Nixie Clock with 6 or 4 Tubes

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Features

-Displays time ;-) with seconds (if 6-Tubes mounted)

-User selectable 12/24 Hour mode with AM/PM indicator (on at AM or PM)

-Blinking colons with adjustable duration

-Selectable date display (from second...to second of every minute)

-Adjustable date format (DDMMYY, MMDDYY or YYMMDD)

-Selectable blanking of leading zeros

-Notice to leap years

-Automatic daylight saving time correction (configurable)

-Selectable digit cross fading for the NIXIEs

-Selectable „Slot machine" every n minutes to prevent cathode-poisoning

-"Night mode" – NIXIEs (and LEDs) can be switched off for a selectable time

-Alarm clock

-NIXIEs can be dimmed by key-press: full+fading, full, half, off)

-NIXIEs can be switched on by key-press during „Night mode" (slot machine and date display are suppressed)

-NIXIEs are switched on during alarm in „Night mode" (for a selectable time)

-All settings are saved in the EEPROM and will be kept in case of disconnection to mains

-Alarm output is configurable to connect a speaker (output of alarm sound) or an external device (output is switched from low to high for a sound module or relays ...)

-Connector for a PIR/LDR/switch..) - triggering the display for a few (selectable) minutes

-Clock is synchronous to mains frequency or any other external clock source (configurable from 1Hz up to 64Hz).

-Connector for power failure backup (battery or accu) – the clock will run with the internal oscillator (may be calibrated)

All options (start/end times, intervals etc.) can be configured with 2 switches (the third is for the alarm handling) during operation.

Hardware:

-Minimalistic circuit, cheap Attiny2313

-Many types of NIXIEs usable

-Uses a 9...12V AC wall wart – circuit is not directly connected to mains!

-Software controlled PWM (high voltage generation) – only a few parts necessary

-Because of the multiplexing of all 6 tubes , only one 74141 NIXIE driver (you can get it from EBAY or from several internet sellers) is needed

-All functions are controlled with 3 keys, all options can be configured by editing a parameter list during operation

-If you omit key 3, all alarm functions are hidden and you get a „normal" NIXIE clock

Operation

The default configuration is 50Hz mains frequency, German daylight saving, 24 hour time display, date display from second 20 to second 25, the date format is DDMMYY, colon bulbs are blinking.

Attention! The "Night-mode" (tubes off during night) is set by default from 23:00 to 06:00. You can change or disable this feature by changing parameter 9/10.

Keys:

<u>Key1 („Dim")</u>

if pressed in

Normal operation:
   changes between NIXIEs off, dimmed, normal, cross fading

„Night mode" (NIXIEs off for a selected time):
   time is displayed (date display and slot machine are suppressed)

<u>Key2 („Setup")</u>

Only used for setup (time, date, options), place it hidden on the backside of the clock

Setting date and time:

If pressed short:
   setting of date and time -
   Day is displayed on the first 2 digits – changeable with Key1

   press Key2 short again: month is displayed on the second 2 digits – changeable
   with Key1

   Key2 again – year on the second 2 digits (because of clocks with only 4 tubes)
   next Key2: hours
   next Key2: minutes

If everything is adjusted, press Key2 again and the clock runs in normal mode with the
adjusted date and time (the seconds will start at 00).

**!!!!!Only for advanced users – you should know, what you are doing – look at
„Configuring the Options" first !!!!!**

Setting the options:

press Key2 long:

The number of the option is displayed at the first 2 digits, the value at the second 2 digits.
The value is changeable with Key 1 (short), the number of the option is changed with
Key2 (short).

Because there is a long list of options, you can leave this mode with pressing Key2 long –
all changes are kept.

A detailed list of the options, there meanings and values are shown in „**Configuring the Options**".

Key3 („Alarm")

if pressed in

Normal operation and „Night mode":

Display of the alarm time for a few seconds

The first 4 digits display the alarm hours and minutes, the 5th digit is off, the 6th digit is

„1" if the alarm is activated,
„0" if deactivated

(the colon bulbs are switched on or of together with this digit – for clocks with only 4 tubes)

Case of alarm:

Alarm is switched off for 24 hours.

Setting of the alarm time or enabling/disabling the alarm

Press Key3 long, the alarm hour is displayed at the first two digits and can be changed with Key1.

If OK, press Key3 again, the alarm minutes are displayed at the second two digits and can be changed with Key1.

Key3 again – the last digit (or the colon bulbs) can be changed from 0-alarm deactivated to 1-alarm activated and v.v..

Key3 again leaves the alarm setting.
If the alarm time is changed, the alarm is activated automatically.

Shortcut:If you only want to activate/deactivate the alarm, press Key3 long twice – the activation setting will be toggled

Configuring the Options

<u>Default values (first start of the clock)</u>

```
Option              Value  Comment

01                  0      Time display (12h or 24h)(0/1): 0-24h
02                  0      Date display (0..2):0-DDMMYY
03                  0      Blank leading 0(0/1): 0 (no)
04                  50     Blink duration (in 1/(hzmax*2) steps (10 ms
                           step at 50 Hz): 50
05                  0      AM/PM blink (0..2): 0 (off)
06                  10     Repeat slot machine(min.): 10 (slot machine
                           every 10 min.)
07                  20     Date display from (incl. sec.): 20 (date
                           display will start at second 20
08                  25     Date display to (incl. sec.): 25 (date display
                           will end after second 25)
09                  23     Night mode starts at (incl. hour): 23 (tubes off
                           at 11:00 pm)
10                  6      Night mode  ends at hour: 6 (tubes are switched
                           on at 6:00 am)
11                  10     Duration of the display at alarm (min.): 10
                           (if in night mode, the tubes are switched on for
                           10 min. if the alarm starts)
12                  59     Alarm duration(sec.): 59 (alarm sounds 59 sec.)
13                  1      Speaker mode(0/1): 1 (sound)
14                  0      Display duration PIR(min.): 0 (PIR switched off,
                           tubes always on)
15                  50     Mains frequency(Hz): 50 (Hz) (Europe)
16                  50     Calibration of the internal. oscillator (only
                           used during mains failure: 50(not calibrated)


Daylight saving options for Germany beginning 2010

17                   3     Daylight saving starts at this month: 3 (March)
18                  10     Daylight saving ends at this month: 10 (October)
19                   2     Clock is adjusted forward at this hour:  2
20                   3     Clock is adjusted backward at this hour: 3
21                   1     Adjust how many hours: 1

22                  10     Table of the adjustment dates starts with year:
                           10 (2010)
```

Dates for every year

```
23                  28     March 2010
24                  31     October 2010


25                  27     March 2011
26                  30     October 2011


and so on ...


49                  26     March 2023
50                  29     October 2023
```

Detailed description of the several options

Option 01 – Time display (24h or 12 h)

Adjustable from 00-01
Default:00

If the value of is set to 00 - 24h mode, if 01-12h mode.
In 12h mode it's a good idea to configure the colon bulbs as AM/PM indicator (**Option 05).**

Option 02 –Date display (00-DDMMYY; 01-MMDDYY; 02-YYMMDD)

Adjustable from 00-02
Default:00

Date format:

00 – Day/Month/Year

01 – Month/Day/Year

02 - Year/Month/Day

Option 03 – Blank leading zero (00 – no, 01 – yes)

Default:00

Is this value set to 01, a leading zero in 1th digit will be blanked (the 1th tube is switched off). Example: the time is 07:34:12 but you will see 7:34:12.

Option 04 – Blink duration of the colon indicator (neon bulb(s))

Adjustable from 00-99 (steps)
Default: 50

At the begin of every new second the colon indicator is switched on (except **Option 04** = 00). This value defines the delay for the indicator to be switched off.

If **Option 04 = 00,** the indicator is switched off permanently.

The measurement for this option depends on the clock of the mains frequency (**Option 15**), it's 1/(hz*2) seconds.

Examples:

Is the value of **Option 04** = **Option 15** (mains frequency), the duration of the colon blink will be ½ second.

If you use an external clock soure of 1Hz and set **Option 04** to 01 – the duration is ½ second (if you chouse 2 or higher, the indicator is always on).

Option 05 – AM/PM indicator (00 – off [works as defined in **Option 04**], 01 – on at AM, 02 – on at PM)

Adjustable from 00-02
Default: 00

Colon bulbs can be configured as AM/PM indicator.

00 - no AM/PM function
01 - on at AM
02 - on at PM

Option 06 – Repeat interval of the effect „Slot machine" (aka. one-armed bandit or fruit machine)

Adjustable from 00-60 (minutes)
Default: 10

The clock can start at the begin of every minute an effect called "Slot machine". It will last about 6s. With this option you can configure the repeat interval (in minutes) of this effect.

00 – Slot machine disabled
01..n..60 Slot machine every n minutes

Examples:

01 - at the begin of every minute
60 – at the begin of every hour

This is not only an optical effect, it prevents the tubes from "cathode poisoning" (sputtering material on unused cathodes).

Option 07 – Start second of the date display in every minute   Default: 20
Option 08 – End second of the date display in every minute   Default: 25

Adjustable from 00-59 (second)

The date information can be displayed in every minute, this to options define the start/end second.

If both values are equal, the date is displayed for 1 second.

The date display is disabled if the value of **Option 08** is less then the value of **Option 07**.

Option 09 – Start of "Night mode" (hour)   Default: 23
Option 10 – End of "Night mode" (hour)   Default: 06

Adjustable from 00-23 (hour)

With this option, you can switch off the tubes (and the high-voltage generation) during night (good for saving tube lifetime and energy).

Certainly the clock continues running (with tubes off) and the alarm will work properly.

The value of **Option 09** defines the hour at which the tubes will be switched off, the value of **Option 10** set the hour when the tubes will switched on again.

Example: **Option 09** = 23
               Option 10 = 06

The clock will get dark at 11 pm and display the time again from 6 am.

If the value of **Option 10** is equal to the value of **Option 09 -** the "Night mode" will be deactivated.

Option 11 – Duration of display at alarm

Adjustable from 00-59 (minutes)
Default: 10

If in "Night mode", the display will switched on this duration from beginning of the alarm.

If you choose 00, the display will stay dark at alarm.

Parameter 12 – Duration of the Alarm(Sound)

Adjustable from 00-59 (Sec.)
Default: 59

The alarm will last this time (but you can cancel it with Key3).
If this parameter is set to 00, the alarm is disabled (overrides the alarm clock setting!)

Parameter 13 – Speaker mode

Adjustable from 00-01 (off/on)
Default: 01

If you don't connect a speaker to the appropriate output pin, you can use this pin for an external sound module or switching proposes (choose setting 00) - you will get HIGH (TTL) level at alarm (shortcut C6 and R25!).

For a normal speaker (about 8 Ohm) chose setting 01.

Parameter 14 – Display duration on PIR

Adjustable from 00-59 (Min.)
Default: 00

You can control the display oft the clock by connecting a PIR or LDR (or simple switch to ground) to the PIR input port (low active, internal pull-up is on) .
If **Parameter 14 > 00**, the tubes are normally off and will only switched on when the PIR (LDR, Switch..) is activated (time in minutes – posttrigger enabled).

If 00 is chosen, the tubes are always on (depending on the other settings).

Parameter 15 – (Mains) input frequency

Adjustable from 00-64 (Hz)
Default: 50

Frequency of the external clock, normally taken from the AC-Wallwart (9...12 V, via RC -see schematic). For America you should choose 60 Hz, for Europe 50.
If you want connect other clock sources (clock cristal + 4060 → 2Hz or a temperature compensated DS32kHz), adjust the correct frequency here.
The clock will run with its internal oscillator in case of a mains blackout (with connected battery/accu option ;-))

The internal oscillator backup will only work for frequencys of 22Hz and higher.
If the frequency of your clock source ist lower, you have to backup your clock source with a battery/accu.

Another option is to use this parameter to run the clock slower or faster (for testing proposes).

Parameter 16 – Calibration of the internal oscillator (only for backup)

Adjustable from 00-99
Default: 50

With this parameter you can make a correction of the accuracy of the internal oscillator (only used during power fail)- if accu or battery connected).
If the value is increased, the clock (during backup) runs slower – if decreased it will run faster (about 3.6 min. per 12h and tick).

Parameter 17 – Start month of daylight saving

Adjustable from 00-12
Default: 03 (March)
(00 – no daylight saving)

Parameter 18 – End month of daylight saving

Adjustable from 00-12
Default: 10 (October)

(00 – no daylight saving)

Parameter 19 – Starting hour of daylight saving

Adjustable from 00-24
Default: 02 (2:00 am)

Parameter 20 – End hour of daylight saving

Adjustable from 00-24
Default: 03 (3:00 am)

Parameter 21 – Clock adjustment at begin/end of daylight saving

Adjustable from 00-23
Default: 01 (hour)

Parameter 22 – Starting year of the (following) table (dates of daylight saving start and end)

Adjustable from 00-99
Default: 10 (2010)

Parameter 23 - Day of start daylight saving year 1 (2010)

28

Parameter 23 – Day of end daylight saving year 1 (2010)

31

etc.
.
.
Parameter 49 - Day of start daylight saving year 14 (2023)

26

Parameter 50 – End of start daylight saving year 14 (2023)

29

The table is preconfigured for Germany – if your clock runs up to year 2023 - you can edit the table for the next 14 years ;-)

Summery of operation

Normal mode (clock displays time)

Key1: Dim
Key2: Setup date and time
Key3: Displays alarm time for 3 seconds

Key2 long: Setup parameters
Key3 long: Setup: alarm time and alarm enable/disable

Alarm sounds

Key3: Alarm off (24 hours)

Display is dark ("Night mode")

Key1: Display on

Alarm-Setup (Key3 pressed long)

Key1: Increment value
Key2: Cancel *Alarm-Setup* (changed values are kept)
Key3: Next setting

Order of settings: Hour / Minute / Alarm enabled/disabled

Key3 long : Alarm enabled/disabled (toggled)

Setup mode (Key2 pressed long)

Key1: Increment value
Key2: Next setting

Order of settings: Day / Month / Year
                       Hour / Minute

Key2 long: Setting the options

Setting the options (Key2 pressed long twice)

Key1: Increment value
Key2: Next option
Key2 long: C*ancel options setting* (changed values are kept)

Construction

Disclaimer

The circuit and the software are well tested **but you are COMPLETELY at your own risk when trying to build this clock. Provided 'AS-IS' and without warrenty of any kind. I am not responsible for any damage!**

You are dealing with voltages of 180 V and higher (up to 450 V)!!

If you are in any way unfamiliar with high voltage circuits dont risk to build it!

You should use a power source of 9V...12V AC!! (wallwart) 0.5 A minimum.

The clock was build several times and the circuit is well checked.
Your PCB should have a good grounding (for the HV generation) – keep the HV wires short!

Due to the multiplexing and the PWM (HV generation) there can be some RF disortion to some RF receivers – keep the clock a few feet away.

The clock can easy made on a testboard or printed circuit.

If all tubes are on, adjust the HV with the trimmer to 180V.

During the operation, the FET is getting worm/hot – kepp the air circulation in mind and protect the FET from touching.

You can variate the values for the coil L1 and the ELKO C8 – 100...330 uH (0.5 A min.) and 1—10 uF (250V min.) should work (if not, try to adjust the PWM settings in the source code)..

To hear the alarm sound, simply connect a cheap 8 Ohm (PC)speaker to the SPK-Output. If you like to switch something (external sound module or what ever), shorten R25 and C6 and change **Parameter 13** to 00.

Keep the maximum load (20 mA) of the output pin in mind.
For a relays use a transistor (with basis resistor) and a suppressor diode!

If you don't need the alarm, omit Key3 and R25/C6

For use with only 4 tubes omit R5,R6,R15,R17,T7,T8,T12,T13.
If the alarm is used, I recommend to mount the colon (neon) bulbs – this is the only way to see (with only 4 tubes) the alarm active setting..

To protect the clock from mains blackout, you have to connect an accu or a battery.

If not, you can omit D1,D7,D8 and R22,
If you use a battery (not an accu), don't assemble D8 and R22!

The backup was checked with 3 x NiMH Accu AA 1700 mA/h – the clock survived about 2 weeks.

The mounted accu will be charged permanently ("trickle load"; C40 method), the value of R22 is chosen with aximum security (actually you will get C80) – keep this in mind if you change R22 or the type of accu.

You can flash the micro in the circuit (ISP), but disconnect the accu or battery first!

The LEDs in the circuit are optional (blue, mounted underneath the tubes), they are switched on/off together with the HV (because of the "Night mode").

If you don't need this, omit the LEDs, T14, R27 and R31.

Connection of a PIR, LDR or external switch:

May be, your clock is located at the toilet room ;-), the tubes should be on only, if there is someone in the room.

In this case, you can connect a PIR, LDR or external switch to the PIR input pin (low active, internal pull up of the micro is on).
The tubes will be switched on after triggering for the chosen time (**Parameter** 14).

Use of an external clock source:

If you don't use the mains frequency as clock source (you prefer a quartz, DS32Khz or any other), connect it to PB3 of the Attiny2313.
The clock must be lower or equal 64 Hz – use for example a 4060 for dividing (adjust **Parameter 15** !)..
For using a clock lower 22Hz, the internal backup clock of the Attiny will not work – connect the clock source to the battery/accu too.

Software

In the package is the full source and the compiled .hex and .eep file. You can easy flash this files with ISP or a HV-Programmer.

But set the right fuses!
For a fresh ATTINY2313 you have to change the following fuses:

ckdiv8 – the clock must run at the full 8 Mhz

Brownout – chose 4.3V (if accu/battery set it to 2.7V)

Compiling the source:

The current files are compiled with WinAVR 20070525 (GCC 4.1.2) and AVR Studio (no external makefile).

New versions of GCC will produce normally larger code!

Set the following project options in the in the project properties dialog:

Device:attiny2313
Frequency:8000000
Optimization:Os

under

Project/Configuration Options/Custom Options

in the list for All Files:

-Wall
-gdwarf-2
-std=gnu99
-mint8
-ffreestanding
-DF_CPU=8000000UL
-Os
-fsigned-char