NTP sync over Wi-Fi for Nixie clocks

User Manual

Version 2.5 – 4th October 2017

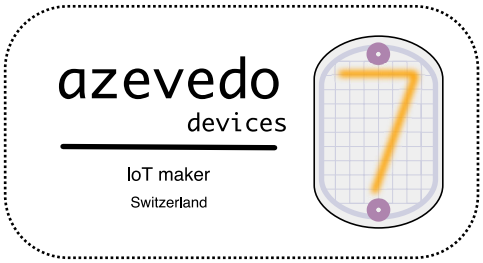


Table of Contents

Disclaimer

nwts devices, were tested with several Nixie clock models. For a complete and updated list of compatible devices, please visit:

http://www.azevedo-devices.com/compatibility.html

Even following all the specs, it cannot be guaranteed that this device will work with your clock or your network.
There is no guarantee that the device will perform always as expected.

Introduction

Thank you for acquiring a **nwts** time sync module.
This module connects over Wi-Fi to your home network and, using NTP, will synchronize your GPS enabled Nixie clock.

nwts 2.5, the current version, has also the following features:

- HTTP authentication (new in 2.5)
- Improved NTP reliability (new in 2.5)
- Time zone and DST support.
- DST now supports fixed dates (new in 2.5)
- Custom latitude and longitude. Selected browsers can auto-fill
- Select which NMEA messages to send and send only when clock RTC is in sync
- Select date/time format in Webpage
- Adjust delay or advance of time with drift correction

The module's setup is quite easy and once running will automatically provide your clock date and time with approximately 1s precision.

The **nwts-ub3** board was originally designed to replace the GPS module for PV Electronics Nixie clocks. It's pin and electrically compatible[1] with the PV Electronics GPS module and if you already own one GPS module, it can be replaced immediately, without reconfiguring the clock.

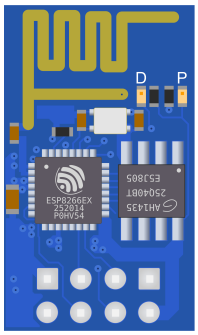
Note: Replacing modules with the clock running can damage both the clock and the **nwts** module. Please disconnect your clock from power before installing or removing modules.

[1] **nwts** draws more power from your clock than the PV Electronics GPS module. Please refer to the specs

Package contents

The **nwts** module is comprised of these two components:

ESP8266-ESP-01



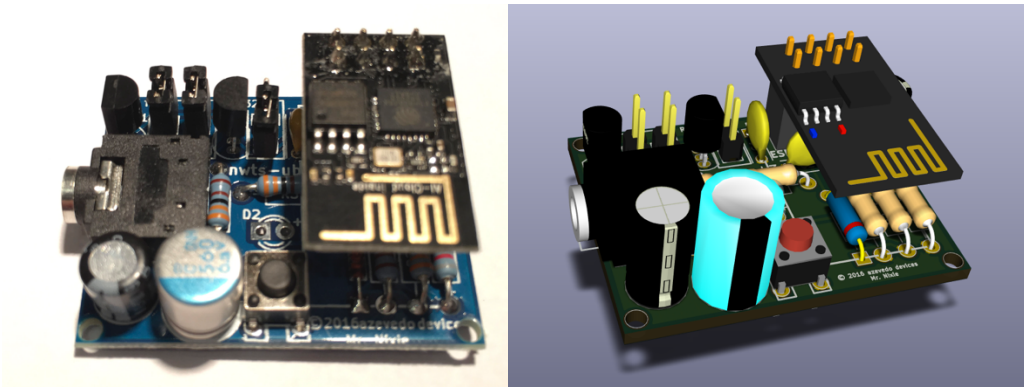
The ESP-01 is provides the Wi-Fi connectivity. It has two LEDs:

- D Blue Data – When data is sent to the clock, it blinks
- P Red Power – Indicates the module is powered

The ESP-01 module exists in two different models. They can be identified by their PCB colour: blue or black. They differ only on their flash size - 512K (blue) or 1M (black):

Only the 1M modules work with the current **nwts** firmware.

nwts-ub3

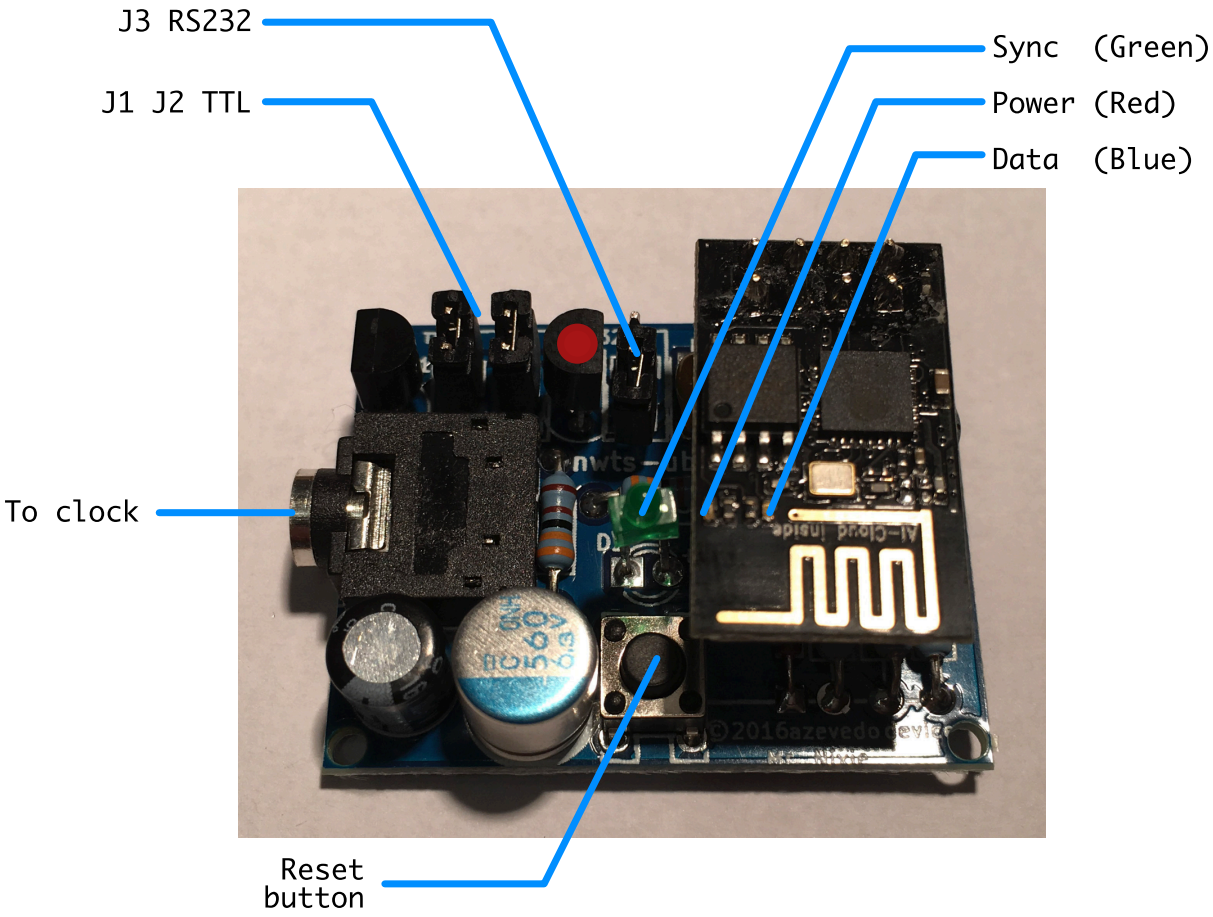


The nwts-ub3 board contains:

- 3.5mm jack to connect to Mr Nixie and PV Electronics Nixie clocks[2]
- 8 pin (4x2) female header to connect the ESP-01 module
- Reset button
- Jumpers for TTL or pseudo inverted RS-232 signal selection
- Sync LED

[2] For other brands, please check the clock's manual. Signal cable information can be found in Appendix A – Technical details (page 28)

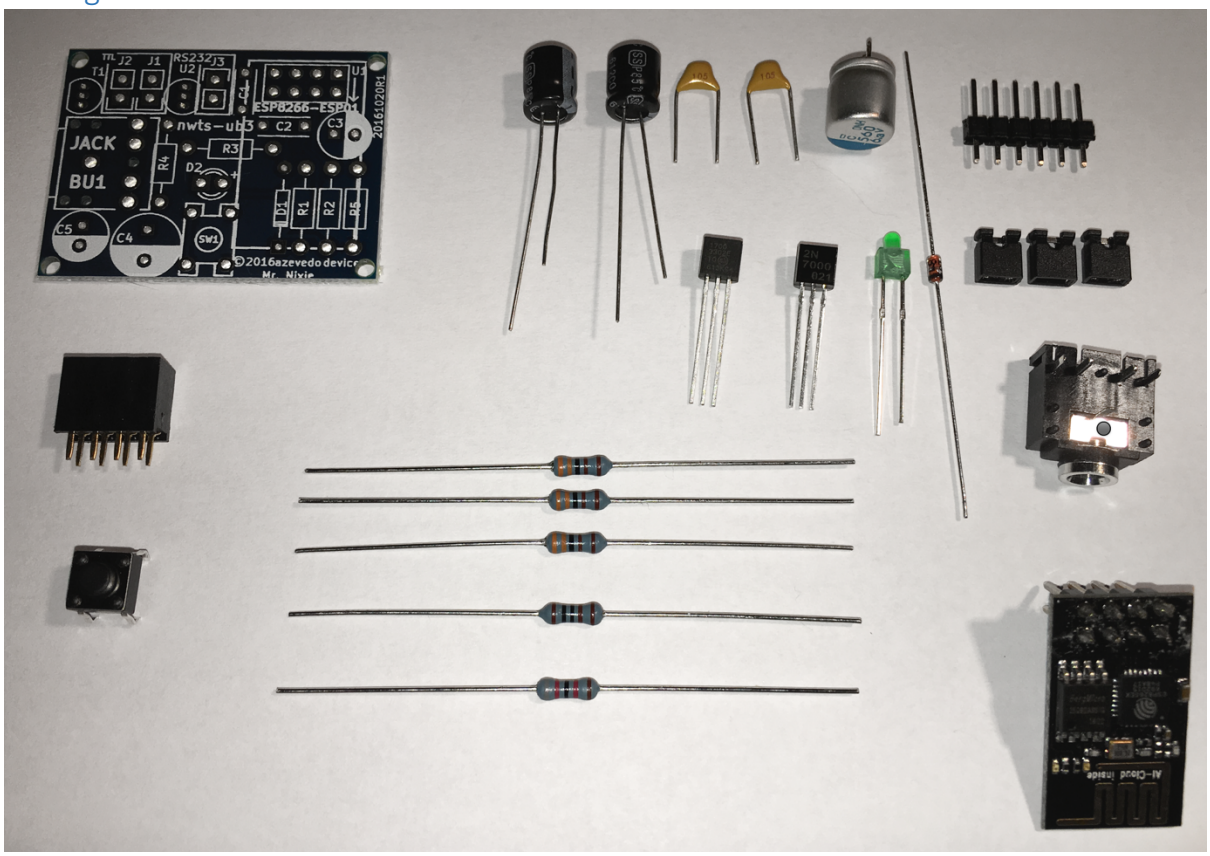
Hardware


J3 RS232
J1 J2 TTL
To clock
Reset button
Sync (Green)
Power (Red)
Data (Blue)

Kit assembly instructions

Your **nwts** device might have already been assembled, depending on your ordering options. If this is the case, you can skip to the "Installation and setup" section on page 15.

Package contents



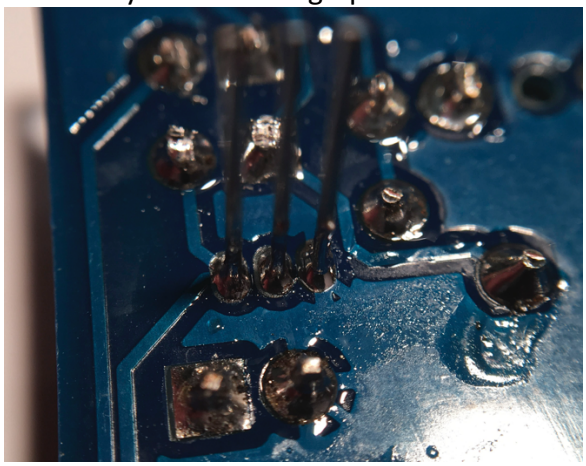
Make sure that all components are included.
Please note that due to different suppliers, the components you receive might not be 100% the same. They are however fully tested and should work as the components depicted in the pictures.

Your package should contain the following material:

Name	Type	Value	Codes	Qty
PCB1	PCB board	-		1
BU1	3.5mm jack	-		1
C1, C2	Ceramic capacitor	1µF	105	2
C3, C5	Electrolytic capacitor	100µF		2
C4	Polymer capacitor	560µF		1
D1	Diode	1N4148		1
D2	LED	Green		1
J1, J2, J3	Male 2.54mm pin header	-		6
JC1, JC2, JC3	Jumper cap	-		3
R1	1/4W resistor	1KΩ		1
R2, R3, R4	1/4W resistor	3.3KΩ		3
R5	1/4W resistor	82KΩ		1
SW1	4 pin 6mm switch	-		1
T1	MOSFET	2N7000		1
U1	8 (4x2) Pin block header	-		1
U2	Voltage Regulator	MCP1700-3302E/TO		1
IC1	ESP8266 ESP-01			1
Card 1	License card			1

Soldering tips

Use a good soldering iron with a fine and always clean tip.
Have some mesh available to remove any excess solder.
You might get better results with lead solder, though it might not be the best environment friendly option.
Use a very fine soldering tip. You need to solder the TO-92 components:



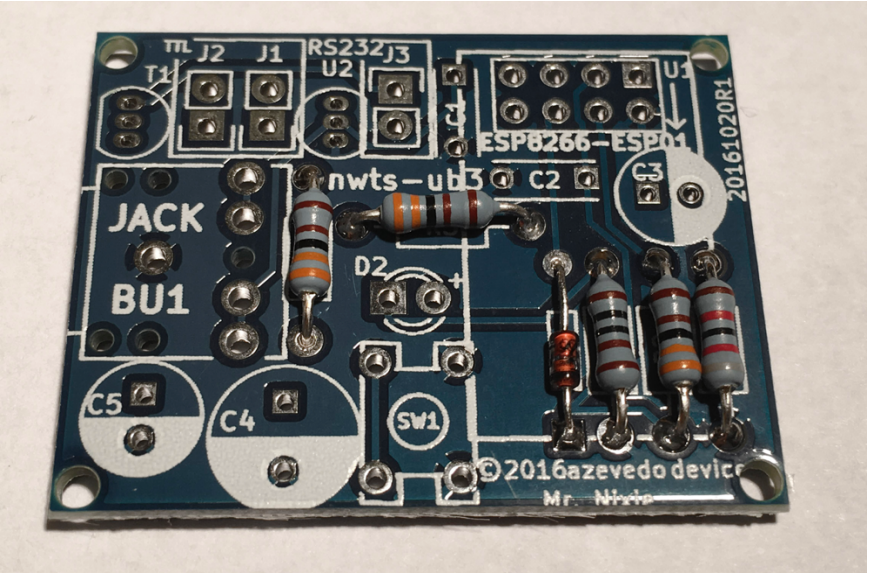
Using only a tiny bit of solder, just touch the component wires while they're hot from the soldering iron. If you create a bridge, use mesh to remove it.
Use a magnifying lens to check you haven't created any bridges.

Building up

The recommended method to build is to start with flat components and progressively add taller components, with the sole exception for the green LED: this should be the last soldered component.

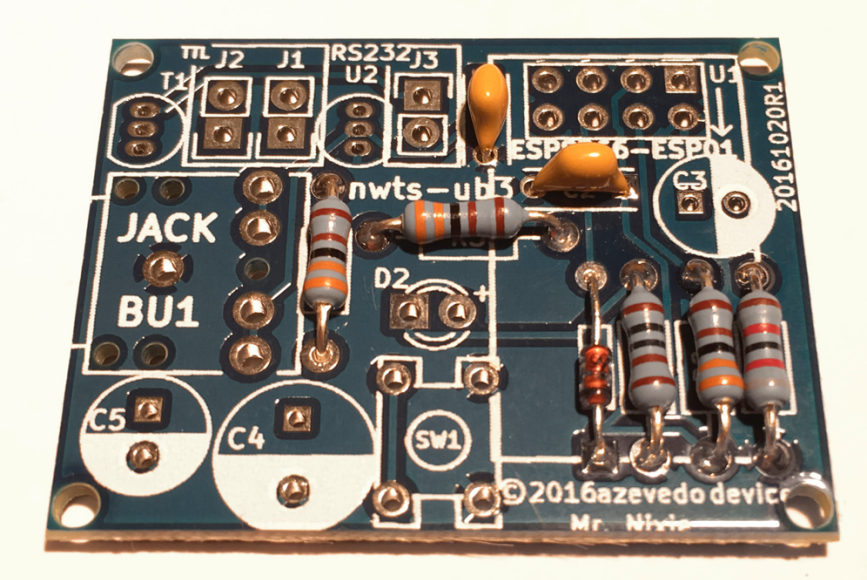
Flat components

Start by soldering R1 to R5 and D1:



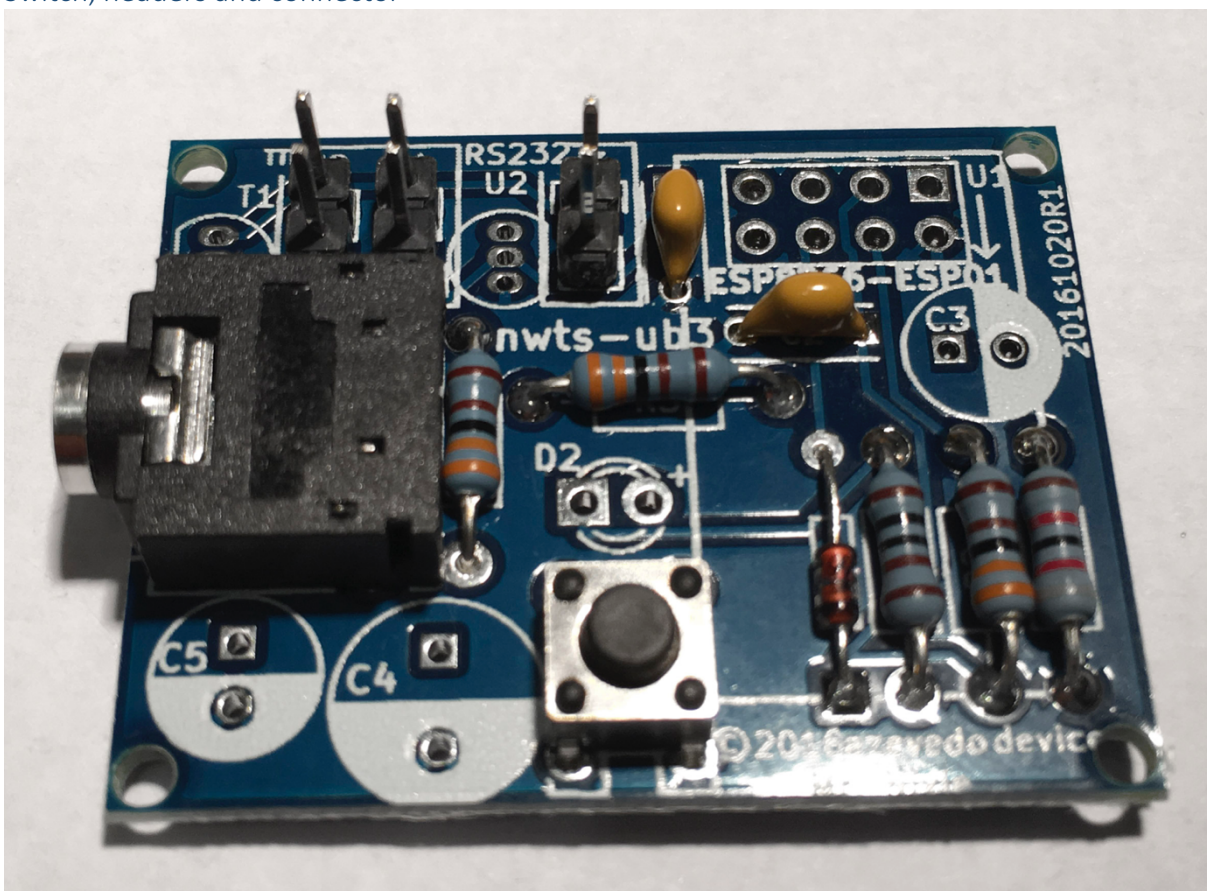
Name	Type	Value	Codes	Qty
D1	Diode	1N4148		1
R1	1/4W resistor	1KΩ		1
R2, R3, R4	1/4W resistor	3.3KΩ		3
R5	1/4W resistor	82KΩ		1

Ceramic capacitors



Name	Type	Value	Codes	Qty
C1, C2	Ceramic capacitor	1µF	105	2

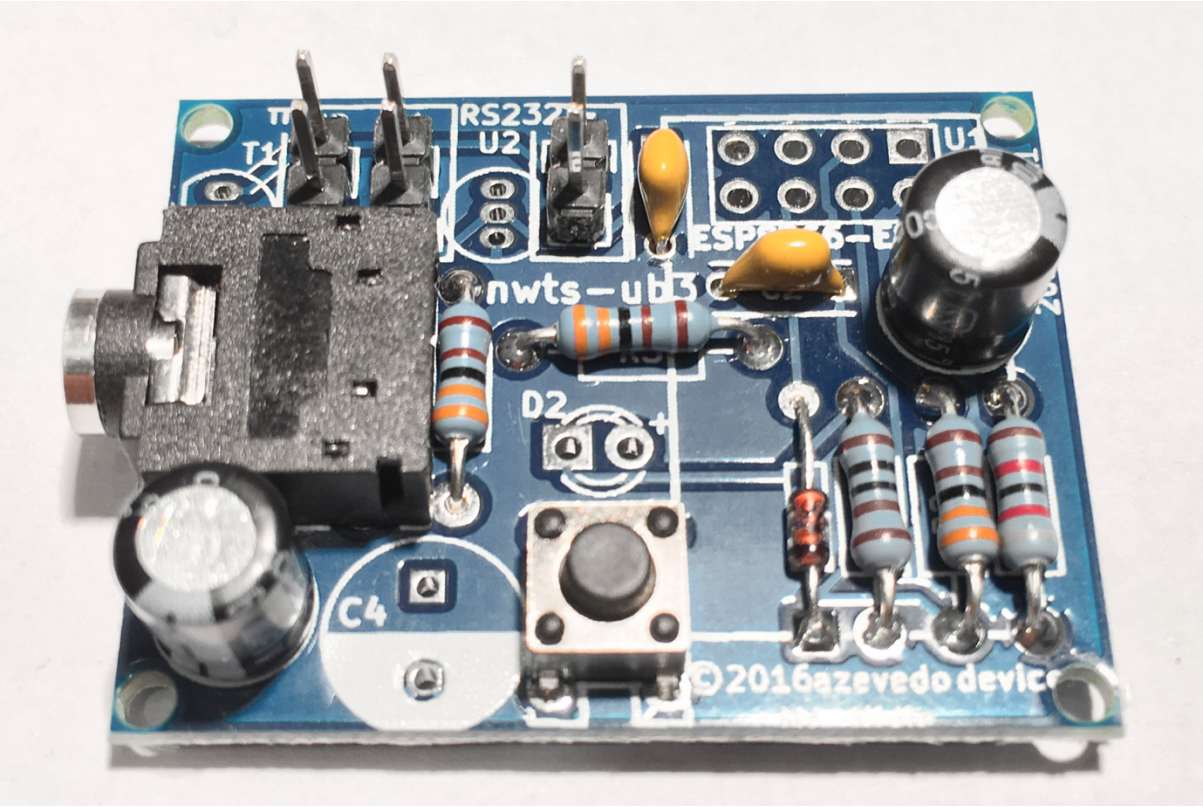
Switch, headers and connector



The headers might be connected to each other. Using a side cutter, make 3× two-pair headers, for J1, J2 and J3.
For the moment, reserve the jumper caps. You'll use them later.

Name	Type	Value	Qty
BU1	3.5mm jack	-	1
J1, J2, J3	Male 2.54mm pin header	-	6
SW1	4 pin 6mm switch	-	1

Electrolytic and polymer capacitors



Notice that these capacitors are polarized – i.e. – you need to solder them correctly or they might burst.
The electrolytic capacitors have a longer leg (positive) and have the negative leg marked with a grey band on the capacitor body. The negative leg is to be aligned with the white part of the capacitor drawing in the PCB.
The polymer capacitor has a blue mark that should be aligned with the white mark in the capacitor drawing in the PCB.

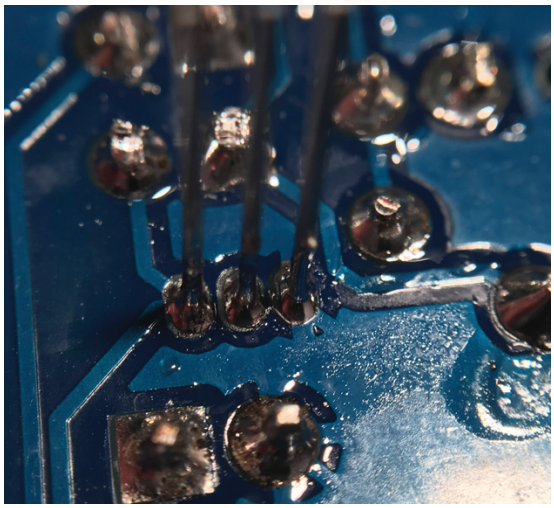
Name	Type	Value	Qty
C3, C5	Electrolytic capacitor	100µF	2
C4	Polymer capacitor	560µF	1

Transistor and voltage regulator

The transistor and voltage regulator should be aligned with the drawing on the PCB (flat and round part).

The voltage regulator is marked with a red dot. Don't confuse with the MOSFET!

They should be soldered very carefully as their pins are only 1.27mm apart.



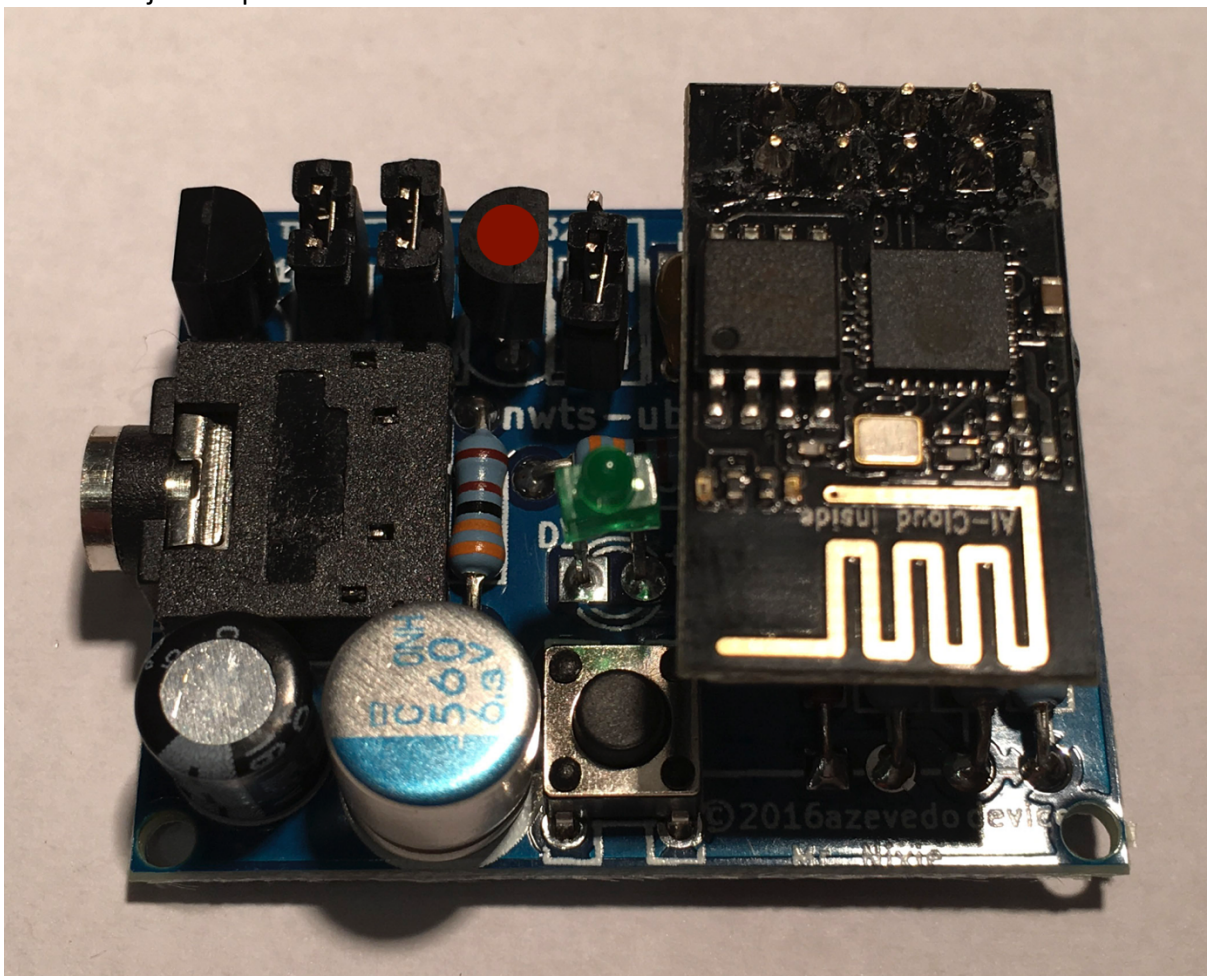
Name	Type	Value	Qty
T1	MOSFET	2N7000	1
U2	Voltage Regulator	MCP1700-3302E/TO	1

ESP header and LED

Solder the ESP header. After it is soldered, insert the ESP01 device and the LED.

Please notice that the LED longer leg goes to the pin marked +.

Align the LED with the LEDs from the ESP board as shown in the picture. Using solder, fix the LED and adjust its position:



Name	Type	Value	Qty
D2	LED	Green	1
U1	8 (4x2) Pin block header	-	1
IC1	ESP8266 ESP-01		1
JC1, JC2, JC3	Jumper cap		3

Finally add the jumper caps to the jumpers – connect the jumper caps as shown in “Setting device mode” on page 15.

Your device should be ready for use.

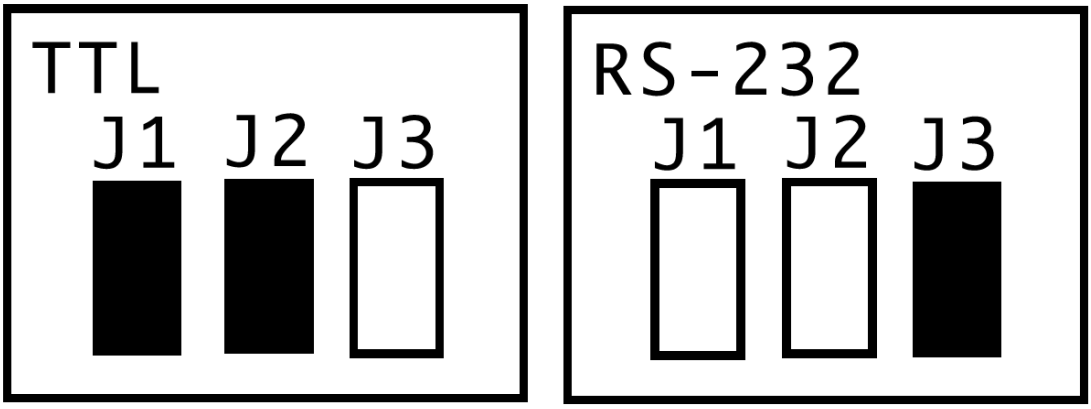
Installation and setup

Setting device mode

The nwts-ub3 board supports TTL or inverted pseudo RS232 signal.
Check with your clock manufacturer which signal type the clock uses.

All PV Electronics and Mr Nixie clocks use TTL level signal.

The jumpers on the board should be configured like shown:



A black filled block means that the jumper is shorted (cap is connecting both pins) and white filled block means the jumper is open (cap is connected on only one of the pins or not used).

Any other jumper configuration is invalid and the device will not work.

Connecting to clock and first setup

Note: These instructions are based on PV Electronics and Mr Nixie clocks. For other clocks, please check the technical details in Annex A.

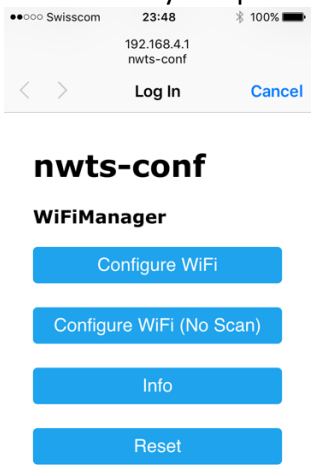
1. Disconnect your clock from power.
2. On most PV Electronics clocks and Mr Nixie clocks there is a GPS/RFT labelled 3.5mm jack.
    a. Using either a 3.5mm male/male adaptor or a short male/male cable, connect the **nwts** module to one end of the cable and the other end to the GPS/RFT jack
    b. If your clock does not have this jack, check the clock instructions
3. Power on your clock
4. On the **nwts** module you should now see one red LED on the ESP-01 module. This means that power is OK and the ESP-01 module is correctly powered.

5. The blue LED should start to blink fast – this indicates the device is in AP configuration mode. If the device is connected to a network this fast blinking does not occur
6. Using either your Wi-Fi enabled mobile phone or your computer, connect to a new network that should appear on the list of available networks:

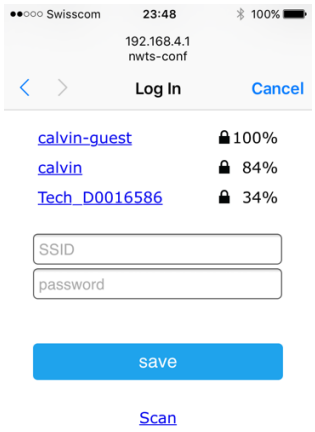
SSID:	`nwts-conf`
Password:	`config-me`

a. 

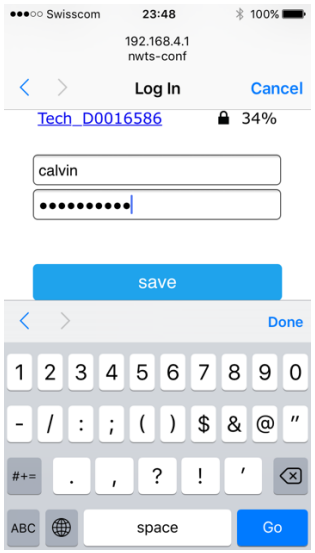
7. As soon as your phone/computer is connected to the **nwts** module, you should get a captive portal redirection, you should see the following page. If not, just open the web browser and try to open any page:

a. 

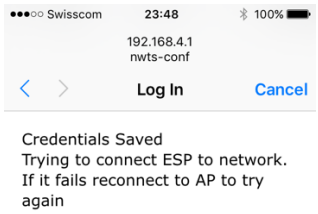
8. Select configure Wi-Fi. You'll be presented with a list of found networks:

a. 

9. Select your network by clicking it. The SSID field will be populated. If your network requires a security key (indicated by the padlock icon), also enter the necessary password:

a. 

10. As soon as you press “save” the following message will appear:



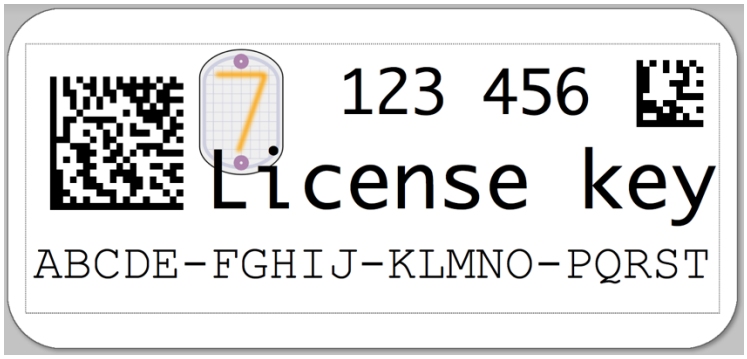
a. _____

11. The “nwts-conf” network should now disappear if your device successfully connects to your Wi-Fi network. If it doesn’t, the “nwts-conf” network will appear again. Then please repeat the previous steps.
12. **Congratulations** – you have your device now connected to your network. If you have internet access and NTP is accessible, you should see the ESP-01 blue LED blinking regularly every 1s. The green LED should be solid green. This means that **nwts** has synchronized the time from `pool.ntp.org`. If the blue LED is not blinking regularly, this might mean that the initial NTP synchronization failed. If the green LED is blinking, this means that the last ntp synchronization failed and the **nwts** device is only using the internal RTC of the ESP-01 to keep time. This should not be a problem for short periods (up to a month, the ESP-01 clock is quite accurate). **nwts** is configured to sync NTP every two minutes. If after 4 minutes (two sync cycles) the device does not synchronize, cycle power your clock. See the Troubleshooting section for more troubleshooting options.
13. You should now configure your clock per the instructions provided for GPS synchronization:
    a. UART speed: 9600 bps (this is the default for PV Electronics clocks. Mr Nixie clocks use 4800 bps)
    b. **Time zone needs to be set on the clock**, as GPS (and **nwts**) only provide UTC time

License

Your device should come already licensed – i.e. – the license was loaded into the device at the kit manufacturing time.

You should have received a card with a label like this:



Please notice the following:

- The license is locked to your ESP device – you cannot use one ESP device's license on another ESP device
- "Factory reset" of the device (when using the Reset switch) does not delete the device's license information.
- **Re-flashing the firmware will invalidate your license**. The device will work normally, but will not synchronize the time on the clock until a valid license is entered.

Normally you will not need to enter your device license. In case you need to, see the "Advanced configuration" section on page 19.
With minimal configuration, your **nwts** will behave like a GPS receiver. If you want to configure additional features, like time zone, DST, chose which NMEA messages are sent among other options, see the next section.

Advanced configuration

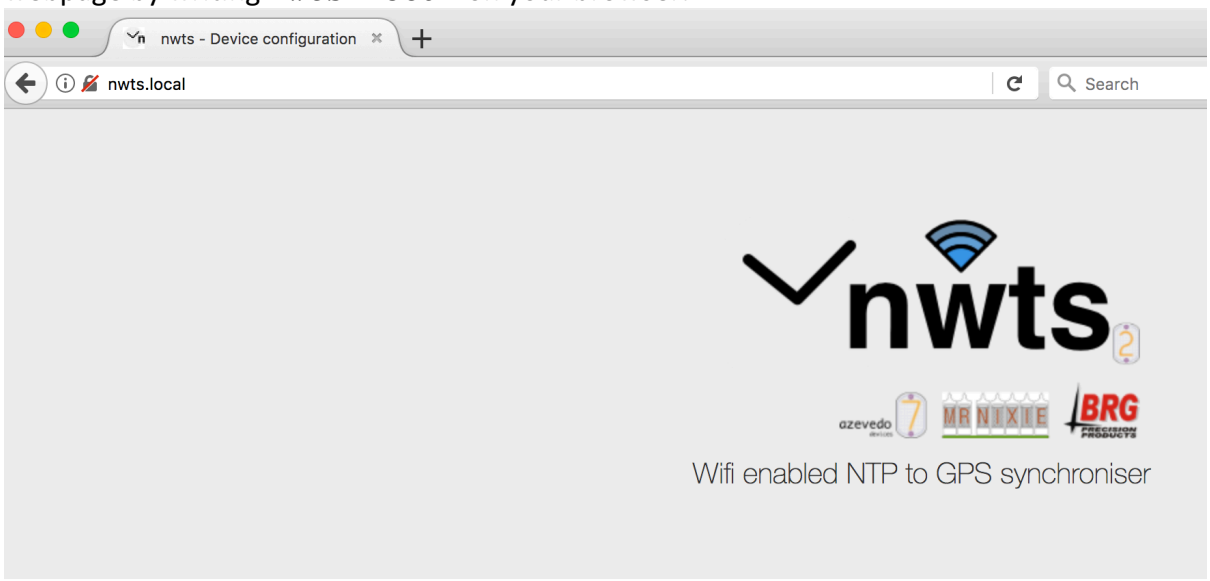
The default settings in **nwts** should be enough for normal operation.
Should you require to:

- Check device's serial numbers
- Change **nwts** hostname (important if you have more than one device)
- Enable Authentication
- Change NTP server, retries and sync interval parameters
- Change Baud rate with your clock
- Enter the device's serial key
- Configure time zone
- Configure daylight savings
- Change the date/time format on the webpage
- Enable/disable specific NMEA messages
- Adjust a positive or negative offset on the time send by **nwts** to your clock
- Configure the GPS position **nwts** sends to the clock

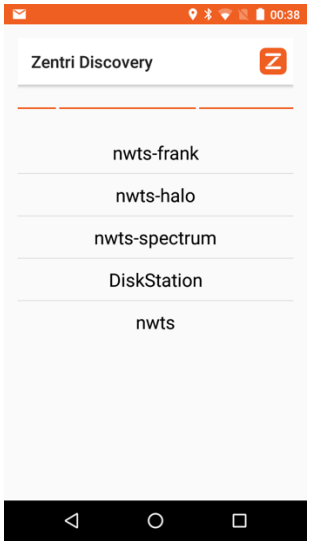
Then you must configure the device through its webpage. There are several methods to access the device's webpage:

Apple (Mac or iOS), Windows with Bonjour or Linux with mDNS

If you have an Apple device (Mac or iOS), a Windows computer with Bonjour installed (iTunes installs Bonjour on the PC) or Linux with an mDNS daemon, you can access **nwts**' webpage by writing `nwts.local` on your browser:



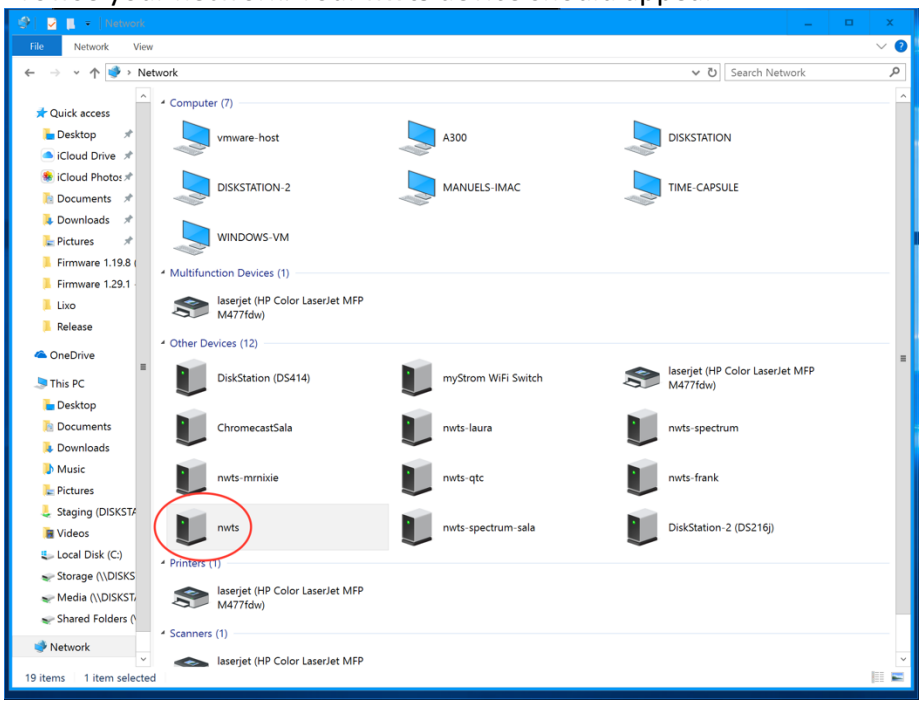
If using an Android device, you can also use Bonjour by installing **Zentri Discovery** free app:



Clicking on **nwts** will open the device's webpage.

Windows 7/8/10

On a Windows computer without Bonjour installed, the device can be found by using SSDP. Browse your network. Your **nwts** device should appear



Double clicking it, will open the device's webpage.

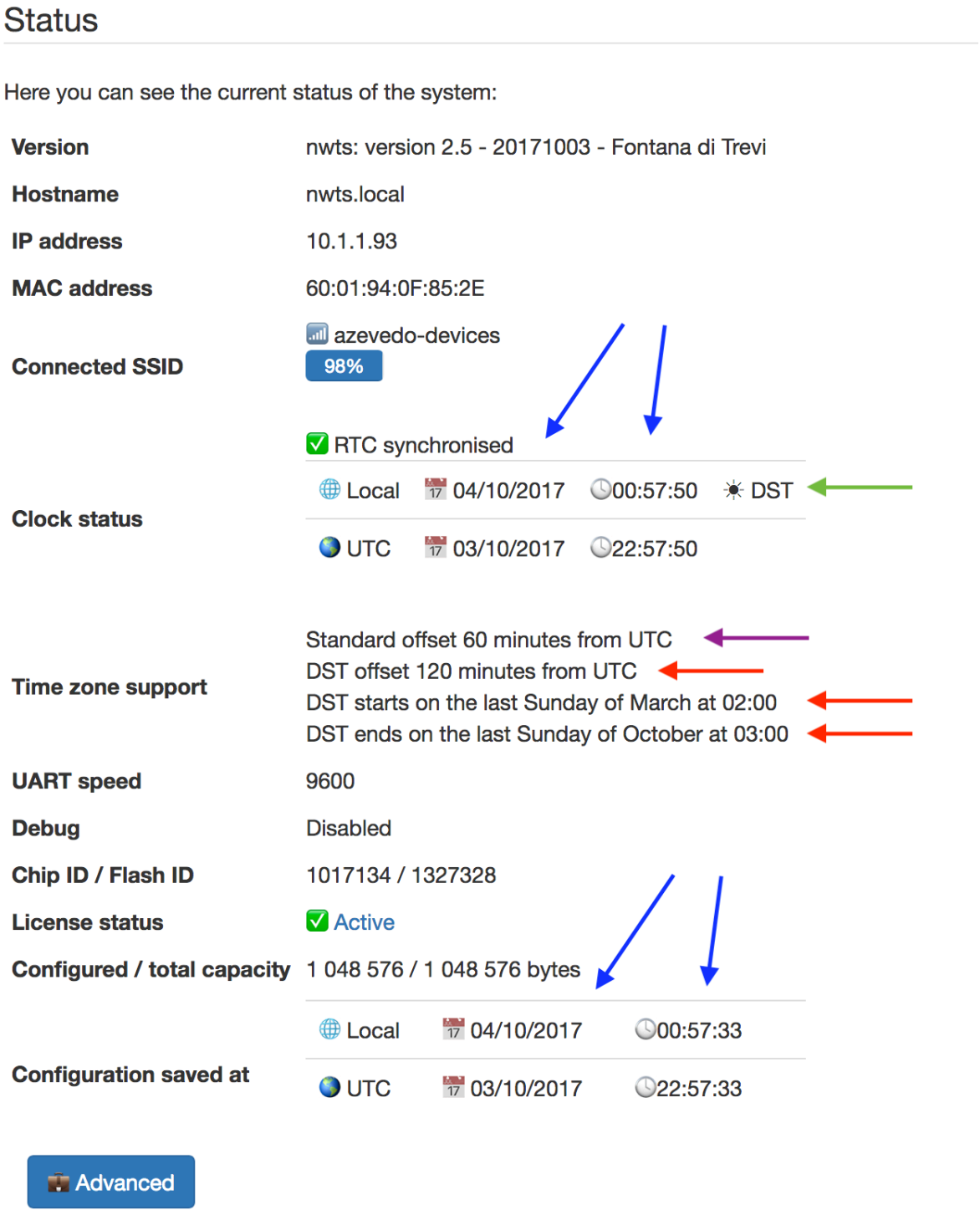
Other methods

Check your DHCP router for any entry with your **nwts** device.

Device configuration page

This page is divided in two sections:

Status



- → Date format
  - DD/MM/YYYY 24 hour

    - MM/DD/YYYY 12 hour am/pm
    - YYYY/MM/DD 24 hour
- → DST indicator
- → Standard time zone offset
- → DST time zone offset, DST start and end

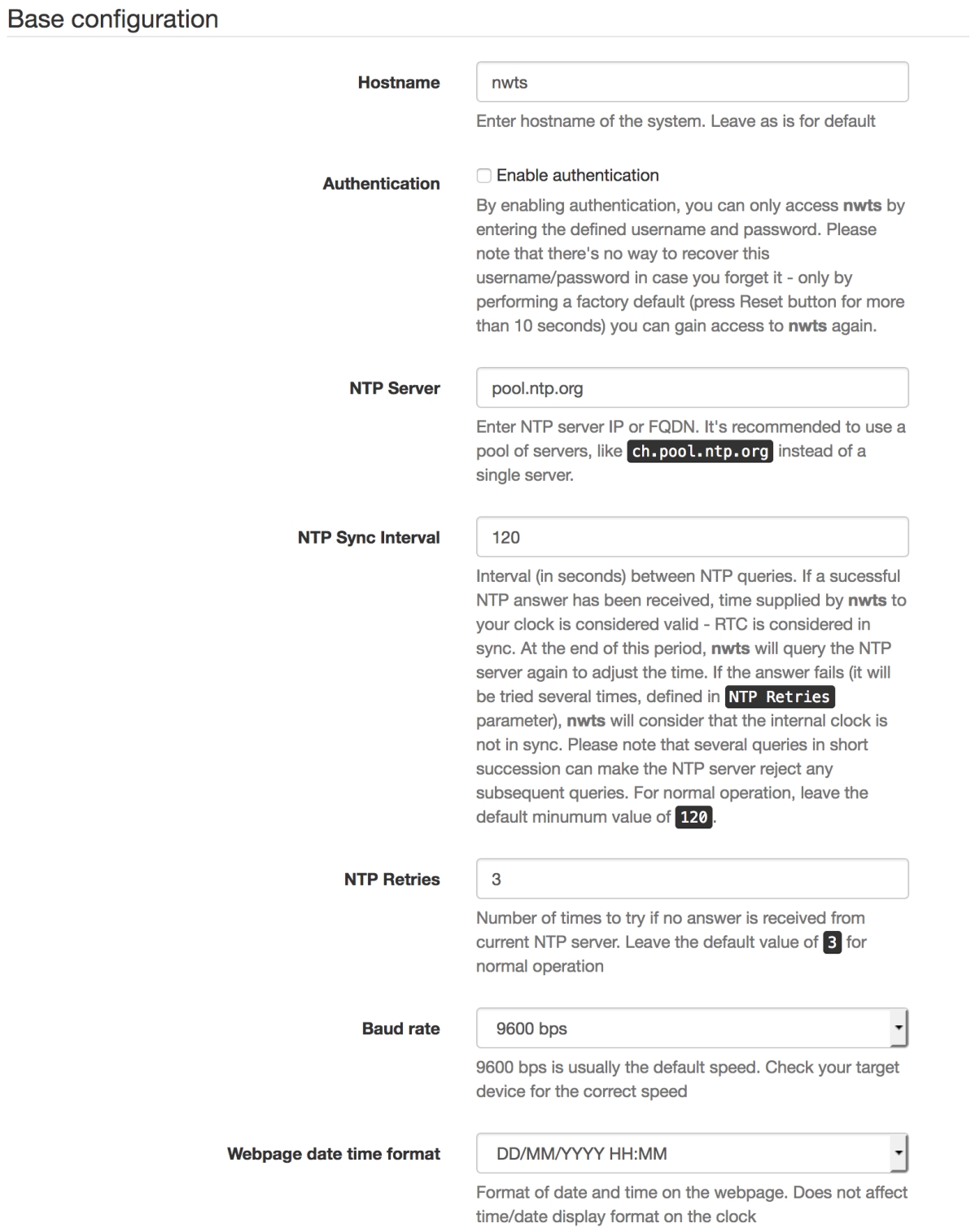
Version	Current firmware version
Hostname	The device's hostname
IP address	The device's IP address
MAC address	The device's MAC address
Connected SSID	The connected network and signal quality
Clock status	✅ RTC synchronised. ❌ Time not synchronised. ⚠️ Last sync failed. Please monitor! Display's current RTC time when page was loaded. If DST is configured, during DST it shows "☀ DST" **The browser will show you the time received from nwts in both your local computer time and UTC. It will not report the time it is sending to the clock!**
Time zone support	"Standard offset" is the normal time zone offset in minutes "DST offset" is the time zone offset during daylight savings time.
UART speed	The speed between **nwts** and the clock.
Debug	Debug messages are sent to the serial interface alongside with GPS messages. The clock will ignore them, but they might be useful for troubleshooting when connected to the computer.
Chip ID / Flash ID	This is the serial number of the ESP-01 module.
License status	Clicking this value will open the license page. Valid status is: ✅Active ❌Invalid
Configured / total capacity	This is the total capacity of the ESP-01 flash memory.
Configuration saved at	If the configuration was changed from default, it will show the last time it was saved. If the clock was not

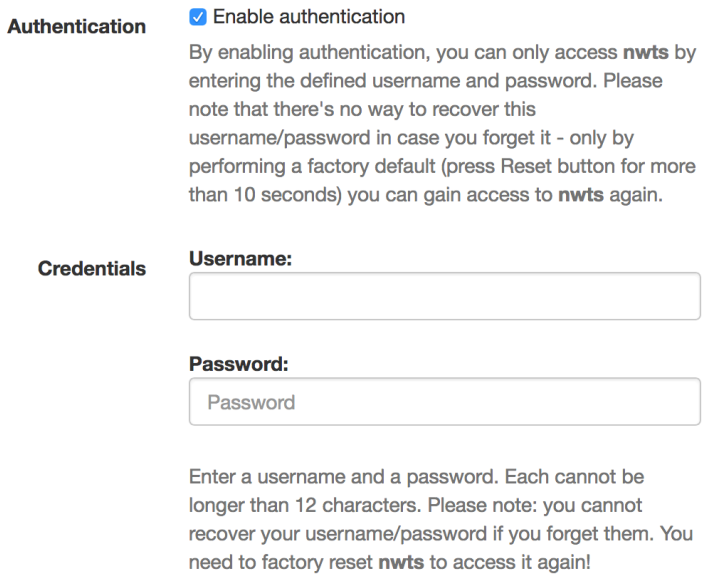
	synchronized when it was saved, it will show as saved in January 1st 1970.

Configure nwts

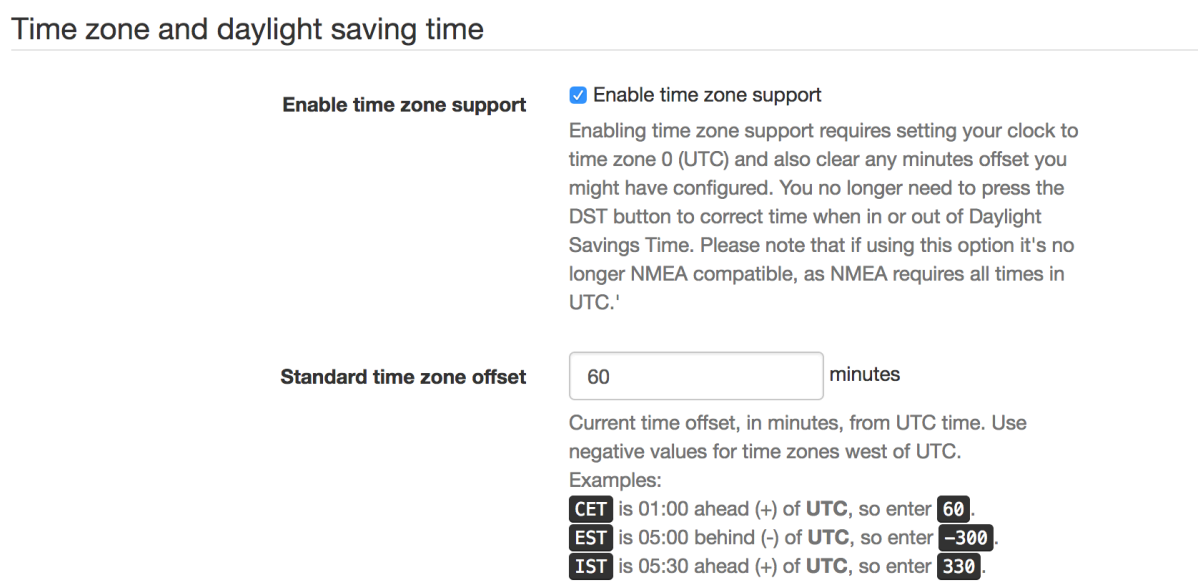
Pressing  you can configure your device:

Base configuration



Hostname	The device's hostname. Don't include ".local" in the name or any dot – just a hostname!
Authentication	 If you enable authentication, your browser will ask for a username/password pair to login into **nwts**. **Please not that both username and password are case sensitive and limited to 12 characters!**
NTP server	NTP server for your clock. It's recommended to use a pool instead of a single host for redundancy. If using `ntp.org`, it's preferable to use geographical relevant pools for speed and accuracy.
NTP Sync interval	Interval between NTP queries – the optimal period of 120s (2 min) is enough to keep your clock in sync and without making too much queries to the NTP server. This period can be longer, but preferably under 5 mins. The ESP8266 does not have an internal RTC and time will drift eventually.
NTP Retries	For each NTP query, retry up to three times if no answer is received. If at the 3rd attempt there's still no response, consider that the internal RTC is not reliable (green LED will blink).
Baud rate	The speed that **nwts** uses to communicate with the clock. Default and recommend value is 9600.
Webpage date time format	You can select how time and date are shown in the webpage Valid values are • DD/MM/YYYY HH:MM • MM/DD/YYYY hh:mm am/pm • YYYY/MM/DD HH:MM

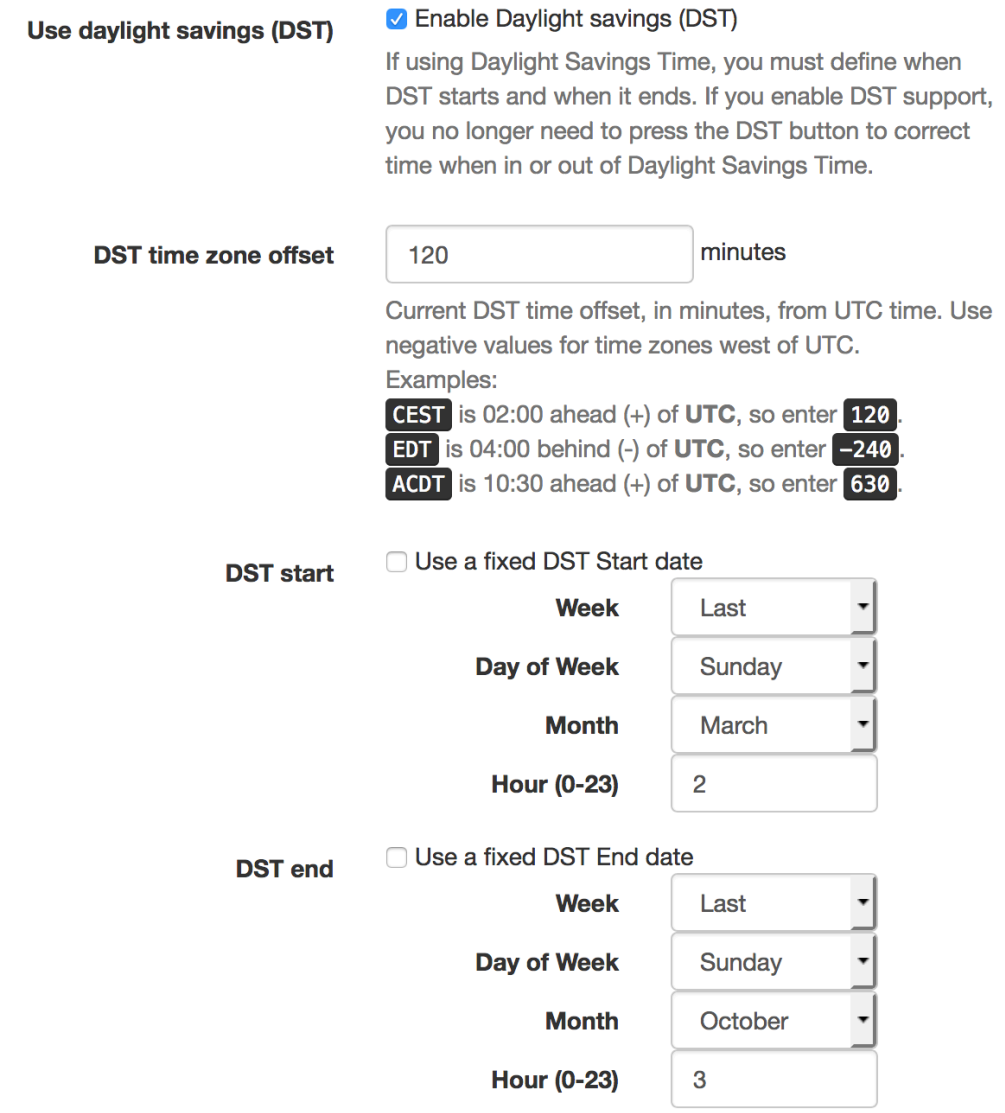
Time Zone and Daylight Saving Time



Enabling Time Zone support will only change the GPRMC message. The rationale behind it is that the GPZDA contains the time zone information (if not enabled, GPZDA will report UTC as time zone) and GPGGA messages are used by Jeff Thomas' clocks to derive the time zone, so they expect GPGGA to be in UTC.

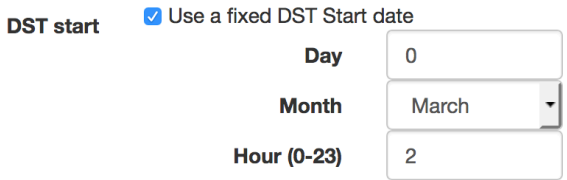
You need to enter the offset in minutes from UTC – for values east of UTC the values are positive. To West are negative. There are no bounds checking, so be careful with the entered values.

Minutes allows more granularity with time zone selection.



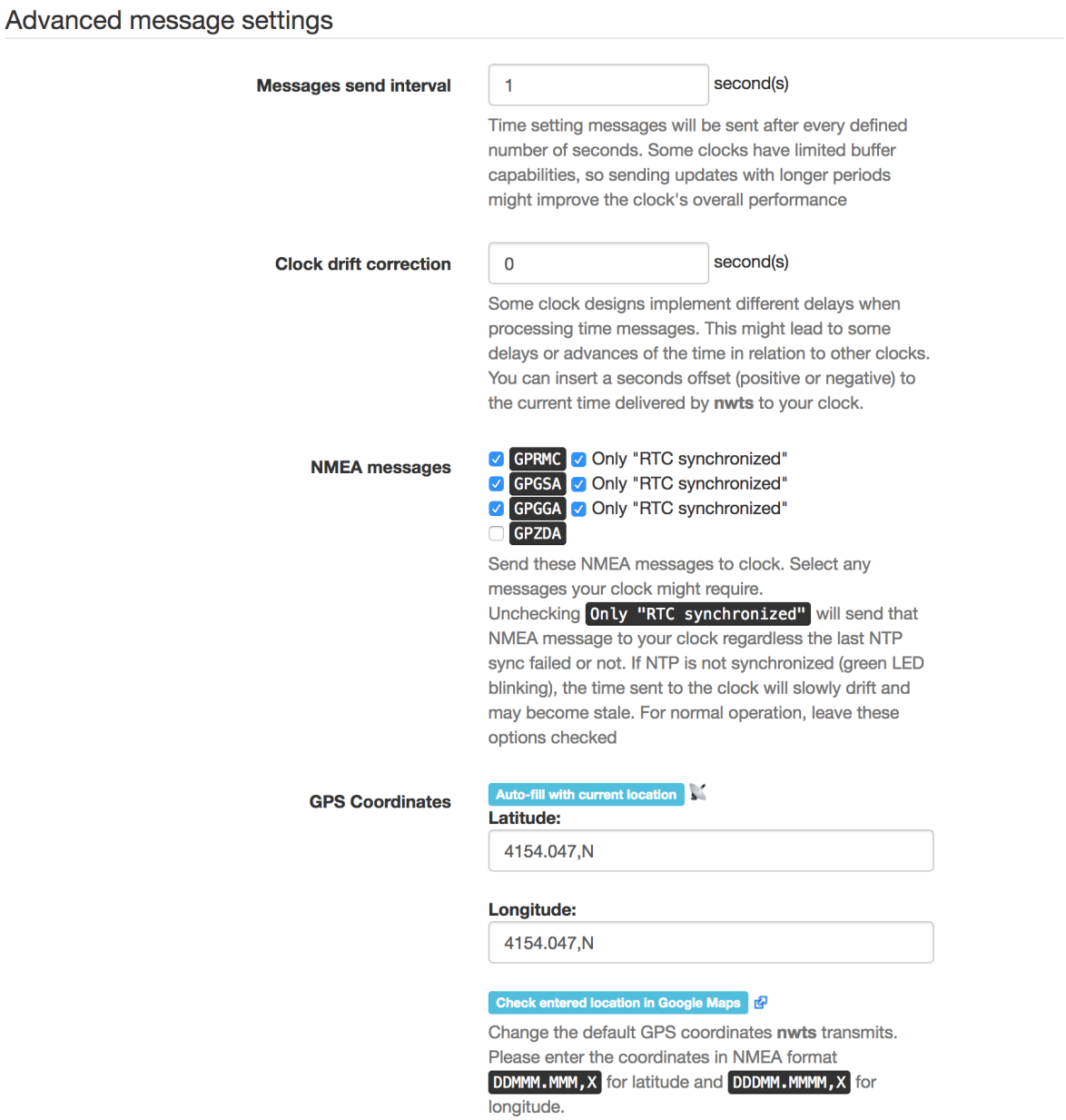
Enabling daylights saving (DST) will allow for two time-zone configurations. You need to enter the offset also for the DST time zone.
You can configure when the DST starts and ends by selecting the week, day of the week, moth and hour the time changes to DST. Likewise, you can configure when DST ends. The various parameters allow for flexible DST rules.

You can also select if DST starts on a fixed date, instead of a Rule based approach. If selecting a fixed date:



The change will be then made on the specified day of the month.

Advanced Message settings



By default, **nwts** sends GPS messages every 1 second. You can change this interval in the "NMEA messages send interval" option. Some clocks, like the Dutchtronix Scope, recommends sending NMEA messages every 5 seconds.

Some clocks introduce delays while processing time messages. This becomes evident when using two different brand clocks and the time is different between a few seconds. You can drift nwts time so that the clock delay can be corrected. Using "Clock drift correction", you can advance or delay nwts' reported time.

You can also select which NMEA messages you want **nwts** to send regularly.

When **nwts** boots, and has no defined time, no NMEA messages are sent. After the first sync, the internal RTC gets a defined time – and until the next NTP update, the status is "In Sync". Every two minutes, **nwts** check for the time using NTP. If the next update fails, **nwts** sets the internal flag "Time needs sync", the green LED on the **nwts** device starts blinking and it stops sending GPS messages. If you want nwts to keep sending messages even when sync fails, then uncheck the "Only RTC synchronized" checkbox. If there are no updates for a long time, the internal clock of the ESP will slowly skew and the sent time will be invalid.

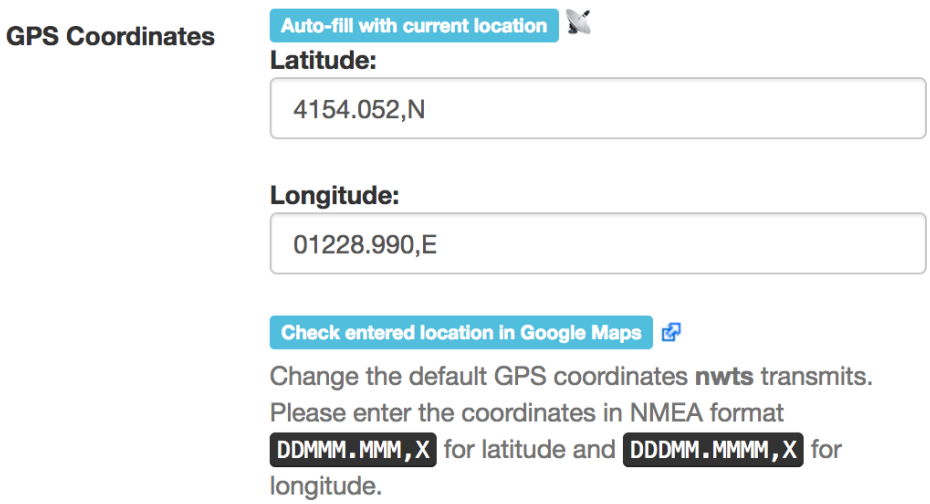
The "Only when in Sync" flag tells **nwts** to only send the respective NMEA message when the internal time is "in Sync", which means: "Send only when the latest NTP update is under two minutes". This is from version 2.5 the default behaviour.

The NMEA messages contain the following information:

	Time	Date	Coordinates	Time zone	Fix	Used by
GPRMC	✓	✓	✓		✓	Most clocks
GPGSA					✓	NCH will only accept GPRMC when GPGSA exists
GPGGA	✓		✓		✓	Jeff Thomas' clocks to get T Z info using coordinates
GPZDA	✓	✓		✓		Used by some VFD clock makers

Again, when using time zone, only GPRMC gets time zone adjusted time. GPGGA and GPZDA still send time in UTC.

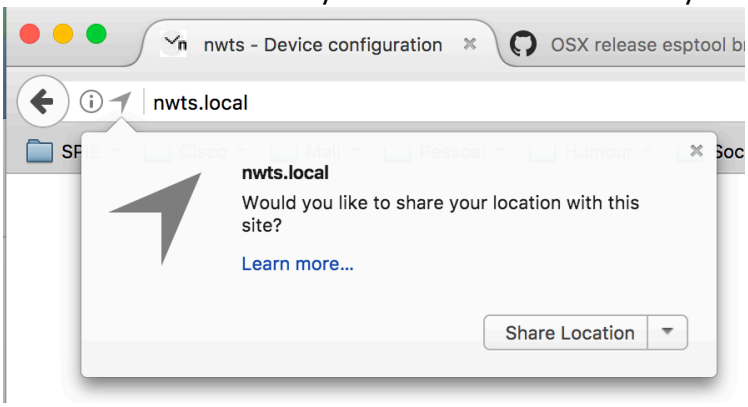
GPS coordinates



You can customize your GPS messages' position information by changing these coordinates.

If using Firefox (tested up to version 52. Firefox 56 doesn't support it), Internet Explorer or Microsoft Edge, you can press the "Auto-fill with current location" button.

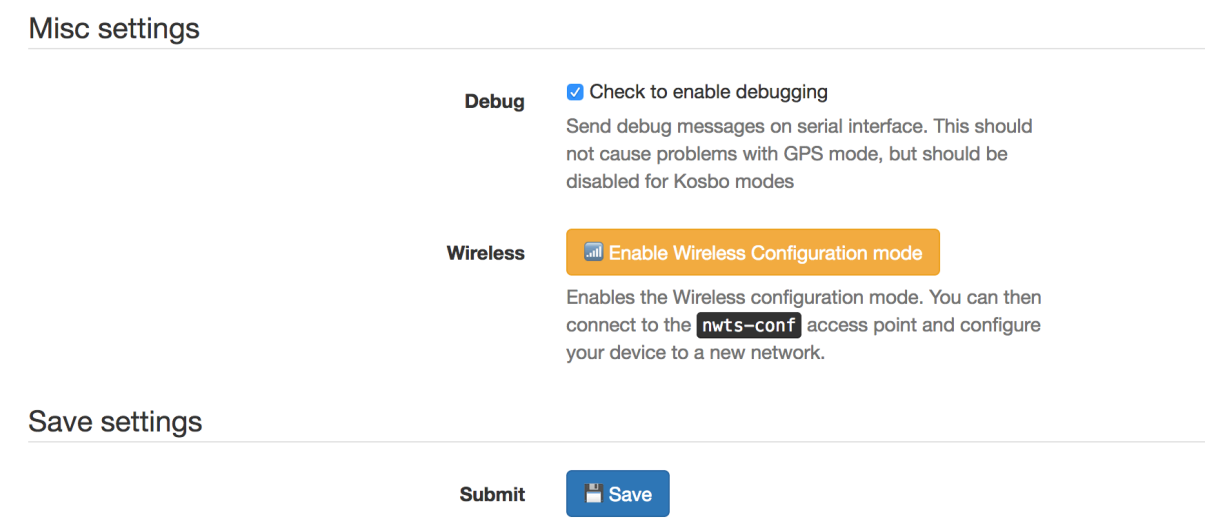
The browser will ask for your authorization to share your coordinate with **nwts** :



The coordinates must be entered in NMEA format:

- 11 characters for latitude
  - DDMMM.MMM,X
    - DD Degrees
    - MMM.MMM Minutes (3 decimal places)
    - X N or S
- 12 characters for longitude
  - DDDMMM.MMM,X
    - DDD Degrees
    - MMM.MMM Minutes (3 decimal places)
    - X E or W

You can convert from different coordinate systems to the NMEA format here:
http://www.hiddenvision.co.uk/ez/



Debug	Enabled by default, shows additional messages used in troubleshooting issues with **nwts**. Does not affect GPS synchronization messages on most clocks, but some clocks seem to suffer from buffer overruns if turned on. By default, keep it disabled.
Wireless	Pressing this button will invoke the Wireless configuration mode, so you can assign another network to your device. The blue LED should start to blink fast.

Pressing save will store the configuration and reboot the device. After 15s, the device's webpage will be loaded again.

Troubleshooting

Power

- When starting the clock, **nwts** red LED does not turn on
  - Check if the 3.5mm cable is correctly inserted in the GPS/RFT jack and not the PIR jack
  - Check if the male/male cable or adapter is working. Replace with another
- When starting the clock, only the red LED on the **nwts-pv1** board turns on
  - Check if the ESP-01 module is correctly aligned with the arrow next to the 8-pin socket: the module should be over the **nwts-pv1** board.
- My clock's digits are now fading during some hours of the day. If I connect my old GPS module this issue won't happen.
  - PV Electronics power recommendation for a IN-18 clock is a 12V 1A power supply. This is not enough, as the **nwts** device (100mA) uses 4 times more power than a GPS module (22mA). A 1.5A power supply fixes the issue.
  - With 500mA clocks, a 1A power supply also solves the issue.

Wi-Fi & Network

- When connecting to the Wi-Fi network **nwts-conf**, a password is required:
  - Use `config-me` as the password.
- I've connected the device, but I cannot see the **nwts-conf** network. The blue LED blinks regularly
  - Your device is already connected to a network. If you need to connect to a new network, press the Reset button for more than 2 seconds. The **nwts-conf** network will appear.
- When connecting with my computer/mobile/tablet to the **nwts-conf** network, I don't see any landing page
  - Maybe your device did not recognize it was using a zero-conf network. Open a browser and try to open any web-page. The WifiManager webpage should appear
  - Restart your device (power cycle your clock)
- My network is not shown because it's hidden
  - On the WifiManager page, select "Configure WiFi (No Scan)" and enter your network details manually
- I want to setup a static IP address on my device
  - You'll have to make a reservation on your DHCP server. It's not possible to set a manual IP address at the device.
- I have more than one device. When connecting to `http://nwts.local` I get randomly connect to one of the devices
  - Disconnect all **nwts** devices but one
  - Access the **nwts.local** page
  - Change the hostname to another name. Save.
  - Make the same for the remaining devices

    - You can now access each device independently.

Configuration web-page

- Entering `nwts.local` on my browser I get either a "Server not found" page or a timeout
    - Did you change your **nwts** device hostname?
        - On the command line either on the PC or the Mac issue: `dns-sd -B _http._tcp`
        - You should see a list of all found Bonjour devices in your network. Use the name of your device.
    - Does your Windows computer have Bonjour installed? Or mDNS if it's a Linux machine?
    - If you're using a Windows computer without Bonjour, you can try to discover the device in your network neighbourhood. Got to "My Computer". Select "Network". Make sure that Network Discovery is running. Your device should appear. Double clicking it should open the device's webpage
- I get the webpage, but I see only XXX instead of values
    - Make sure that JavaScript is not disabled in your browser. **nwts** requires JavaScript to read information from the device.
- I see "❌ Time not synchronised" in the "Clock Status" section
    - Make sure you've configured a reachable NTP server.
    - The device loses real time clock information every time it is power cycled, so it requires NTP to synchronize after each startup – maybe it failed the initial NTP requests. Wait up to 4 min before power cycling the device.
- I see "⚠️ Last sync failed. Please monitor!" in the "Clock Status" section
    - The clock only makes one query every 2 minutes. If one query fails, the clock might show this warning until the next synchronization. If this persists, use a different NTP server

Operation

- Time is mismatched in my clock
    - **nwts** provides the time both in UTC only or when time zone is configured:
        - If not using time zone support, you must set up your time zone in your Nixie clock
            - UTC does not observe Daylight Savings Time, so, during summer time, press the DST button on your clock to show the correct time
        - If using time zone support, you need to setup your clock without any time zone
            - Check if you have DST enabled and correctly configured in nwts
            - Make sure the DST LED in the clock is OFF! nwts handles the DST change, not your clock anymore.
    - The green LED flashes from time to time

        - **nwts** by default is configured to pool NTP from `pool.ntp.org`. This might give you a random server from a region far away and the NTP request might timeout.
        - It's recommended to setup a closer NTP source. A good indication is to use *xx*`.pool.ntp.org` where *xx* is the code of the country where you reside. For a complete list of available options, please visit http://support.ntp.org/bin/view/Servers/WebHome
    - **nwts** does not average NTP times for accuracy
        - **nwts** only queries NTP once per synchronization call, so the time will have minor network delays (usually less than 3s)
        - Its precision is about 1s, which is enough for consumer clocks. Tests have shown no difference between GPS, DCF and NTP synchronization and they are always synchronized within less than 1s of each other.
        - Future versions might have better NTP handling code.
- The blue LED blinks regularly, but my Nixie clock does not get synchronized
    - Make sure you've set up the correct UART speed on both your clock and in **nwts**
    - It is recommended to use 9600
        - Configure your Nixie clock for 9600
        - Configure your **nwts** for 9600
    - Make sure the license is loaded. The license status should be "Active". If not, re-enter the license.
- I want to see the debug messages
    - You need to connect your **nwts** device to a USB adaptor
- I want to program a new firmware into my **nwts** device
    - You need to connect your **nwts** device to a ESP programmer

Specifications

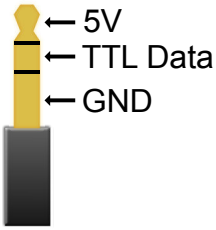
Hardware	ESP8266EX (ESP-01) Custom made **nwts-ub3** board
Power requirements	nwts-ub3 board: 5V Client mode: 75mA AP mode: 120mA
Wi-Fi	802.11 b/g/n 2.4GHz-2.5GHz WPA/WPA2 WEP/TKIP/AES
Operating modes	AP mode: Wi-Fi setup only Client mode: Normal operation
Network Protocols	IPv4 DHCP DNS mDNS (Apple Bonjour) SSDP (Service Discovery) NTP HTTP
Reset button	Press: >3s Invoke Wi-Fi setup >10s Reset factory defaults
UART signal type	TTL Inverted Pseudo RS-232
UART speed	4800 9600 (default) 19200 38400 57600 74880 115200
NTP server	Configurable NTP address
Debug	Additional debug messages can be enabled to aid troubleshooting
Firmware update	**nwts** firmware can be updated Requires additional hardware

The module is made of two parts:

- ESP8266-ESP01 Wi-Fi MCU
    - Blue or black PCB with 8 male pin header
- **nwts-ub3** custom made board
    - Blue PCB with 3.5mm headphone jack and 8 pin female header

Appendix A – Technical details

nwts uses a 3.3V ESP-01 module. Most clocks use 5V power.



The **nwts-pv1** board contains a 3.5mm connector, a voltage regulator (5V-3.3V), reset button circuitry and an 8-pin header to connect the ESP-01 module. Also, three jumpers to define the signal type: TTL or Inverted pseudo RS-232. The TX pin from the ESP-01 module is protected with an electrical circuit against voltage peaks. The PIC16F used in the PV Electronics clocks supports signal voltages from 1.8V to 5.5V.
nwts only sends data, so by sending at 3.3V, this is enough.

Boot process

nwts boot process is linear and follows these steps:

- Check internal FS for configuration file
- If found, load values. Else use defaults
- Initiate serial interface
- Check if connected to Wi-Fi network
- If not, enable Wi-Fi setup mode. Blue LED blinks every 0.2s
- Enable mDNS
- Enable SSDP
- Enable HTTP server
- Start main cycle

Main cycle

The main cycle executes these functions:

- Check if reset button was pressed
- Check if connected to Wi-Fi
- If time is set
    - Set green LED as always ON
    - Send GPS message every 1 second
- If time is not set
    - Set green LED off
- If last sync failed
    - Set green LED to blink
- Handle HTTP queries

Furthermore, the following processes are running “in the background”:

- NTP synchronization
- mDNS and SSDP handling

Appendix B - References

- Nixie clock manufacturers
  - Mr Nixie
    - http://nixiekits.eu/
  - Nixie Clock Home
    - http://www.nixieclock.org/
  - PV Electronics
    - http://www.pvelectronics.co.uk/

http://adlerweb.deviantart.com/art/ESP8266-ESP-01-Module-Pinout-Diagram-Cheat-Sheet-575950438

Appendix C – Firmware upgrade

Please check the page http://www.azevedo-devices.com/downloads.html for the current version of **nwts**' firmware and upgrade instructions