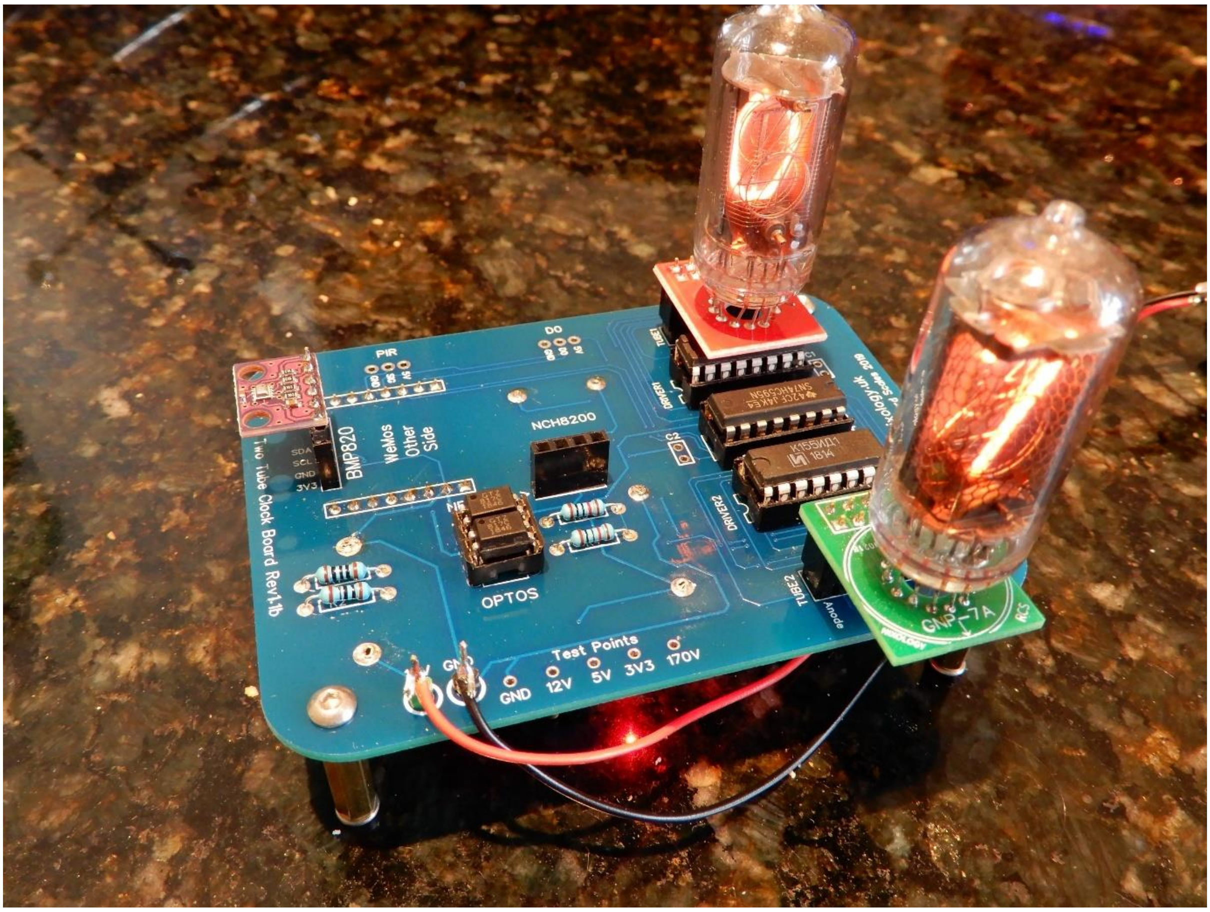
Assembly Instructions
Gemini Two tube clock

nixology.uk

REVISION HISTORY

Issue Number	Date	Reason for Issue
Draft 1	24/04/2019	New document
First Release	06/05/2019	
Update #1	21/05/2019	Added initial setup and updating info



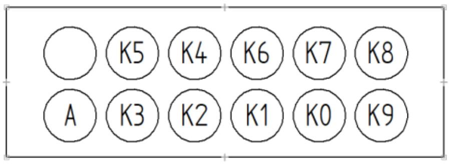
Gemini Two Tube Clock – Features

- Hours, Minutes and Seconds display
- Date Display
- Temperature and Pressure display
- Drives a wide range of tubes
- Reliant on access to an NTP Time source for operation
- WiFi connection configured via a captive portal on the clocks own Access Point
- Supports NeoPixels for tube illumination and confirmation of data type being displayed
- Display is turned off from 21:00 to 06:00
- Support for **OPTIONAL** PIR device to trigger clock at any time
- PIR delay shorter during night time operation
- 'Slot Machine' Cathode poisoning prevention routine

Tubes Supported

The clock drives only two tubes, each one being driven directly by a dedicated Nixie Tube Driver IC.

The connections for the tubes are provided by 2x6 pin headers with the following details (viewed from the top of the connector):



Attach a suitable ribbon cable from this connector to your choice of tubes*. The arrangement of the signals on the connector matches those available from PV Electronics for the QTC clock range. Tube Cells for other tube types are available from nixology.uk including those for the connection of Z566M/GN4P, IN-18, ZIN-18 and RJ568M (Dalibor Farny).

Tube cells for the larger tube types incorporate connections for additional APA106 LED’s

*Depending on the chosen tube type it may be necessary to change R3 and R4 from the 10k supplied to match your tubes.

SAFETY

DANGER: This clock includes an NCH8200HV 170V power supply module. This generates nominally 170 Volts DC. Assembly may only be undertaken by individuals who are suitably qualified and experienced in electronics assembly and are familiar with safe procedures for working with high voltages. If in doubt, refer to a suitably qualified engineer before proceeding.

The voltages generated by this circuit can give a potentially LETHAL ELECTRIC SHOCK.

DISCLAIMER: This product is supplied as a kit of parts, intended only for suitably qualified electronic engineers, who are suitably qualified and experienced in electronics assembly, and are familiar with safe procedures for working with high voltages. The supplier, their agents or associates accept no liability for any damage, injury or death arising from the use of this kit of parts.

This is not a finished product, and the person assembling the kit is responsible for ensuring that the finished product complies with any applicable local regulations governing electrical equipment.

TOOLS AND EQUIPMENT REQUIRED

Tools required to assemble the PCB.

The following tools will be required to assemble the PCB:

Soldering iron with a small tip (1-2 mm).
Wire cutters to trim the excess component leads after soldering
Wire strippers
Multimeter for voltage tests and for identifying the resistors.
Laptop or mobile device with WiFi for initial setup.

Materials you will need.

Solder – lead / tin solder is highly recommended. **USE LEAD/ TIN SOLDER!** Lead free solder, as now required to be used in commercial products in Europe, has a much higher melting point and can be very hard to work with. Desoldering wick (braid) or a 'solder sucker' can be useful if you accidentally create solder bridges between adjacent solder joints.

Other items you will need.

The clock kit does not include a power adapter. The clock is designed to be built in to your own housing design and as such you will need to make your own power supply arrangements. You will need to provide a 12V DC regulated supply capable of supplying a minimum of 500mA. Take care to connect the power the right way around.

This clock is supplied as a kit of parts, please pay careful attention to the order with which components are added and voltage measurements are taken.

DO NOT – solder the Buck converter to the clock PCB without having first soldered R1 – R4 and the 8 pin DIL socket on the top side.

DO NOT insert the WeMos, HV Power supply or other IC's before you have successfully measured 5V from the 5V test point.

Component List

QTY		Description
3		16 pin DIL IC Sockets
1		8 pin DIL IC Socket
1		4 Way Header Socket for Neopixel connection
1		6 Way Header Socket for BMP280 connection
1		NCH8200HV 170 V PSU – includes 4 x mounting pins
1		12V to 5V Buck Converter PSU module
4		1mm Socket Pins
2		2 x 6 Male Headers
4		Mounting pins for 12v to 5v converter (strip of 4 single header pins)
1		74595 Shift Register IC
2		74141 or K1551 Nixie Driver IC
2		EL817 Opto Coupler IC
2	R1, R2	100R Resistor
2	R3, R4	10K Resistor
0		100nf Capacitors – optional -
4		M3 Hex Standoffs
4		M3 Screws
1		BMP 280 Temperature / Pressure Sensor
1		5V LED WS2811 / APA106 or similar
1		WeMos D1 Mini with 2 x pin headers and 2 x socket headers Pre-Programmed
1		Two Tube Clock PCB

You will also need 2 x your choice of Nixie Tubes (not supplied). The board uses the same 2x6 header arrangement as the PV Electronics QTC clock so any PV Electronics QTC compatible tube cell PCB will work, just connect via a ribbon cable with suitable connectors.

Anode Series Resistor Selection

R3 and R4 have been supplied as 10K which should provide an anode current in the region of 3mA from the 170V supply when using a tube with a maintaining voltage of around 140V.

You may wish to vary this value up or down depending on your selection of Nixie Tubes. You will need to know the Anode Voltage required for your tube and the desired current. The HV supply voltage is 170V.

Consider a ZM1210 from Telefunken, it has a maintaining voltage of 140V and requires 2mA.

From Ohms Law (i=v/r or r=v/i), r=(170-140)/0.002 = 15K

Similarly, for a ZM1175 from Mullard, it has a maintaining voltage of 145V and requires 2.5mA so r=(170-145)/0.0025 = 10K

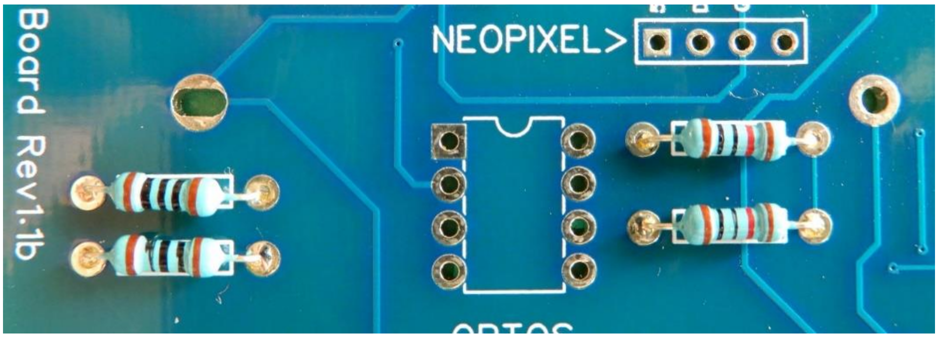
Assembly of the PCB

DUE TO PRODUCT DEVELOPMENT AND IMPROVEMENTS, YOUR PCB MAY NOT LOOK EXACTLY LIKE THE ONE PICTURED.

Resistors

Start by adding the resistors to the top side of the board. If you are in any doubt as to what the values of the resistors are then use a multimeter to check them.

R1, R2	100R	(Brown, Black, Black, Black)
R3, R4	10K	(Brown, Black, Black, Red)

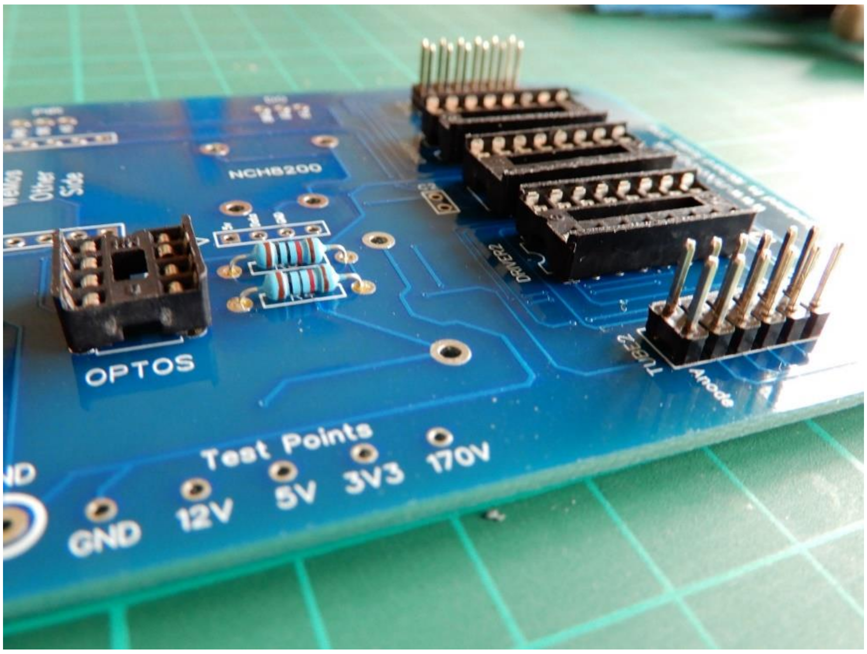


Sockets and Headers

These are all mounted on the top of the PCB. Add the 3 x 16 pin IC Sockets – note that the orientation differs between each socket, take care to orient the 'notch' in the socket with the symbol on the PCB.

Next Add the two 2x6 male headers for the tube connections.

Next Add the 8 pin DIL socket for the Opto Couplers.



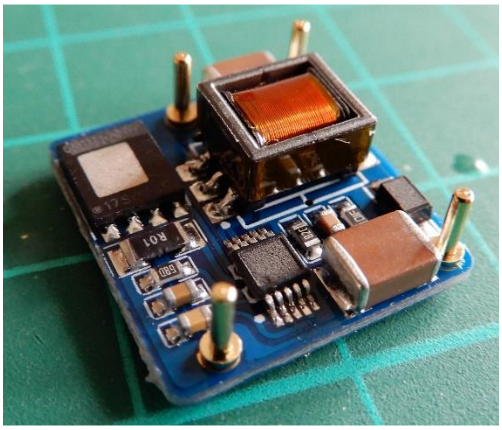
170V Power Supply

NCH8200HV Mounting position

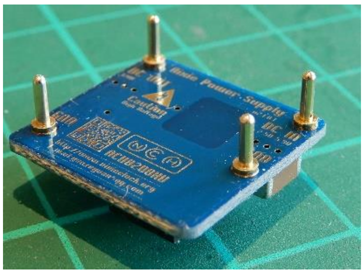
This can be mounted either on the top of the board or the bottom. Take care to solder the pins to the right side of the NCH8200HV and the socket pins to the right side of the clock board to suit your preferred mounting position.

Please note that if the NCH8200HV is mounted on the underside of the PCB then it will not be possible to connect a USB cable to the WeMos for monitoring status information without inserting the optional 'extension headers' that are supplied with the WeMos.

If mounting the NCH8200HV under the board then mount the pins on the component side of the NCH8200HV.

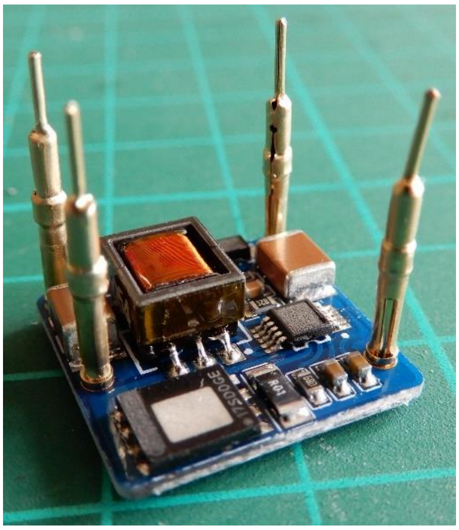


If mounting the NCH8200HV on the top of the main board then mount the pins on the underside of the NCH8200HV.



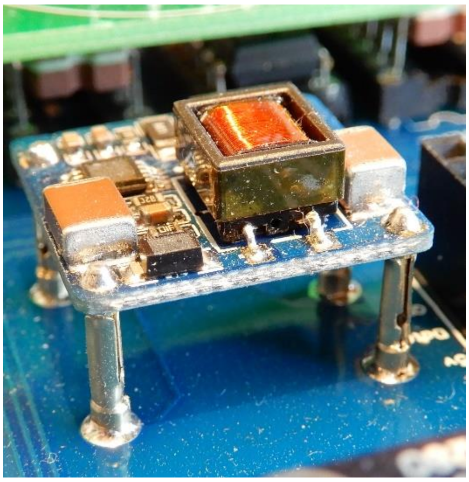
Add the 4 x socket pins for the NCH8200HV power supply, do this by first soldering the 4 pins that came with the power supply to the power supply itself.

Next push 4 x socket pins onto the power supply pins and inset the completed assembly into the PCB and solder the socket pins to the main board.

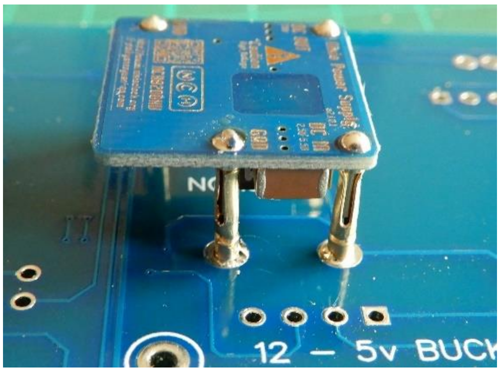


Remove the power supply and trim the short ends of the socket pins on the other side of the board.

Mounting pins cut off after soldering (NCH8200HV mounted on bottom of board)



NCH8200HV when mounted on the top of the board

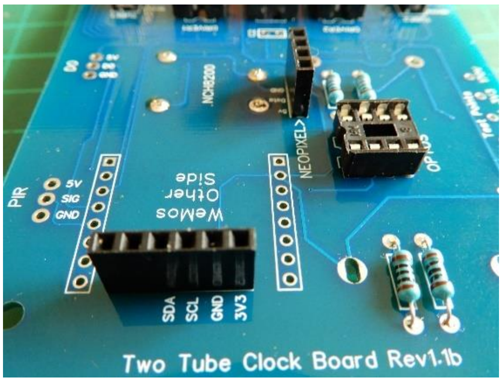


NCH8200HV mounted on the bottom of the board

Remove the NCH8200HV from the clock

Headers for BMP280 and Neopixels

Solder the 4 way header for the NeoPixel connections and the 6 way header for the BMP280 sensor. Both are mounted on the top of the board.

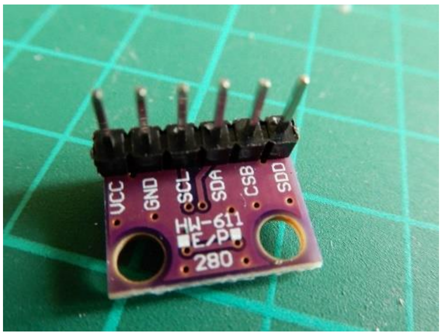


Only three out of the four connections are used for the Neopixels and only four out of the six connections are used for the BMP280.

BMP280

For testing this can be plugged directly in to the header on the clock PCB though for better results it could be mounted remotely where it may not be affected so much by any heat generated by the clock and associated components.

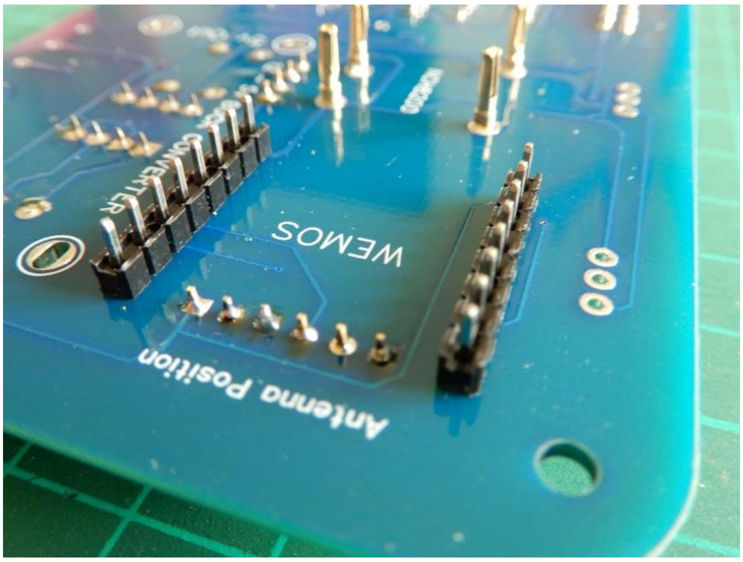
Solder the header pins to the BMP280. Which side you solder the pins to will depend on your chosen mounting method. This example shows them set for direct attachment of the BMP280 to the PCB Header. Be sure to align VCC on the BMP280 with VCC on the PCB.

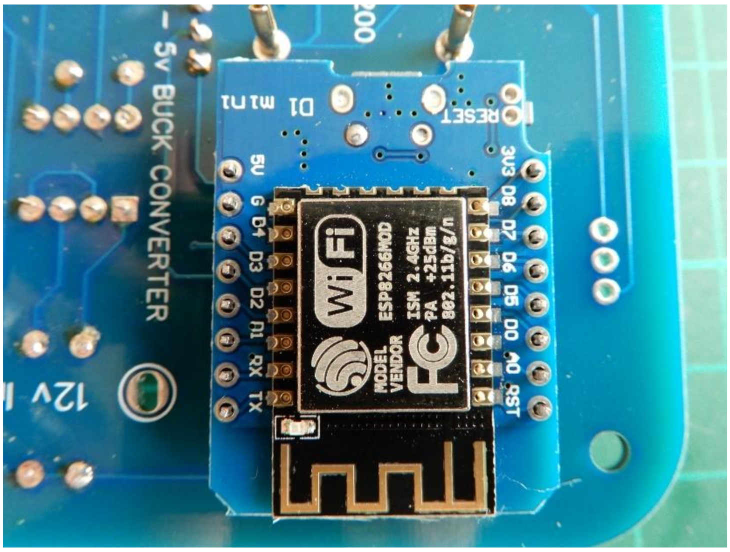


Turn the board over and solder the following components:

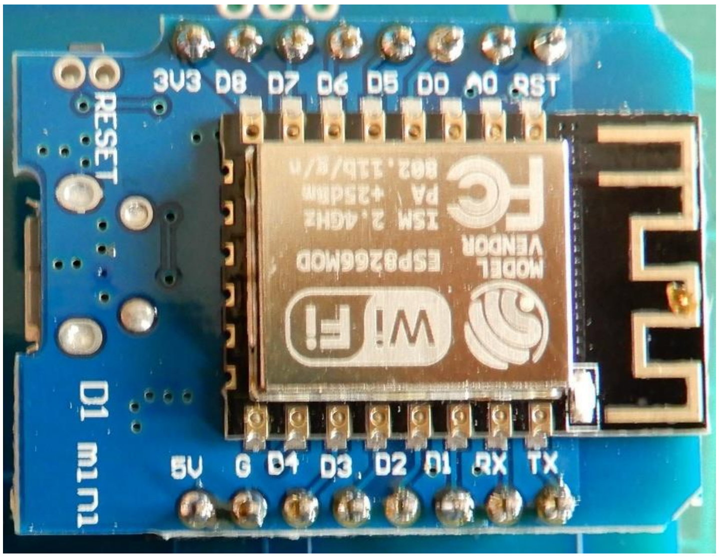
WeMos mounting pins and sockets

Insert the two rows of header pins (that were supplied with the WeMos) into the PCB 'long' end first, leaving the 'short' ends for soldering to the WeMos (**for location only DO NOT SOLDER**). Put the Wemos on to the two rows of pins and solder the pins to the Wemos **ONLY**.

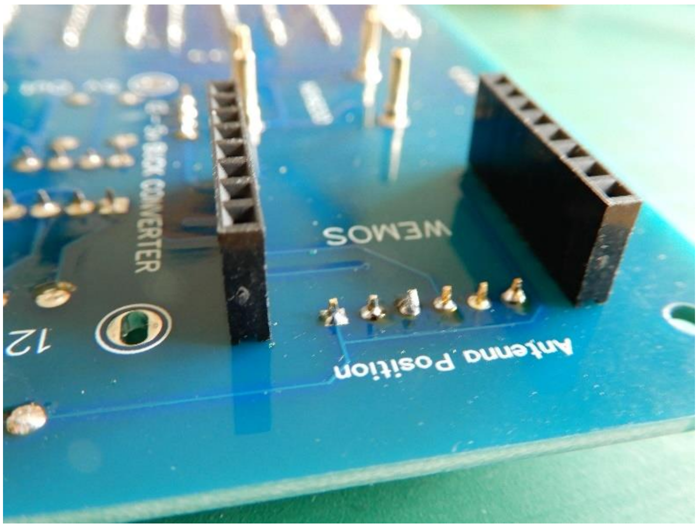


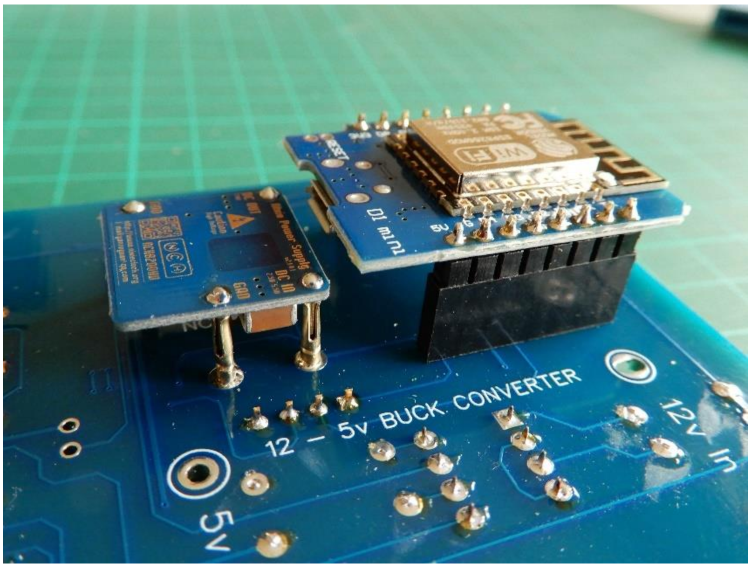


Take care to orient the WeMos correctly so that the pins get soldered to the correct side!



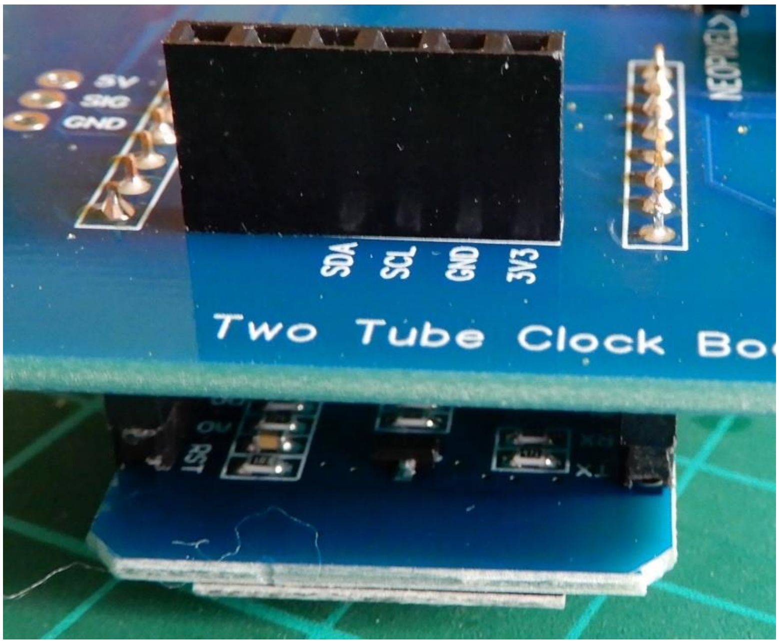
Now remove the Wemos and insert the two sockets headers (that were supplied with the WeMos) into the underside of the PCB and then plug the WeMos in to these headers. The purpose of plugging the WeMos in at this stage is to help get the socket headers straight.





Turn the board over and solder the sockets in to place.

Your board should now look like this:



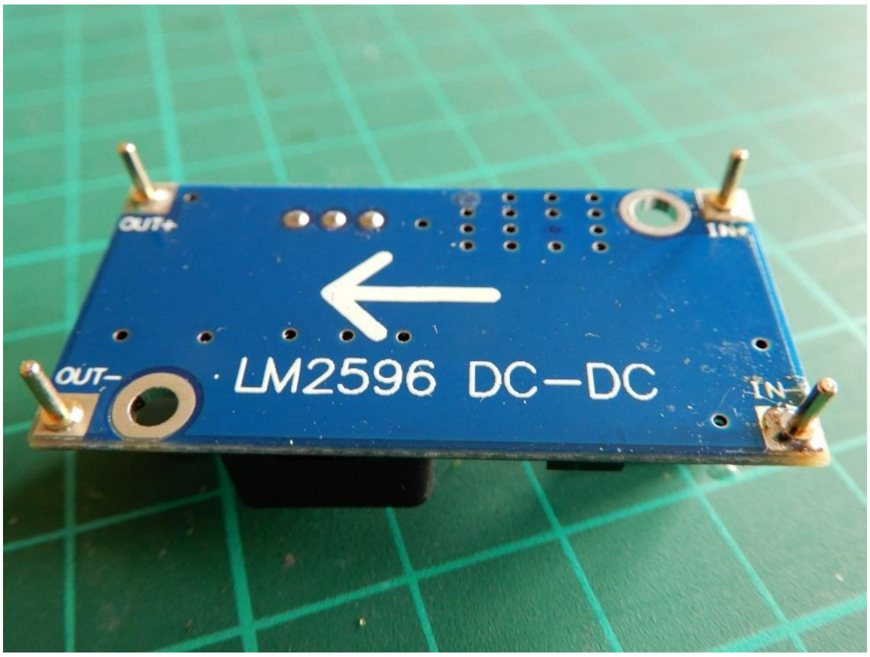
Remove the WeMos from the clock PCB

12V Buck Converter pins and sockets – this is designed to mount ONLY on the underside of the PCB

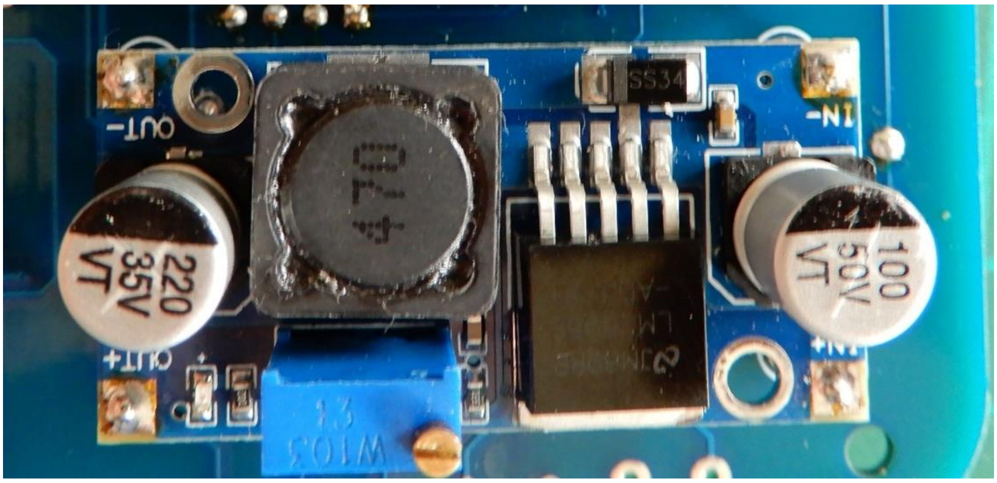
PLEASE NOTE – PIN/SOCKET Method now superseded – skip to the 'Alternative Space Saving' method

Follow the same procedure as used for the NCH8200HV power supply.

Start by soldering 4 x pins to the underside of the Buck converter (**Not the component side**).



Push 4 x socket pins on to the pins that you just soldered and push the complete assembly in to the PCB from the Underside.

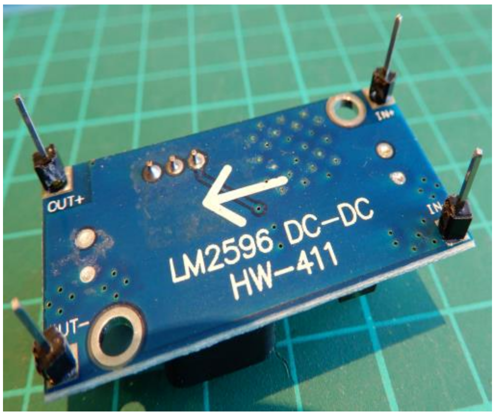


Solder the pins and remove the Buck Converter. When re-fitting, make sure that you have the buck converter the correct way around, 12V ‘IN’ towards the outer edge of the PCB.

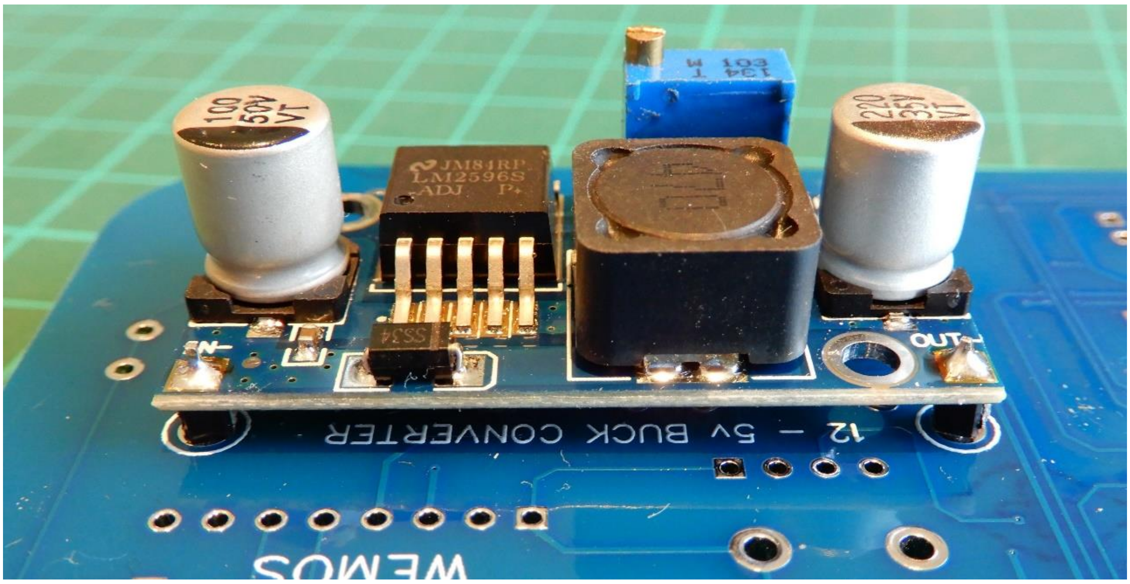
Alternative SPACE SAVING method:

This MUST BE DONE AFTER soldering R1, R2, R3, R4 and the 8 pin DIL socket in to place

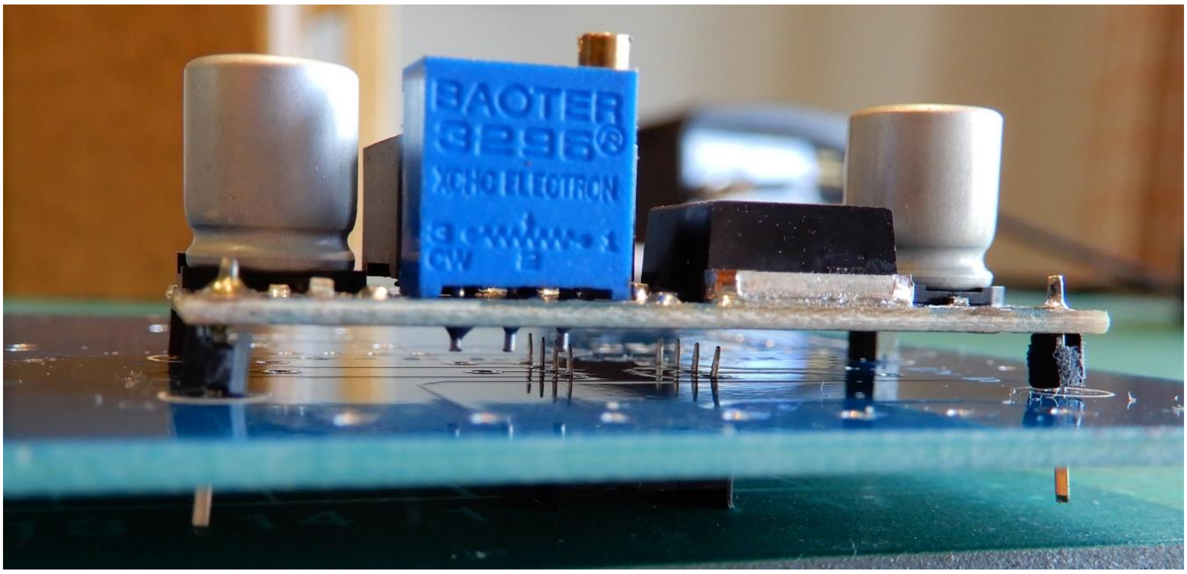
If you would like to reduce the overall height of the clock then use the four single pins (supplied as a 1x4 way header pins that you can cut in to 4 individual pins) by soldering the ‘short’ ends to the Buck Converter.



Mount the Buck Converter on the underside of the PCB taking care to mount it the right way around the solder in to place from the top side of the PCB.



This MUST BE DONE AFTER soldering R1, R2, R3, R4 and the 8 pin DIL socket in to place. Be sure to clip the legs of these components as close to the PCB as possible so that there is sufficient clearance between them and the Buck Converter PCB. With the mounting pins provided (4 way header pins) there is no need to trim the legs of the 8 pin DIL socket used for the opto couplers as there will already be sufficient space Trim the legs of R1, R2, R3 and R3 so they are no longer than the IC socket pins.



REMEMBER, THIS MUST BE DONE AFTER soldering R1, R2, R3, R4 and the 8 pin DIL socket in to place and trimming their leads.

First Test – Setting the 5V supply.

With **ONLY** the Buck converter mounted on the board, connect a 12V supply to the PCB at the points provided taking care to connect the supply the right way around and measure the output of the Buck converter with a multimeter by using the GND and 5V test points. Adjust the potentiometer with a small screwdriver until 5v is measured. **IT IS IMPORTANT THAT NO OTHER COMPONENTS ARE PLUGGED IN TO THE BOARD AT THIS STAGE AS THE BUCK CONVERTER WILL ALMOST CERTAINLY BE SET TO OUTPUT MORE THAN 5V WHICH COULD DAMAGE OTHER COMPONENTS.**

<Picture of 5V Test>

Do not proceed until you have a solid 5V reading.

Disconnect the 12V supply.

Second Test – checking the 170V supply

Inset the NCH8200HV power supply into the sockets on the board. Re attach the 12V supply and check that 170V is being produced by the NCH8200HV by connecting a multimeter to the GND and HV test points.

<Picture of 170V Test>

Do not proceed until you have a solid reading in the region of 170V to 174V.

REMOVE THE POWER CONNECTION

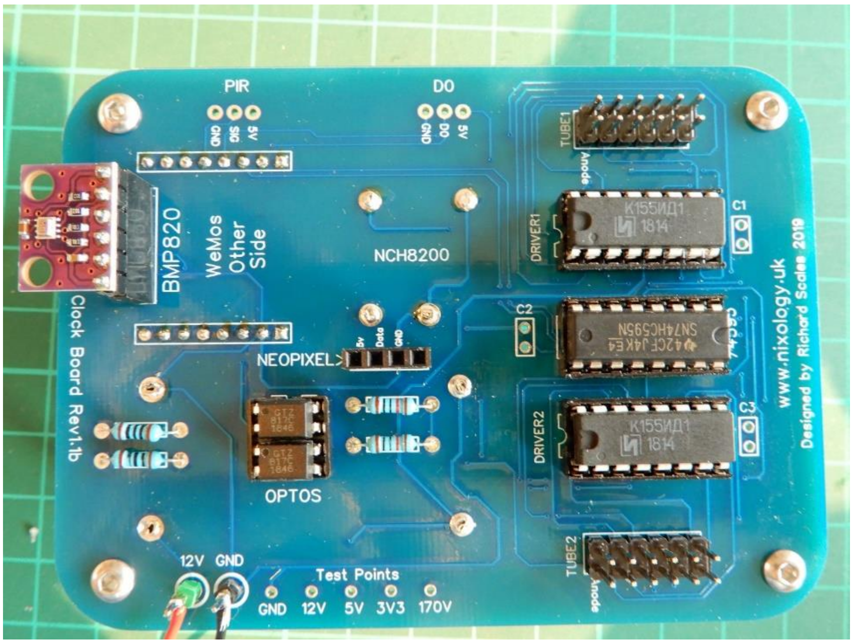
Continue as follows:

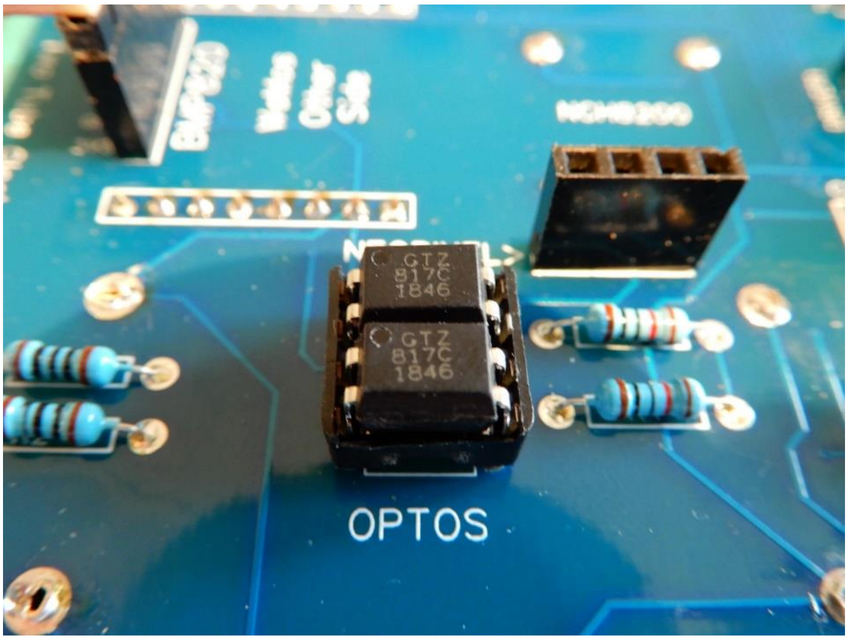
Plug in the following on the top side of the PCB

2 x 74141 or K1551D1 drivers and 1 x 74595 shift register into their respective locations according to the markings on the PCB taking care to align the notch on each IC with the notch on the socket and PCB.

2 x EL817 Opto Couplers taking care to align them correctly. Pin 1 has a small 'dot' and should be located towards the edge of the PCB.

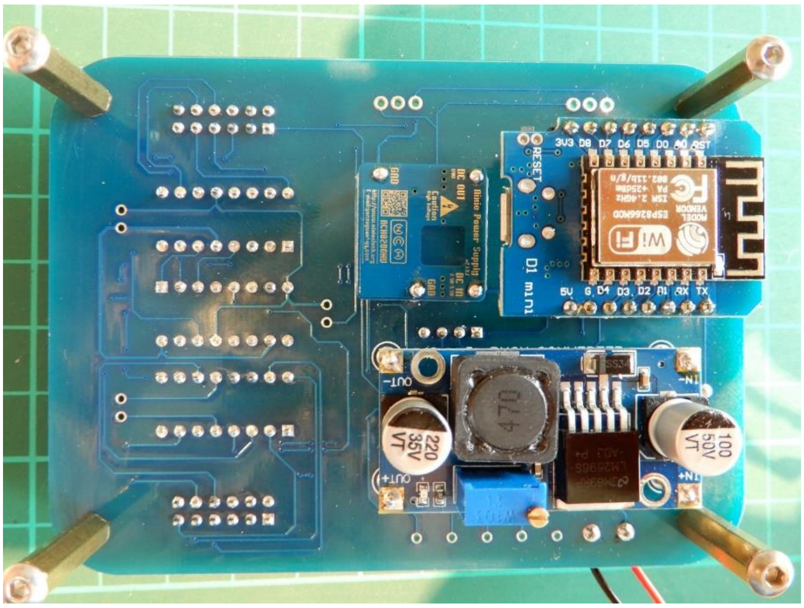
1 x BMP280 sensor module – this can be mounted directly or via a length of cable if remote mounting is preferred. If it is not properly connected then the temperature and pressure will not be displayed.





Plug in the following on the bottom of the PCB

1 x WeMos D1 Mini, taking care to align the pins correctly and orient the WeMos so that the ‘Antenna’ end is closest to the outside edge of the PCB.



Connect 1 or more LED’s to the header on the PCB. These LED’s require 5V, GND and Data In to operate. Connect the ‘data in’ of subsequent LED’s to the ‘data out’ of the previous one.

The APA106 LED has two longer legs, two shorter legs and a flat side and has the following connections:

For testing purposes, attach the supplied APA106 LED using only DIN, 5V and GND as follows:

<Picture of APA106 in position>

Reattach the 12V supply and switch on, at this point, the WeMos will be trying to connect to a WiFi signal and failing.

You could also connect the WeMos to a PC using a micro USB cable (not supplied) and use the terminal mode of the Arduino IDE or PuTTY to monitor the output of the serial port on the Wemos at 9600 baud for status information. **Note that this will not be possible if you have mounted the NCH8200HV on the underside of the board unless you insert the additional pair of long legged header sockets between the WeMos and the Clock PCB for testing purposes only.**

Configuration of WiFi Connection

The software is using a standard Library for managing the WiFi connection. When it fails to connect, it will set itself up as an Access Point with a Captive Portal.

Using a mobile phone, tablet or laptop, connect to the AP called 'TwoTubeClockAP'. The Captive Portal should be displayed from where you can set up the connection to your own WiFi. If the portal does not appear automatically following connection to the AP then it should be visible at 192.168.4.1, point your browser to that IP address.

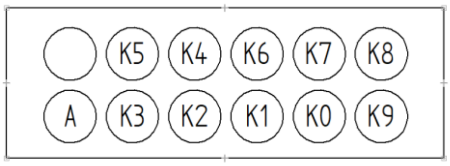
After configuration, the WeMos will reboot and connect to your WiFi, if it fails then the AP will be restarted, and you will need to connect to it and reconfigure the WiFi connection details.

Tube Testing

You can now attach your chosen tubes to the board for testing.

The connections for the tubes match those used on the PV Electronics QTC clocks so any PV Electronics Tube Cell mounted tube should work. Tube Cells are available for other tubes such as Z566M, IN-18, ZIN-18 and Dalibor Farneys tubes. These tube cells also have provision for 'Neopixel' style LED's (APA106).

Tube Cell connections are arranged as follows:



(Viewed from above)

Tubes can be attached in a variety of ways. If your Tube Cells have female socket headers then these could be attached directly to the board for testing.

Take care to orient the connectors so that the Anode on the Main PCB connects to the Anode on the Tube Cell.

When mounting tubes remotely you may elect to put male header pins on the tube cells and use female sockets at each end of the ribbon cable, or use Female headers on the Tube Cells and have a male header at one end of the ribbon cable and a female header at the other (to connect to the PCB).

You may find when using Female headers on the tube cells with matching Male connectors on the ribbon cable that the housing of the Male connector clashes with the mounting hole on the tube cell, it depends on the style of Female Header selected.

PIR Connection

The board and software have provision for the connection of a PIR or other motion sensing device. A regular PIR connects to 5V, GND and Data. Once activated, the clock will remain on for a period of 5 minutes during daytime and 1 minute during night-time after which it will go off until re-activated.

The clock has been tested with the following types commonly available of PIR:

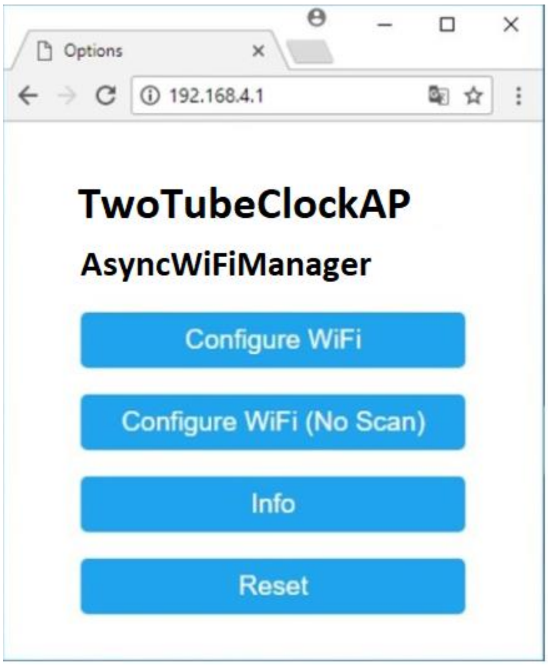
Initial Power Up

Upon startup, the WeMos will try to connect to the last Wireless Access Point that it was connected to. If it fails to connect then it will broadcast it's own AP with the name "TwoTubeClockAP".

Connect to the AP with a laptop or mobile device (phone or tablet).

You should be directed automatically to a captive portal. If not then point your browser to the IP address 192.168.4.1 and the configuration screen should be displayed.

It should look similar to this:



Select 'Configure WiFi' and choose your AP from the list of those found.

Enter the WiFi password if needed then select 'Save'.

The Wemos will restart and connect to your network.

This activity can be monitored using a USB cable connected to the WeMos and the Serial monitor (9600bd) of the Arduino IDE or similar tool.

Once running you should see the clock status giving details of what is being sent to the tubes etc.

This can be done either with the WeMos mounted on the clock PCB or with the WeMos removed and in complete isolation.

Normal Operation

Once operating, the clock will sync time with an NTP time source and display it on the two tubes as a sequence of HH, MM, then several consecutive SS. This sequence repeats continuously. Please note that it can take over 5 minutes to sync NTP time once connected to your WiFi after initial power up.

During normal time display, the LED colour is **BLUE**

Shortly after 30 seconds past the minute either the date or the temp+pressure will be displayed – the data being displayed alternates each minute.

The Date is displayed as a sequence of DD, MM and YY. The date display is accompanied by a change of LED lighting colour to **ORANGE**

The Temperature is displayed in degrees Celsius as TT whilst the LED changes to **RED**

The pressure is displayed as PP then pp where PP is the first two digits and pp are the last two digits of the pressure whilst the LED changes to **GREEN**

eg.

A pressure of 1014mb would be displayed as '10' then '14'.

A pressure of 998mb would be displayed as '09' then '98'

The clock is active between 06:00 and 21:00. Connection of a PIR overrides these times. The PIR activation period is set to 1 minute between 21:00 and 06:00, it is set to 5 minutes between 06:00 and 21:00.

Loading new software

The WeMos will come pre-programmed, In order to load the latest software into your WeMos you will need to use a tool called esptool.exe which, if you have installed the Arduino IDE on a Windows PC and have added WeMos support then you will find it in your profile path. Mine was located at:

AppDataLocal/Arduino15/packages/esp8266/tools/esptool.4.13/esptool.exe

Once you have located the tool, copy it to a working directory where you have also saved the latest bin file for the clock code then execute the following command:

esptool.exe -vv -cd nodemcu -cb 921600 -cp COMx -ca 0x00000 -cf software.bin

Be sure to replace COMx with the relevant COM port for your connected WeMos and replace software.bin with the name of the .bin file that you have received.

eg.

esptool.exe -vv -cd nodemcu -cb 921600 -cp COM6 -ca 0x00000 -cf GemeniOTA-PIR-Async-BMPckeck.ino.bin

Once the software has been loaded, the WeMos will restart and will try to connect to WiFi. Use a mobile phone or other WiFi enabled device to connect to the AP that is broadcast and set it up to access your WiFi. Once this has been done, the clock should run, place the WeMos back on the clock PCB taking care to orient it correctly and power up the clock.

You can monitor the serial port in order to see what the clock is doing, you should see some activity on the tubes if they have been connected.

The software also supports OTA programming so if you already have it connected to your network and you know its IP address, you can update the software OTA using the espota.py python script. You will need to have installed Python for this to work.

A typical command line for this method would look something like this (assuming that the WeMos is connected to your LAN and is at IP 192.168.100.125, the password for OTA uploads is 'Z566'):

python.exe espota.py -i 192.168.100.125 -p 8266 –auth=Z566 -f C:\bin\GemeniOTA-PIR-Async-BMPckeck.ino.bin

Here is a link to an instructable on OTA programming: https://www.instructables.com/id/IoT-Over-the-Air-Update-OTA-ESP8266/