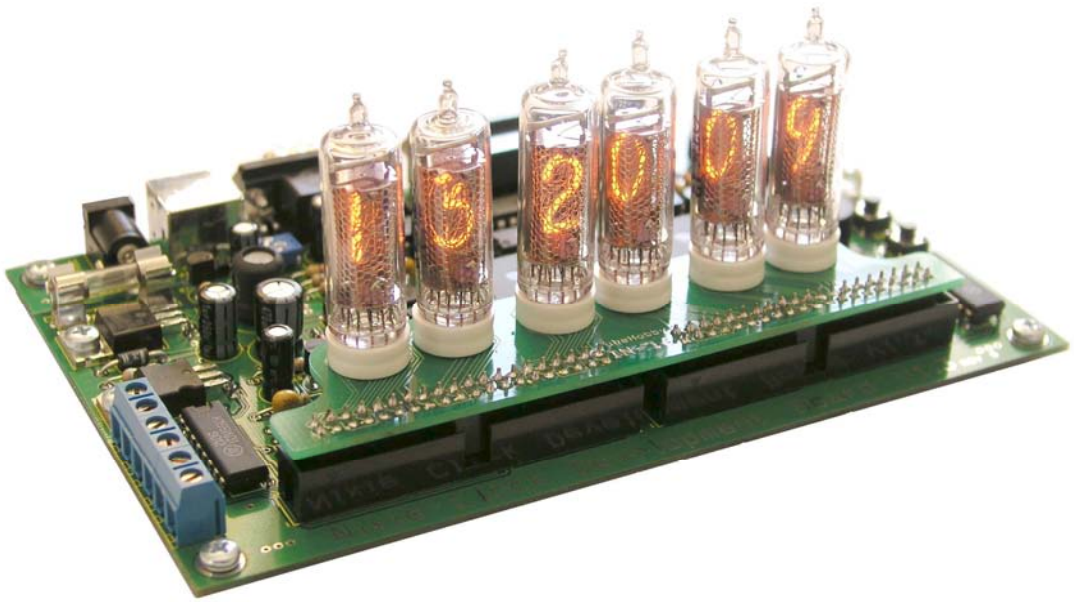
TubeHobby Nixie Clocks Tubes & Accessories

Nixie Clock Development Board v1.3

User's guide



Revision B-1

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1. Introduction

The “Nixie Clock Development Board v1.3” is first nixie clock experimenter's platform. This flexible, professionally designed development board is an ideal platform for any nixie clock project. While simple clock kit boards allow you to create your own projects with a minimum of hassle, the “Nixie Clock Development Board v1.3” goes one step further. It provides a test bed containing most of the circuitry commonly used by the Nixie clocks. Board has standard connectors for the tubes and adjustable power supply so any nixie tubes may be used.

Many different projects such as: precise time base clock, GPS clock, heating system controller or coffee machine timer may be created using the “Nixie Clock Development Board v1.3”. Some examples written in C are included with the board as well as fully featured RTOS based firmware. The “Nixie Clock Development Board v1.3” is able to run programs written in assembler, C and PicBasic or PicBasic Pro. It also includes in-system programmer, so the resident PICmicro™ MCU may be reprogrammed on the fly.

PRECAUTION

Relatively high voltage is generated on this board. Do not touch power supply, high voltage drivers and tube connections when clock is working. Otherwise is risk of electric shock.

1.1. Technical data

Feature	Specification
Software	
Core[1]	Cooperative multitasking Real-Time Operating System.

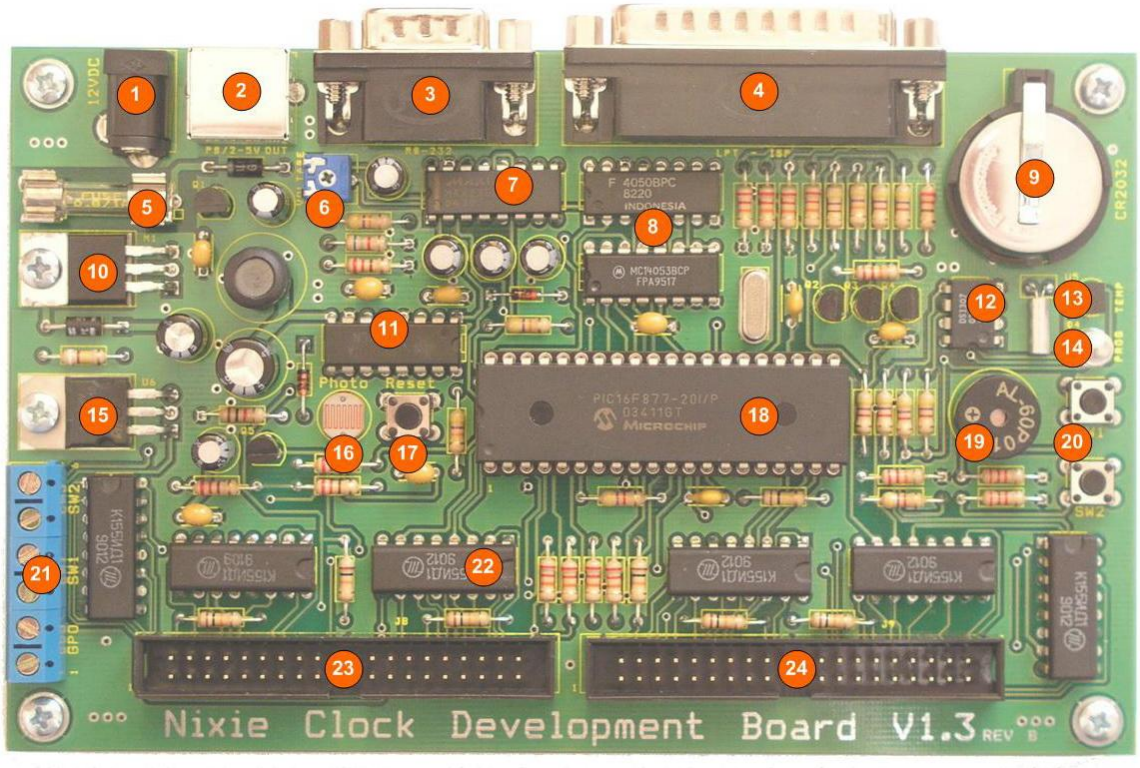
Functions[1]	• Clock HH:MM:SS
	  o 12/24 hour mode
	• Date
	  o DD:MM:YY mode
	  o MM:DD:YY mode
	• Temperature
	  o Celsius mode
	  o Fahrenheit mode
	• Alarm clock
	• GPS time and date synchronization[2]
	• Selectable time zone
	• Visual effects
	  o Crossfade (selectable deep)
	  o Scrolling line[3]
	• Night dimming (selectable level)

Your own software	PICmicro™ is not locked. You can write your own software to meet custom functionality requirements. Several board related functions and examples (written in C) is provided with the board.
Programmer	Third party software, freely downloadable.
Hardware	
Power supply	Unregulated 12VDC 1A supply via PSU 5.5mm jack, positive inner. Fuse protection from reverse polarity.
Power consumption	Depends on tubes and external devices used. With small and medium size nixie tubes approx. 500mA at 12V.
Number of nixie tubes	Board is able to interface up to 6 nixie tubes. Any NIXIE tubes[4] may be interfaced due standard connectors.
High voltage output	When using 10K anode resistors, board is able to supply 3.5mA at 180V to each tube[5]
High voltage power supply	High efficiency “Boost” topology switched mode power supply with pulse width modulation. Regulated output voltage in range 100-180V. PWM input from PICmicro™ microcontroller hardware module. PICmicro™ is able to adjust the output voltage by 20V.
Driving mode	Direct drive, 6 high voltage BCD decoders (74141 or derivates). Hardware 1Hz output to colon separators (may be programmed to other frequency, blanked or lit constantly).
Tubes connector	2x 40PIN connectors. Outputs directly for tubes and colon separators.
COM (DB9) port	Tx/Rx only, RS232 levels. Supports all standard and custom baud rates provided by PICmicro™ hardware USART
LPT (DB25) port	Buffered LPT port, for microcontroller programming only.
PS/2 port	Provides up to 150mA @ 5V power supply for external devices. Data

	I/O not implemented.
Main processor	Microchip PIC16F877, 8-bit, 20MHz, CMOS FLASH microcontroller. 8K x 14 words of FLASH Program Memory 368 x 8 bytes of Data Memory (RAM) 256 x 8 bytes of EEPROM data memory
Programmer	Fully automatic in system programmer with automatic switches. Onboard RESET pushbutton. Programming mode LED.
Time base	Real-time clock (RTC) counts seconds, minutes, hours, date of the month, month, day of the week, and year with leap-year compensation valid up to 2100. 56-byte, battery-backed, nonvolatile (NV) RAM for data storage. Battery backup up to 10 years. I2C interface.
Backup battery	Lithium, 3V, CR2032 type.
Temperature sensor	High precision digital thermometer. Measures temperature from –55°C to +125°C (–67°F to +257°F). 0.5°C accuracy from –10°C to +85°C. 0.1°C accuracy may be achieved using special algorithms.
Sound	On board buzzer (shared port with light sensor). Resonance frequency 2.048 KHz
Light sensor	On board photo resistor. Sensitive to 520-590nm wavelength.
Control	2 pushbuttons onboard with external connectors. Implemented PICmicro™ I/O over current protection.
General purpose output	12V, 200mA programmable output. (Shared with colon separator)
Physical dimensions	Nixie Clock Development Board (W, L, H): 100mm x 160mm x 17mm, 4 mounting holes, 3.1mm in diameter each (Euro PCB). Weight 160g.
Working temperature range	–10°C to +70°C [6,7]
Parts, PCB	No SMD parts used, therefore easy to assembly. Professionally routed and manufactured, silk-screened, solder masked, FR4 type PCB. 2 – layers with via's metallization.

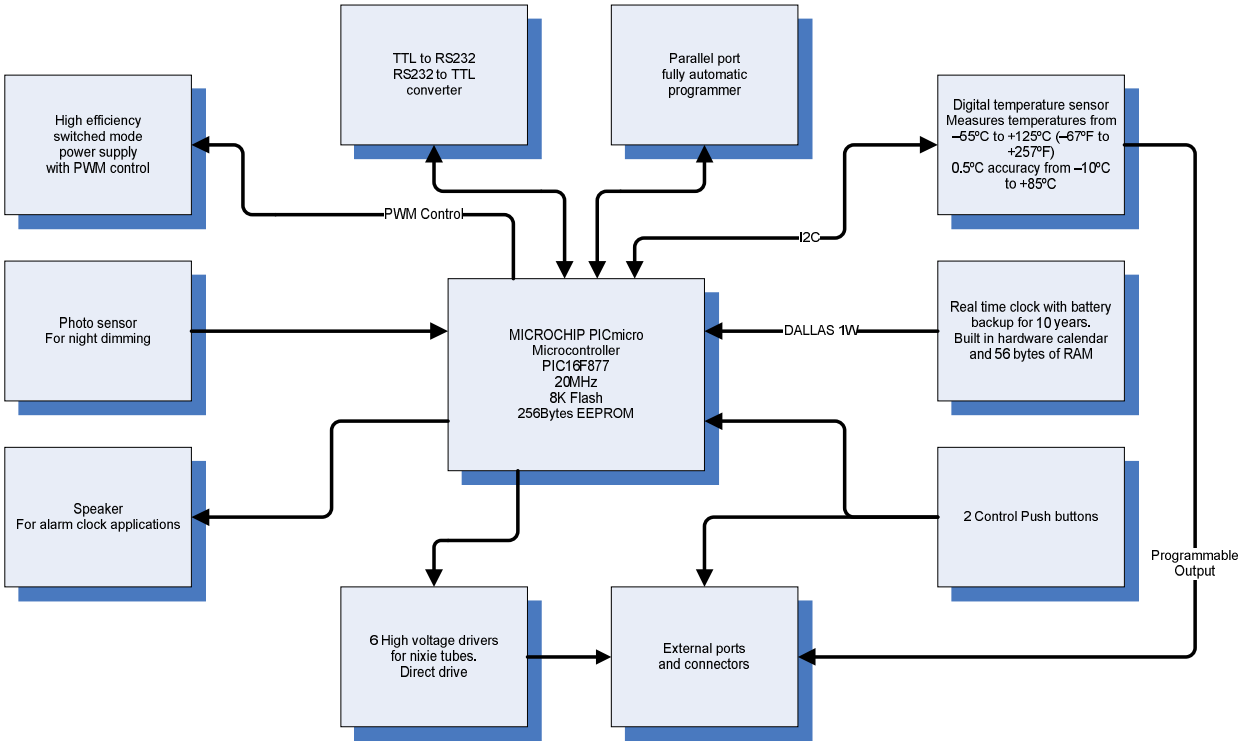
[1]- Firmware v1.3
[2]- Via external GPS receiver at RS232 port, 4800 baud (NMEA-0183 protocol, $GPRMC message)
[3]- Scrolling line effect also protects nixie tubes from cathode poisoning.
[4]- Except CD47 / GR-411 and B-7971 tubes.
[5]- It is recommended to use 2.2K anode resistors (R33 - R35, R40 – R42) for large tubes such as IN-18 or Z566M.
[6]- Most parts on the Nixie Clock Development Board have industry temperature range.
[7]- It is allowed for nixie tubes to use them in –10°C temperature not longer that 4 hours in a day. Lifetime of the tubes in this case is reduced.

1.2. Features

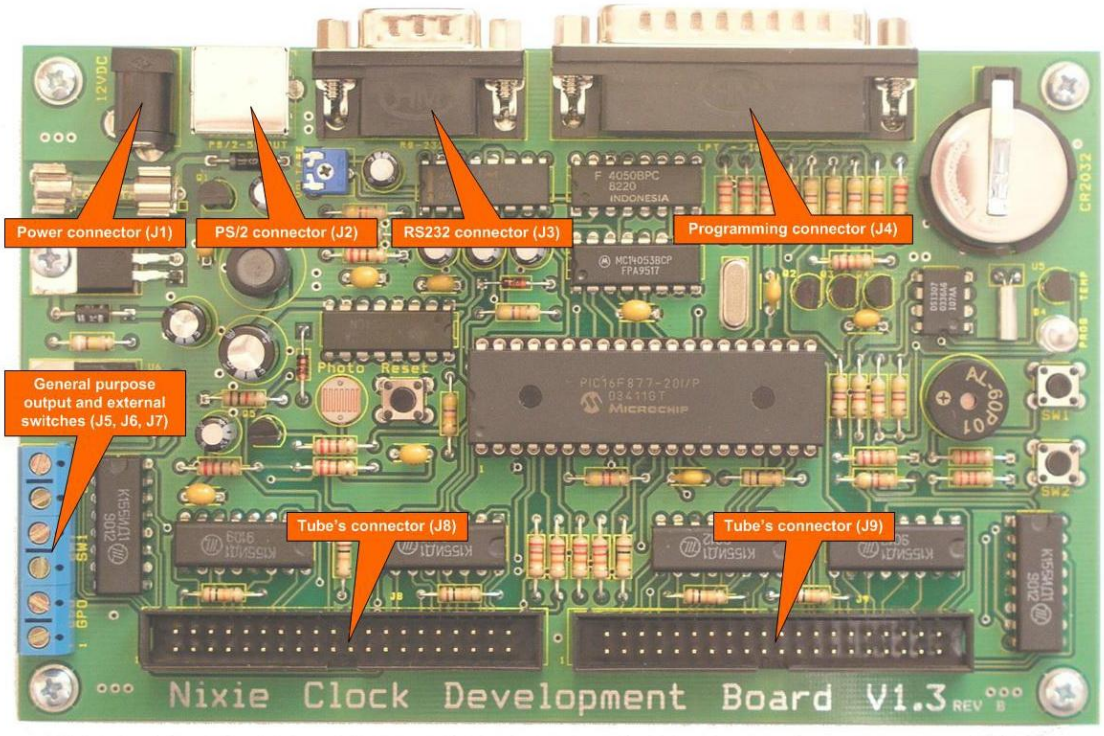


1. Power connector - unregulated 12VDC 1A supply via PSU jack (positive inner)
2. PS/2 standard connector to supply 5V power to external devices (such as GPS)
3. DB9-plug RS232 (COM) connector. Connects external devices with the board
4. DB25-plug connector - connects board to PC - LPT port via standard 25 way cable
5. Fuse protection
6. High voltage regulator
7. RS232 – TTL – RS232 Driver
8. Programmer logic
9. Backup battery
10. Switch mode power supply MOSFET transistor
11. Switch mode power supply controller
12. Real time clock and battery backupped RAM
13. Digital temperature sensor
14. Programming mode LED
15. 5V regulator
16. Light sensor
17. MCU reset pushbutton
18. Microchip PIC16F877 MCU
19. Buzzer
20. Control pushbuttons
21. Connector for external buttons and programmable output
22. High voltage BCD drivers
23. Connector for NIXIE tubes
24. Connector for NIXIE tubes

1.3. Block diagram



2. Connectors



2.1. Tube connectors (J8, J9)

WARNING: High voltage on these connectors.

40-pin (100mil) header (compatible with an IDE flat cable).
Used to connect nixie tubes and colon separators. Each connector involves connection for 3 tubes and 2 semicolon separators.
Typical pin descriptions of these connectors are shown in the table below.
Tubes is counted from the left to the right, assuming that hours most significant digit is on the left and seconds least significant digit is on the right.

Following shortenings will be used:
1-1 – meaning: 1-st tube's "1" cathode
1-9 – meaning: 1-st tube's "9" cathode
3-A – meaning: 3-d tube's anode
S1-A – meaning 1-st semicolon separator's anode
S1-C – meaning 1-st semicolon separator's cathode

Pin	Description	
	Connector J8	Connector J9
1	1-A	4-A
2	1-A	4-A
3	1-1	4-1
4	1-2	4-2
5	1-3	4-3
6	1-4	4-4
7	1-5	4-5
8	1-6	4-6
9	1-7	4-7
10	1-8	4-8
11	1-9	4-9
12	1-0	4-0
13	2-A	S3-C
14	2-A	S3-A
15	2-1	S4-C
16	2-2	S4-A
17	2-3	5-A
18	2-4	5-A
19	2-5	5-1
20	2-6	5-2
21	2-7	5-3
22	2-8	5-4
23	2-9	5-5
24	2-0	5-6
25	S1-C	5-7
26	S1-A	5-8
27	S2-C	5-9
28	S2-A	5-0
29	3-A	6-A
30	3-A	6-A
31	3-1	6-1
32	3-2	6-2
33	3-3	6-3
34	3-4	6-4
35	3-5	6-5
36	3-6	6-6
37	3-7	6-7
38	3-8	6-8
39	3-9	6-9
40	3-0	6-0

2.2. Programming connector (J4)

DB25-type standard connector. Plug type.
Connects board to PC - LPT port via standard 25 way cable. Designed for programming PICmicro™ microcontroller. Can't be used for other purposes.

Pin	Description
1	Not connected
2	DATA IN
3	CLOCK
4	Not connected
5	RESET
6	PROGRAM
7	Not connected
8	Not connected
9	Not connected
10	DATA OUT
11	BUSY
12	Not connected
13	Not connected
14	Not connected
15	Not connected
16	Not connected
17	Not connected
18	Ground
19	Ground
20	Ground
21	Ground
22	Ground
23	Ground
24	Ground
25	Ground

2.3. RS232 connector (J3)

DB9-type standard connector. Plug type.
Connects external devices with the board.
RS232 levels, Rx/Tx only, modem control lines are not available.

Pin	Description
1	Not connected
2	COM- Rx
3	COM -Tx
4	Not connected
5	Ground
6	Not connected
7	Not connected
8	Not connected
9	Not connected

2.4. PS/2 connector (J2)

PS/2-type standard connector, receptacle type.
Provides 5V power supply to external devices such as GPS receiver.

Pin	Description
1	Not connected
2	Not connected
3	Ground
4	+5V
5	Not connected
6	Not connected

2.5. Power connector (J1)

Jack type 5.5x2.1mm standard connector, receptacle type.
Provides power to the board. Should be connected **12V, 1A** unregulated **direct current** power supply.

Connector:
Positive inner
Negative outer

2.6. General purpose output and external switches (J5, J6, J7)

6 terminal screw connector.
Connections for external pushbuttons and 12V programmable output.

Connector	Pin	Description
J7	1	Open collector output (npn transistor)
	2	+12V
J6	3	SW1 input
	4	SW1 power
J5	5	SW2 input
	6	SW2 power

3. Functions implemented on the development board

3.1. High voltage drivers

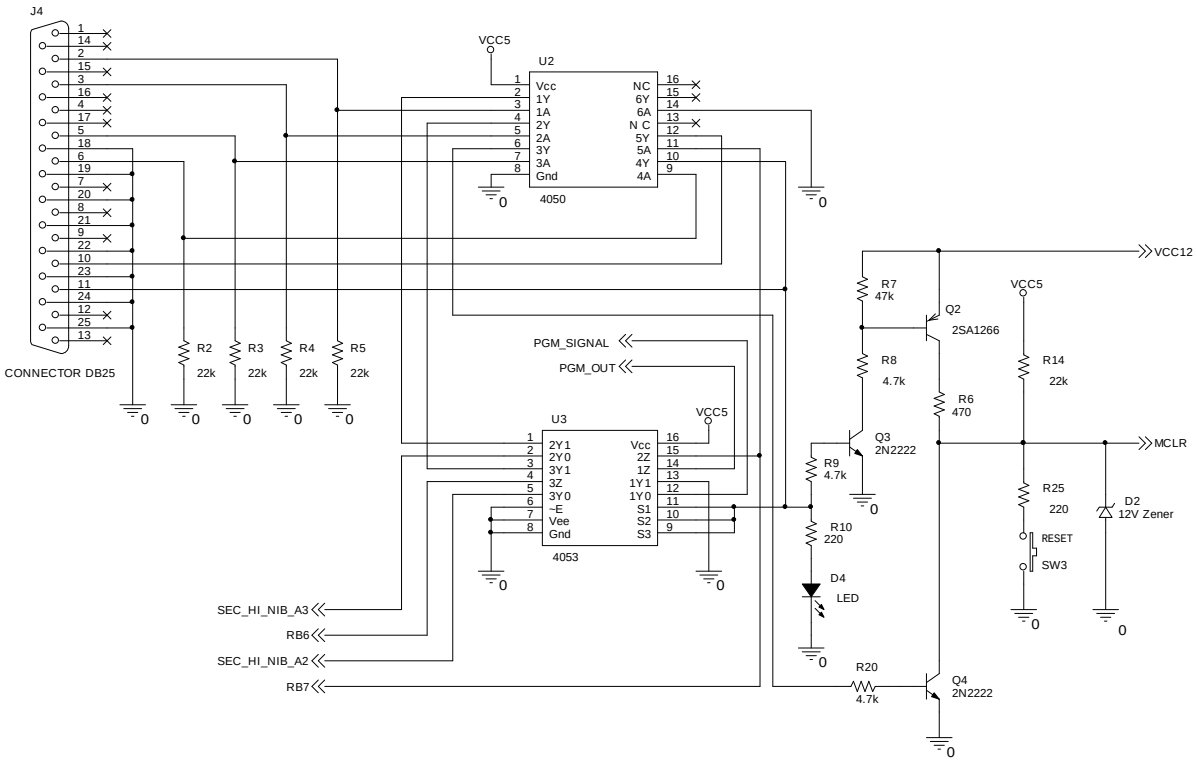
The 74141 (K155ID1) is a BCD-to-decimal decoder designed to drive gas-filled NIXE tubes. The device is also capable of driving other types of low current lamps and relays. Full decoding is provided for all possible input states. For binary inputs 10 through 15, all the outputs are OFF. Therefore the 74141, combined with a minimum of external circuitry, can use these invalid codes in blanking leading- and/or trailing-edge zeros in a display. Input clamp diodes are also provided to clamp negative voltage transitions in order to minimize transmission-line effects.

To limit maximum current for the tubes, anode resistors are used. It is recommended to use following resistors:
for small and medium nixie tubes - 10K,
for large nixie tubes - 2.2K (included on request),
for colon separators – 22K.

Tubes is counted from the left to the right, assuming that hours most significant digit is on the left and seconds least significant digit is on the right.

Tube	IC on the PCB	Address	PICmicro™ output
T1	U10	A3	RA5
		A2	RE2
		A1	RE1
		A0	RE0
T2	U9	A3	RA4
		A2	RA3
		A1	RA2
		A0	RA1
T3	U11	A3	RD7
		A2	RD6
		A1	RD5
		A0	RD4
T4	U12	A3	RD3
		A2	RD2
		A1	RD1
		A0	RD0
T5	U14	A3	RB7
		A2	RB6
		A1	RB5
		A0	RB4
T6	U13	A3	RB3
		A2	RB2
		A1	RB1
		A0	RB0

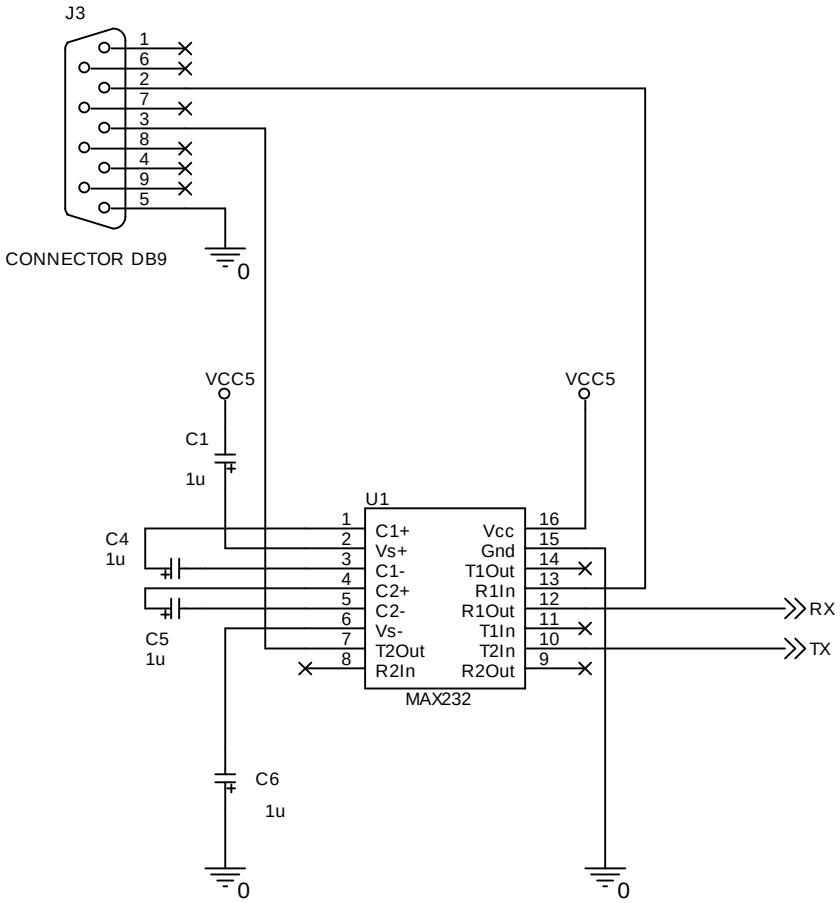
3.2. In system programmer



Signals from the PC are buffered, to ensure consistent voltage levels, by U2 - a 4050. The pins RB6 and RB7 are used on the PICmicro™ device for both programming and reading data and the PC needs direct control of these devices. This is facilitated by the use of two analogue switches U3:2 and U3:3 which are controlled by the program pin (pin 6) on the parallel port via U2:4. When the program pin is high, data in and clock in are directed to the PICmicro™. When the program pin is low then RB6 and RB7 on the PICmicro™ are routed to the rest of the port B bus.
The program pin also ensures that 12V is routed to the PICmicro™ via the combination of Q2 and Q3 using zener diode to provide a regulated programming
voltage. Automatic reset after programming is provides by the reset line from the parallel port (pin 5) and Q4.

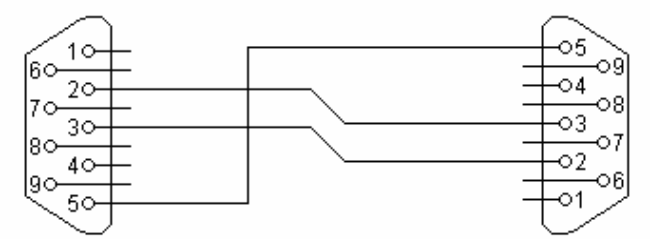
3.3. RS232 port

Nixie clock development board provides RS-232 serial interface for communication with external devices such as GPS receiver or personal computer.



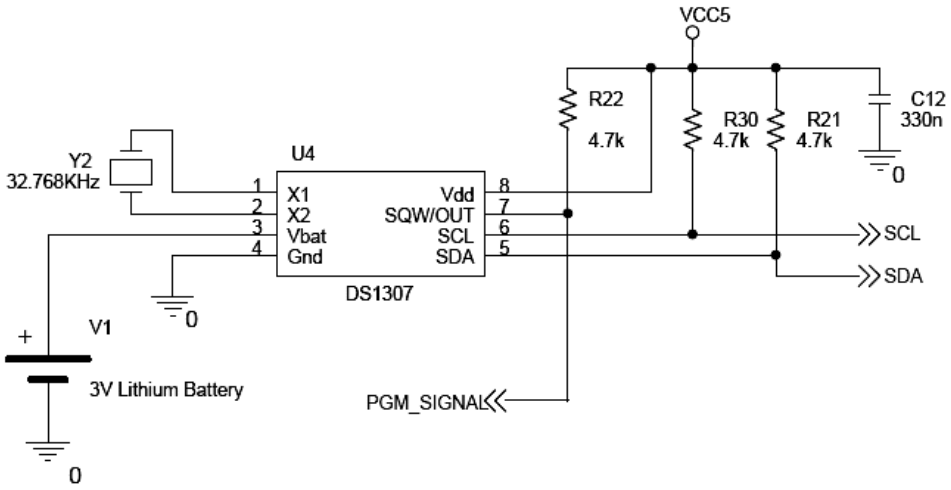
The interface is provided via DB9 type plug connector. MAX232 interface driver/receiver is used to convert native RS-232 voltages to PICmicro™ compatible TTL voltage levels.
TTL Tx and Rx nets are routed to the PICmicro™ RC6 (pin 25) and RC7 (pin 26) pins, so internal *USART* module may be used.

For connecting the board to PC use a serial null-modem cable:



3.4. Real time clock

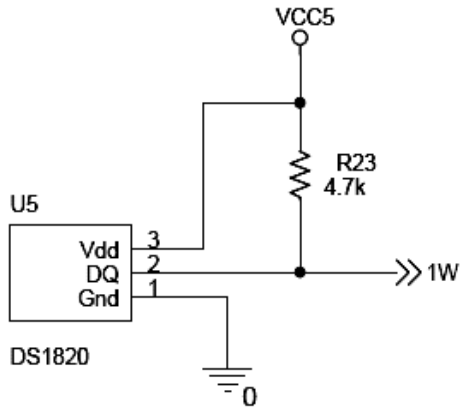
A real time clock (RTC) provides time data for the PICmicro™ and 56-byte battery-backed nonvolatile RAM for data storage.



DS1307 RTC with I2C interface is used in nixie clock development board. 3V battery supply is needed for correct RTC functionality and storing time data in case of a power failure. DS1307 and PICmicro™ communicate through I^2C, bidirectional bus. RC3 (pin 18) and RC4 (pin 23) PICmicro™ pins are used for I^2C bus operations by internal *MSSP* module. DS1307 also provides programmable square-wave output signal (*PGM_SIGNAL*) or constant level programmable output, which is routed through multiplexer U3 and transistor Q5 directly to tube connectors and general purpose J7 connector. *PGM_SIGNAL* provides signal for nixie tube's colon separator pins. A square-wave frequency of 1 Hz, 4.096 kHz, 8.192 kHz or 32.768 kHz might be chosen. General purpose output (connector J7) provides programmable output with output voltage 12V and current up to 200mA. Programmable output signal is shared between colon separators and general purpose output.

3.5. Temperature sensor

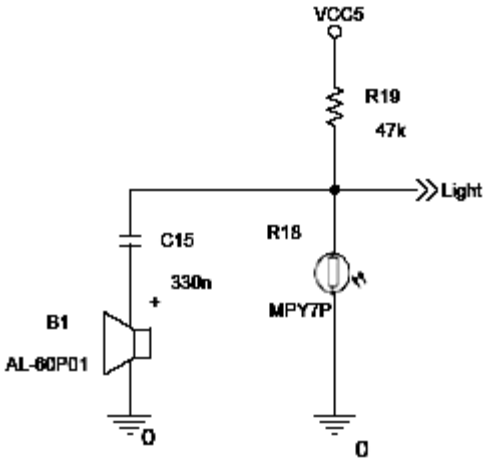
The board is equipped with high precision digital thermometer DS1820.



It measures temperature in range from –55°C to +125°C (–67°F to +257°F). Temperature is converted to digital word in several milliseconds and read from the DS1820 over a 1–Wire™ interface, so that only one wire is connected to PICmicro™ RC5 (pin 24).

3.6. Photo sensor and buzzer

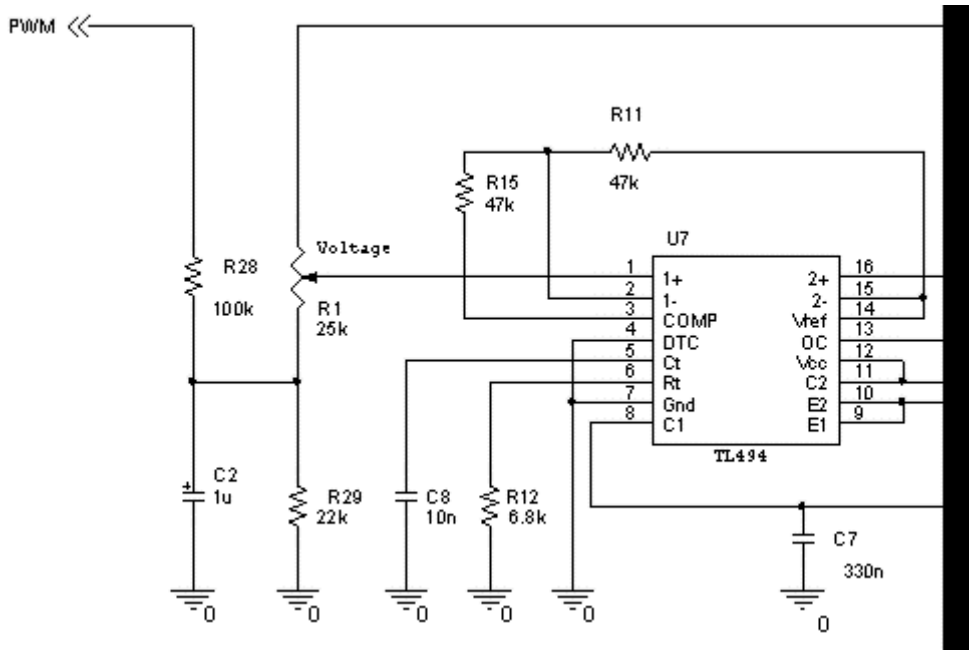
The board is equipped with photo resistor for measuring environment illumination and buzzer for sound generation.



Analogue signal from photo resistor is routed to the PICmicro™ RA0 (pin 2) analogue input. An internal PICmicro™ *Analog-to-Digital* module is used to convert analog singal to digital.
Onboard buzzer is connected to the PICmicro™ RA0 (pin 2) via decoupling capacitor C15. When configured as output, RA0 pin generates sound signal for buzzer.
It is recommended to measure illumination not sooner than 1s after pin direction change.

3.7. Power supply

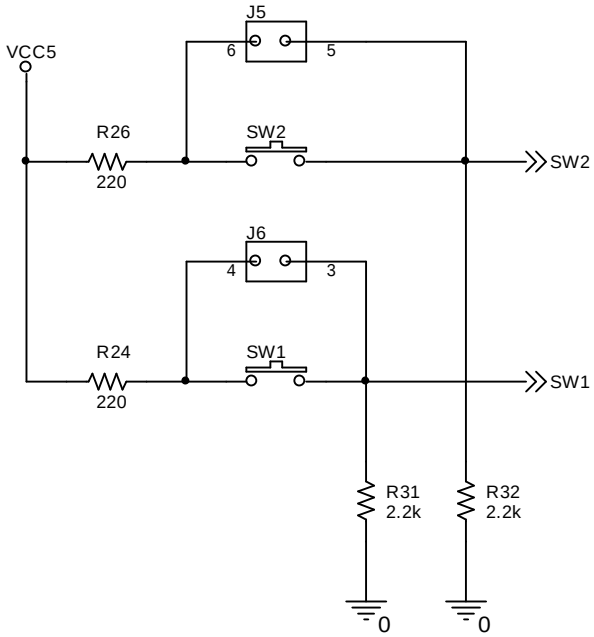
There are two power supply modules onboard. One – the LM7805 based 5V regulated power supply. And another one for supplying nixie tubes – high efficiency boost topology switched mode power supply with pulse width modulation.



The TL494 (U7) is used for the control circuit of the PWM switching regulator. Output voltage may be set in a range 100-180V by R1 potentiometer. Additionally, PICmicro™ is able to adjust the output voltage by 20V via internal *PWM (CCP)* module, RC2 (pin 17).

3.8. Buttons

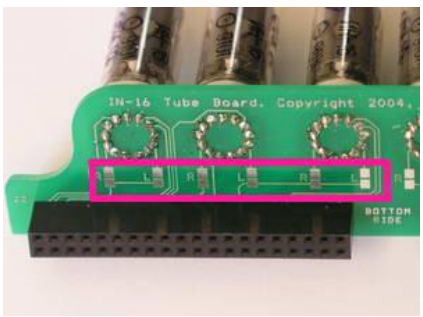
The board has 2 control buttons, SW1 and SW2.



Onboard buttons SW1 and SW2 are connected to the PICmicro™ RC0 (pin 15) and RC1 (pin 16) respectively. An R24 and R26 resistor protects PICmicro™ port from accidental port direction mis-setting. It is possible to connect external control buttons to J5 and J6 connectors.

3.9. Tube's board

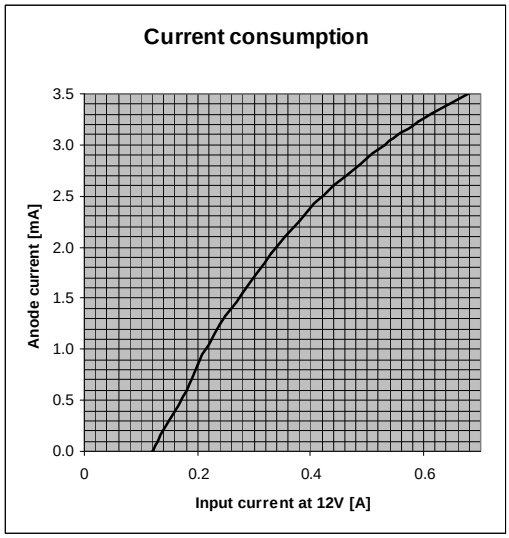
A small PCB is included with "Nixie Clock Development Board v1.3" which carry 6 nixie tubes. Two 40-pin receptacle type connectors may be connected directly to the development board.

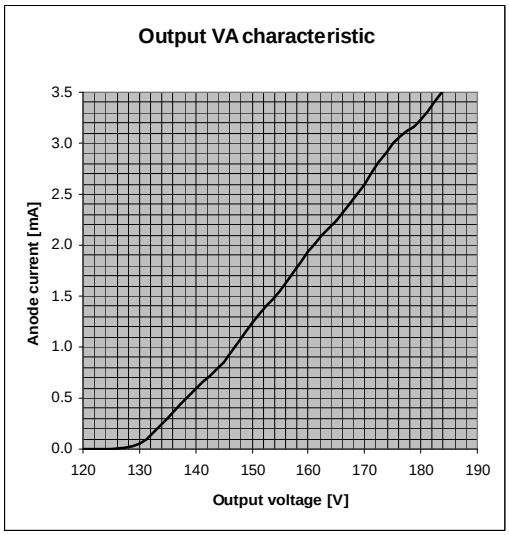


There are two solderable jumpers across each tube on the bottom side of tube's board, which connects appropriate dots of the tube to the programmable output.
Recommended anode current for the IN-16 nixie tubes is 2 mA. It is easy to measure voltage across the anode (limiting) resistor and then calculate current.

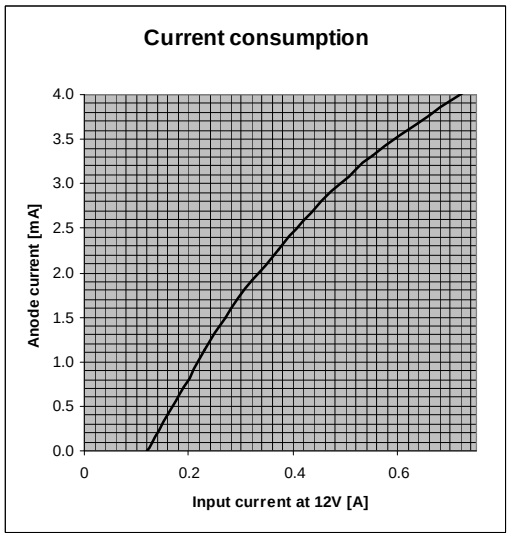
4. Typical performance characteristics

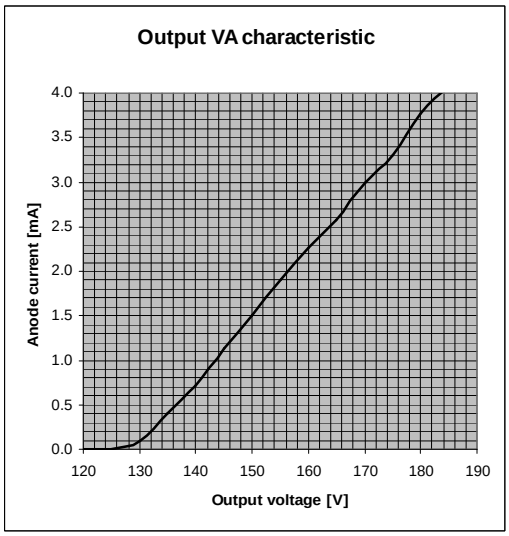
4.1. Nixie Clock Development Board with 6 x IN-16 tubes, 10K anode resistors



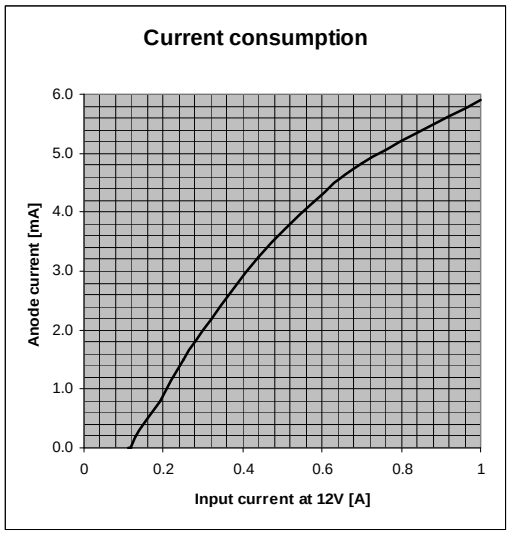


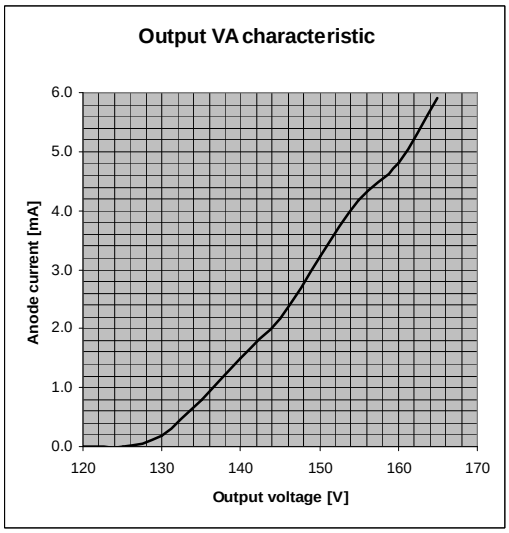
4.2. Nixie Clock Development Board with 6 x IN-18 tubes, 10K anode resistors

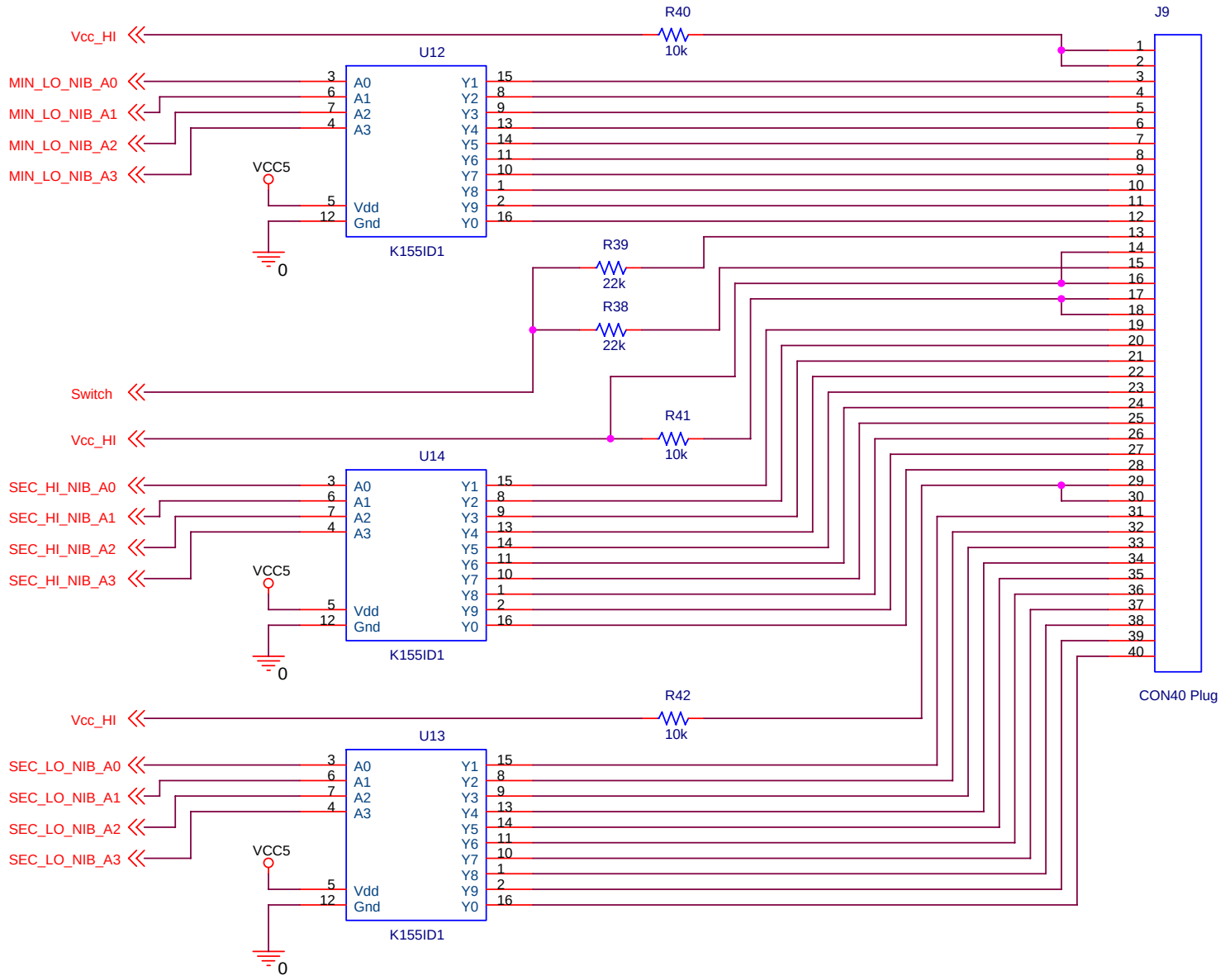




4.3. Nixie Clock Development Board with 6 x IN-18 tubes, 2.2K anode resistors







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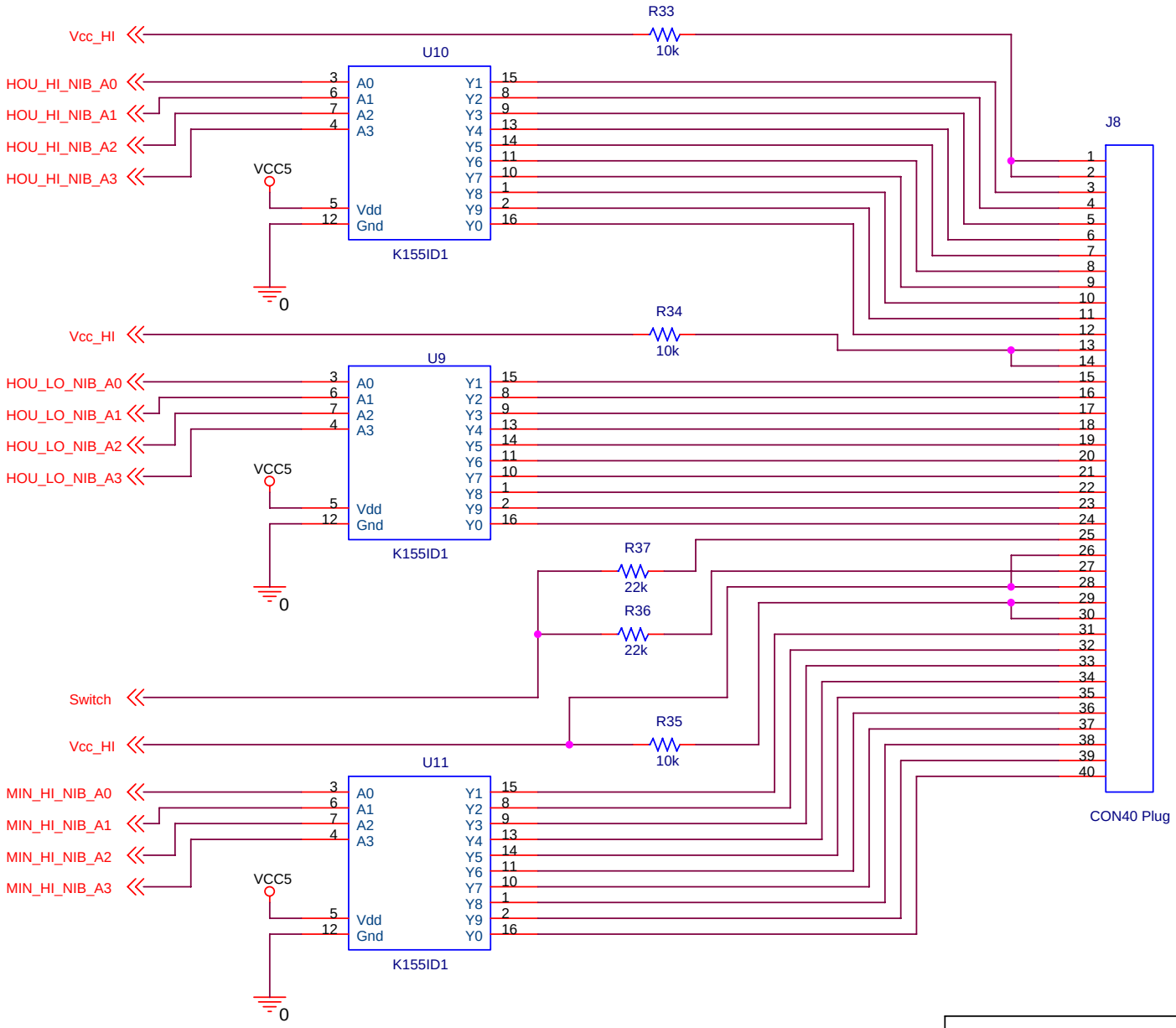
Date: Saturday, November 20, 2004	Sheet 1 of 6	



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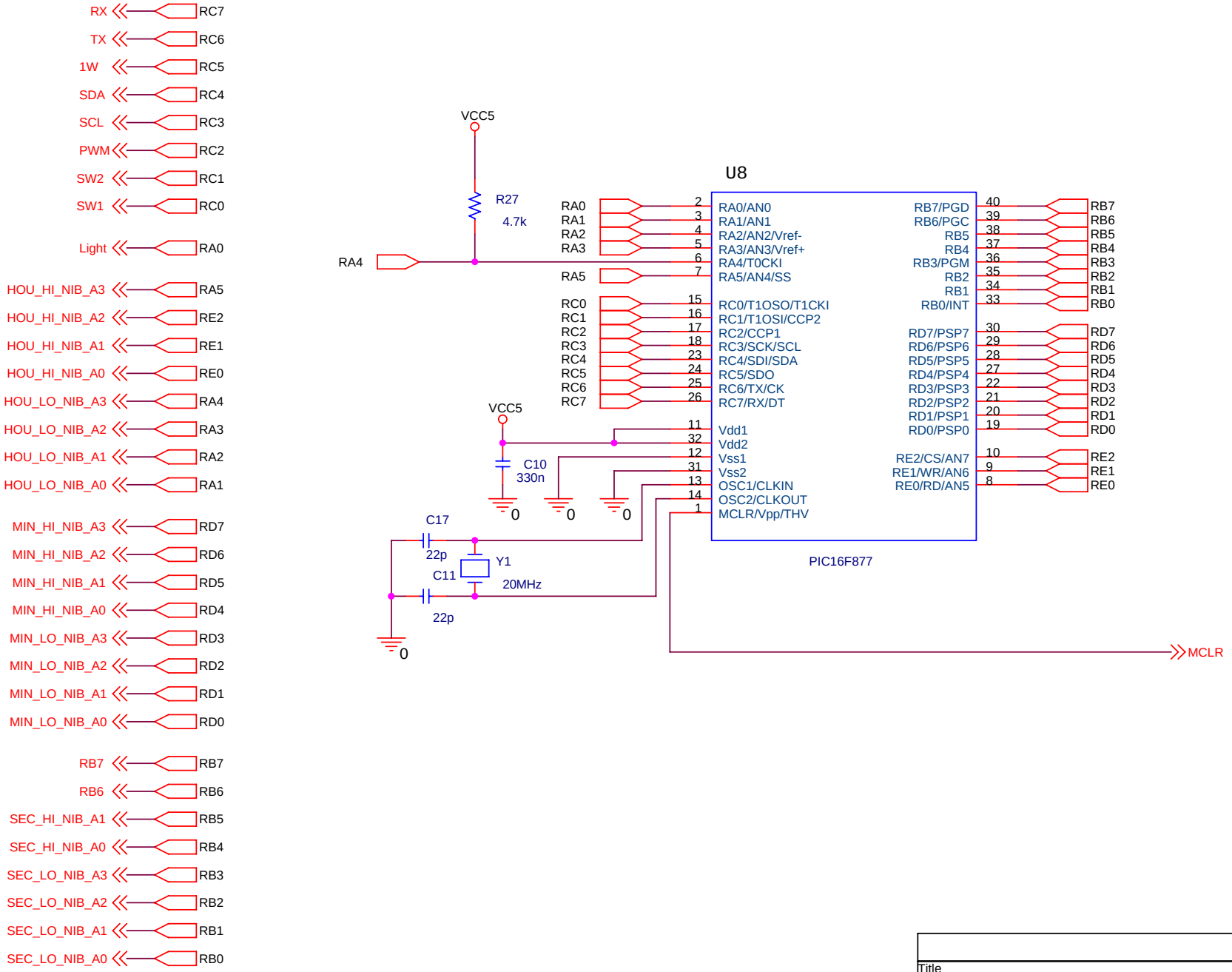

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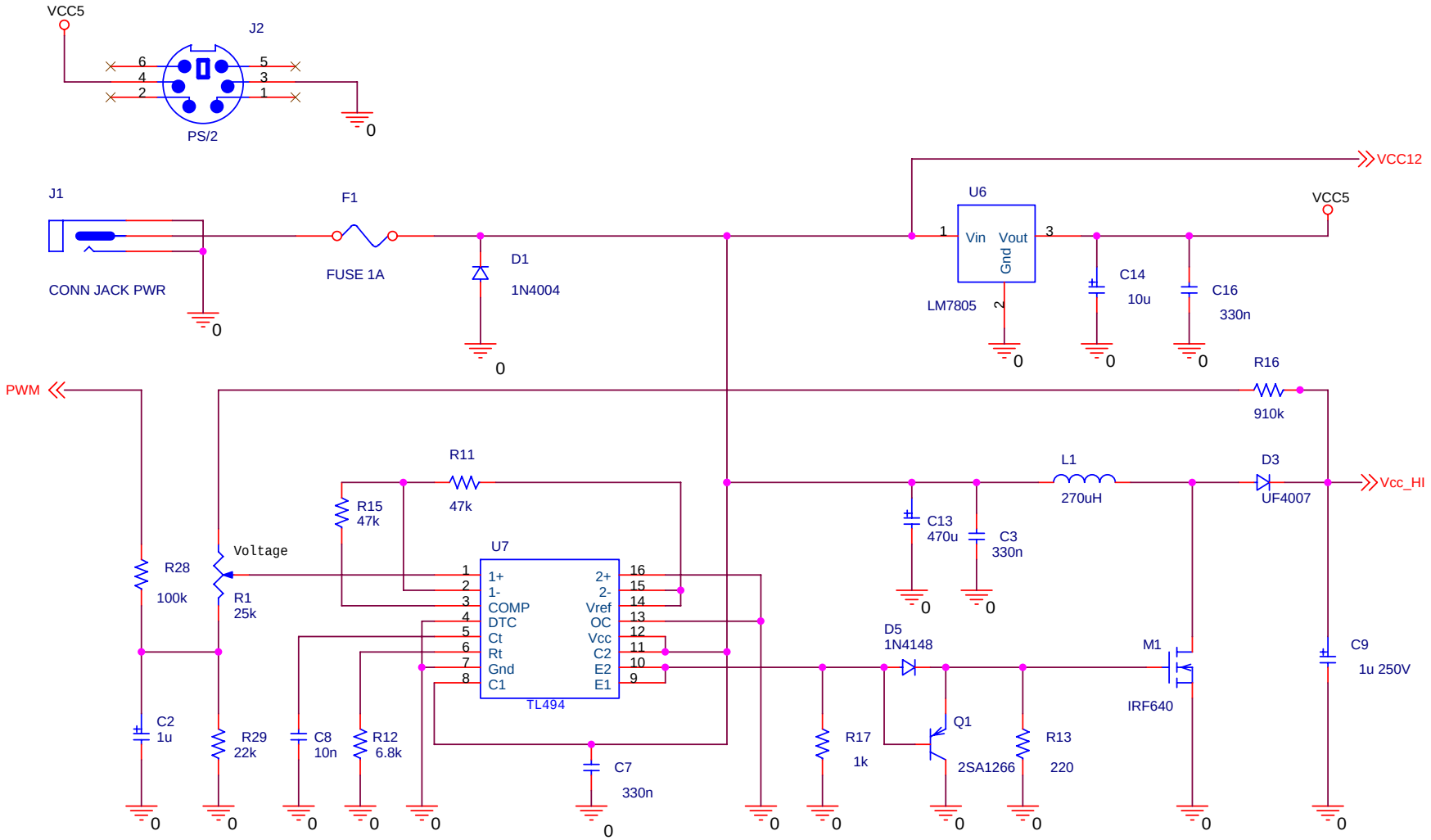

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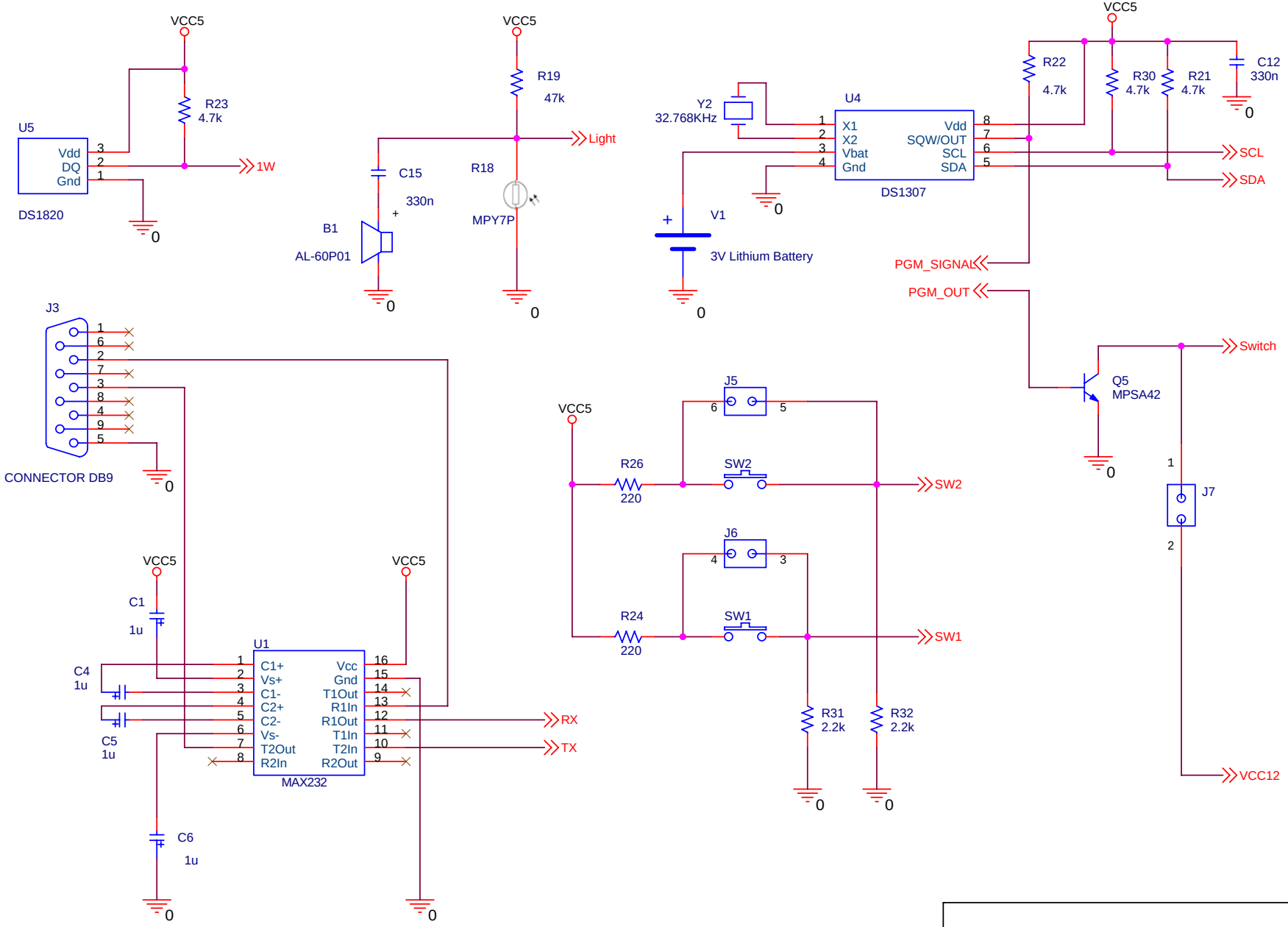
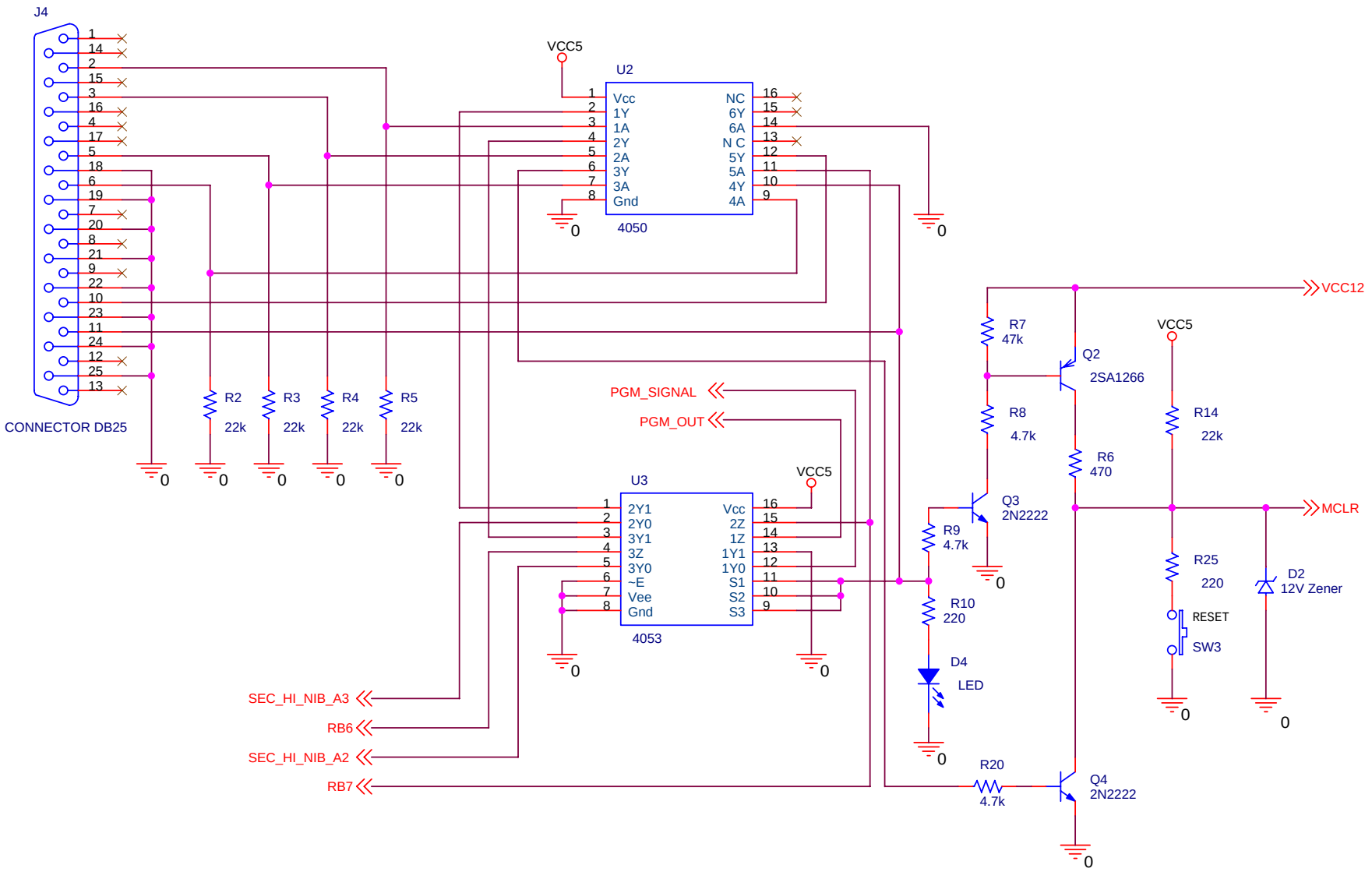
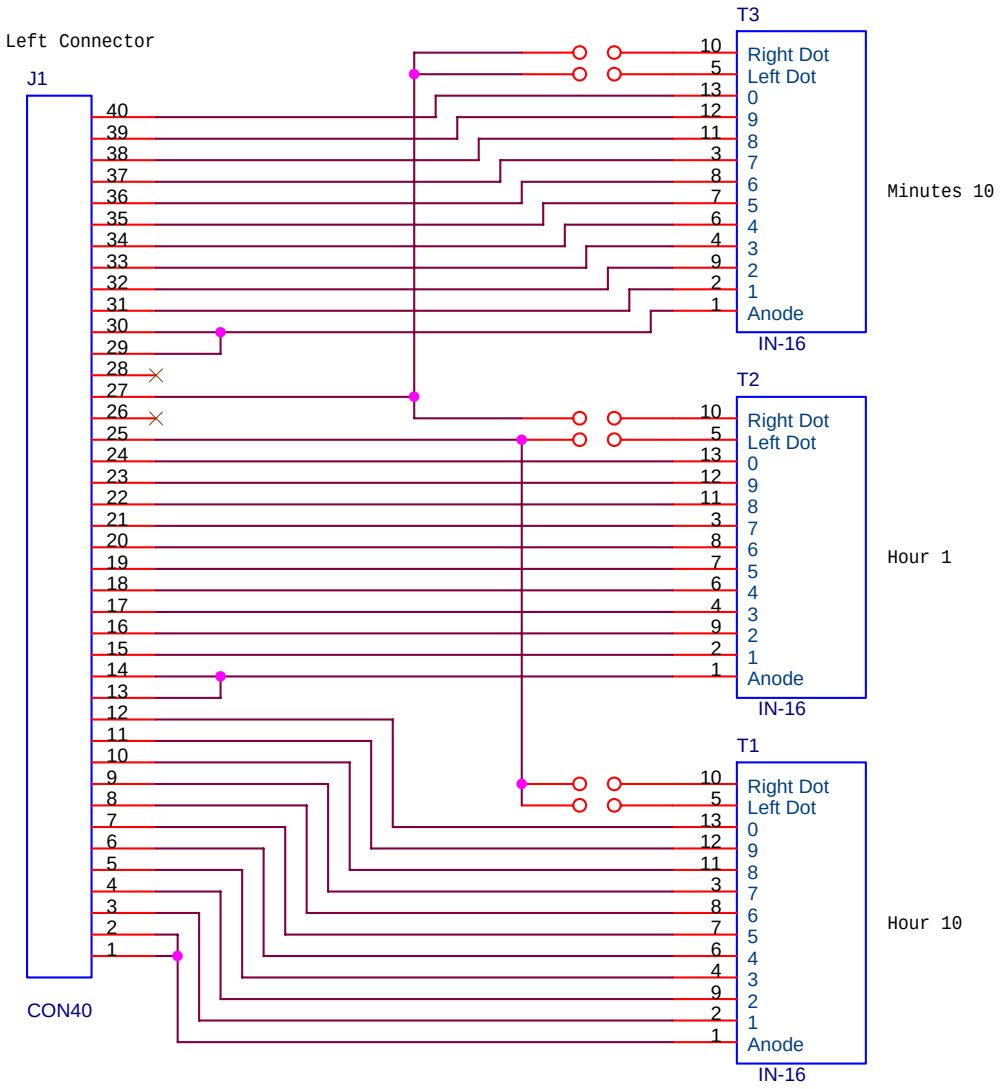


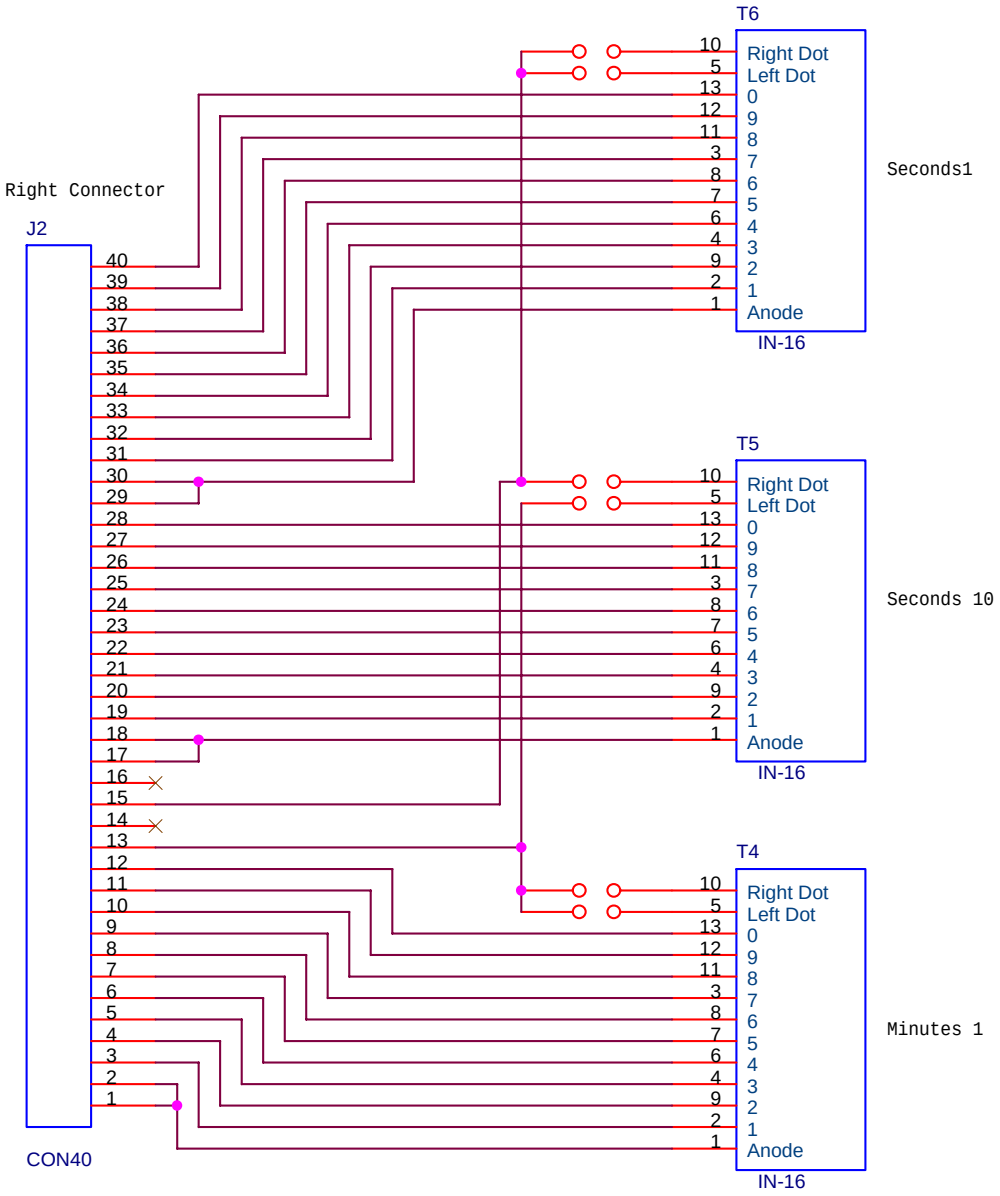
Title	Peripheral	
Size A4	Document Number Copyright 2004, TubeHobby	Rev 1.3
Date: Saturday, November 20, 2004	Sheet 5 of 6	



Title	Parallel port programmer	
Size A4	Document Number Copyright 2004, TubeHobby	Rev 1.3
Date: Saturday, November 20, 2004	Sheet 6 of 6	



Title	Tube's Board - part 1	
Size A	Document Number Copyright 2004 TubeHobby	Rev 1.3
Date: Sunday, November 21, 2004	Sheet 1 of 1	



Title	Tube's Board - part 2	
Size A	Document Number Copyright 2004 TubeHobby	Rev 1.3
Date: Sunday, November 21, 2004	Sheet 1 of 1	