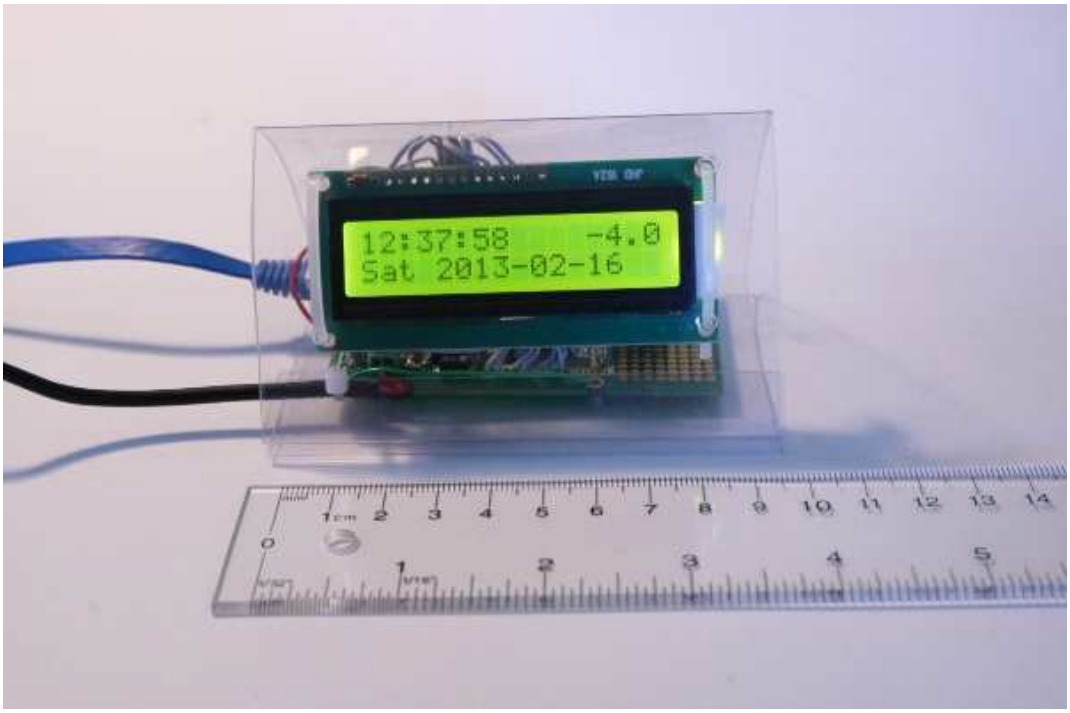
Tuxgraphics NTP clock with DHCP client, version 2.X



Abstract:

The Network Time Protocol (NTP) has revolutionized the world. Suddenly one could have anywhere in the world accurate time and date. NTP is a simple UDP based protocol and can be implemented in a microcontroller.

The tuxgraphics NTP clock has been very popular over the years. This version 2.0 has a built-in DHCP client. You just plug this clock into any network and everything else is automatic. You don't need any knowledge about IP networking.

A NTP client

The NTP protocol is described in RFC958. Essentially it is just a 64 bit time-stamp. 32 bits of this time-stamp are the seconds in UTC (=GMT Greenwich mean time) since since Jan. 1st 1900. The other 32 bits are fractions of a second. In other words NTP can be very very accurate. For our purposes it is however enough if we just evaluate the seconds.

The AVR NTP clock synchronizes at startup with a NTP server and uses then a timer interrupt to maintain time locally. Every hour it tries then to synchronize again. If your DSL router is however off during the night then it's not a problem. The clock just continues. We use the on board crystal to maintain accurate time over several week. Once the network connection is back it will just synchronize again. A little status indicator appears in the lower right corner while the clock is waiting for an answer from the NTP server.

Public NTP servers are maintained by various universities, government organizations and big computer companies like apple. A suitable server is already pre-configured in the tuxgraphics ntp server code.

How to build a clock

A clock is essentially just a counter. Since NTP is already a 32-bit "counter" we just take a 32bit variable and increment it. That is: the initial setting of the counter comes via NTP and then we just count up every second.

For this we just generate a timer interrupt every second. The 16bit timer/counter of the atmega328p supports this already at a hardware level.

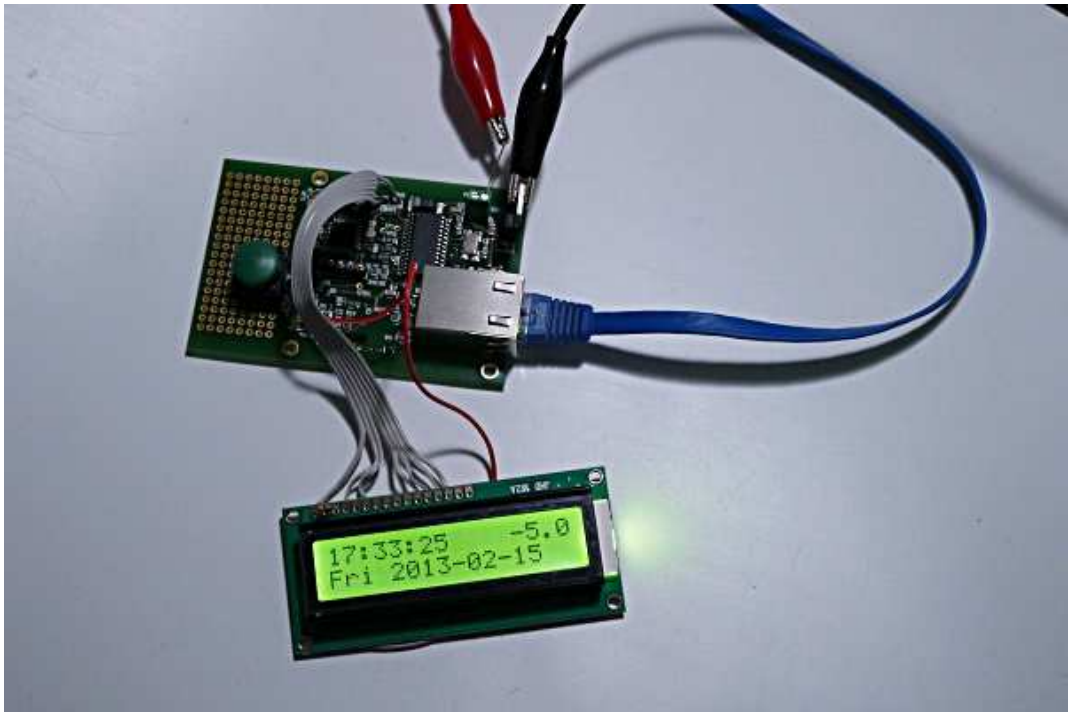
The basic clock is therefore just this:

```
// interrupt, step seconds counter
ISR(TIMER1_COMPA_vect){
        time++;
}
```

The hardware interrupt is generated every second and we step the counter "time". Very easy.

A NTP server sends out the time as seconds (and fractions of seconds) since 1-Jan-1900 GMT. The math to convert seconds since day-X into a human readable format is a quite heavy for a microcontroller. The AVR is a 8-bit processor therefore 32-bit math is expensive but it can still be done.

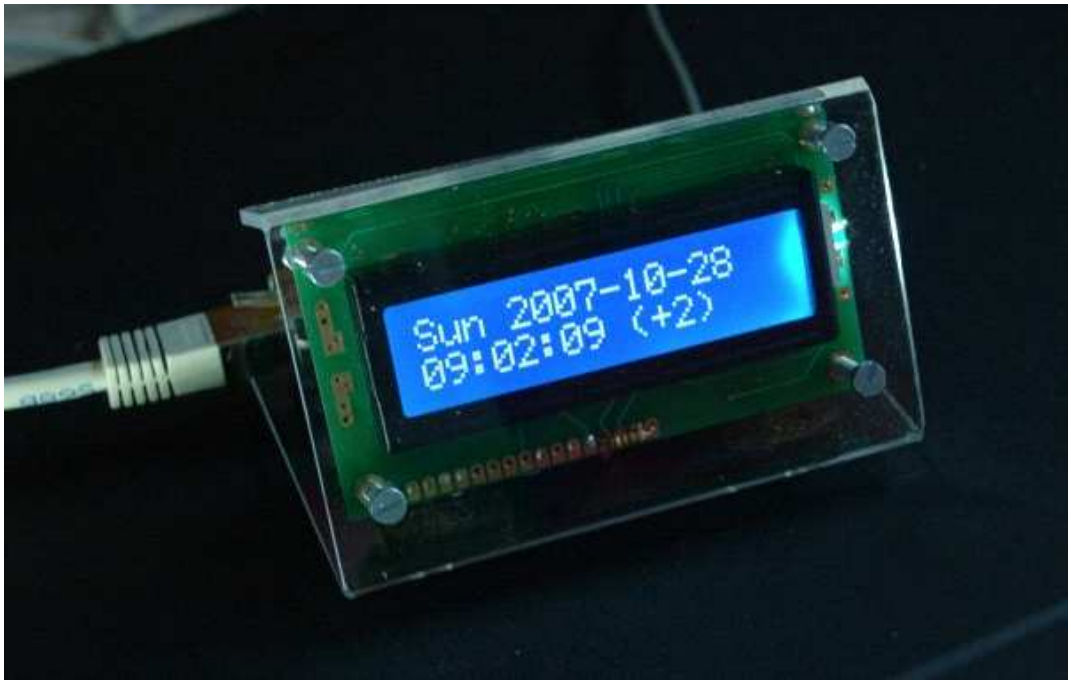
The tuxgraphics NTP clock with LCD display



A 16x2 character LCD display + AVR ethernet SMD board + a push button is all you need.

The large push button on the ethernet board can be used to change the offset to GMT. E.g. to change between summer time and winter time.

I am always asked for ideas on how to build a good case for the clock. For all previous version I have used a thin (2-4mm) polycarbonate (lexan) or acrylic-glas (plexiglas) sheet and I just bend it into an L-like shape. You can find such sheets on ebay or in bigger hardware stores.



NTP clock with clear polycarbonate case

NTP clock with clear polycarbonate case

You need to heat the polycarbonate sheet along a thin line in order bend it without breaking it. For this you can build a plastic sheet bending machine out of a constantan wire from an old toaster or an electric heater.

A plastic sheet bending machine. A spring holds the constantan wire straight inside the groove because the wire expands while heated. The groove is lined on the sides with ordinary aluminum foil.

You run about 3 ampere DC through the wire to heat it. The exact amount depends on the diameter of the constantan wire. The wire must be hot but not glow red. The plastic sheet is then placed over the groove and heated just along that thin line for about 2 minutes. Note that the plastic does actually not touch the wire.

Once heated to the right temperature you can bend the plastic sheet like warm wax. Since we have heated the sheet only along that thin line it will just bend there.

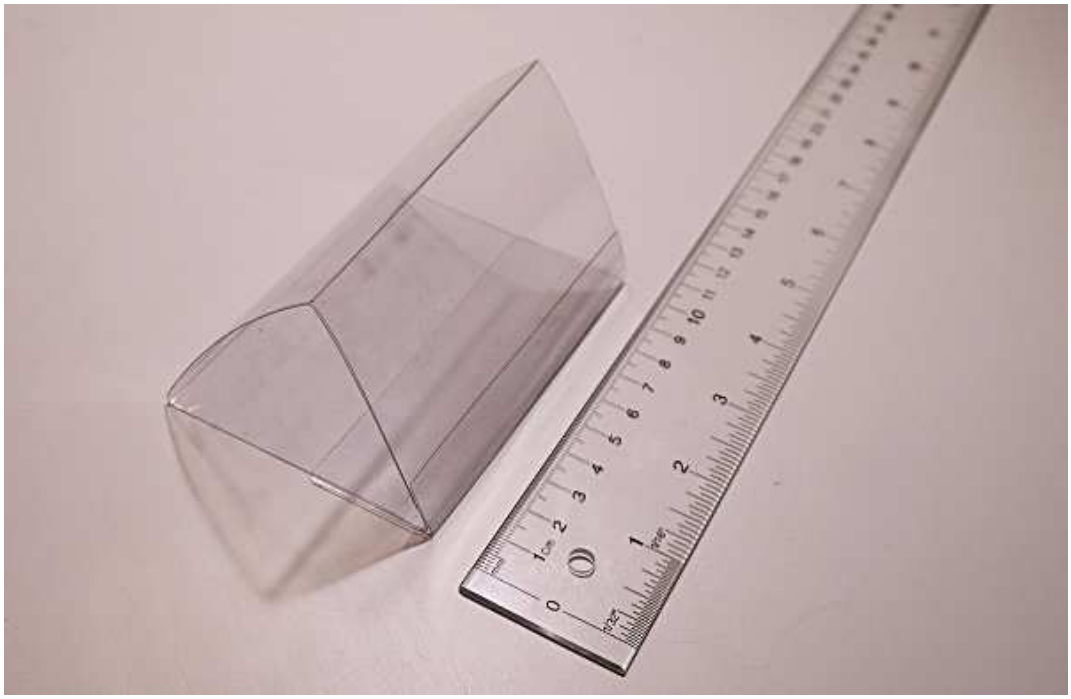
Such a polycarbonate case is very nice and strong but it requires this plastic bending machine to bend the clear plastic sheet.

A much simpler case can be made out of clear packaging material with just household scissors.

A bit of clear plastic packaging can as well be used if folded into a triangle.

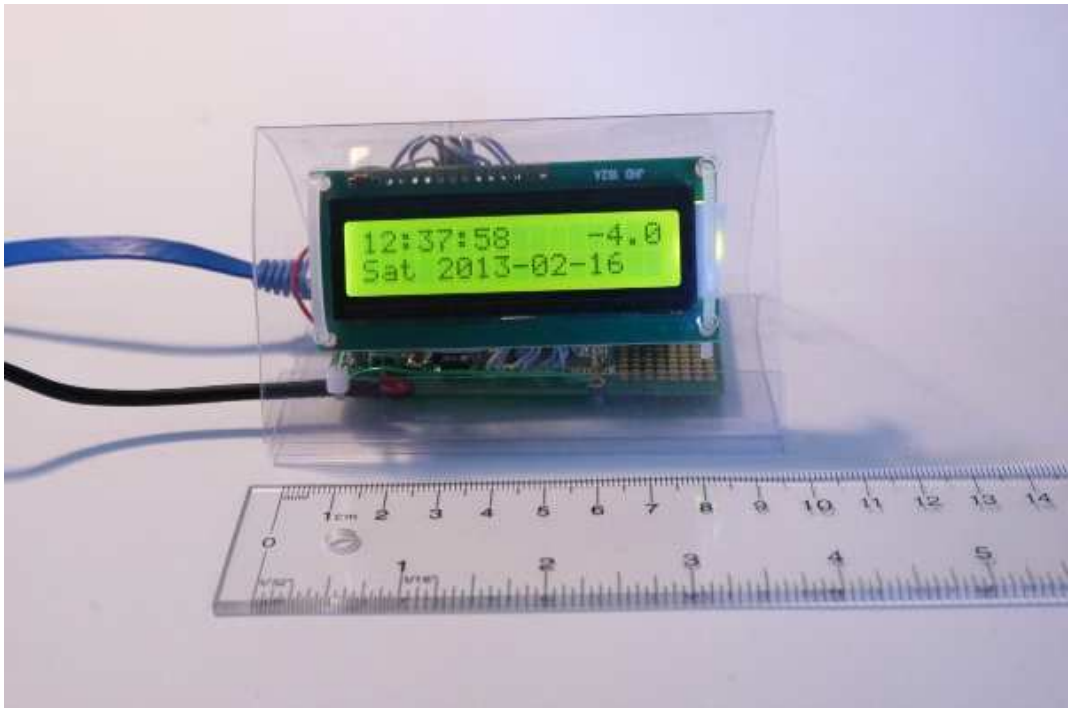
The ultra thin clear plastic packaging as found in the grocery store is too thin and not suitable to make a case. It should have some strength. Consumer electronics or toys are often packaged in bit stronger clear plastic. You may as well be able to use a large clear plastic bottle from which you slice out a ring and then cut it open to get a sheet of plastic.

The clear plastic packaging can just be cut with scissors and you can bend it along the edge of a ruler without heating it first. Cut out a long stripe about 10cm (4 inch) wide and fold it into a triangle as shown below.



A stripe of clear plastic packaging folded into a triangle shape.

Now just punch-in some holes and mount the ethernet board and the display with thin cable-ties.



Using the clock

The clock has a LCD display with the following LCD display fields:

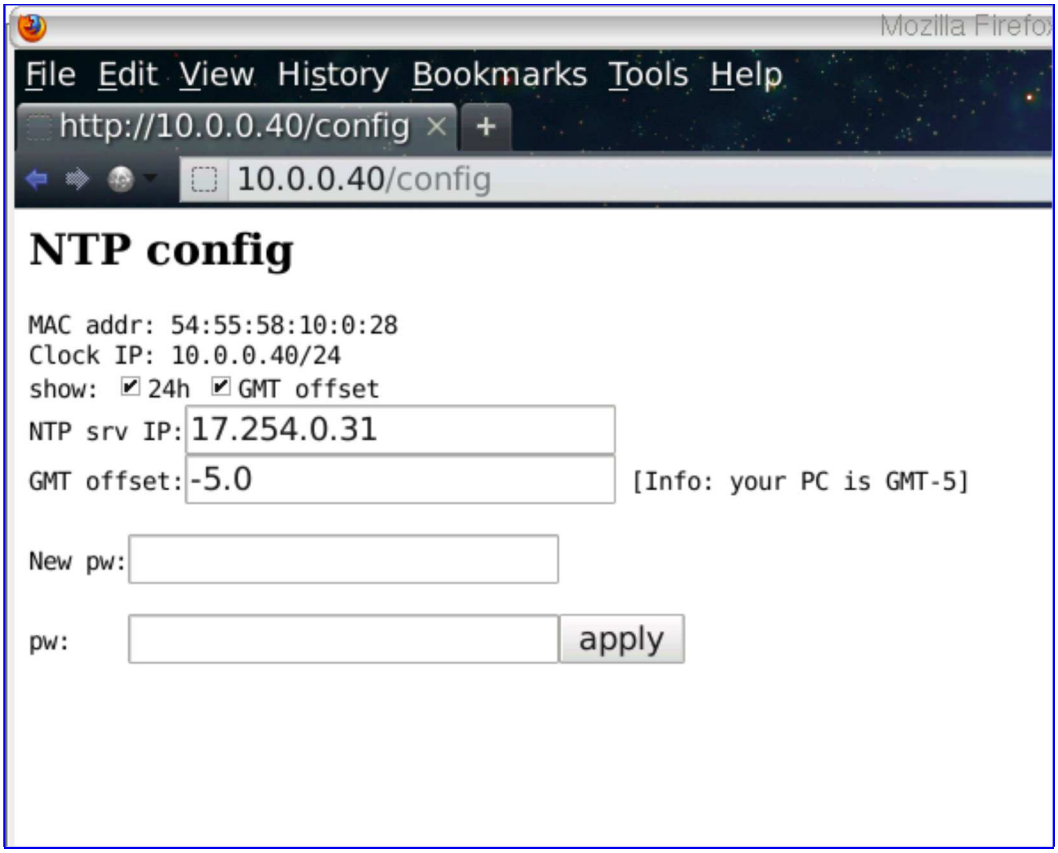
```
Time     offset-to-GMT

DayOfWeek Date  Status
```

The "Status" in the right corner is a one character wide status indicator:

- nothing: ETH link ok, NTP time sync up-to date
- '/': ETH link down
- '|': ETH link up we are waiting for an answer from the NTP sever. The clock tries to sync every hour. Thus if you cut your Internet connection during the night then you will see this character. Note that the clock will continue to run form the internal crystal.

The clock has as well a built-in web interface. You just point your browser to the IP address of the clock (it shows it's IP address at power-on) and you can read the time over the web or you can configure the clock. The settings are stored in eeprom and not lost at power down.

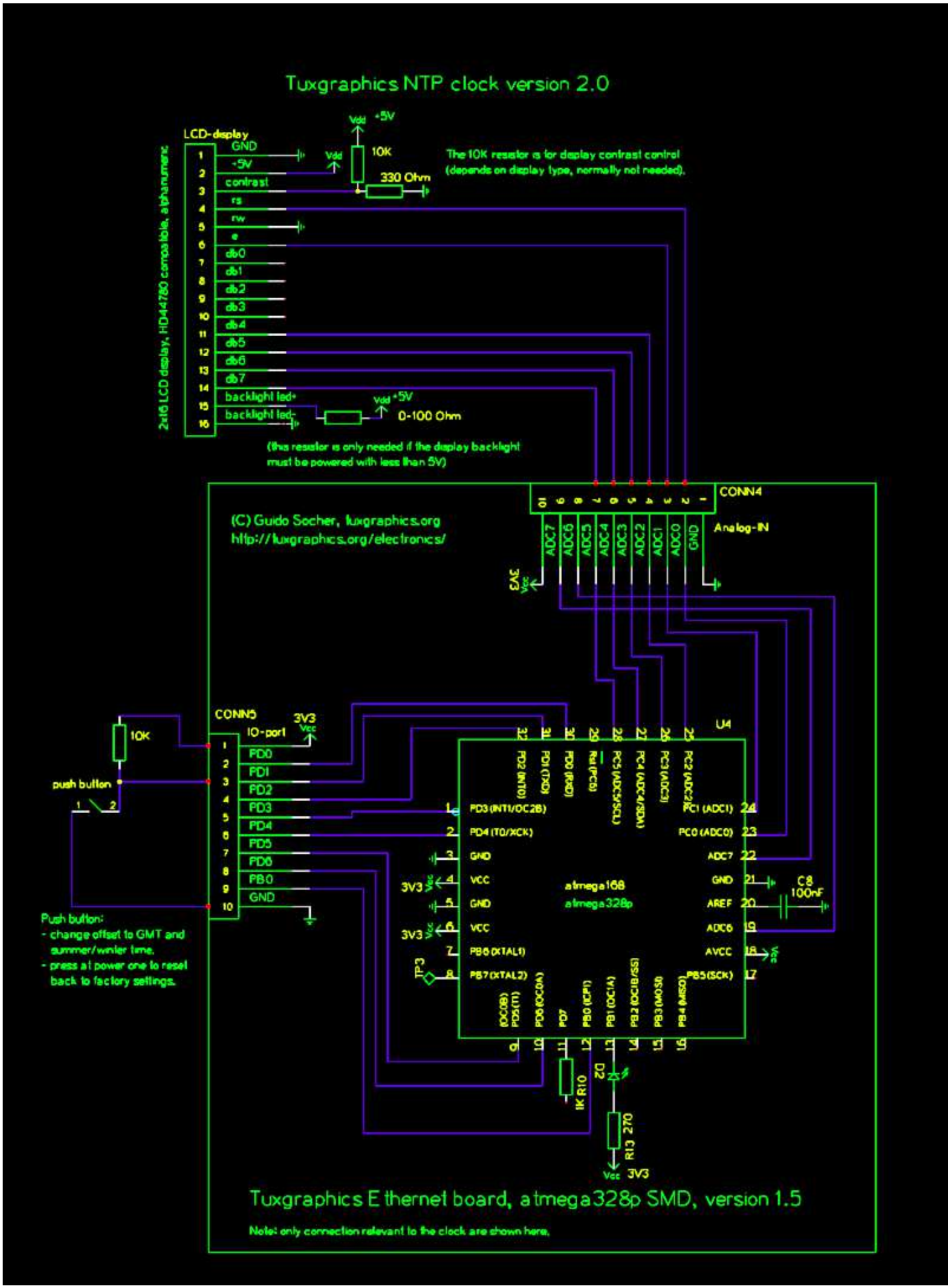
Tuxgraphics desk top NTP clock, web interface, main page



Tuxgraphics desk top NTP clock, web interface, configuration page

The NTP clock hardware

The hardware is the tuxgraphics AVR ethernet board (aka avr webserver board) and a 16x2 HD44780 compatible LCD display. An optional small push button is required to change the time-offset to GMT but this can as well be done via the web-interface that this clock has. I recommend to use for the ethernet board our SMD board as it fits nicely behind the display. The LCD display and the push button needs to be connected as follows:


Tuxgraphics NTP clock version 2.0
LCD-display
2x16 LCD display, HD44780 compatible, alphanumeric
GND
+5V
contrast
rs
rw
e
db0
db1
db2
db3
db4
db5
db6
db7
backlight led+
backlight led-
Vdd +5V
10K
330 Ohm
The 10K resistor is for display contrast control (depends on display type, normally not needed).
0-100 Ohm
(this resistor is only needed if the display backlight must be powered with less than 5V)
(C) Guido Socher, tuxgraphics.org
http://tuxgraphics.org/electronics/
CONN4
Analog-IN
ADC7
ADC6
ADC5
ADC4
ADC3
ADC2
ADC1
ADC0
GND
3V3
CONN5
IO-port
PD0
PD1
PD2
PD3
PD4
PD5
PD6
PB0
GND
push button
Push button:
- change offset to GMT and summer/winter time.
- press at power one to reset back to factory settings.
U4
atmega168
atmega328p
PD3 (INT1/OC2B)
PD4 (T0/XCK)
GND
VCC
PB6 (XTAL1)
PB7 (XTAL2)
PC1 (ADC1)
PC0 (ADC0)
ADC7
AREF
ADC6
AVCC
PB5 (SCK)
C8
100nF
TP3
R10
1K
D2
R13
270
Tuxgraphics Ethernet board, atmega328p SMD, version 1.5
Note: only connection relevant to the clock are shown here.

NTP clock circuit, LCD connection (click for a circuit diagram in PDF format)

You can power the 3.3V regulator of the ethernet board, the LCD display and the LCD-backlight from a 5V DC power supply.

FAQ section

Q: My clock works but it is almost 5min off before the next synchronization at the full hour.
A: You forgot to set the fuse bytes. Change the low fuse byte from 0x62 to 0x60: avrdude -p m328p -c stk500v2 -u -v -U lfuse:w:0x60:m

Q: When I access the clock via the web browser then everything is fine. The LCD display shows however no time. I see just a row of squares.
A: Make a table on paper and note down which ATmega pin name needs to be connected to which LCD pin name and number. After that check every wire between ethernet board and LCD. There is a mistake somewhere.

Q: What do I have to configure on my DSL router to use this clock?
A: In most cases you will not need to do anything as most home DSL router run already a DHCP server. Just plug this clock into an ethernet-jack at the router and that's it.

Conclusion

A very nice clock and very pretty to look at ;-). Now you have one place in your house where you have always exact date and time.

Have fun!

References

- Download page (source code): **NTP clock download page**
- Tuxgraphics electronics section: **tuxgraphics.org/electronics/**
- The components for this NTP clock are available at: shop.tuxgraphics.org

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