

ESD2

by Joshua Asare

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1 Introduction

This assignment examines existing weather stations and sets out to research, specify and design a weather station capable of recording environmental variables (temperature, humidity, VOC levels, airborne particle count, sunlight levels; UV levels, wind speed and wind direction) for use by amateur weather forecasters to forecast weather. A suitable enclosure and power supply is identified to power and store the portable weather station, allowing it to be deployed at a remote location for up to two weeks.

2 Background research

2.1 Measurement techniques

Wind speed and direction can be measured with an anemometer, which come in 'cup' and 'sonic' variants [1].



Figure 1: An Anemometer that measures wind speed and direction [2]

To measure both wind speed and direction, a three-cup anemometer can be combined with a wind vane, used to measure wind speed and direction respectively. An example of this configuration is shown above in Figure 1 which is responsible for converting the angular velocity of the cups into a wind speed, using a calibrated constant based on the radius of the cups from the centre of rotation and aerodynamic properties from the design of the anemometer [1]. These anemometers are capable of measuring wind speed in a single axis but in conjunction with wind direction this becomes a 2D vector. One limitation of these sensors is they can only measure wind speed and direction in the horizontal plane.

The sampling frequency and window that wind speed and direction are measured over affects which characteristics can be measured. Taking a measurement using samples collected over a longer period time (e.g. 10 seconds) will produce measurements that can be used to show trends in wind speed and direction over time. Measurements taken over a short period allow wind gusts, short-duration (seconds) maximum of the fluctuating wind speed [1], to be measured.

Sonic anemometers calculate wind speed by measuring the travel time of travel between two ultrasonic transducers [3]



Figure 2: A sonic anemometer used to measure wind speed and direction with no moving parts

An example is shown above in Figure 2 of an ultrasonic anemometer set up on a shore. These sensors vary how many ultrasonic transceivers they have depending on the desired dimensions of measurement.

2.2 Comparison of portable weather measurement systems

Table 1: Three existing portable measurement systems features compared against one another

		
Bresser 7-in-1 WiFi weather station [4]	Davis Wireless VP2 Station [5]	6327C Cabled VP2 ISS Plus [6]
£219.95	£995.00	£382.96
Assignment-specific sensors		
Temperature	Temperature	Temperature
Humidity	Humidity	Humidity
Wind speed	Wind speed	Wind speed
Wind direction	Wind direction	Wind direction
No Airborne particle count	No Airborne particle count	No Airborne particle count
Sunlight brightness	Sunlight brightness	Sunlight brightness
UV levels	UV levels	UV levels
GPS position	GPS position	GPS position
VOC level	VOC level	VOC level
Additional sensors		
Rainfall	Rainfall	Rainfall
Power supply		
3x AA batteries	3-volt CR123 lithium	3 C-cells
	Small solar panel	Mains AC power adapter
Battery life		
Not specified	8 months	1 month
Optional mounting pole	Optional mounting pole	Optional mounting pole

All three portable weather stations record temperature, humidity, wind speed and direction, and rainfall.

3 Sensor measurement frequency

The Davis 7911 Anemometer calculates wind speed by taking samples over a 2.25 second period, then applying the following equation to calculate speed in mph.

$$V = P * \frac{2.25}{T}$$

Equation 1: Wind speed equation for samples collected over a 2.25 second period. [7]

To reject noise in measurements, sensors can be sampled at a greater rate than data is recorded but consideration must be taken into how this is implemented for readings that are subject to sudden changes, such as wind speed and direction, that vary during gusts.

The frequency at which sensors will be read are detailed in Section 5.

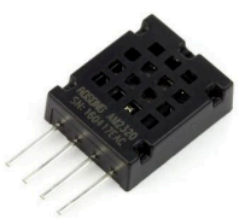
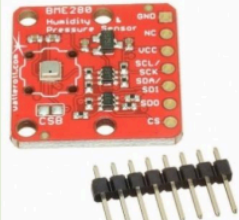
Table 2: The rate at which sensor readings are recorded

Sensor	Time between measurements
Temperature	15 minutes
Humidity	15 minutes
VOC	15 mintues
Airborne particle count	15 minutes
Wind speed	2.25 seconds
Wind direction	2.25 seconds
Sunlight level	15 minutes
UV level	15 minutes
GPS position	Once

4 Component and Sensor selection

4.1 Temperature and Humidity - BME280

Table 3: A comparison of Temperature and humidity sensors

 Figure 3: A breakout board for the Bosch BME680 pressure, humidity, temperature and gas sensor	 Figure 4: A digital temperature and humidity sensor	 Figure 5: A breakout board for the Bosch BME280 temperature, humidity and pressure sensor
Adafruit/Bosch	Pimoroni	Watterott Electronic GmbH
BME680 [8]	AM2320 [9]	BME280 [10]
£14.98	£3.60	£12.14
I2C / SPI	I2C	I2C / SPI
3 – 5.5 V @ 12 mA (1 Hz sample rate)	350 µA @ 3.3-5 V	3 - 5.5 V @ 2.7 µA (1 Hz sample rate)
Relative humidity (%)	Relative humidity (%)	Relative humidity (%)
Sensor measurement (Units)		
Ambient temperature (°C)	Ambient temperature (°C)	Ambient temperature (°C)
Index for Air Quality		

A breakout board for the Bosch BME280 temperature, humidity and pressure sensor has been selected as it combines two desired measurements into a single package. The AM2320 has the highest current draw while measuring the same environmental factors as the other two choices. The BME680 sensor was not chosen even though it has a sensor that incorporates VOC, as it combines several measurements to produce an “Index for Air Quality” [11], not relaying VOC levels directly.

4.2 VOC - SGP30

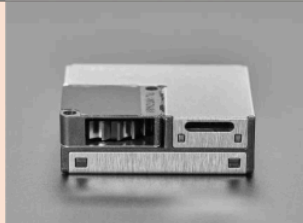
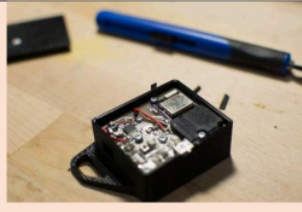
Table 4: A comparison of VOC and air borne particle count sensors

			
Figure 6: A breakout board produced by Renesas for the ZMOD4410 sensor	Figure 7: A solid polymer electrolyte gas sensor from SGX Sensortech [12]	Figure 8: A breakout board for the Sensirion SGP40 VOC and air quality sensor	Figure 9: A breakout board for the Sensirion SGP30 VOC and air quality sensor
Renesas	SGX Sensortech	Adafruit/Sensirion	Adafruit/Sensirion
ZMOD4410-EVK-HC-WP [13]	PS4-VOC-200 [12]	SGP40 [14]	SGP30 [15]
£112.30	£74.68	£11.82	£16.63
I2C	Analogue	I2C	I2C
16.32 mA @ 3.3 V	Current output	Not specified @ 3.3 / 5 V	Not specified @ 3.3 / 5 V
Sensor Measurement (Units)			
TVOC (ppm)	TVOC (ppm)	VOC index	TVOC (ppb)
16-bit digital	Analogue	16-bit digital	16-bit digital

The VOC sensor that has been chosen is the Sensirion SGP30 as it provides access to the raw TVOC levels, instead of providing an index like the newer SGP40 sensor does. This provides greater freedom to process the raw sensor data in software. For this sensor to operate, the Relative Humidity must be written to it, this value will be taken from the previously selected BME280 in Section 4.1.

4.3 Airborne particle count - SEN-15103

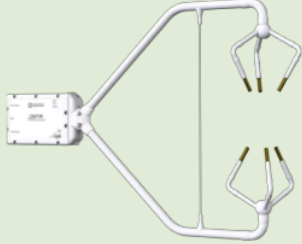
Table 5: A comparison of airborne particle count sensors

		
Figure 10: A PMSA003I particle sensor from PLANTOWER	Figure 11: An Optical particulate matter sensor from Sparkfun	Figure 12: An assembled DIY particle count sensor [16]
Adafruit/PLANTOWER	Sparkfun	Hybrid Ecologies Lab, UC Berkeley
PMSA003I [17]	SEN-15103 [18]	Open Source [16]
£31.80	£41.57	£59.44
100mA @ 3.3 V	60 mA @ 4.5 – 5.5 V	Not specified
I2C	UART, I2C	UART
PM1.0, PM2.5, PM10	PM1.0, PM2.5, PM4, PM10	PM2.5, PM10

The selected sensor is the Sparkfun SEN-15103 which covers the widest range of

4.4 Wind speed and direction - CSAT3B-SS2-NC

Table 6: A comparison of Wind speed and direction sensors

 Figure 13: A sonic anemometer from Campbell Scientific	 Figure 14: An Ultrasonic wind speed and direction sensor from Renke	 Figure 15: A cup anemometer and wind vane
Campbell Scientific	Renke	ZQ Meter Store
CSAT3B-SS2-NC [19]	RS-CFSFX-*-3-EX [20]	GD-FS-RS485 [21]
£8,987.50	£58.11	£21.71
SDM, CPI, USB, RS-485	RS-485 / Analog	RS-485, Analog
110 mA @ 12 V (10 Hz) 145 mA @ 12 V (100 Hz)	10 mA @ 10-30 V	0-5 V output
Sensor Measurement Units		
Wind speed (X, Y, Z) ms^{-1} Sonic Temperature $^{\circ}C$	Wind speed ms^{-1} Wind direction $^{\circ}$	Wind speed ms^{-1} Wind direction $^{\circ}$
	Min 0.5 m/s	
IP67	IP65	No IP rating

The Campbell Scientific anemometer has been selected as it has an IP rating suitable for continued outdoor use.

4.5 Sunlight and UV levels - WDF5002 UV window and 4831 Ambient Light and UV sensor

4.5.1 Visible and UV window

The ultraviolet (UV) portion of the electromagnetic spectrum is split into three distinct bands: UV-A, UV-B, and UV-C with wavelengths of 400-315 nm, 315-280 nm, and 280-100 nm respectively. UV-C emitted from the sun is prevented from reaching the surface of the Earth by the atmosphere [22] while 95% [22] of UV-B is absorbed by ozone in the atmosphere. The wavelengths of UV this weather station should observe is from 400 down to 280 nm. To allow the UV sensor to remain inside the enclosure, a window has been selected which allows the transmission of UV in the specified (400-280 nm) range.

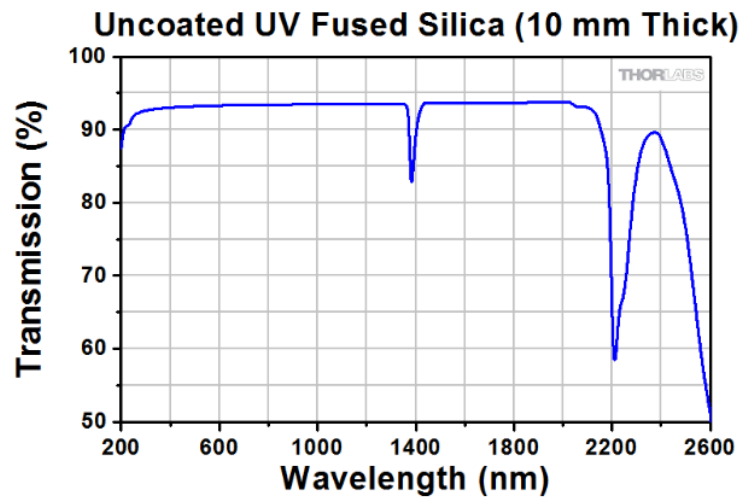


Figure 16: The electromagnetic transmission spectrum for a fused silica window from a Thor Labs product

Figure 16 shows the transmission data [23] from Thorlabs for a 10mm uncoated UV fused silica window, which shows that the window can be used for both UV and visible light.

4.5.2 Comparison of UV and sunlight sensor solutions

Table 7: A comparison of solutions to monitor UV levels

		
Figure 17: An optical dome from Knight Optical	Figure 18: A rectangular UV window from Thorlabs	Figure 19: A combined Ambient Light and UV sensor on a breakout board
Knight Optical	Thorlabs	Adafruit
WDF5002 [24]	WG41010R [23]	4831 [25]
£379.50	£121.64	£4.70
		Not specified @ 3.3-5 V
		I2C
UV Fused Silica	UV Fused Silica	

The dome from Knight optical has been selected as this allows for both UV and visible light to pass through, while also having a shape that prevents water or moisture from building up on the top of the sensor and interrupting measurements, which would prove problematic if the rectangular window was installed at the top of the enclosure housing the sensor.

The sensor chosen supports both UV and ambient light, which will be used to record UV and sunlight levels respectively.

4.6 GPS position

Table 8: A comparison of GPS solutions

		
Figure 20: A GNSS module from Pulse Electronics	Figure 21: An RS pro GPS and Galileo antenna	Figure 22: A GPS module on a breakout board
Pulse Electronics	RS PRO	Adafruit
GPSLPMB403 [26]	RRDM-LA2-4665-9F-X-001 [27]	PA1616S [28]
£48.43	£40.56	£25.80
11 mA @ 3.3-5 V	25 mA @ 2.5-10 V	20mA @ 3.3-5 V
GPS, Galileo, Glonass, Beidou	GPS, Galileo	GPS, Galileo, Glonass, Beidou
IP67	IP67	N/A

The GPS module that has been selected is the PA1616S, which supports a variety of GNSS standards across different regions of the world, allowing the weather station to be deployed almost anywhere.

4.7 Microcontroller – PIC18F25K50

Table 9 below shows the interfaces supported by each sensor, and the logic levels they operate at. Due to several sensors having an I2C interface, I2C has been selected for 4 out of the 6 sensor modules. Additionally, a UART transceiver has been used to interface with the sonic anemometer over RS-485. In total, a PIC MCU supporting I2C and UART is required. A USB interface is required for data transfer to a computer, alongside an SPI interface to record data to an SD card.

Table 9: Selected components and their supported interfaces

Sensors	Supported Interfaces						Voltage (V)	
Temperature and Humidity Sensor – BME280		I2C			SPI		3.3	5
VOC Sensor – SGP30		I2C					3.3	5
Airborne particle count – SEN-15103		I2C				UART	3.3	5
Sonic Anemometer – CSAT3B-SS2-NC	CPI		RS-485	SDM			USB	5
Light and UV sensor – 4831		I2C					3.3	5
PA1616S						UART	3.3	5

4.8 Battery selection

The average total power consumption of the selected components is approximately 120 mA, detailed in Table 10 below. To operate continuously for 14 days, drawing 120 mA at 12 V, a 12V battery with a capacity of at least 41 Ah should be selected.



Figure 23: A 12 V 50 Ah car battery

YBX3205 12V 60Ah 540A Yuasa SMF Battery [29]
£60.00
12 V
60 Ah
230x174x205 mm

To account for additional power consumption due to changes in temperature, a battery with approximately 50% redundant capacity has been selected.

4.8.1 Power consumption

Table 10: Selected sensors, additional components and their power consumption

Sensors	Power consumption
Microcontroller - PIC18F25K50	100 mA

Temperature and Humidity Sensor – BME280	2.7 μ A during measurement 0.1 μ A in sleep mode Avg @ 0.103 μ A
VOC Sensor – SGP30	48.2 mA during measurement 10 μ A in sleep mode Avg @ 55 μ A
Airborne particle count – SEN-15103	60-80 mA during measurement <8 mA standby Avg @ 8.08 mA
Sonic Anemometer – CSAT3B-SS2-NC	110 mA Not sent to sleep
Light and UV sensor – 4831	110 μ A Ambient light sensor 100 μ A UV sensor 1 uA standby Avg @ 1.23 μ A
PA1616S	20 mA for 60 seconds
Total	8.06 mA @ 5V 110 mA @ 12V

5 Non-volatile memory

A microSD card will be used to store the total of 16.45 Megabytes of data.

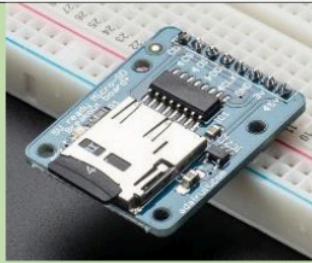


Figure 24: A microSD card breakout board from PiHut

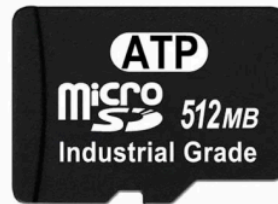


Figure 25: An industrial grade MicroSD card

ADA254 [30]	AF512UDI-5AFXM [31]
£7.20	£14.84
SPI	
3.3, 5V	
	512 Mb

Sensor	Data recording frequency	Data size	Total
PA1616S - GPS	Once	2x 32 bit	8 bytes
BME280 - Temperature	Once per 15 minutes	8 bit	10,752 bytes
BME280 - Humidity	Once per 15 minutes	8 bit	10,752 bytes
SEN-15101 - Particle Count	Once per 15 minutes	8 bit	10,752 bytes
4831 – Sunlight level	Once per 15 minutes	8 bit	10,752 bytes
4831 – UV level	Once per 15 minutes	8 bit	10,752 bytes
Wind speed	Every 2.25 seconds	16 bit	8,601,600 bytes
Wind direction	Every 2.25 seconds	16 bit	8,601,600 bytes

Grand Total			17209920 bytes (16.4 MB)

Data will be stored in a series of arrays on the SD card as shown below:

Table 11: Memory layout on the microSD card for recorded data

Sensor	Memory address Range
PA1616S - GPS	0 – 8
BME280 - Temperature	9 – 10,760
BME280 - Humidity	10,760 – 21,529
SEN-15101 - Particle Count	21,530 – 32,288
4831 – Sunlight level	32,289 – 43,049
4831 – UV level	43,050 – 53,808
Wind speed	53,809 – 8,655,409
Wind direction	8,655,410 – 17257009

6 Schematic

6.1 Proteus schematic

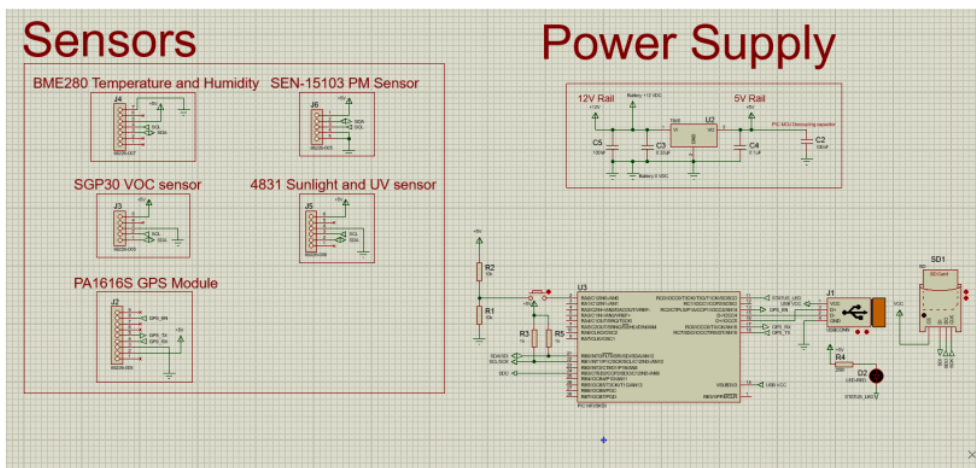
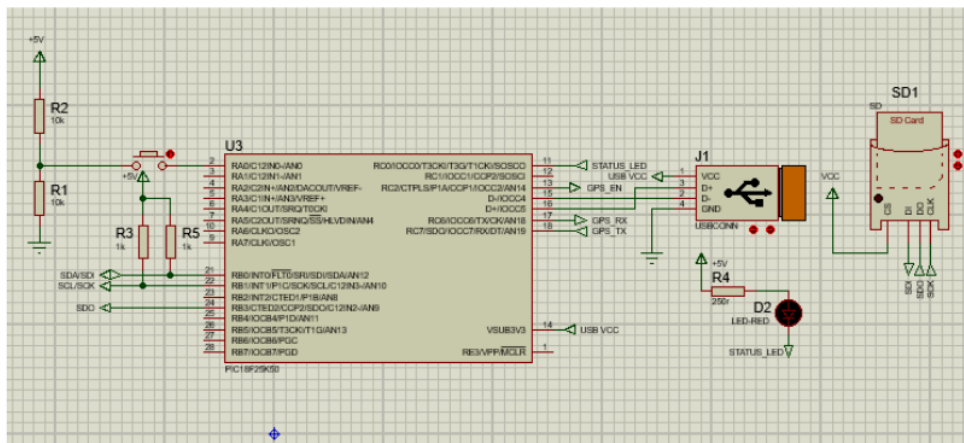
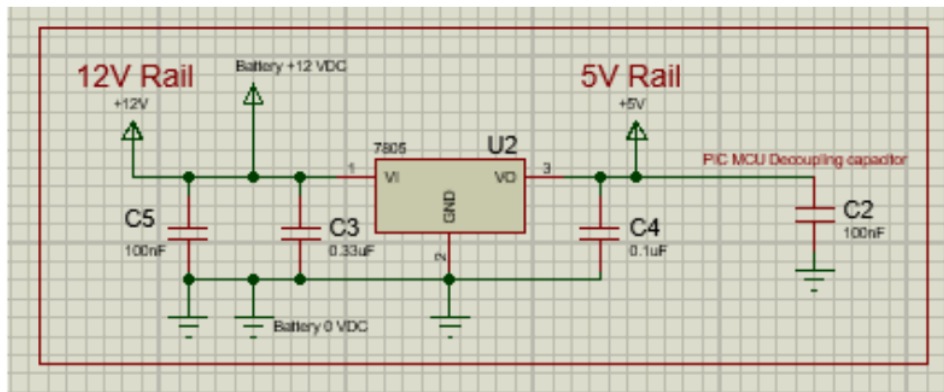


Figure 26: Schematic designed in Proteus

6.2 Circuit Power supply

A decoupling capacitor is connected between the +5V rail powering the PIC microcontroller and ground to prevent a sudden draw in current, for example when toggling pins or reading from sensors, dropping the voltage supplied to the PIC too low for it to operate.



7.1 Easy-PC Schematic

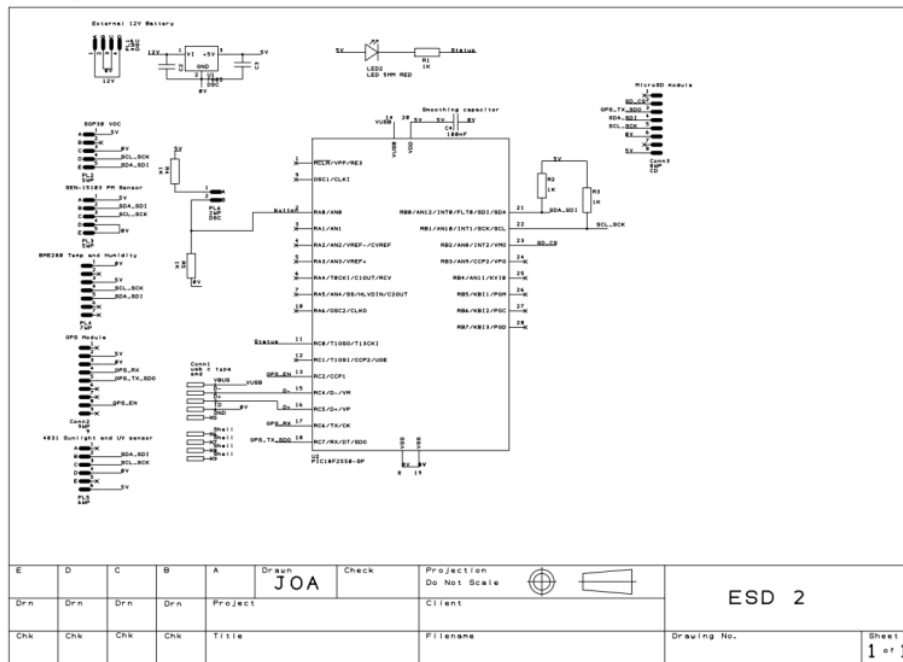


Figure 29: The Schematic layout from Easy-PC

7.2 Easy-PC PCB

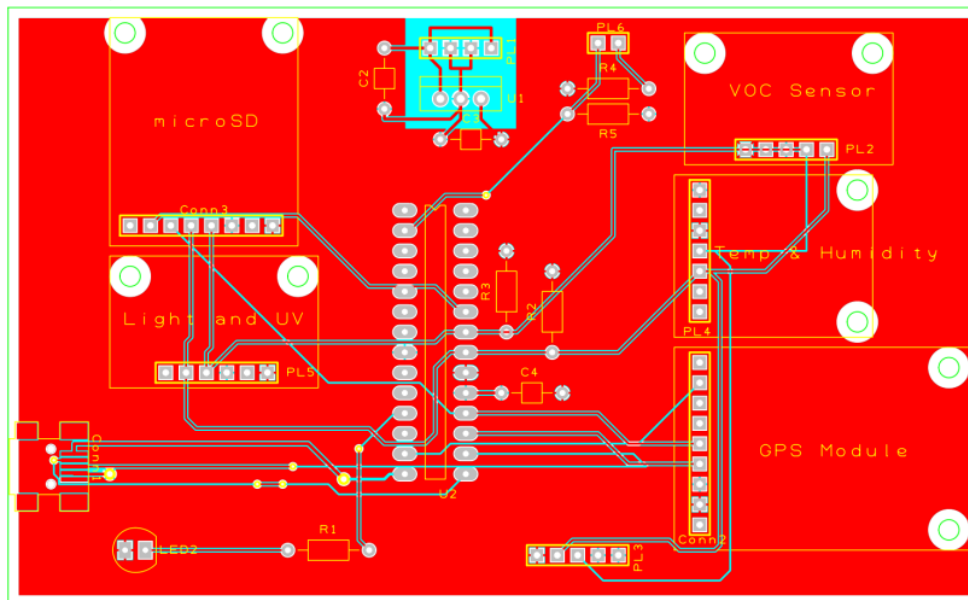


Figure 30: The PCB layout from Easy-PC

7.3 PCB fabrication

Including shipping, the cost of the PCB comes to a total of £14.20 from JLC PCB. To comply with health and safety standards, a lead-free finish has been selected for the PCB.

The screenshot shows the JLCPCB quote interface. At the top, there are tabs for 'Standard PCB/PCBA', 'Advanced PCB/PCBA', 'SMT Stencil', and '3D Printing/CNC'. Below these are two images of a green PCB. The main configuration area includes:

- Back to Upload File** and **Gerber Viewer** links.
- Detected 2 layer board of 72.38x120.62mm(2.85x4.75 inches)**.
- Base Material**: FR-4 (selected), Flex, Aluminum, Copper Core, Rogers, PTFE Teflon.
- Layers**: 1, 2 (selected), 4, High Precision PCB, 6, 8, 10, 12, 14, 16, More.
- Dimensions**: 120.62 x 72.39.
- PCB Qty**: 5.
- Product Type**: Industrial/Consumer electronics (selected), Aerospace, Medical.

 On the right, the **Charge Details** section lists:

- Engineering fee: \$4.00
- Via Covering: \$0.00
- Surface Finish: \$1.20
- Board: \$3.40

 The **Build Time** section shows:

- PCB: 2 days (\$0.00)
- 24 hours (\$7.20)
- 24 hours (PCBA Only) (\$0.00)

 The **Calculated Price** is \$8.60. A **Shipping Estimate** of \$17.50 is shown for DHL Express (2-4 business days, 0.26kg). A **SAVE TO CART** button is at the bottom.

Figure 31: A quote for a PCB with lead free HASL from JLCPCB.com

8 Enclosure

The PCB measures 122 x 73 mm, an enclosure that is greater than this is required, however due to the power requirements, the limiting factor is the battery which measures 230 x 174 x 205 mm in volume.

		
Figure 32: The 1620 Protector case from Peli Products UK	Figure 33: A resin case from HPRC	Figure 34: The 1630 Protector case from Peli Products UK
1620-001-110 [32]	HPRC2700W [33]	016300-0010-110 [34]
£421.15	£316.26	£555.90
508 mm x 292 mm x 232 mm	480 mm x 310 mm x 175 mm	533 mm x 365 mm x 216 mm
IP67	IP67	IP67

To accommodate for the use of non-IP rated sunlight and ultraviolet sensors, a small window made of UV Fused Silica has been selected to allow both the sunlight and UV levels to pass through to the sensor.

9 Prototype build cost

Table 12: Cost of each element of the prototype

Item	Cost
Sensors	£9,527.84
Storage	£21.94
PCB	£14.20
Enclosure	£555.90
Total	£10,119.88

10 Software flow chart

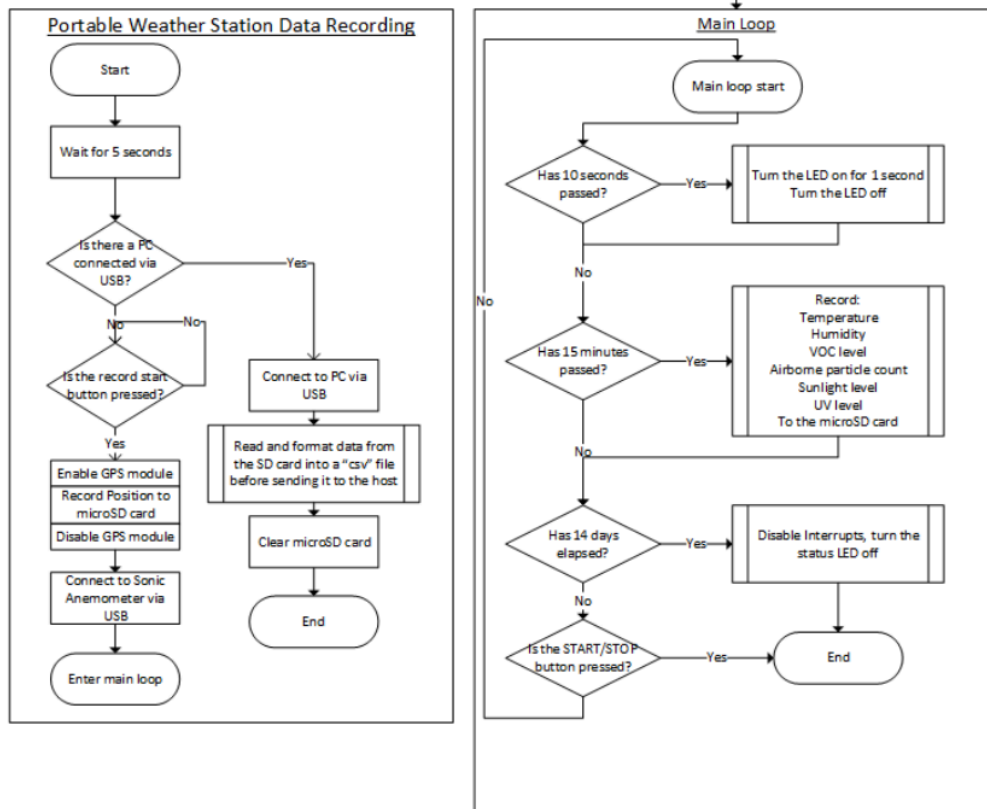


Figure 35: Software flow chart of the weather station

11 Suggested improvements

A conformal coating is suggested for the PCB to expand the lifetime of the weather station since it will be subject to long duration outdoor use. An acrylic-based coating as it is “low cost” [35] and provides moisture protection, which is the primary concern for the weather station. Additionally, acrylic-based coatings provide protection against UV [36], which this circuit board would be partially exposed to due to the design of the UV level sensor.

Additionally, many of the sensors that come on individual breakout boards could instead be integrated into the main PCB to save space and use a smaller enclosure. This would also reduce the power consumption because some of the breakout boards use separate voltage regulators, lowering the efficiency of the system.

Analysis of existing products show that they include pressure and rainfall sensors. To provide additional information for amateur weather forecasters, incorporating additional environmental sensors would further aid in their predictions. Pressure is also an environmental factor that is used in weather forecasts which could be recorded in a future design.

As this product operates using battery power, the estimated lifetime of the battery could be calculated and if it is estimated to be less than 14 days, the weather station could signal this to the installer by repeatedly flashing the LED every 0.5s to indicate low battery. This would prevent measurements from starting if they would stop part way through the recording period.

For ease of transfer, a WiFi network could be used instead of a USB connection to receive data from the weather stations at the end of their recording period instead of connecting the station to a computer to retrieve that data. This would allow for data to easily be retrieved from weather stations that are placed in areas that are difficult to access.

12 Bibliography

- [1] I. Suomi and T. Vihma, "Wind Gust Measurement Techniques-From Traditional Anemometry to New Possibilities," *Sensors (Basel, Switzerland)*, vol. 18, no. 4, pp. 1300-, 2018.
- [2] Davis Instruments, "Anemometer for Weather Monitor or Wizard - SKU 7911," Davis Instruments, [Online]. Available: <https://www.davisinstruments.com/products/anemometer-for-weather-monitor-or-wizard>. [Accessed 15 October 2024].
- [3] The University of Manchester, "Sonic Anemometers (Centre for Atmospheric Science - The University of Manchester)," The University of Manchester, [Online]. Available: <http://www.cas.manchester.ac.uk/restools/instruments/meteorology/sonic/>. [Accessed 10 October 2024].
- [4] Weather Shop, "Bresser Clearview 7-in-1 WiFi Weather Station with Light Intensity, UV Monitoring & Ice/Frost Alert 7002586 | Weather Shop UK," Weather Shop, [Online]. Available: <https://www.weathershop.co.uk/bresser-7-in-1-wifi-weather-station-7002586>. [Accessed 8 October 2024].
- [5] Prodata Associates Ltd, "Davis Wireless VP2 Station & WeatherLink Console 6252UK," Prodata Associates Ltd, [Online]. Available: <https://shop.weatherstations.co.uk/davis-wireless-vp2-station--weatherlink-console--6252uk-2147-p.asp>. [Accessed 8 October 2024].
- [6] Prodata Associates Ltd, "6327C Cabled VP2 ISS Plus," Prodata Associates Ltd, [Online]. Available: <https://shop.weatherstations.co.uk/6327c-cabled-vp2-iss-plus-198-p.asp>. [Accessed 8 October 2024].
- [7] "7911_Anemometer_Rev_G_Web.fm - 7911_SS.pdf," Davis Instruments, [Online]. Available: https://cdn.shopify.com/s/files/1/0515/5992/3873/files/7911_SS.pdf. [Accessed 15 October 2024].
- [8] Adafruit, "Adafruit BME680 - Temperature, Humidity, Pressure and Gas Sensor - STEMMA QT," Adafruit, [Online]. Available: <https://www.adafruit.com/product/5046>. [Accessed 20 November 2024].
- [9] Pimoroni, "AM2320 Digital Temperature and Humidity Sensor," Pimoroni, [Online]. Available: <https://shop.pimoroni.com/products/digital-temperature-and-humidity-sensor?variant=35611648138>. [Accessed 20 November 2024].
- [10] DigiKey, "201877 Watterott Electronic GmbH | Development Boards, Kits, Programmers | DigiKey," DigiKey, [Online]. Available: <https://www.digikey.co.uk/en/products/detail/watterott-electronic-gmbh/201877/10071155>. [Accessed 20 November 2024].
- [11] Bosch, "BME680 Low power gas, pressure, temperature & humidity sensor," Bosch, July 2017. [Online]. Available: <https://cdn-shop.adafruit.com/product-files/3660/BME680.pdf>. [Accessed 11 November 2024].

- [12] SGX Sensortech, "SGX - SGX Sensortech Sensor," SGX Sensortech, [Online]. Available: <https://www.sgxsensortech.com/sensor/ps4-voc-200>. [Accessed 25 October 2024].
- [13] Farnell, "ZMOD4410-EVK-HC-WP RENESAS, Evaluation Kit, ZMOD4410, Gas Sensor | Farnell® UK," Farnell, [Online]. Available: <https://uk.farnell.com/renesas/zmod4410-evk-hc-wp/evaluation-kit-gas-sensor-module/dp/3588801>. [Accessed 25 October 2024].
- [14] Adafruit, "Adafruit SGP40 Air Quality Sensor Breakout - VOC Index - STEMMA QT / Qwiic," Adafruit, [Online]. Available: <https://www.adafruit.com/product/4829>. [Accessed 20 November 2024].
- [15] DigiKey, "3709 Adafruit Industries LLC | Development Boards, Kits, Programmers | DigiKey," DigiKey, [Online]. Available: <https://www.digikey.co.uk/en/products/detail/adafruit-industries-llc/3709/8258468>. [Accessed 20 October 2024].
- [16] S. S. C. M. a. E. P. Rundong Tian, "How to Build a Portable, Accurate, Low Cost, Open Source Air Particle Counter," 7 November 2016. [Online]. Available: <https://www.instructables.com/How-to-Build-a-Portable-Accurate-Low-Cost-Open-Sou/>. [Accessed 25 November 2024].
- [17] Adafruit, "PM2.5 Air Quality Sensor with I2C Interface - PMSA003I," Adafruit, [Online]. Available: <https://www.adafruit.com/product/4505>. [Accessed 25 October 2024].
- [18] Sparkfun, "SEN-15103 SparkFun | Mouser United Kingdom," Sparkfun, [Online]. Available: <https://www.mouser.co.uk/ProductDetail/SparkFun/SEN-15103?qs=0lSvoLzn4L9ubslfZz13%252BA%3D%3D>. [Accessed 20 October 2024].
- [19] Campbell Scientific, "CSAT3B: 3-D Sonic Anemometer with Integrated Electronics," Campbell Scientific, [Online]. Available: <https://www.campbellsci.com/cs3b>. [Accessed 20 October 2024].
- [20] Renke, "Ultrasonic Anemometers | Wind Anemometer - Renke," Renke, [Online]. Available: <https://www.renkeer.com/product/ultrasonic-anemometer/>. [Accessed 20 October 2024].
- [21] ZQ Meter Store, "Wind speed and direction transmitter three cups meteorological anemometer sensor pulse wind speed monitor anemometer," ZQ Meter Store, [Online]. Available: <https://www.aliexpress.com/item/1005006689866648.html>. [Accessed 20 October 2024].
- [22] NASA, "Ultraviolet Waves - NASA Science," NASA, 2010. [Online]. Available: https://science.nasa.gov/ems/10_ultravioletwaves. [Accessed 26 November 2024].
- [23] Thorlabs inc., "UV Fused Silica High-Precision Windows," Thorlabs inc., [Online]. Available: https://www.thorlabs.com/newgrouppage9.cfm?objectgroup_id=3983. [Accessed 20 November 2024].
- [24] Knight Optical, "Optical Domes | BK7 | UV Fused Silica | Underwater applications," Knight Optical, [Online]. Available: <https://www.knightoptical.com/stock/windows-and-diffusers/dome->

windows.html?product_list_dir=desc&product_list_order=sku&sap_material_1=UV+grade+fu
sed+silica. [Accessed 26 November 2024].

- [25] DigiKey, "4831 Adafruit Industries LLC | Development Boards, Kits, Programmers | DigiKey," DigiKey, [Online]. Available: <https://www.digikey.co.uk/en/products/detail/adafruit-industries-llc/4831/13619756>. [Accessed 20 October 2024].
- [26] Pulse Electronics, "GPSLPMB403 Datasheet (PDF)," [Online]. Available: https://www.mouser.co.uk/datasheet/2/447/plei_s_a0003551753_1-2903859.pdf. [Accessed 26 11 2024].
- [27] RS PRO, "RS PRO Square GPS Antenna | RS," RS PRO, 31 May 2018. [Online]. Available: <https://uk.rs-online.com/web/p/gps-antennas/1766856>. [Accessed 20 November 2024].
- [28] Pimoroni, "Ultimate GPS Module - 66 channel w/10 Hz updates - PA1616S - MTK3339 Chipset," Pimoroni, [Online]. Available: <https://shop.pimoroni.com/products/ultimate-gps-module-66-channel-w-10-hz-updates-pa1616s-mtk3339-chipset?variant=40411456929875>. [Accessed 26 November 2024].
- [29] Halfords, "YBX3205 12V 60Ah 540A Yuasa SMF Battery | Halfords UK," Halfords, [Online]. Available: <https://www.halfords.com/motoring/batteries/car-batteries/ybx3205-12v-60ah-540a-yuasa-smf-battery-485198.html>. [Accessed 28 November 2024].
- [30] ThePiHut, "MicroSD card breakout board+," ThePiHut, 18 August 2024. [Online]. Available: <https://thepihut.com/products/adafruit-microsd-card-breakout-board>. [Accessed 29 November 2024].
- [31] RS Pro, "ATP 512 MB Industrial MicroSD Micro SD Card, UHS," RS Pro, [Online]. Available: <https://uk.rs-online.com/web/p/sd-cards/1958358>. [Accessed 7 Decemeber 2024].
- [32] Peli Products UK, "Peli 1620 Protector Case," Peli Products UK, [Online]. Available: <https://peliproducs.co.uk/products/1620-protector-case>. [Accessed 20 November 2024].
- [33] HPRC, "HPRC 2700W Case," HPRC, [Online]. Available: https://www.hprc.it/en/resin-case_hprc2700w.html. [Accessed 14 December 2024].
- [34] Peli Products UK, "1630 Protector Case," Peli Products UK, [Online]. Available: <https://peliproducs.co.uk/products/1630-protector-case>. [Accessed 26 Novemebr 2024].
- [35] JLCPCB, "Conformal Coating in PCB Technology: Benefits, Challenges, and Future Developments," JLCPCB, 25 July 2023. [Online]. Available: <https://jlcpcb.com/blog/conformal-coating-in-pcb-technology>. [Accessed 20 November 2024].
- [36] M. Harris, "Everything You Need to Know about Conformal Coating," Altium, 31 March 2023. [Online]. Available: <https://resources.altium.com/p/everything-you-need-know-about-conformal-coating>. [Accessed 20 November 2024].
- [37] RP Photonics, "Ultraviolet Optics – transparency, scattering, damage and degradation, solarization, chromatic dispersion, fluorides, UV-transparent media," RP Photonics, [Online].

Available: https://www.rp-photonics.com/ultraviolet_optics.html. [Accessed 15 October 2024].

- [38] Z. Peterson, "Decoupling Capacitor Calculations: What Size Should You Use For Digital ICs?," Altium, 1 July 2019. [Online]. Available: <https://resources.altium.com/p/what-size-decoupling-capacitor-should-i-use-my-digital-ics>. [Accessed 16 October 2024].
- [39] Analog Devices, "MT-101: Decoupling Techniques," 2009. [Online]. Available: <https://www.analog.com/media/en/training-seminars/tutorials/MT-101.pdf>. [Accessed 16 October 2024].
- [40] Logoele, "Light Intensity Sensor – logoele.com," Logoele, [Online]. Available: <https://logoele.com/product/light-intensity-sensor/>. [Accessed 20 November 2024].
- [41] Analog Devices, "MAX481 DS - max1487-max491.pdf," Analog Devices, September 2014. [Online]. Available: <https://www.analog.com/media/en/technical-documentation/data-sheets/max1487-max491.pdf>. [Accessed 21 November 2024].
- [42] Halfords UK, "YBX3205 12V 60Ah 540A Yuasa SMF Battery | Halfords UK," Halfords UK, [Online]. Available: <https://www.halfords.com/motoring/batteries/car-batteries/ybx3205-12v-60ah-540a-yuasa-smf-battery-485198.html>. [Accessed 28 November 2024].

FINAL GRADE

GENERAL COMMENTS

70/100

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GRADING FORM: SMU GENERIC_GJ

JOSHUA ASARE

69.95

RESEARCH-INFORMED LITERATURE



Good literature review of available systems with a good comparison table of relevant information but a short section of the manufacturers specification would have improved it. 75%

7.5

KNOWLEDGE AND UNDERSTANDING



Reasonable overall schematic design but a things to be kept in mind. When designing a complex board it is beneficial, from a understanding point of view, to limit the number of lines travelling around and instead use net names which you

16.25

have done. All of your connectors should be fitted around the perimeter of the board, to stop the cables crossing over each other and possibly causing noise, this is something you should remember for future projects. 65%

ANALYSIS



Good selection of microcontroller. Good selection of components, almost all of your components are i2c have you checked the PIC can drive this many. Good case selection. No connectors selected.68%

23.8

PRACTICAL APPLICATION AND DEP.



Costings were included but spread out through out the document they should have been included in a table with an image and the manufacturers part number along with the supplier's name and part number. Very good attempt at future enhancements.72%

14.4

SKILLS FOR PROFESSIONAL PRAC.



The report is well presented with some good explanations of concepts. Very good selection of references. 80%

8