Instrumentation ReadMe

General

For most of the wiring you need a low voltage 2 core cable; however, for the pressure gauge you need a three core low voltage cable. As such buying a 3 core cable would be the way to go and simply isolate the cable core you don't use for the 2 core cabling:

e.g. CPC's (https://cpc.farnell.com/) 3 core cable part MP002314

Solar Thermal

The Solar Thermal Building Monitoring System (BMS) aims to measure:

- the flow rate between the solar collector on the roof and the hot water cylinder in your loft / airing cupboard / etc.
- the average temperature of the hot water in the collector on the roof;
- the temperature at the top, middle and bottom of the hot water cylinder;
- the pressure of the solar hot water circuit; and
- the electricity consumed by the hot water pump to circulate water around the solar thermal hot water circuit

Instruments to purchase

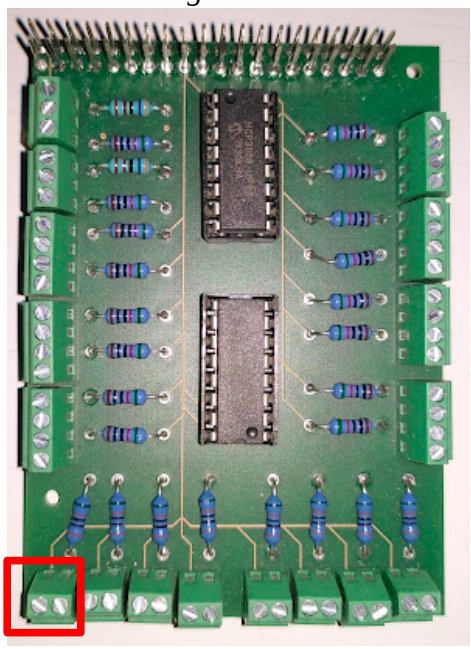
- 4x 10k NTC thermistor – ½" BSPP connection: https://www.sterlingsensors.co.uk/ntc-thermistor-sensor-with-fixed-process-connection.html – c£25 each = £100
- 1x EMLITE ECA2 MID SINGLE PHASE 20-100A DIRECT CONNECTED METER C/W PULSE https://www.metermarket.co.uk/product/emlite-eca2-mid-single-phase-20-100a-direct-connected-meter/ - c£35
- ¾" hot water meter with pulse output – I used AWE but there are a large number of options. Key is understanding the pulse output when buying and ensuring the size is correct for your system and so should be agreed with your installer. https://www.awe-ltd.co.uk/products/water-meter/hot-water-meter.html – c£150
- 5V G1/2" pressure sensor transducer – c£15 – the one I bought is no longer listed; however, the 10bar version here should be fine - https://www.aliexpress.com/i/4001128266089.html

Total cost: approximately £300

Hot water meter

The hourly flow rate of the solar pump will be far lower than that of the heat pump circuit. As such it is advisable to buy a hot water flow meter with the pulse reading calibrated to 0.25L per pulse and certainly no higher than 1L per pulse. 0.25L/pulse is the default assumption within "A_Initialise.py". If you purchase a hot water pulse meter with a different pulse value then you will need to amend variable "Solar_flow_meter_pulse_rate" in module "A_Initialise.py" from 0.25 to the value of your pulse meter.

Hot water meter wiring to the PCB



Hot water meters generally use a reed switch (i.e. use a magnet to create a connection between the poles) and as such it doesn't really matter which way you wire it. Usually they have a red and black wire, so follow that approach:

- The positive terminal is the left terminal in the block – wire to red;
- the ground terminal is the right terminal in the block – wire to black.

Temperature sensors

Many hot water measuring systems use a PT1000 temperature sensor. A good system would use a 3 or ideally 4 wire type (to eliminate the resistance of the wire); however, many do not. As far as I can tell the reason this particular sensor is preferred is that it is easy to read: there is a linear relationship between the measured resistance of the sensor and the temperature; at a resistance of 1000 ohms it is 0 degrees Celsius and each 1 degree Celsius increase represents a reduction of 3.9 ohm resistance of the sensor.

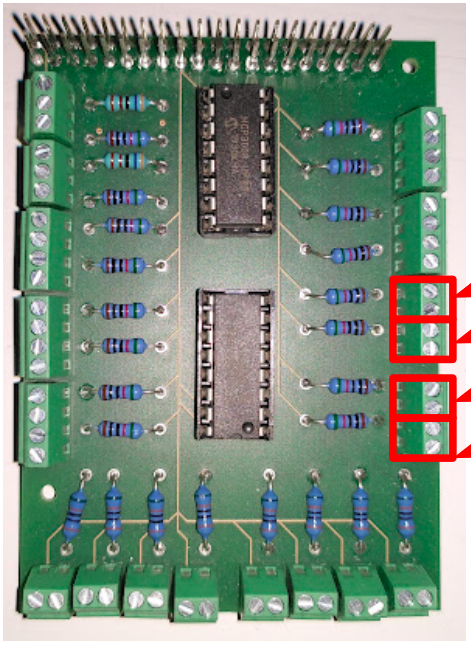
My issue with the PT1000 is that you have to insert it into a pocket – it cannot be directly plumbed into the cylinder or solar collector. A pocket, while it will have a good level of conductivity, will introduce a degree of resistance that will influence temperature readings. I experimented with a PT100 (so resistance of 100 ohms at 0 degrees Celsius) and I was getting a 5 degree Celsius difference both to the thermistor used in the HeatSet Home BMS system and a kitchen electric thermometer, which were giving the same temperature. While this could be corrected for, I believe this adds needless complexity and the risk that it is simply not corrected for. I therefore opted for a sensor that can be directly plumbed into a system.

A 10k ohm NTC thermistor is used in the HeatSet Home BMS system. I purchased the ones used from Sterling Sensors. **If you opt for a different 10k NTC thermistor then you need to take note of the Beta value resistance of the one you are buying as this varies. You will need to update the variable "Beta" in routine "TenK_NTC_Thermistor()" in module "F_Sensors.py" from 3977 ohms to the Beta value of the thermistor you purchase**:

Product	Thermistor Sensor with Process Connection
Type (R25Ω)	10k NTC Thermistor
Temp Range	-50 to 150°C
Beta (B25/85)	3977 Ω
Accuracy	±0.2K (over 0-70°C)
Length	50, 100 & 150 as standard
Diameter	6mm
Connection	½" BSPP and ¼" BSPP
Lead wires	1 metre PFA insulated
Material	316 Stainless Steel
Part Number	NFTHR

It is also essential that you purchase a **10k ohm** NTC Thermistor. This is because the code (module "F_Sensors.py") and circuit board (see "PCB Assembly ReadMe.pdf") are designed on the basis of a voltage divide measured between the 10k ohm thermistor and a 10k ohm resistor.

Temperature sensor wiring to the PCB



The sensor is essentially a resistor whose resistance varies depending on its temperature. As such, like a resistor it doesn't matter which way you wire it. Just so you know – the positive terminal in each block marked is the one closest to the header pins at the top.

Bottom of hot water cylinder temperature sensor
Top of hot water cylinder temperature sensor
Middle of hot water cylinder temperature sensor
Solar collector temperature sensor

Pressure sensor

A ½" BSPP connection is desirable as it is readily plumbed into standard brass fittings. Many versions have quite odd connections so please pay particular attention to this when buying! The HeatSet Home BMS is calibrated to assume a 0.5-4.5V output signal with a 5V supply voltage. You must not buy a pressure gauge with a different supply voltage but if the output signal range is different then in module "F_Sensors.py", routine "pressure_5V_via_MCP3008()" please amend the variable "minVoltage" 0.5 value to the minimum output signal and "maxVoltage" 4.5 value to the maximum output signal. Please note that the 10000 / 13600 within the calculation reflects the voltage divide within the circuit board that is stepping down the maximum signal output of 4.5V down to 3.3V – this must not be changed (unless you have selected resistors with a different resistance within the circuit board than those specified – see "PCB Assembly ReadMe.pdf").

If the maximum pressure is other than 175 PSI then you must amend the "maxPressure" variable in routine "pressure_5V_via_MCP3008()" within module "F_Sensors.py" to the rated maximum PSI of the pressure gauge you are buying.

Pressure sensor wiring of the PCB

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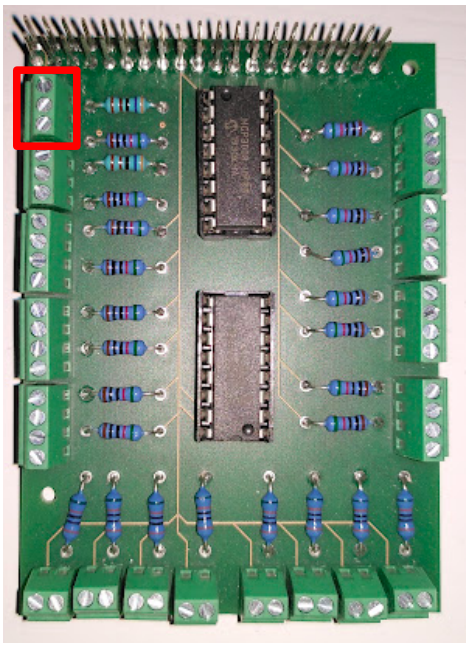


The wiring of the pressure sensor needs to be correct.

The live wire (red) needs to be connected to the first terminal (the terminal closest to the header pins).

The data wire (yellow) needs to be connected to the second terminal (the terminal in the middle of the three way block).

The ground wire (black) needs to be connected to the third terminal (the terminal furthest away from the header pins).

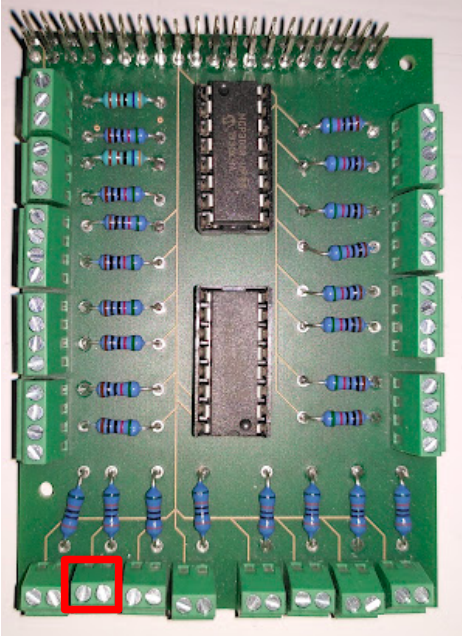
Electricity sub-meter

The electricity consumed by a solar thermal pump will be minimal and as such monitoring this could be seen as overkill. I won't judge you if you elect not to do this but if you do you will need to get your electrician to wire the meter for the live feed to the pump via the meter. Either you or the electrician will then need to wire the low voltage + and – cables from the meter to the PCB. Low voltage wiring is not certified under Electrical Installation Certificates but you should still discuss this with your electrician just to ensure that he/she understands what you are doing.

I have used Emlite electricity sub-meters for all the electrical sub-metering. They are compliant with government regimes such as the Renewable Heat Incentive (on the Heat Pump side of things) and are very easy to wire. They are calibrated to provide a pulse reading for each 1Wh of electricity consumed – this is an excellent level of granularity. If you opt for a different meter you need to ensure that you know what the pule reading value is. If it is other than 1Wh per pulse then in module "A_Initialise.py" you will need to amend "lstSolarSensors" as follows:

- ['DictID=21', 17, 1]] - the 1 in the third position (2nd in Python logic) represents the Wh value;
- Change this to the value of your meter. For example, a 1kWh pulse would be amended to: ['DictID=21', 17, 1000]]

Electricity sub-meter wiring of the PCB



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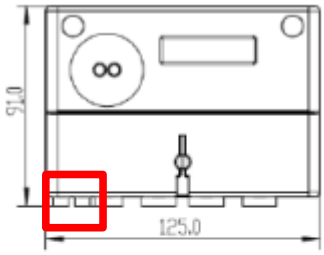
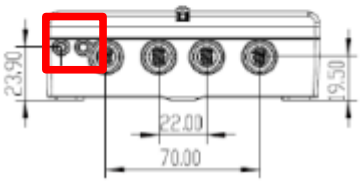
As I understand it, it **does** matter which way you wire the pulse meter. The left terminal on the PCB 2 way terminal highlighted is the live terminal and should be wired to the positive terminal in the electricity meter.

The right terminal on the PCB 2 way terminal is the neutral terminal and should be wired to the negative terminal in the electricity meter.





Heat Pump

The Heat Pump Building Monitoring System (BMS) aims to measure:

- the flow rate of the heat pump's hot water circuit;
- the temperature of the flow and return pipes;
- the pressure of the heat pump's hot water circuit; and
- the electricity consumed by the heat pump's external unit and internal unit (immersion heater and pump)

Instruments to purchase

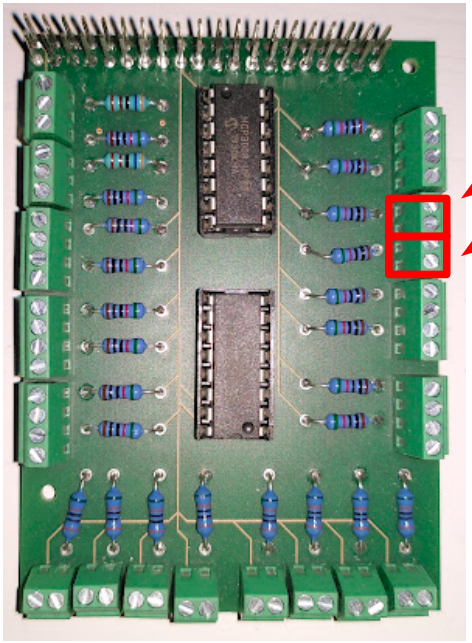
- 2x 10k NTC thermistor – ½" BSPP connection: https://www.sterlingsensors.co.uk/ntc-thermistor-sensor-with-fixed-process-connection.html – c£25 each = £50
- 2x EMLITE ECA2 MID SINGLE PHASE 20-100A DIRECT CONNECTED METER C/W PULSE https://www.metermarket.co.uk/product/emlite-eca2-mid-single-phase-20-100a-direct-connected-meter/ - c£35 each = £70
- 1" hot water meter with pulse output – I used AWE but there are a large number of options. Key is understanding the pulse output when buying and ensuring the size is correct for your system and so should be agreed with your installer. https://www.awe-ltd.co.uk/products/water-meter/hot-water-meter.html – c£200
- 5V G1/2" pressure sensor transducer – c£15 – the one I bought is no longer listed; however, the 10bar version here should be fine - https://www.aliexpress.com/i/4001128266089.html

Total cost: approximately £335

Temperature sensors

Please see solar thermal *temperature sensors* above for the make and model proposed.

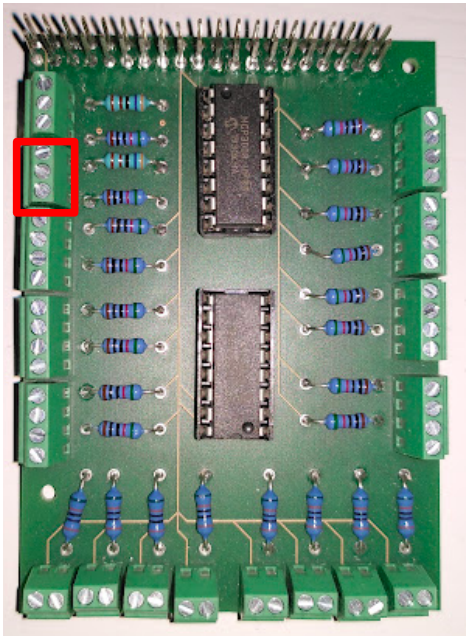
Wiring Heat Pump temperature sensors



Pressure sensor

Please see solar thermal *pressure sensor* above for the make and model proposed.

Wiring Heat Pump sensor gauge

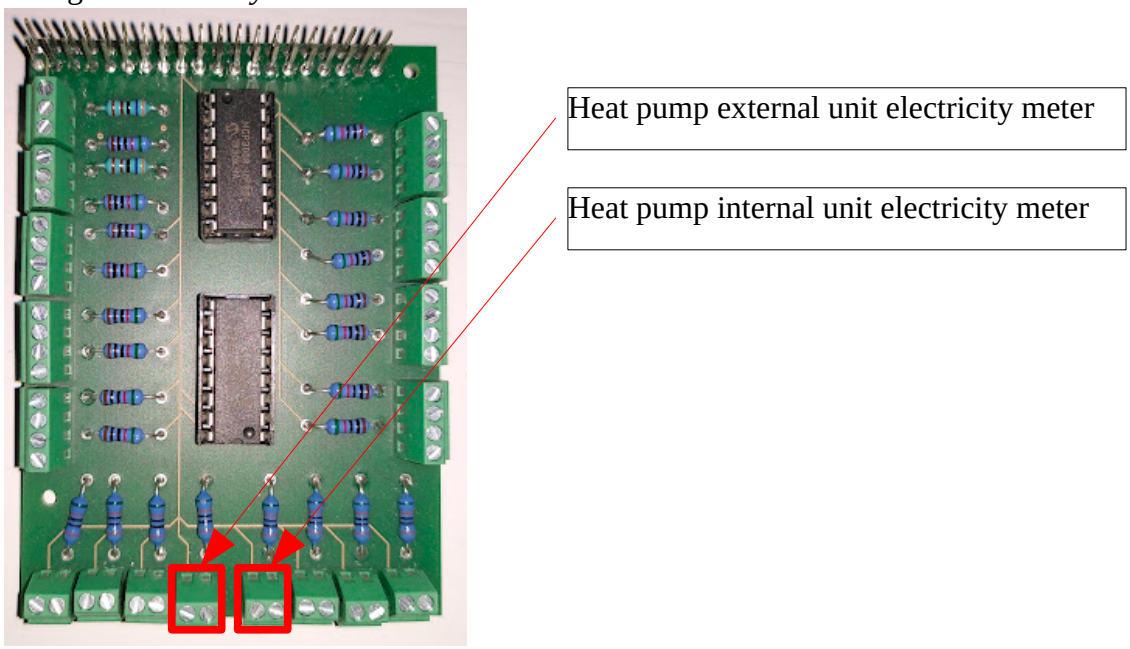


Heat Pump electricity meters

Two electricity meters are used to measure the electricity supplied to the external unit (the outdoor compressor and fan) and the indoor unit (the immersion heater and pump). These should be metered separately so that you can monitor the extent to which the system is relying on the immersion heater (lowering overall efficiency) vs relying on the heat pump.

See the Solar Thermal section above *electricity meter* wiring.

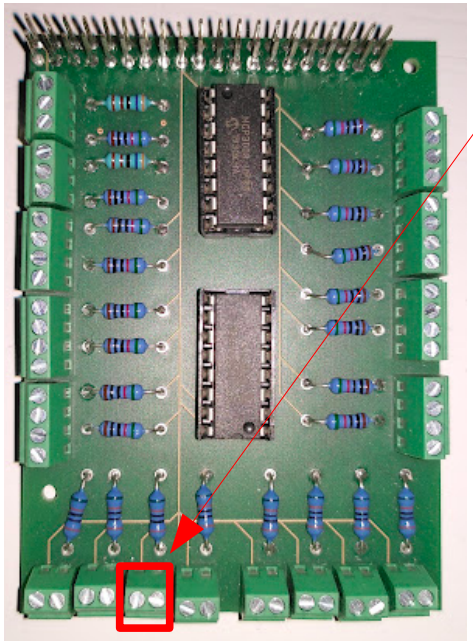
Wiring the e*lectricity meters*



Hot water meter

See the Solar Thermal section *hot water meter* above for more detail. The default pulse value for the heat pump hot water meter is 1L per pulse. If you buy a hot water meter with a different pulse value then you need to change the variable “HP_flow_meter_pulse_rate” in module “A_Initialise.py” from “1” to the value of the pulse in litres.

Wiring the HP hot water meter



Heat pump hot water meter

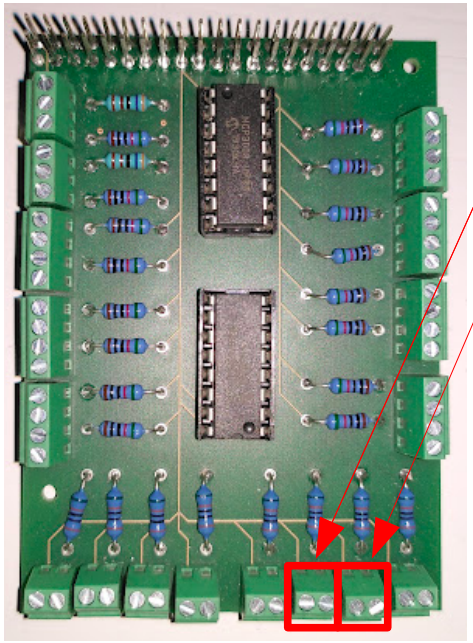
Battery

If you install a battery two electricity sub-meters are used: one to measure electricity charging the battery and one to measure the electricity discharging from the battery. The Emlite sub-meters only measure electricity flow in one direction. As such when the electrician is wiring the meters one needs to be wired in reverse and you need to make sure you know which is which!

Instruments to purchase

- 2x EMLITE ECA2 MID SINGLE PHASE 20-100A DIRECT CONNECTED METER C/W PULSE https://www.metermarket.co.uk/product/emlite-eca2-mid-single-phase-20-100a-direct-connected-meter/ - c£35 each = £70

Wiring the battery sub-meters



Battery discharge sub-meter

Battery charge sub-meter

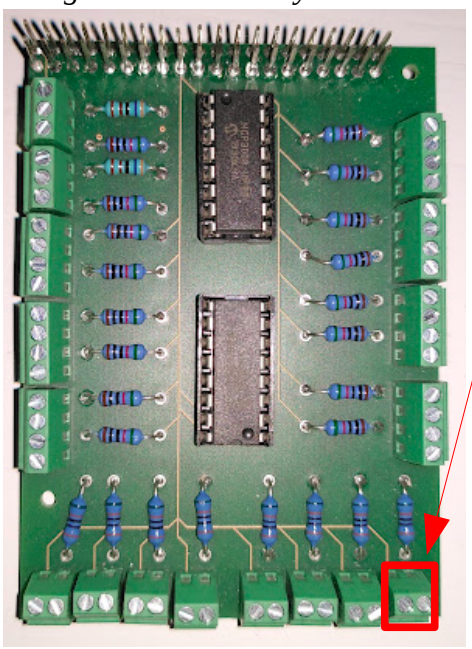
PV

If you install photo-voltaic panels, one electricity sub-meter is used in the HeatSet Home BMS to measure the electricity generated.

Instruments to purchase

- 1x EMLITE ECA2 MID SINGLE PHASE 20-100A DIRECT CONNECTED METER C/W PULSE https://www.metermarket.co.uk/product/emlite-eca2-mid-single-phase-20-100a-direct-connected-meter/ - c£35

Wiring the PV electricity sub-meter



PV electricity sub-meter