

Circuit Board

Everything you need to build the circuit board is provided below; however, it can be daunting to do this and you will need a soldering iron if you don't have one. If this is all too much, then please get in touch (grobinsn105@gmail.com) and I can build it for you at cost (approximately £40 at time of writing), depending on how much time I have.

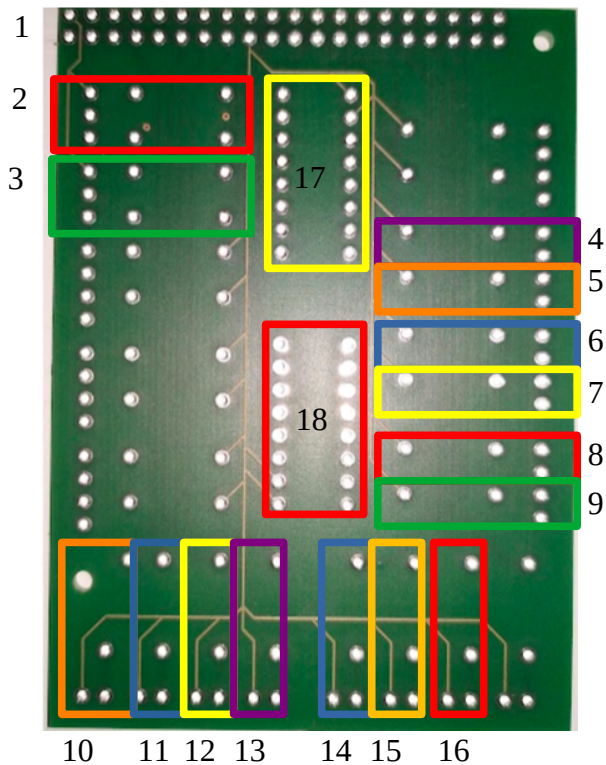
The PCB has been designed using the free software KiCad: <https://www.kicad.org/download/> - it is not necessary to download it but if you want to inspect or amend the PCB design then you will need this. The file is "PCB BMS (printed v2).kicad_pcb".

Components you will need to build the PCB are set out below. In the UK I purchased components from RS Components: <https://uk.rs-online.com/web/> and cpc: <https://cpc.farnell.com/>. The component numbers for each are provided for each and can be found on their website. You can source from elsewhere but it is essential that you purchase components with the same pitch (i.e. distance between the pins). If selecting resistors try to get a tolerance of 1% or better (I was able to get better with 0.5% tolerance):

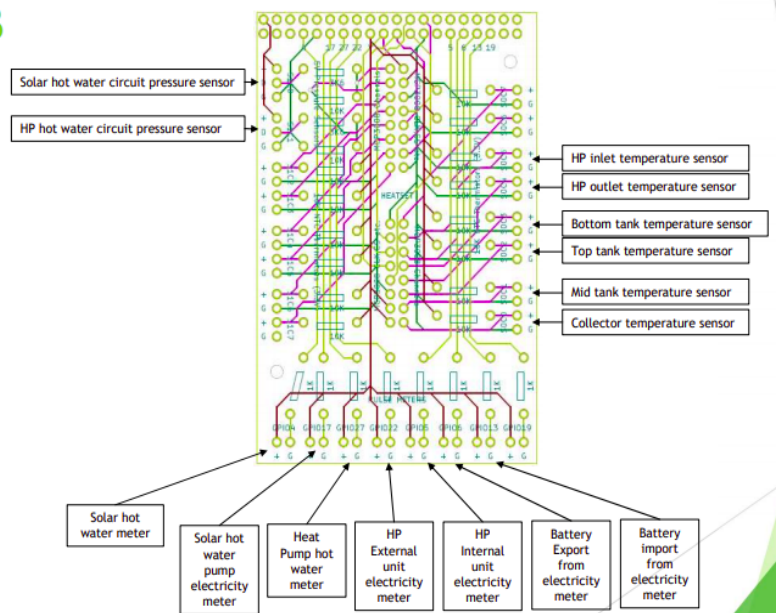
1. 8x 2 way PCB terminal block 2.54mm pitch– RS Component 7901098
2. 2x 3 way PCB terminal block 2.54mm pitch – RS Component 7901092
3. 7x 4 way PCB terminal block 2.54mm pitch – RS Component 7901102
4. 1x 72 way, 2 row, Straight Pin Header – RS Component 2518395
5. 2x 3k6 resistor – RS component 148635
6. 16x 10k resistor – RS component 1997530 (I bought from a different company to get 0.5%)
7. 8x 1k resistor – RS component 1743038
8. 2x MCP3008 – cpc component SC12789
9. 2x 16pin 2 row (8x8) holder socket 2.54mm pitch in row and 5.35mm between rows – I sourced from amazon
https://www.amazon.co.uk/dp/B089RQ3Y5K/ref=pe_2515581_431334481_fb_remail_prod_pg
10. 1x 40way ribbon cable – cpc component SC13726

The file "PCB BMS (printed v2).kicad_pcb" should be downloaded and emailed to a PCB printing company. When specifying: the board is 4 layers and it would be helpful to select "Marking print - yes" to be included. I used a German printing company multi-cb (<https://www.multi-circuit-boards.eu/en/index.html>) but you need to be a company to make the purchase. There will be UK based ones as well but their website was easy to follow which is why I chose them. It cost about 50EUR per board and I bought two.

Overview of the board



PCB



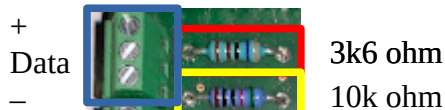
1. Headers



RS Component 2518395

Break the pins off to leave 20x20 pins. The image above actually uses a slightly different component where there is a socket connection on the underside allowing for the board to sit on the Raspberry Pi as a hat. I ended up not doing that for my final version as I found it hard to wire the sensors into the terminal. As such the black plastic would be on the upper side of the board and the solder would be on the underside.

2. Solar hot water circuit pressure sensor



RS Component 7901092

RS component 148635

RS component 1997530

The pressure sensor used (see Instrumentation ReadMe document) requires a 5V supply; however, the reference voltage in the MCP3008 is 3.3V. As such it is necessary to step down the voltage to a maximum of 3.3V. At maximum pressure the gauge will read 4.5V, as such a 3k6V as resistor 1 and a 10k resistor as resistor 2 would provide 3.3V:

$$V_{out} = (4.5 * 10,000) / (3600 + 10000)$$

$$V_{out} = 3.3V$$

As such it is very important that the 3k6 ohm resistor is inserted in the slot closest to the header pins (41D and 41E in the PCB diagram) and the 10k ohm resistor in the slot below (slots 41F and 41G). Failure to do this would result in a much lower voltage being read by the MCP3008 chip and therefore a much lower pressure on the BMS display.

3. HP hot water circuit pressure sensor

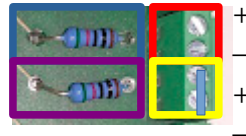
See 2

4. HP inlet temperature sensor



10k ohm

10k ohm



HP inlet temperature sensor

HP outlet temperature sensor

RS Component 7901102

RS component 1997530

To save space a four way terminal block is used. Each four way terminal block accommodates two temperature sensors. A 10k ohm resistor is used because a 10k ohm thermistor is used for measuring temperature and the calculations within F_Sensors.py routine “temp_from_MCP3008_10k_NTC_Thermistor” rely on this resistance for accurate temperature calculations based on the measured thermistor resistance.

5. HP outlet temperature sensor

See 4

6. Bottom tank temperature sensor

See 4

7. top tank temperature sensor

See 4

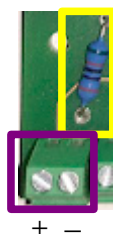
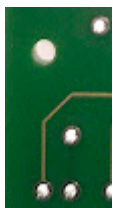
8. Mid tank temperature sensor

See 4

9. Collector temperature sensor

See 4

10. Solar hot water meter



1k ohm

+ -

RS component 1743038

RS Component 7901098

A 1k ohm resistor is used to protect the Raspberry Pi pin when a pulse is read. A 2 way terminal block is used.

11. Solar hot water pump electricity meter

See 10

12. Heat pump hot water meter

See 10

13. HP external unit electricity meter

See 10

14. HP internal unit electricity meter

See 10

15. Battery export from electricity meter

See 10

16. Battery import from electricity meter

See 10

17. MCP3008 – 1



*2x 16pin 2 row (8x8) holder socket 2.54mm pitch in row and 5.35mm between rows
cpc component SC12789*

The MCP3008 chip is delicate and would likely be damaged by a soldering iron. For this reason an 8 pin socket is used with the correct spacing between rows. It is important that the chip is put the correct way up. The semi-circle on the chip should face up, i.e. towards the header pins.

18. MCP3008 – 2

As with 17; however, the chip's semi-circle needs to face down, i.e. away from the header pins.

You will note that there are several slots that are not used (8 temperature sensors and 1 pulse meter). The reason that they are included is to allow for additional sensors to be included should it be necessary for bespoke monitoring systems. This would require additional coding to include such sensors. It is not necessary to fill these slots although the final image below has done so.

The completed board:

