Phillip's Clock Thing - an NTP synchronised time piece

v2.5 Aug 2021 - Phillip Musumeci

This document applies to software releases from 2020 onwards.

Overview

The "Clock Thing" is an example of an "Internet of Things" application that provides accurate time display. The ubiquitous internet and recent availability of low cost computer modules with WiFi are the underlying technology used in "Phillip's Clock Thing". The clock is composed of two modules - an esp8266 IoT module called Nodemcu that uses a chip designed by Espressif in Taiwan and for the display, either a 7-segment LED display from Adafruit, New York, or a 32x8 dot matrix LED display from east Asian suppliers. There is also an optional LCD display that might interest the experimenter.

The clock derives its fundamental time from international agencies such as NIST (USA), CSIRO (Australia), PTB (Germany), etc., and accesses this time information via an international volunteer network of time servers provided by pool.ntp.org.

Features

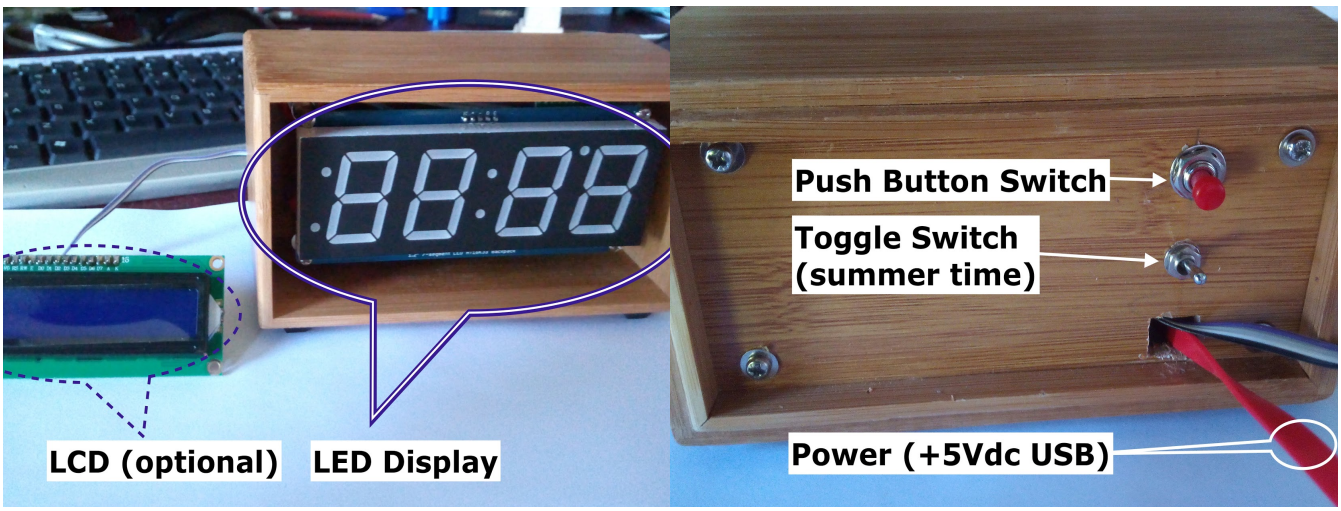
The clock will normally display the current time but it will also show startup messages or occasional status messages when being configured. It uses +5Vdc power provided via a USB cable and it can be powered from almost any USB charger plug pack e.g. one taken from an old mobile phone.

While the clock is normally used in a "set and forget" way, it does have two switches on the back:

- a toggle switch selects daylight savings mode (i.e. advances display time by +1 hour)
- a push button switch is used in a number of ways:
    - when held depressed at power up until the display says **Rel PB for Conf** and with the user then *releasing* the **P**ush **B**utton switch, the clock enter setup or configure mode (when left untouched at power up, normal time keeping occurs even if the push button is faulty);
    - when momentarily pressed during normal time keeping, the PB switch triggers a time resynchronisation over the internet;
    - (for the technical user) when held depressed for a time up to 9 seconds, the clock counts to 90 and spends a few seconds displaying its network IP address to assist with telnet access;
    - (for updates to software) when held depressed for a time between 10 seconds and 19 seconds, the clock shows the message **OTA** and it does an over-the-air software update.

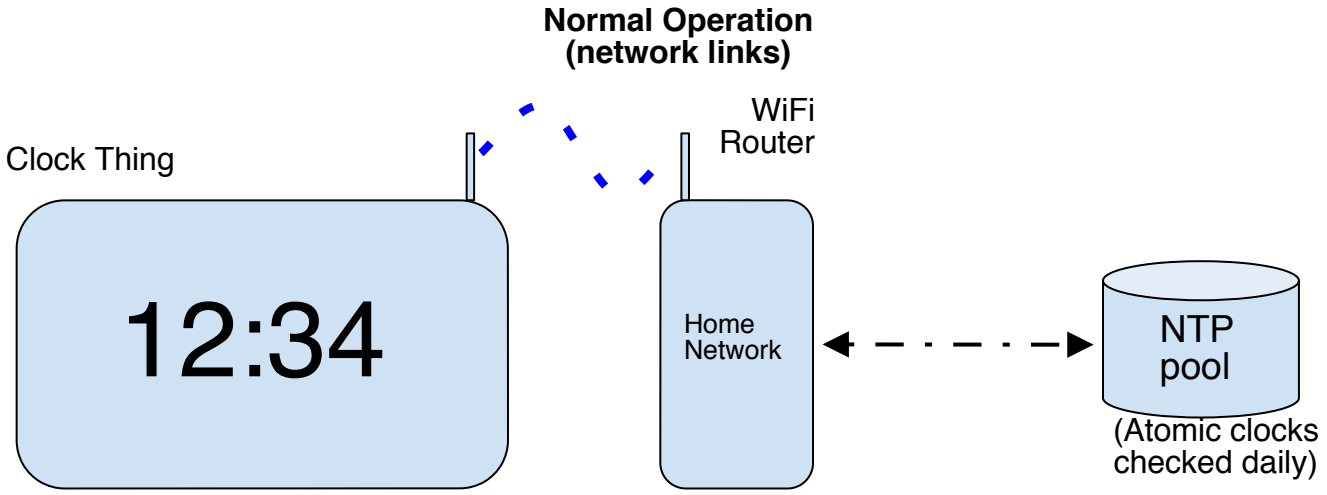
Normal Operation

Front View **Rear View (switches)**



The typical display is a large 7-segment LED Display or a 32x8 dot matrix LED display but if you are experimenting with clock enhancements, consider an additional LCD text display (see Appendix B).

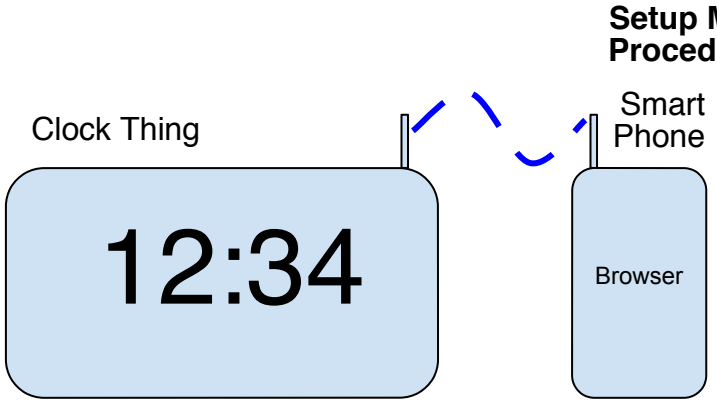
After being configured for your local network, just plug the clock into a power source and within 10 to 50 seconds (depending on network access), it will connect to your WiFi network and start providing an accurate time-of-day display. Every morning, at 2:03:04 local time, it will resynchronise with one of the network time protocol servers at pool.ntp.org (it specifically tries servers 0,1,2,3 in order until one is contacted, as provided from the server pool for your country).



In order to display local time, the clock must be given your time zone as an offset with respect to UTC (also known as GMT) e.g. London uses 0, Berlin uses 1, Brisbane uses 10. To allow the clock to synchronise each day, it also needs the name and password for your home WiFi network. This information is entered in the setup procedure. To manage summer time, toggle the switch.

Setup Procedure

To enter setup mode (also referred to as **Conf** mode), unplug the clock from its power supply. Then while holding the push button switch depressed, reapply clock power and wait until the LED display shows **Rel PB for Conf** before releasing the push button switch (if your clock has old software and does not do this, please contact Phillip). The clock will then become a WiFi access point so you can access it with a smart phone. You now use your smart phone or laptop with WiFi to connect to the clock's temporary WiFi network called **clockthingXX** (each clock has some *unique* digits XX in its network name but you will normally see only one open clockthing wifi network). With WiFi connected, visit URL http://192.168.4.1 to enter the configuration information. This procedure is summarised in the following figure and pictures on the next page.

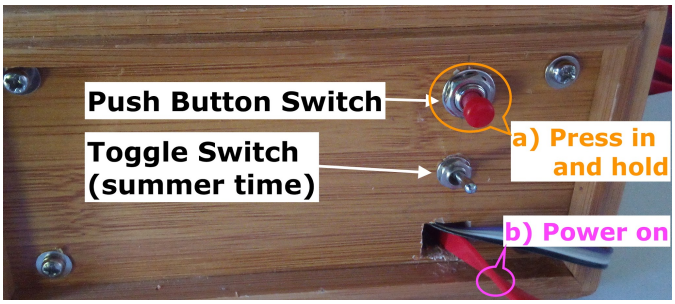


1. Connect the phone WiFi to **clockthingXX** (no password is required to join)
2. In phone browser, visit **http://192.168.4.1** to display a setup web page
3. Enter the home WiFi **network name**
4. enter the home WiFi **password**
5. enter your **time zone offset** to UTC (e.g. Berlin is 1, Brisbane is 10, etc.)
5. enter **D** for dimming schedule
6. enter **1** for TEST LED/dot matrix (ignore if your clock has a 7-segment display)
7. Press **SUBMIT** and the phone will now display instructions to turn the clock off and on. Return phone to normal settings

After submitting the configuration details, wait a few seconds and then power cycle the clock (off then on).

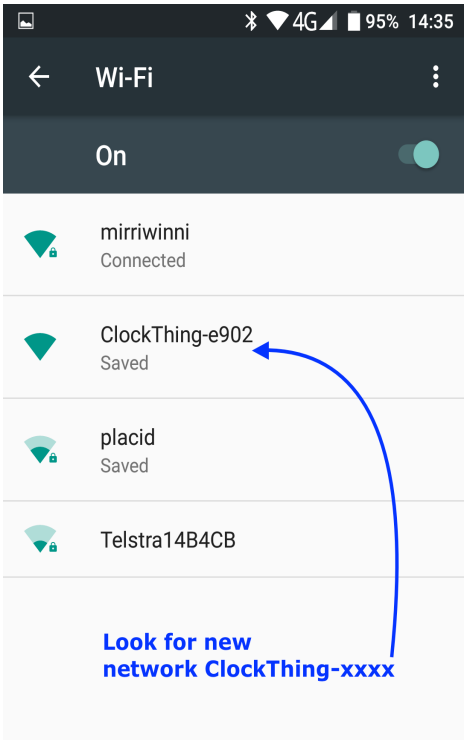
Setup Procedure in Pictures

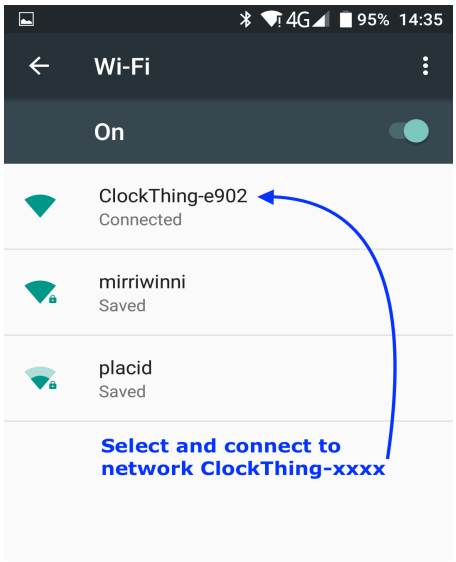
i) With push button pressed, apply power. Release push button when display says Rel PB for Conf.



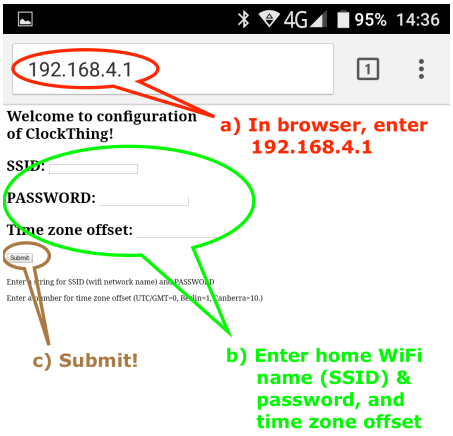
You need to keep pressing the push button switch until the display shows **Rel PB for Conf** and then you must release it.

ii) Enable Wifi on mobile phone, and connect to network ClockThing-xxxx.





iii) Enter details and submit.



Config items: the config window showing items a,b,c (above) now has some additional items that allows you to specify options such as when to dim the display, enable the dot matrix LED display, specify an alternative NTP time server, etc. Users with a dot matrix LED display *must* enter a **1** for the TEST LED item, and most users enter a **D** for display dimming at night (10pm through to 6am).

Appendix A: Available methods to update clock software

A.1 Over-The-Air Update (normal users)

Hold the push button depressed for 10 to 15 seconds and release → your clock will access a web server in Cairns, download the update while showing a percent progress, apply the update, and then restart.

A. 2 Manual Update (hackers!)

This section is for hackers only. If you know what telnet is and have the app installed on your computer, you can use telnet to connect a terminal session to the clock and issue commands. To connect, you need to know the clock's IP address. Press the push button for 9 seconds so that you see a counter displayed and keep an eye out for 4 separate numbers distinct to the count sequence and which are the IP address of the clock. Connect to the clock over the network using telnet and press **h <enter>** for help. Note that command **u <enter>** corresponds to an over-the-air update which is the same as A.1 above. The help display shows status details e.g. IP of the NTP server, time of last time resync, display details, commands to reconfigure via telnet (or via the NodeMCU USB-uart interface which is included in the clock), etc.

In addition, all clock owners who have been an IT, CS or engineering student of Phillip will find that *their* clock contains a USB-UART interface (115200 bps) and so it can be connected to just like a typical Arduino microprocessor.

Appendix B: Clock Software (source code)

Current software is online at https://github.com/pcvm/embedded_systems/tree/master/esp8266_clock_thing and this site also includes circuit details for optional displays, 1-wire temperature sensors, etc.

Appendix C: Copy of on-line help for hackers using telnet

The system status and user commands when connected via telnet or via USB-uart are:

```
NTP server=192.168.1.10 (preference was 192.168.1.10)
Time of last clock synchronisation: 20:07:00
Push button switch is on GPIO input 16 (default)
LED 7-seg display brightness = 15/15
LED display = dot-matrix
  (probe of dot-matrix returns false)
  (12 hour mode)
  (brightness schedule ==> 0/15 during 22..6)
Source code is online at https://github.com/pcvm/embedded_systems
Documentation is kept at http://placid.duckdns.org:48064/docs
S/W: 2021 r32ds :-)

Time: 20:46:59

h --> this help
s --> sync with a time server now
u --> upgrade firmware to latest from server placid.duckdns.org:48064/Clock_Thing2.nodemcu.bin
n --> configure system via network communications
c --> configure system via USB connected serial communications
t --> TEST MODE (bootup config) using wifi access point ClockThing-da42, URL http://192.168.4.1
r --> trigger a system restart
l --> perform network upgrade of firmware via web page http:192.168.1.183/update
d --> dump miscellaneous config bytes
; --> toggle 12/24 hour display mode
q --> quit from telnet session
0..9 [ ] \ , . / --> LED brightness 0..15
```

Appendix D: Diagnostics

Failure of: the push button switch → detected and handled at power up; the toggle switch → we could handle this in software. Contact Phillip for further information.