

Project Report – Weather Monitoring Device

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L6 – Electronic Systems Design

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3. Abstract

This report explains the research and design process for producing a weather and air-quality monitoring device, which is controlled with a microcontroller. The test period was to take place over a 14 day period, so the microcontroller was required to record and store all measured data over this period.

A PIC18F25K50 microcontroller was chosen to control this device.

A schematic was produced in Proteus, and then another schematic was produced by following this in Easy-PC. A PCB design was made with the same components and nets as the schematic, which the program then produced a 3D model from.

This 3D model was sent to JLCPCB for a quote.

The microcontroller could effectively record all data taken over the 2 week period, and has an enclosure to protect it over this time.

4. Introduction

This report covers the research and design process for the production of a weather and air quality monitoring device. The device must be portable and weather resistant, meaning the device must be enclosed in a compact and sealed enclosure, and be plug & play. The device must have the capability to send the recorded data to a pc and clear it if required via a USB connection. The device must also have a flashing LED mounted on the enclosure to notify a user that the device is powered on and is recording data.

The data required from the weather logging device includes the following:

1. Ambient air temperature
2. Environment humidity
3. Wind direction and velocity
4. Air borne particle count
5. Sun brightness and UV levels
6. GPS location
7. VOC level



[1] Figure 1 - Example of a Weather Station

5. Research

5.1. Existing Examples of Weather Logging Devices

To aid with producing an effective and user-friendly weather monitoring device, research must be conducted on existing devices that are currently available online. This will show what features and design elements are effective, and provide some guidance that will help to design this device.

5.1.1. Bresser 5-in-1 WiFi Weather Station [2]

This weather station shown in figure 2 is a portable device that can measure various weather aspects and save it to its internal memory. This device comprises of an outdoor base station with the weather sensors mounted to it, and a separate display screen to provide the user with live weather data.



[2] Figure 2 - Bresser 5-in-1 WiFi Weather Station

Specifications: [2]

- Price - £115.00 + £42.00 (Wireless Temperature & Humidity Sensor (BR-7009999)) [2]
- Product code – SKU BR-7002580
- Supplier – WeatherShop.co.uk
- Measures the following :
 - Temperature (-40°C - +60°C)
 - Wind direction and speed (0-112mph)
 - Rainfall (0-19999mm)
 - Weather forecast
 - Barometric pressure (540-1100)
 - Humidity
- Sensor unit dimensions - 343 x 393 x 136mm
- Supplied by 3 x 1.5V alkaline AA batteries

5.1.2. Kestrel 5500 Professional Weather Meter [3] [4]

This device shown in figure 3, can be hand-held or mounted to a pole as shown in figure 4. This can measure many metrics related to the weather conditions in the local environment. This has buttons for controlling the device, and a display screen to view the live weather readings.



[3] Figure 3 - Kestrel 5500 Professional Weather Meter



[3] Figure 4 - Kestrel 5500 Professional Weather Meter Mounted Outdoors

Specifications: [3] [4]

- Price - £548.33 [4]
- Product Code – SKU NK-0855LVYEL
- Supplier – WeatherShop.co.uk
- Measures the following :
 - Temperature
 - Wind direction and speed
 - Wind chill
 - Altitude
 - Compass direction
 - Barometric pressure
 - Humidity
- Dimensions - 12.7 x 4.5 x 2.8 cm
- Weight – 121g
- Supplied by a AA lithium battery (400 hour life span)
- IP67

5.1.3. Davis Vantage Pro2 Wireless Weather Station [5] [6]

The weather monitoring device shown in figure 5 communicates with its main control unit wirelessly, allowing the main control unit to be up to 300m away, or even 2.7km via wireless repeaters. [7] This features a small display screen with buttons for user interfacing. This allows weather data to be recorded over a wide geological area.

Sensors used include a solid state magnetic sensor for measuring wind, a PN junction silicon diode for temperature, a film capacitor element for humidity, and utilizes a solar panel to detect UV light intensity. [7]



[5] Figure 5 - Davis Vantage Pro2 Wireless Weather Station

Specifications: [7]

- Price - £1,499
- Product Code – 6163UK
- Supplier – WeatherSpares.co.uk
- Measures the following data
- Measures the following :
 - Temperature (-40°C - +65°C)
 - Wind direction and speed
 - Rainfall
 - Weather forecast
 - Barometric pressure
 - Humidity
 - UV solar radiation
 - Soil moisture
- Dimensions – 528 mm x 239 mm x 406 mm
- Weight – 850g
- Supplied by 3 x C-cells batteries (up to 2 years supply)

5.1.4. RWS-07 Portable Weather Station [8]

This weather station shown in figure 6 comes with a tripod mount and a highly secure, waterproof and tough case for the main data acquisition device.



[8] Figure 6 - RWS-07 Portable Weather Station



[8] Figure 7 - RWS-07 Portable Weather Station Case

Specifications: [8]

- Price – No data as device is built to order
- Product Code – RWS-07
- Supplier – OmniInstruments.co.uk
- Measures the following data:
 - Temperature (-40°C - $+60^{\circ}\text{C}$), $\pm 0.5^{\circ}\text{C}$
 - Wind direction and speed
 - Rainfall, using a TR525 rain gauge, which is a cup that catches, and measures frequency of rain drops entering the unit, and measures the accumulation of total water to measure volume. [9]
 - Weather forecast
 - Barometric pressure 750-1250mBar, $\pm 0.1\%$
 - Humidity 0-100%RH, $\pm 1.5\%$ RH

- UV solar radiation
- Soil moisture
- Dimensions – No data as this will vary depending on customer requirements.
- Weight – No data
- Battery powered, no data on expected life.

5.1.5. Comparison of the Researched Weather Monitoring Devices

Table 1 shows a comparison of the four weather stations that were researched in this report. They are compared depending on what measurement features they have.

Name of Device	Bresser 5-in-1 WiFi Weather Station [2]	Kestrel 5500 Professional Weather Meter [3] [4]	Davis Vantage Pro2 Wireless Weather Station [5] [6]	RWS-07 Portable Weather Station [8]
Image of Device	 [2] Figure 8 - Bresser 5-in-1 WiFi Weather Station	 [3] Figure 9 - Kestrel 5500 Professional Weather Meter	 [5] Figure 10 - Davis Vantage Pro2 Wireless Weather Station	 [8] Figure 11 - RWS-07 Portable Weather Station
Portable	Yes	Yes	Yes	Yes
Battery powered	Yes	Yes	Yes	Yes
Wind direction	Yes	Yes	Yes	Yes
Wind speed	Yes	Yes	Yes	Yes
Temperature	Yes	Yes	Yes	Yes
Rainfall	Yes	No	Yes	Yes
Humidity	Yes	Yes	Yes	Yes
Barometric Pressure	Yes	Yes	Yes	Yes
UV Intensity	No	No	Yes	Yes
GPS position	No	No	No	No
VOC (Volatile Organic Compounds) level	No	No	No	No
Air borne particle count	No	No	No	No
Sun light brightness	No	No	Yes	Yes
IP Rating	No	IP67	'Weather-resistant' [5]	'Weatherproof' [8]

Table 1 - Comparison of the Four Weather Monitoring Devices Researched

6. Weather Station Design

6.1. Comparison and Selection of Sensing Devices

In order to design an effective weather monitoring device, research must be conducted on the different types of sensors that are currently available. This is so that the best suited sensors for this application can be chosen after comparing them with others on the market.

6.1.1. Wind Speed & Direction Sensors

Name of Sensor	WSD-V Wind Speed & Direction Sensor [10] [11]	Trumsense STTWSWDI505C Integrated Wind Speed and Direction Sensor C Type [12]	Raindao Pulse Output Integrated Wind Speed And Direction Sensor [13]	Ultrasonic Wind Speed and Direction Sensor [14] [15]
Image of Sensor	 [10] Figure 12 - WSD-V Wind Speed & Direction Sensor	 [12] Figure 13 - Trumsense STTWSWDI505C Integrated Wind Speed and Direction Sensor C Type	 [13] Figure 14 - Raindao Pulse Output Integrated Wind Speed And Direction Sensor	 [14] Figure 15 - Ultrasonic Wind Speed and Direction Sensor
Supply Voltage	24V $\pm$ 10%	5V DC	5V DC	10-30V DCV DC
Output Voltage	0-5V DC	0-5V DC	0-5V DC	0-5V DC or 0-10V DC
Operating Current	30mA	20mA	20mA	20mA
Pins	4	4	6 (RS485)	6
Supplier	MSL Measurement Systems / Measurement-systems.co.uk	Trumsense.com	Raindao Science and technology Co. Limited Shop912063265 / Aliexpress	Micro Robotics, Sentec Meteorology
Product Code	WSD-V	STTWSWDI505C Item no. 00364	N/A	WS303U-B2
Cost	£552	Requires quote	£156.04	£183.52
Measurement Range	No data	0-45m/s wind speed	0-45m/s wind speed	0-40m/s wind speed

		• 0-359 °wind direction	• 0.359° wind direction	• 0-360 ° wind direction
Measurement Accuracy	• 1.5m/s wind speed • ±10° wind direction	• ±0.3m/s wind speed • ±3° wind direction	• (0.3+0.03V)m/s wind speed • ±3° wind direction	• ±0.5+2%FS wind speed • ±3 ° wind direction
Resolution	• 0.5m/s wind speed • <1° wind direction	• 0.1m/s wind speed • 1° wind direction	• ±0.3m/s wind speed • 0.1° wind direction	• 0.01m/s wind speed • 1 ° wind direction
Weight	250g	520g	No data	No data
Dimensions				
IP Rating	IP65	IP64	IP65	IP54

Table 2 - Comparison of Wind Speed & Direction Sensors

6.1.2. Best Suited Wind Speed & Direction Sensor

Raindao Pulse Output Integrated Wind Speed And Direction Sensor [13]

This wind speed and direction sensor was chosen due to it meeting the following requirements of this weather monitoring device:

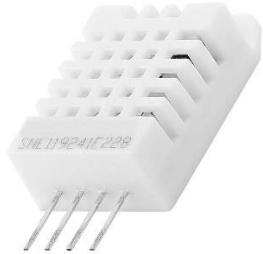
- Rated to IP65, which is waterproof. [16]
- Works with 5V supply which matches typical PIC outputs.
- Provides a 0-5V DC output which is suitable for a PIC. [17]
- Is sufficiently accurate, and can monitor all values of wind that the device will encounter outdoors in the UK.



[13] Figure 16 - Raindao Pulse Output Integrated Wind Speed And Direction Sensor

6.1.3. Temperature & Humidity Sensors

Table 3 shows a comparison of temperature and humidity sensors. The temperature and humidity function is being combined in a single sensor to save cost as these sensors can measure both effectively.

Name of Sensor	AZDelivery DHT22 Digital Temperature And Humidity Sensor Module [18] [19]	BME280 Digital Temperature Humidity Atmospheric Barometric Air Pressure Sensor Probe [20]	TE Connectivity HTM2500LF Temperature & Humidity Sensor, Voltage Output, Through Hole Mount [21] [22] [23]	Amphenol Advanced Sensors T9602-5-A Temperature and Humidity Sensor [24] [25] [26]
Image of Sensor	 [18] Figure 17 - AZDelivery Digital Temperature And Humidity Sensor Module	 [20] Figure 18 - BME280 Digital Temperature Humidity Atmospheric Barometric Air Pressure Sensor	 [21] Figure 19 - TE Connectivity Temperature & Humidity Sensor, Voltage Output, Through Hole Mount	 [24] Figure 20 - T9602-5-A Temperature and Humidity Sensor
Supply Voltage	5V DC	3.3V-5V DC	4.75V-5.25V DC	4.75V-5.25V DC
Output	5V DC	SPI or I2C	1-4V analogue	I2C or PDM (Convertible to analogue) [25]
Operating Current	No data	No data	1.2mA	750uA
Pins	4	4	5	4
Supplier	AZ-Delivery-Shop, Amazon.co.uk	Electrochemical experiment one-stop shopping Store, AliExpress	TE Connectivity, RS-Online	AMPHENOL ADVANCED SENSORS, UK.Farnell
Product Code	DHT22	BME280	- HTM2500LF - RS stock no. – 893-7373	- Mfr. part no. – T9602-5-A - Order code - 2845665
Cost	£6.99	£33.84	£128.95	£47.57
Measurement Range	-40-+80°C temperature	-40-+85°C temperature	-40-+85°C temperature	-40-+85°C temperature

	• 0-100%RH (relative humidity)	• 0-100% humidity • 300-1100 HPA pressure	• 1-99%RH humidity	• 0-100% RH humidity
Measurement Accuracy	• $\pm 0.5^{\circ}\text{C}$ temperature • $\pm 2\%$ RH (relative humidity)	• $\pm 1^{\circ}\text{C}$ temperature • $\pm 3\%$ humidity • $\pm 1\text{Pa}$ pressure	• 1% temperature • $\pm 3\%$ RH humidity	• $\pm 0.5^{\circ}\text{C}$ temperature • $\pm 2.0\%$ RH (20~80% RH) $\pm 3.5\%$ RH (0% to 20%) and (80% to 100%)
Resolution	• 0.1°C temperature • 0.1%RH	• 0.01°C temperature • 0.008% humidity • 0.18Pa pressure	• 1% temperature [23] • 1% RH humidity	• 0.01°C temperature • 0.01%RH humidity
Weight	10g	No data	17.5g	31.885 g [26]
Dimensions	15 x 25 x 7,7mm	No data	76.3x11.6mm	45.89x12.45mm
IP Rating	IP44 [19]	No data but is mentioned as being suitable for outdoor use. [20]	No data but is mentioned as having a 'hermetic housing' [22] & 'not affected by water immersion' [23]	IP67

Table 3 - Comparison of Temperature and Humidity Sensors

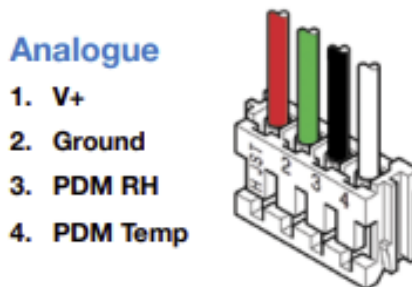
6.1.4. Best Suited Temperature and Humidity Sensor

Amphenol Advanced Sensors T9602-5-A Temperature and Humidity Sensor [24]

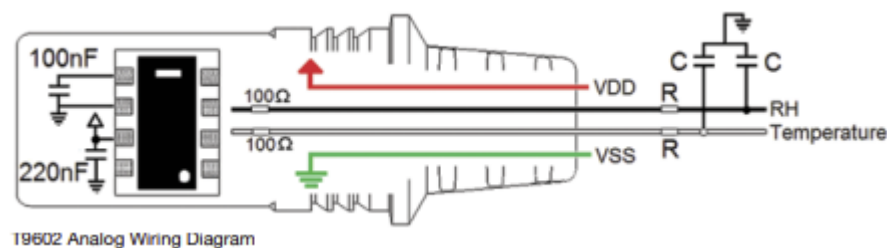
This temperature and humidity sensor was chosen due to it working with a 5V supply which matches most PIC microcontrollers, having more manufacturer's informational data than the other sensors, and being rated to IP67 which makes it suitable for harsh environments. This sensor also has a smaller resolution as well as superior accuracy when compared with the other 3 sensors. There are wiring diagrams to follow to aid with connecting this sensor to the PIC, shown in figures 22 and 23.



[24] Figure 21 - T9602-5-A Temperature and Humidity Sensor



[25] Figure 22 - Sensor Pin Design



[25] Figure 23 - T9602 Sensor Analog Wiring Diagram

6.1.5. Air Borne Particle Count Sensors

Table 4 shows a comparison of air borne particle sensors.

Name of Sensor	MLMLH PM2.5 Sensor - G5 PMS5003 PM2.5 Sensor [27] [28]	HPMA115Co-003 HPM Series Particulate Matter Sensors (Laser Sensor) [29] [30]	TERA Sensor Next-PM, Particle Matter / Dust Air Quality Sensor (Optical Sensor) [31] [32]	Dust / air quality sensor - PM2,5 PMS1003 - 5V UART [33] [34]
Image of Sensor	 <i>[27] Figure 24 - MLMLH PM2.5 Sensor - G5 PMS5003 PM2.5 Sensor</i>	 <i>[29] Figure 25 - HPM Series Particulate Matter Sensors</i>	 <i>[32] Figure 26 - TERA Sensor Next-PM, Particle Matter / Dust Air Quality Sensor</i>	 <i>[33] Figure 27 - Dust / air quality sensor - PM2,5 PMS1003 - 5V UART</i>
Supply Voltage	4.8V-5.5V DC	5V±0.2v DC	5V DC	5V DC
Output	0.4V – 2.9V PWM, UART @ 3.3V	UART baud rate: 9600 databits: 8	UART Modbus (RS485)	UART
Operating Current	100mA	80mA	300mA	120µA
Pins	8	8	8	8
Supplier	- Manufacturer – MLMLH - Seller- OKBY, Amazon	- Manufacturer - Honeywell - Seller - Farnell	- Manufacturer – TERA Sensor - Seller – RS-Online	Botland
Product Code	MAGARET-0358	- Manufacturer part no. - HPMA115C 0-003 - Order code - 3215576	- Manufacturer part no. - Next-PM - Stock no. - 195-3770	- Index: PLA-14485 - EAN: 59033512490 65
Cost	£28.29	£73.82	£93.16	€18.23 + €4.18 shipping

Working Temperature Range	-40-+60°C	-20-+50°C	-20-+70°C	-10-+60°C
Response time	≤3s	6s	1s	≤10 s
Measurement Range	0-1000µg/m³	0-1000µg/m³	0-1000µg/m³	• 0.3 µm to 1.0 µm • 1.0 µm to 2.5 µm • 2.5 µm to 10 µm [33]
Measurement Accuracy	• ±10%@100-500µg/m³ • ±10µg/m³ @ 0-100µg/m³	±15%	<3%	• ±10%@100~500µ g/m³ • ±10µg/m³@0~100µ g/m³
Resolution	1µg/m³	2.5µg/m³	0.3µm diameter	1µg/m³
Weight	42g	No data	45g	No data
Dimensions	50x38x20mm	43x36x23.7mm	62x52x23mm	65x42x23mm
IP Rating	No data	No data	No data	No data

Table 4 - Comparison of Air Borne Particle Count Sensors

6.1.6. Best Suited Air Borne Particle Sensor

MLMLH PM2.5 Sensor - G5 PMS5003 PM2.5 Sensor

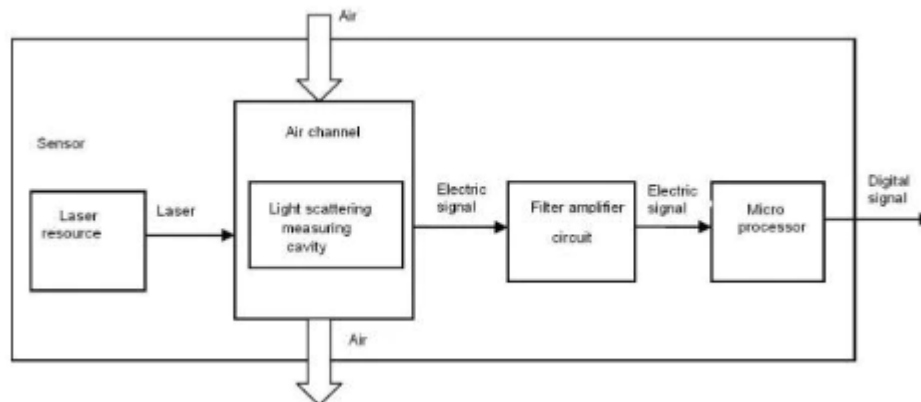
This sensor has been chosen due to it meeting the following requirements better than the other sensors being compared:

- Has good accuracy ($\pm 10\mu\text{g}$) and resolution ($1\mu\text{g}/\text{m}^3$).
- Can operate in temperatures as low as -40°C , which is suitable for the UK, where temperatures have been recorded as low as -27.2°C in North and East Scotland, and -25.2°C in the Midlands. [35]
- Has a good response time of $\leq 3\text{s}$.
- Works with a 5V DC supply which is suitable for a Microchip PIC microcontroller. [17]
- Can communicate with the PIC via pulse width modulation (PWM), which can be read by the PIC by programming the PIC to read the input signal, by following tips 1, 2, 3 and 4 in 'capture tips 'n tricks' Microchip's PICmicro CCP and ECCP tips 'n tricks book. [36]

Figure 28 shows the sensor with its tough aluminium construction and 8 pin supply connection. Figure 29 illustrates the function of the sensor, with a laser detecting particles entering the sensor, and providing a UART output via a micro processor.



[27] Figure 28 - MLMLH PM2.5 Sensor - G5 PMS5003 PM2.5 Sensor



[28] Figure 29 - Functional Block Diagram of the PMS5003 Sensor

6.1.7. Comparison of Sunlight Brightness Sensors

Table 5 shows a comparison of sunlight brightness sensors.

Name of Sensor	Rika 4-20mA 0-5V Analog Output Solar Light Sun Illumination Intensity Sensor [37] [38]	LOGOELE Ambient Light (Lux) Sensor [39]	ABLE ALO-20K Wall Mount Outdoor Light Sensor [40] [41] [42]	S+S Regeltechnik AHKF Outside Light Level Sensor [43] [44]
Image of Sensor	 [37] Figure 30 - 4-20mA 0-5V Analog Output Solar Light Sun Illumination Intensity Sensor	 [39] Figure 31 - LOGOELE Ambient Light (Lux) Sensor	 [40] Figure 32 - ABLE ALO-20K Wall Mount Outdoor Light Sensor	 Figure 33 - S+S Regeltechnik AHKF Outside Light Level Sensor
Supply Voltage	12-24V DC	12V/24V DC	24V DC	15-36V DC
Output	0-5V analogue	0-5V analogue	5-10V analogue output	0-10V analogue
Operating Current	20mA	20mA	20mA	20mA
Pins	4	4	4	3
Supplier	• Manufacturer – Hunan Rika • Seller – Miss Sarah Lee, Made-in-China	• Manufacturer – LOGOELE • Seller – GuangZhou Logoele Electronic Technology	Able Instruments	• Manufacturer – S+S Regeltechnik • Seller - ECProducts
Product Code	Model No. – RK210-01	Model number - Illuminance	Product Code: ALO-20K	Product Code - AHKF-U
Cost	\$52	\$52.30 + \$8.93 shipping	£114	£112

Working Temperature Range	-40-+75°C	0-+60°C	-25-+70°C	-30-+70°C
Response time	1s	No data	No data	No data
Measurement Range	• 0-2000 lux • 0-20k lux • 0-200k lux optional	0-65535 lux or 0-200000 lux.	10-20000 lux	0-60000lux
Measurement Accuracy	<±5%	±7%	No data	<5%
Resolution	<1%FS	No data	No data	No data
Weight	170g	500g	300g	204g
Dimensions	17x16x6cm	11.7x8.6x5.6cm	No data	72x64x43.3mm
IP Rating	IP65	No data	IP67	IP65

Table 5 - Comparison of Sunlight Brightness Sensors

6.1.8. Best Suited Sunlight (Lux) Brightness Sensor

Rika 4-20mA 0-5V Analog Output Solar Light Sun Illumination Intensity Sensor

This sensor was chosen when compared with the other sensors due to effectively meeting the following requirements of this device:

- 0-5V analogue output which will be easy to read by the PIC.
- Has the greatest rated lux accuracy.
- Rated to IP65, which is waterproof.
- Can operate in a very wide temperature range.

Supply voltage is 12-24V DC, which will require boosting from the typical 5V supply from a typical PIC microcontroller from Microchip. [17]



Figure 34 - Rika 4-20mA 0-5V Analog Output Solar Light Sun Illumination Intensity Sensor

6.1.9. Comparison of UV (Ultraviolet Light) Level Sensors

Table 6 shows a comparison of UV level sensors.

Name of Sensor	Rk200-07 0-5V 4-20mA 0-5V Analog Output Metal UV Radiation Sensor [45] [46]	Davis Vantage Pro 2 UV Radiation Sensor [47] [48] [49]	Solar Radiation/Pyranometer Sensor Transmitter [50] [51] [52]	Apogee Instruments SU-202-SS UV Sensor [53] [54] [55] [56]
Image of Sensor	 <i>[45] Figure 35 - Rk200-07 0-5V 4-20mA 0-5V Analog Output Metal UV Radiation Sensor</i>	 <i>[47] Figure 36 - Davis Vantage Pro 2 UV Radiation Sensor</i>	 <i>[50] Figure 37 - Solar Radiation/Pyranometer Sensor Transmitter</i>	 <i>[53] Figure 38 - Apogee Instruments SU-202-SS UV Sensor</i>
Supply Voltage	12-24V DC	3V DC	3.9V-30V DC	5-24V DC
Output	0-5V	0-2.5VDC 150 mV per UV Index, 364 mV per MED/hour	0-2V	0-2.5V
Operating Current	20mA	2.4mA	7mA	1.8mA
Pins	4	3	3	4
Supplier	- Manufacturer – Rika Sensor - Seller – Miss Sarah Lee, Made-in-China	- Manufacturer – Davis Instruments - Seller – Weather Shop	SOONDA	- Manufacturer – Apogee Instruments - Seller – White Cloud Horticulture
Product Code	Model no. – RK200-07	SKU DI-6490	PYR20-AAC005	SU-202-SS
Cost	\$228	£466.66	£60.10	\$925.98
Working Temperature Range	-40-+60°C	-40-+65°C	-40-+85°C	-30-+85°C
Response time	≤1s	50s – 1minute	No data	<1ms

Measurement Range	0-15UV index	0 to 199 MEDs	- Spectral range – 400-1100nm - PYR range – 0-2000W/m²	0-100W/m² - detect UV radiation from 300 to 400 nm
Measurement Accuracy	±5% rdg	±5% of daily total readings	PYR 5%	<0.5%
Resolution	No data	- MEDs to 19.9 MEDs 1 MED above 19.9 MEDS	PYR 1W/m ²	0.04 W m ⁻² per mV
Weight	150g	226g	No data	140g
Dimensions	64x33.5mm	51x70x57mm	75x55x58mm	30.5x37mm
IP Rating	IP65	No mention of an IP rating but the diffuser is described as being 'weather-tight'. [57]	IP66	IP68

Table 6 - Comparison of UV Level Sensors

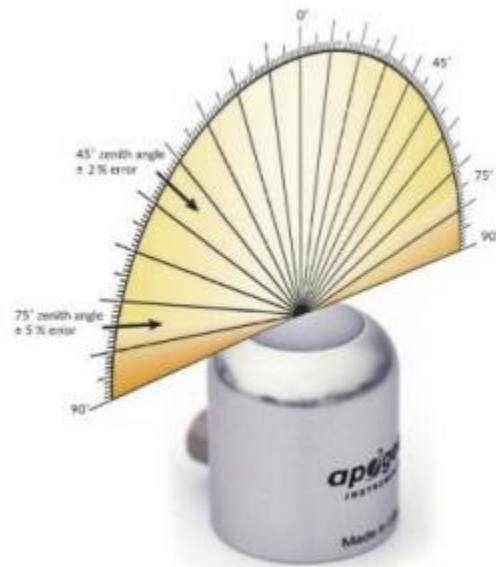
6.1.10. Best Suited UV Sensor

Apogee Instruments SU-202-SS UV Sensor

This sensor was chosen due to it being specified with greater performance and accuracy, as well as being suitable for a typical Microchip PIC microcontroller in the following specifications:

- Works with a 5V supply which matches PIC microcontroller supplies.
- Outputs 0-2.5V DC which can be read by the PIC's ADC inputs.
- Low operating current of 1.8mA.
- Very accurate resolution.
- Rated to IP68 which is immune to water and dust ingress.
- Measures UV intensity in 'energy flux density units of watts per square meter' [56], at 0-100W/m². Maximum level of UV radiation received at ground level is 32W/m². [58]

Figure 39 illustrates the directional readings error at different angles of UV radiation input. Figure 40 illustrates the function of each cable for the sensor.



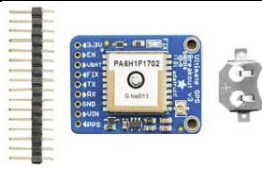
[56] Figure 39 - Apogee Instruments SU-202-SS UV Sensor Cosine Response



[56] Figure 40 - Apogee Instruments SU-202-SS UV Sensor Wiring

6.1.11. Comparison of GPS Location Sensors & Modules

Table 7 shows a comparison of GPS location sensors and modules.

Name of Sensor	NameLessRC Tiny GPS Module 5V 9600dps UBLOX [59] [60]	Ublox NEO-6M GPS UART Module Breakout with Antenna [61] [62] [63]	ADAFRUIT INDUSTRIES 746 GPS Module [64] [65]	HOLYBRO- M8N - 2nd GPS Module #12014 [66] [67] [68]
Image of Sensor	 [59] Figure 41 - NameLessRC Tiny GPS Module 5V 9600dps UBLOX	 Figure 42 - Ublox NEO-6M GPS UART Module Breakout with Antenna	 [64] Figure 43 - ADAFRUIT INDUSTRIES 746 GPS Module	 Invalid source specified. Figure 44 – HOLYBRO - M8N - 2nd GPS Module #012014
Supply Voltage	5V DC	3.3-5V DC	3V-5.5V DC	5V DC
Output	UART RX/TX	UART 9600bps	I2C	I2C & UART RX/TX
Operating Current	No data	10mA	20mA	150mA
Pins	4	4	9	6
Supplier	- Manufacturer – NameLessRC - Seller – King Quad Shop	- Manufacturer – Ublox - Seller – Pi Supply	- Manufacturer – Adafruit - Seller – CPC.Farnell	Holybro
Product Code	SKU: KQP_Nameless_GPS	PIS-1219	- Manufacturer Part No: 746 - Order Code - SC12953	SKU12014
Cost	£13.99	£10.00	£41.66	\$49.00 USD
Working Temperature Range	-40-+85°C	-40-+85°C	-40-+85°C	-40-+85°C
Response time	No data	5Hz	1-10Hz	5Hz

Measurement Range	No data	• 0-50000m altitudes • ≤ 4 g dynamic displacement • Up to 500m/s velocity	• 0-18000m altitudes • Up to 515m/s velocity • ≤ 4 g dynamic displacement	Module incorporates a Ublox M8N GPS module that has a rated maximum altitude of 50km. [68]
Measurement Accuracy	No data	• 2.5m horizontal position accuracy. • 0.05m/s velocity • 0.3° dynamic heading	• 3m positional accuracy • 0.1m/s velocity accuracy	• 2.5m horizontal positional accuracy. • Square area accuracy – 2m [68]
Resolution	No data	-160dBm	-148dBm	-167dBm
Weight	3g	22g	4g	32g
Dimensions	12x16x6mm	36x26mm	16x16x5.2mm	50x14.4mm
IP Rating	N/A as is an exposed IC.	N/A as is an exposed IC.	N/A as is an exposed IC.	No IP rating mentioned but is enclosed in a sealed protective case.

Table 7 - Comparison of GPS Location Sensors & Modules

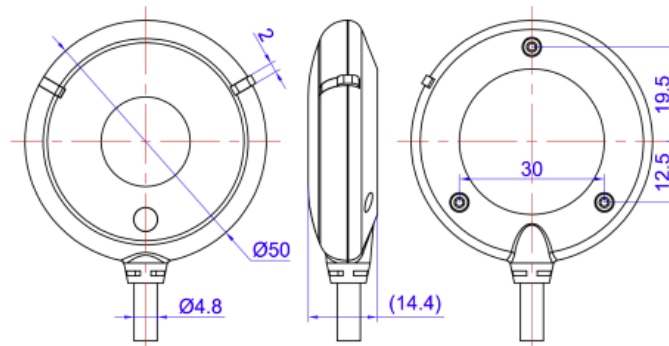
6.1.12. Best Suited GPS Sensor/Module

HOLYBRO- M8N - GPS Module #12014 [66]

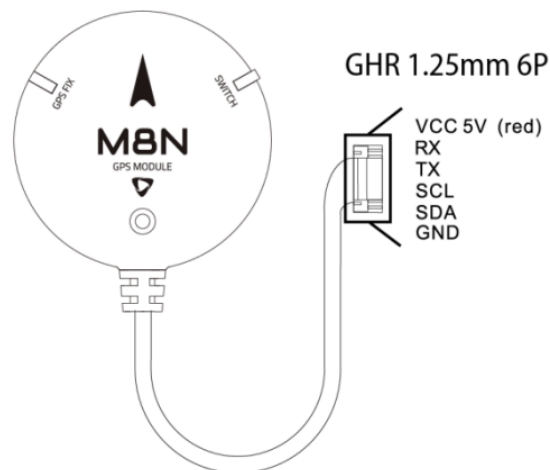
This sensor was chosen due to it out-matching or out-performing the other modules in the following parameters:

- Good positional accuracy of 2m².
- Having a sealed case to enclose the IC, as the others are supplied as exposed circuits boards. The others would require installation inside the main control circuit's enclosure. So this module can be installed externally, which allows the main enclosure to be smaller and easier to handle.
- Can communicate via the PIC's I2C inputs.
- Requires 5v supply which matches Microchip's PIC supply. [17]

Figure 45 shows the dimensions of this module, including the sealed enclosure for mounting the module externally to the main circuit's enclosure. Figure 46 shows the pin out of the supply cable, including the I2C and UART connections.



[67] Figure 45 - M8N GPS Module Dimensions



[67] Figure 46 - SKU12014 Holybro M8N 2nd GP

6.1.13. Comparison of VOC (Volatile Organic Compounds) Level Sensors

Table 8 shows a comparison of VOC level sensors.

Name of Sensor	Taidacent Air Quality Sensor TVOC Detector Volatile Organic Compounds Monitor VOC Meter [69] [70]	Titon TP540 Room sensor VOC 0 – 10VDC [71] [72]	Aeroqual Series 930 – IP65 Fixed VOC Monitor [73] [74] [75] [76]	S+S Regeltechnik Multifunctional on-wall sensors and measuring transducers, for CO ₂ content and air quality (VOC) AERASGARD® ALQ-CO ₂ -W [77] [78]
Image of Sensor	 [70] Figure 47 - Taidacent Air Quality Sensor TVOC Detector Volatile Organic Compounds Monitor	 [71] Figure 48 - TP540 Room sensor VOC 0 – 10VDC	 [73] Figure 49 - Series 930 – IP65 Fixed VOC Monitor	 [77] Figure 50 - Multifunctional on-wall sensors and measuring transducers, for CO₂ content and air quality (VOC) AERASGARD® ALQ-CO₂-W
Supply Voltage	10-30V DC	12-35V DC	12V DC	24V DC
Output	0-5V DC	0-10V DC	10-30V DC	0-10V DC
Operating Current	40mA	125mA	800mA	200mA
Pins	No data	6	6, RS 485	3
Supplier	- Manufacturer - Taidacent - Seller - Shenzhen Taida Century Technology Co.,Ltd.	Titon	Aeroqual	S+S Regeltechnik
Product Code	TDJLTVOCGASMONITOR	Part Number – TP540	Series 930	WG02
Cost	\$87.08	Requires quote	\$1,160.00	530,92 €

Working Temperature Range	-40-+85°C	0-+50°C	0-+40°C	-35-+80°C
Response time	2s	No data	30s	2mins
Measurement Range	0-60000ppb	0 – 10000 µg/m ³	0-2000ppm	0-5000ppm
Measurement Accuracy	±125ppb	No data	0.01ppm	'±20% of final value (referred to calibrating gas)' [77]
Resolution	1ppb	No data	0.01ppm	No data
Weight	No data	No data	850g	No data
Dimensions	110x85x44mm	90x80x31mm	180x110x90mm	126x90x50mm
IP Rating	No data	IP20	IP65	IP65 according to EN 60 529 [77]

Table 8 - Comparison of VOC Level Sensors

6.1.14. Best Suited VOC Sensor

S+S Regeltechnik Multifunctional on-wall sensors and measuring transducers, for CO₂ content and air quality (VOC) AERASGARD® ALQ-CO₂-W

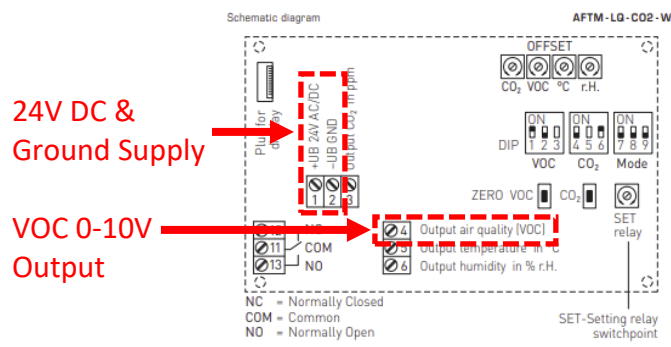
This sensor was chosen for this device as it out-matched or out-performed the other sensors in the following parameters:

- Can operate in temps down to -35°C, which is below the lowest recorded UK temperature. [35]
- Is rated to IP65, which is essential for an outdoor sensor.

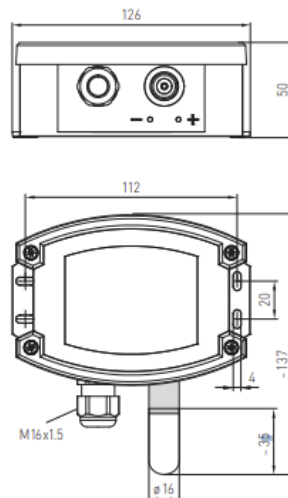
The supply and output voltages do not match the maximum voltage for a PIC of 5V [17], so the supply will require boosting and the sensor's output will require reduction via a voltage divider.



[77] Figure 51 - Multifunctional on-wall sensors and measuring transducers, for CO₂ content and air quality (VOC) AERASGARD® ALQ-CO₂-W



[78] Figure 52 - AERASGARD® AFTM - (LQ) - CO₂ -W Schematic Diagram

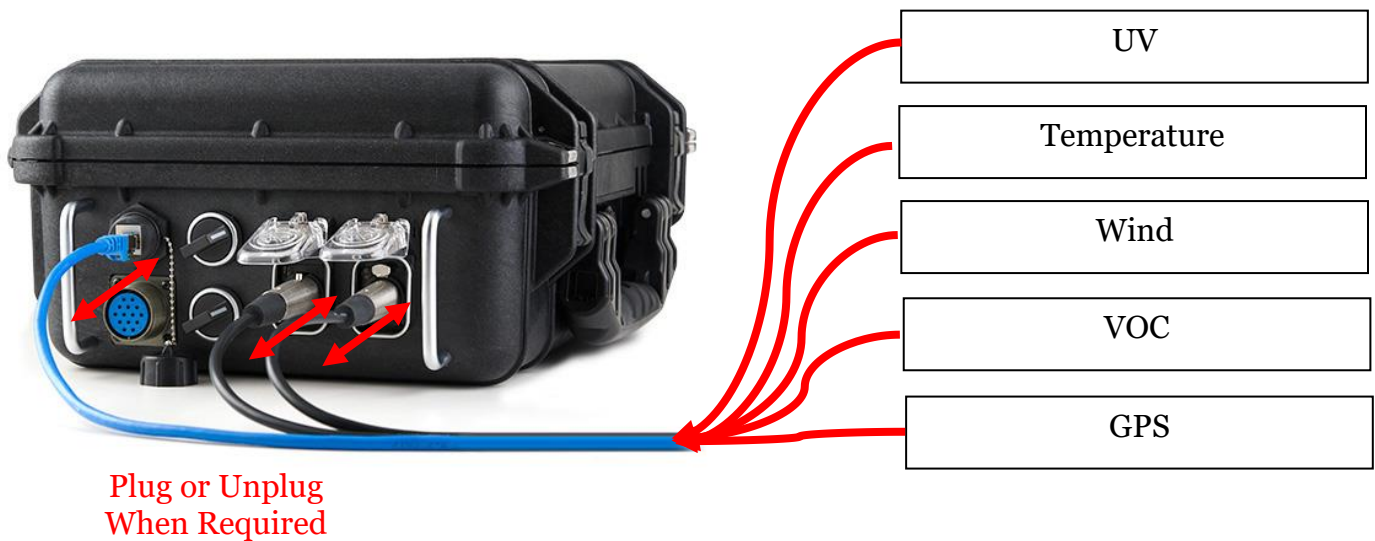


[78] Figure 53 - AERASGARD® AFTM - (LQ) - CO₂- W/ATM - CO₂- SD Dimensional Drawing

6.2. Selection of Connectors

This weather data acquisition device must be plug and play. This means that it must be possible to unplug each sensor and separate them from the main control unit (enclosure containing the PIC microcontroller), and plug them in when measurements are required. In order to fulfill this capability, the best suited connectors for each must be selected after comparing them against others found online. Figure 54 illustrated this plug and play requirement.

To prevent sensors being connected in an incorrect order, each connector must have a varying number of pins. Sensors being connected incorrectly will cause damage due to overvoltage, with each sensor requiring a different supply or providing a different output voltage. The connectors must be sealed to prevent water and dust ingress.



[79] Figure 51 - Demonstration of Plug and Play Capability Requirement

5.4.1. Required Pin Counts

Table 9 shows the minimum number of connector pins required for each sensor.

Type of Sensor	Minimum Number of Pins Required
Wind speed and direction	6
Temperature and humidity	4
Air borne particle count	3
Sunlight brightness	4
UV	4
GPS	6
VOC	3

Table 9 - Number of Pins Required for Each Sensor

6.2.2. Comparison of connectors

Some different ranges of connectors are available, with each range offering numerous pin counts. These different ranges will be compared to identify the most robust and sealed connector for this outdoor weather data acquisition application.

6.2.3. Comparison of Male Connectors

Range of Connectors	Binder Series 423 Connectors [80] [81]	Amphenol MS3106A Cable Mount MIL Spec Circular Connector [82] [83] [84]	Binder 430 Cable Mount Connector [85] [86]	HARTING Han A Heavy Duty Power Connector Insert (Han Series) [87] [88] [89] [90]
Image of Connector	 [81] Table 10 - Binder Miniature Connectors Series 423	 [84] Figure 52 - Amphenol Industrial, MS3106A 3 Way Cable Mount MIL Spec Circular Connector	 [85] Figure 53 - Binder 430 Cable Mount Connector	 [91] Figure 54 - HARTING Han A Heavy Duty Power Connector Insert, 3 contacts, 10A, Male  [90] Figure 55 - HARTING Han A, 3A Top Entry Heavy Duty Power Connector Hood
Available Pin Counts	2-24	1-85	3-8	3-32 (3+PE)
Wire Size	0.25mm ² max core size 4-6mm cable outlet	Max core size ranges between 16AWG/1.29mm ² and max of 0AWG/8.25mm ² . 0.305"-2.145" cable outlet.	0.14-0.25mm ²	Max wire gauge – 2.5mm ²
Current Rating	1A – 24x contacts 3A – 12-19 contacts 5A – 6-8 contacts 6A – 5-4 contacts	Size 16 – 22A Size 12 – 41A Size 8 – 46A Size 4 – 80A	1A - 7-8 contacts 3A – 4-5 contacts 4A – 3 contacts	10A – 3 contacts 10A – 4 contacts 16A – 5 – 32 contacts

	7A – 3-2 contacts	Size 0 – 150A		
Termination Type	Solder	Solder	Solder	Screw
IP rating	IP67	IP67	IP67	IP65
Dimensions	3pin - 60x18.5mm M16x0.75mm	3pin 10SL connector Length – 2.031”/ 51mm Dia – 0.864”/ 21.94mm	48.6x14.5mm	27x21mm
Supplier	- Manufacturer – Binder - Seller – RS-Online	- Manufacturer – Amphenol - Seller – RS-Online	- Manufacturer – Binder - Seller – RS-Online	- Manufacturer – Harting - Seller – RS-Online
Product Code	- RS Stock No.: 807-2845 - Mfr. Part No.: 99-5105-210-03	- RS Stock No.: 475-814 - Mfr. Part No.: MS3106A-10SL-3P	- RS Stock No.: 706-4537 - Mfr. Part No.: 99-4905-00-03	- RS Stock No.: 181-0858 - Mfr. Part No.: 09200032611
Costs	£26.24 (3 contacts)	£19.63 (3 contacts)	£18.54 (3 contacts)	£13.75 + £9.80 for hood [90]
Contact Material	Silver plated bronze	Silver plated copper	Gold plated brass	Copper
Operating Temperature Range	-30-+95°C	-55-+125°C	-25-+85°C	-40-+125°C
Mating Type	Screw	Screw	Push-pull	Push-pull, with a single locking lever
Housing Material	Nickel plated zinc	Zinc plated aluminium, with olive drab chromate treatment	Polyamide (PA)	Power-coated zinc die-cast

Table 11 - Comparison of Male Cable Connectors

6.2.4. Comparison of Female Box Mount Connectors

Range of Connectors	Circular Connector, 423/723/425 Series, Flange Mount Receptacle, 3 Contacts, Solder Socket [92] [93]	Amphenol Industrial, MS3102A 3 Way Box Mount MIL Spec Circular Connector Receptacle [94] [83]	Binder 430 Panel Mount Connector, 3 Contacts, M12 Connector, Socket [95] [96]	HARTING Surface Kit, 3 + PE Way, 10.0A, Female, Han A [97] [88]
Image of Connector	 [92] Figure 56 - Circular Connector, 423/723/425 Series, Flange Mount Receptacle, 3 Contacts, Solder Socket	 [94] Figure 57 - Amphenol Industrial, MS3102A 3 Way Box Mount MIL Spec Circular Connector Receptacle	 [95] Figure 58 - Binder 430 Panel Mount Connector	 [97] Figure 59 - HARTING Surface Kit, 3 + PE Way, 10.0A, Female, Han A
Available Pin Counts	2-24	1-85	3-8	3-32 (3+PE)
Wire Size	0.25mm ² max core size 4-6mm cable outlet	Max core size ranges between 16AWG/1.29mm ² and max of 0AWG/8.25mm ² . 0.305"-2.145" cable outlet.	0.14-0.25mm ²	Max wire gauge – 2.5mm ²
Current Rating	1A – 24x contacts 3A – 12-19 contacts 5A – 6-8 contacts 6A – 5-4 contacts 7A – 3-2 contacts	Size 16 – 22A Size 12 – 41A Size 8 – 46A Size 4 – 80A Size 0 – 150A	1A - 7-8 contacts 3A – 4-5 contacts 4A – 3 contacts	10A – 3 contacts 10A – 4 contacts 16A – 5 – 32 contacts
Termination Type	Solder	Solder	Solder	Screw
IP rating	IP67	IP67	IP67	IP65
Dimensions	26x26x18.1mm	25.40x25.40x41.10 mm	19.2x17.5mm M13x0.5mm	40.50x40.00x24.00m m
Supplier	Manufacturer – Binder	Manufacturer – Amphenol	Manufacturer – Binder	Manufacturer – Harting

	• Seller – Farnell	• Seller – RS-Online	• Seller – RS-Online	• Seller – RS-Online
Product Code	• Manufacturer Part No - 09-0108-300-03 • Order Code - 2949679	• RS Stock No.: 475-707 • Mfr. Part No.: MS3102A-10SL-3S	• RS Stock No.: 706-4657 • Mfr. Part No.: 09-4908-00-03	• RS Stock No.: 473-1360 • Mfr. Part No.: 09200030301+09200032711
Costs	£7.20 (3 contacts)	£15.32 (3 contacts)	£14.10 (3 contacts)	£25.82
Contact Material	Silver plated bronze	Silver plated copper	Gold plated brass	Copper
Operating Temperature Range	-30-+95°C	-55-+125°C	-25-+85°C	-40-+125°C
Mating Type	Screw	Screw	Push-pull	Push-pull, with a single locking lever
Housing Material	Nickel plated zinc	Zinc plated aluminium, with olive drab chromate treatment	Nickel plated steel	Power-coated zinc die-cast

Table 12 - Comparison of Female Box Mount Connectors

6.2.5. Best Suited Cable Connector

6.2.5.1. Male Connector

Amphenol MS3106A Male & MS3102A Female Cable Mount MIL Spec Circular Connectors [82] [83] [84]

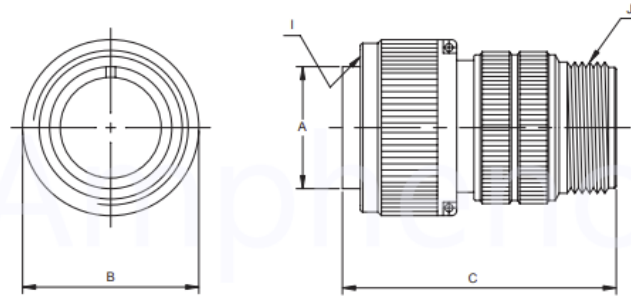
This range of male cable connectors were chosen due to them out-matching or out-performing the other connectors in the following parameters:

- Tough zinc plated aluminium casing is more lightweight than the steel 423 Binder and zinc Harting Han connectors, as well as more corrosion resistant than the plated steel Binder connectors. The polyamide Binder 430 connectors casing will not be as impact resistant as aluminium or steel.
- Larger range of temperature resistance than the other 3 connectors (-55°C - +125°C).
- Screw connectors are more secure than push fit and lever as push fit can be pulled out accidentally, and levers can be bumped, which could flip the lever open and release the connector.
- IP67 rating is waterproof.
- Solder connections are very secure.
- Greatest current rating as the 3pin size 16 has a rating of 22A, which is more than the other 3 pin connectors.
- Cable cover is available to prevent dust and moisture ingress when disconnected. [98]

Figure 60 shows the connector. The device mounted connectors are female to ensure no live conductors are exposed when the device is powered up. Figure 61 shows the dimensions of each connectors.



[84] Figure 60 - Amphenol Industrial, MS3106A 3 Way Cable Mount MIL Spec Circular Connector



(mm)

Shell Size	$\varnothing A$ +0.00 -0.38	$\varnothing B$ Max	C Max	I Thread-2B (UNEF)	J Thread-2A (UNEF)
10SL	11.33	24.61	38.88	5/8-24 NEF	5/8-24 NEF
12S	14.10	26.97	42.87	3/4-20 NEF	5/8-24 NEF
12	14.10	26.97	52.37	3/4-20 NEF	5/8-24 NEF
14S	17.15	29.36	42.87	7/8-20 NEF	3/4-20 NEF
14	17.15	29.36	52.37	7/8-20 NEF	3/4-20 NEF
16S	20.45	31.75	42.87	1-20 NEF	7/8-20 NEF
16	20.45	31.75	52.37	1-20 NEF	7/8-20 NEF
18	23.62	34.13	52.37	1 1/8-18 NEF	1-20 NEF
20	26.67	37.31	55.57	1 1/4-18 NEF	1 3/16-18 NEF
22	29.85	40.48	55.57	1 3/8-18 NEF	1 3/16-18 NEF
24	33.02	43.66	58.72	1 1/2-18 NEF	1 7/16-18 NEF
28	38.61	50.01	58.72	1 3/4-18 NS	1 7/16-18 NEF
32	44.96	56.36	67.92	2-18 NS	1 3/4-18 NS
36	50.29	62.71	67.92	2 1/4-16 UN	2-18 NS

[83] Figure 61 - Amphenol MIL-C-5015 Connectors MS3106A Straight Plug 3 Way Dimensions (mm)

Required Male Connectors						
Sensor	Connector Code	Pin Count	Supplier	Supplier Codes	Price	Ref
Air borne particle count	10SL-3  [84] Figure 62 - Amphenol Industrial, MS3106A 3 Way Cable Mount MIL Spec Circular Connector	3	- Manufacturer – Amphenol - Seller – RS-Online	- RS Stock No.: 475-814 - Mfr. Part No.: MS3106A-10SL-3P	£19.63	[84]
Temp & Humidity	14S-2  [99] Figure 63 - Amphenol, MS3106A 4 Way Cable Mount MIL Spec Circular Connector	4	- Manufacturer – Amphenol - Seller – RS-Online	- RS Stock No.: 298-2465 - Mfr. Part No.: MS3106A-14S-2S	£31.31	[99]
Sunlight	14S-5  [100] Figure 64 - Amphenol 5 Position Circular Connector Plug	5	- Manufacturer – Amphenol - Seller – Digikey	- Digi-Key Part No. - 97-3106A-14S-5P-ND - Mfr. Part No.: 97-3106A-14S-5P	\$24.10 - £19.66	[100]
UV	14S-6  [101] Figure 65 - Amphenol Industrial, MS3106A 6 Way Cable Mount MIL Spec Circular Connector	6	- Manufacturer – Amphenol - Seller – RS-Online	- RS Stock No.: 475-836 - Mfr. Part No.: MS3106A-14S-6P	£20.54	[101]

GPS	 [102] Figure 66 - Amphenol, MS3106A 7 Way Cable Mount MIL Spec Circular Connector	7	• Manufacturer – Amphenol • Seller – RS-Online	• RS Stock No.: 298-2421 • Mfr. Part No.: MS3106A-16S-1P	£22.84	[102]
Wind speed & direction	 [103] Figure 67 - 97-3106A-20-7P Circular Connector, 97 Series, Straight Plug, 8 Contacts, Solder Pin, Threaded, 20-7	8	• Manufacturer – Amphenol • Seller – Newark	• Newark Part No. - 27W9041 • Mfr. Part No.: 97-3106A-20-7P	\$57.91 - £47.25	[103]
VOC	 [104] Figure 68 - Circular Connector, 97 Series, Straight Plug, 9 Contacts, Solder Pin, Threaded, 22-20	9	• Manufacturer – Amphenol • Seller – Newark	• Newark Part No. - 92F5584 • Mfr. Part No.: 97-3106A-22-20P	\$42.34 - £34.54	[104]
Total Costs					£195.77	

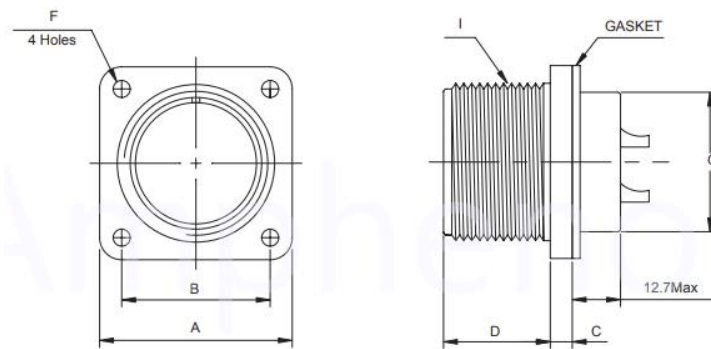
Table 13 - Required Male Connectors

6.2.5.2. Female Connector

These connectors were chosen as they can be mounted to the device's enclosure, allowing the sensors to be plug and play. These are female to ensure no exposed live conductors are present when the device is powered up and attempting to provide voltage to the sensors.



[94] Figure 69 - Amphenol Industrial, MS3102A 3 Way Box Mount MIL Spec Circular Connector Receptacle



(mm)

Shell Size	□ A ±0.79	□ B ±0.12	C ±0.5	D +0.79 -0.00	Ø F +0.25 -0.12	Ø G Max	I Thread-2A (UNEF)
10SL	25.40	18.26	3.0	14.28	3.05	16.0	5/8-24 NEF
12S	27.79	20.62	3.0	14.28	3.05	16.5	3/4-20 NEF
12	27.79	20.62	3.0	19.05	3.05	16.5	3/4-20 NEF
14S	30.18	23.01	3.0	14.28	3.05	20.0	7/8-20 NEF
14	30.18	23.01	3.0	19.05	3.05	20.0	7/8-20 NEF
16S	32.54	24.61	3.0	14.28	3.05	23.0	1-20 NEF
16	32.54	24.61	3.0	19.05	3.05	23.0	1-20 NEF
18	34.93	26.97	4.0	19.05	3.05	26.0	1 1/8-18 NEF
20	38.10	29.36	4.0	19.05	3.05	29.0	1 1/4-18 NEF
22	41.28	31.75	4.0	19.05	3.05	32.0	1 3/8-18 NEF
24	44.45	34.93	4.0	20.63	3.73	35.5	1 1/2-18 NEF
28	50.80	39.67	4.0	20.63	3.73	42.0	1 3/4-18 NS
32	57.15	44.45	4.0	22.23	4.39	48.0	2-18 NS
36	63.50	49.23	4.0	22.23	4.39	55.0	2 1/4-16 UN

[93] Figure 70 - MS3102A 3 Way Box Mount Connector Dimensions (mm)

Required Female Connectors						
Sensor	Connector Code	Pin Count	Supplier	Supplier Codes	Price	Ref
Air borne particle count	10SL-3  <i>[105] Figure 71 - Amphenol Industrial, MS3102A 3 Way Box Mount MIL Spec Circular Connector Receptacle</i>	3	- Manufacturer – Amphenol - Seller – RS-Online	- RS Stock No.: 475-707 - Mfr. Part No.: MS3102A-10SL-3S	£15.32	[105]
Temp & Humidity	14S-2  <i>[106] Figure 72 - Amphenol, MS3102A 4 Way Box Mount MIL Spec Circular Connector Receptacle</i>	4	- Manufacturer – Amphenol - Seller – RS-Online	- RS Stock No.: 298-2465 - Mfr. Part No.: MS3106A-14S-2S	£14.29	[106]
Sunlight	14S-5  <i>[107] Figure 73 - Threaded MS3102A14S-5S 5Pin Socket Female Box Mounting Solder Cup</i>	5	- Manufacturer – Amphenol - Seller – Metabee	- SKU - ID20220400205 - Mfr. Part No.: MS3102A14S-5S	\$6.57 - £5.36	[107]
UV	14S-6  <i>[108] Figure 74 - Amphenol Industrial, MS3102A 6 Way Box Mount MIL Spec Circular Connector Receptacle</i>	6	- Manufacturer – Amphenol - Seller – RS-Online	- RS Stock No.: 475-729 - Mfr. Part No.: MS3102A-14S-6S	£14.04	[108]

GPS	16S-1  [109] Figure 75 - Amphenol, MS3102A 7 Way Box Mount MIL Spec Circular Connector Receptacle	7	• Manufacturer – Amphenol • Seller – RS-Online	• RS Stock No.: 298-2588 • Mfr. Part No.: MS3102A-16S-1S	£26.38	[109]
Wind speed & direction	20-7  [110] Figure 76 - 97-3102A-20-7S Amphenol Connector: circular; size 20	8	• Manufacturer – Amphenol • Seller – TME	• TME Part No. - 97-3102A-20-7S • Mfr. Part No.: 97-3102A-20-7S	£27.63	[110]
VOC	22-20  [111] Figure 77 - 97-3102A-22-20S CONN RCPT FEMALE 9P SOLDER CUP	9	• Manufacturer – Amphenol • Seller – Digi-Key	• Digi-Key Part No. - 97-3102A-22-20S-ND • Mfr. Part No.: 97-3102A-22-20S	£28.26	[111]
Total Costs					£131.28	

Table 14 - Required Female Connectors

6.3. Current Draw

Table 13 shows the current draw of every sensors, modules, and the microcontroller connected to the device in milliampere-hours (mAh), as well as the total current draw over the 2 week test period. There are 336 hours in two weeks, so the total mAh of the sensors will be multiplied by 336 to determine the total current drawn.

Current draw in milliampere-hours is calculated with the simple formula : $(A) \times (h) \times 1000 = mAh$. [112]

Device/Sensor Name	Current Draw	References
Microchip PIC18F25K50	0.0008mAh	[17]
Wind Speed & Wind Direction Sensors	20mAh	[13]
Temperature & Humidity Sensors	0.75mAh	[25]
Air Borne Particle Count Sensor	100mAh	[28]
Sunlight (LUX) Sensor	20mAh	[38]
UV Sensor	1.8mAh	[54]
GPS Module	150mAh	[67]
Volatile Organic Compounds Sensor	200mAh	[78]
Total amps drawn over the 2 week period =	Total = 492.55mAh Total for the 2 week test = 165497.07mA = 165.5Ah	

Table 15 - Calculation of Total Current Draw Over the 2 Week Test Period

6.4. Battery and Holder Selection

6.4.1. Battery

Table 15 showed that 165.5Ah will be drawn by the device of the two weeks. A battery must be selected that has the capacity to supply the device for this time period.

High Power Wholesale Sealed Lead Acid Battery 12V 200Ah Gel 12V200Ah Battery [113]



[113] Figure 78 - High Power Wholesale Sealed Lead Acid Battery 12V 200Ah Gel 12V200Ah Battery

Table 16 shows the specifications of this battery. Figure 82 shows the dimensions of the battery in mm.

Battery Specifications [113]	
Supplier	- Manufacturer – CBL/OEM - Seller – Shenzhen Czw Technology, Alibaba
Product Codes	Model number - 12-24-48V-100A -009PL
Battery Type	LiFePO ₄ Battery, LFP anode material
Nominal voltage	12V
Capacity	200Ah
Weight	22kg
Dimensions	525 x 270 x 220mm
Rechargeable?	Yes
Life Cycle	2000-4000 charges
Price	\$1,050.64USD, £859.00

Table 16 - Battery Specifications

6.5. Microcontroller Selection

6.5.1. Pin Count Required

The PIC Microcontroller must receive data from all of the sensors that are connected, and store the data into the connected SD card. This SD card can then be removed and connected to a pc for an operator to read the recorded data.

To determine the best suited PIC Microcontroller, the amount of pins and communication interfaces must be established. The data transmission connections for each sensor have been identified and included in table 17 below.

Summary of Connections to the PIC's Pins

Device	Required Pins on PIC
Wind Speed & Wind Direction Sensors	2 analog pins
Temperature & Humidity Sensors	2 analogue pins (PDM)
Air Borne Particle Count Sensor	1 x digital input (PWM)
Sunlight (LUX) Sensor	1 x analog pin
UV Sensor	1 x analog pin
GPS Module	2 x I2C
Volatile Organic Compounds Sensor	1 x analog pin
USB	2 data pins (D+/D-)
SD Card	4 data pins (DI & DO), CLK, & CS
Power On LED	1 Pin
Power on/off switch	1 Pin
Power on LED	1 Pin
Supply	4 Pins
Total Pins =	23 pins

Table 17 - Summary of Required PIC Microcontroller Pins

6.5.2. Timeline of Data Being Logged by the PIC Microcontroller

From looking at the datasheets to determine the response times of each sensor, the timeline of data that gets logged by the microcontroller are shown in table 18 below.

Time (secs)	Data Being Read by the PIC Microcontroller							
0.00	UV	GPS	Wind speed & direction	Sunlight brightness	Air borne particles	Relative Humidity	Temperature	VOC
0.001	UV							
0.2	UV	GPS						
0.4	UV	GPS						
0.6	UV	GPS						
0.8	UV	GPS						
1	UV	GPS	Wind speed & direction	Sunlight brightness				
2	UV	GPS	Wind speed & direction	Sunlight brightness				
3	UV	GPS	Wind speed & direction	Sunlight brightness	Air borne particles			
29	UV	GPS	Wind speed & direction	Sunlight brightness	Air borne particles	Relative Humidity		
116	UV	GPS	Wind speed & direction	Sunlight brightness	Air borne particles	Relative Humidity	Temperature	
120	UV	GPS	Wind speed & direction	Sunlight brightness	Air borne particles	Relative Humidity	Temperature	VOC

Table 18 - Timeline of Data Stored in the PIC Microcontroller

6.5.3. Data Being Stored in the SD Card (Non-Volatile Memory)

Measurement Variable	Bytes Per Reading	Response Time	Number of Bytes Per Minutes	Total Minutes in 2 Weeks	Total Data (Bytes)
UV	2 bytes	1 ms / 1000Hz	120000	20160	2419200000
GPS	1 byte UART [114]	0.2s / 5Hz	300	20160	6048000
Wind Speed	2 bytes	1 s / 1Hz	120	20160	2419200
Wind Direction	2 bytes	1 s / 1Hz	120	20160	2419200
Sunlight Brightness	2 bytes	1 s / 1Hz	120	20160	2419200
Relative humidity	2 bytes PWM [115]	29 s / 0.034Hz	4	20160	80640
Temperature	2 bytes PWM [115]	116 s / 0.0086Hz	1.032	20160	20805
VOC	2 bytes	120 s / 0.0083Hz	1	20160	20160
Air borne paticle count	2 bytes	2s / 0.5Hz	60	20160	1209600
				Total Data for the Full 12 days =	2433836805 bytes 2.433 gigabytes (GB)

Table 19 - Data Being Stored in the SD Card (Non-Volatile Memory)

After adding up all of the data being recorded over the 14 day test period in bytes, the total data that will be recorded by the device is 2.433 gigabytes, shown in table 19. An SD card that can contain this much data is required. An SD card with a memory capacity of 4GB at a price of £14.11 is available on RS-Online. [116] RS Stock No. : 758-2556, Manufacturer's Part No. : TS4GSDHC4, Brand : Transcend



[116] Figure 79 - Transcend 4 GB SDHC SD Card

6.5.4. PIC Microcontroller Comparison

Microchip's online website offers a 'parametric search' tool that allows buyers to input their device's requirements, and receive suggestions to the best suited microcontrollers that are currently available to purchase from Microchip. With the required parameters of the microcontroller having been determined in tables 18, 19 and 20. These including pin count, supply voltage, operational voltages, single USB channel, 1 x UART channel, 1 x I2C bus (SD card and GPS module connected to the same bus), and temperature range, the requirements were inputted into the parametric search engine.

Product	CPU Type	Program Memory Size (KB)	RAM (KB)	Max I/O Pins	CPU Speed (MIPS/DMIPS)	Pricing	Automotive Recommended	Functional Safety Support
☐ PIC18F24K20 Buy from Microchip	8-bit PIC MCU	16	768	25	16	1.6200	Yes	No
☐ PIC18F2458 Buy from Microchip	8-bit PIC MCU	24	2048	24	12	4.7100	Yes	No
☐ PIC18F24K11 Buy from Microchip	8-bit PIC MCU	16	3800	21	12	2.2200	Yes	No
☐ PIC18F2459 Buy from Microchip	8-bit PIC MCU	16	3800	22	12	2.5100	Yes	No
☐ PIC18F24K22 Buy from Microchip	8-bit PIC MCU	16	768	25	16	1.8900	Yes	No
☐ PIC18F24K50 Buy from Microchip	8-bit PIC MCU	16	2048	25	12	2.0400	Yes	No

Figure 80 - Microchip Parametric Search Engine Results

The PIC18F24K50 was chosen as this has sufficient I/O pins, RAM, and is low cost when compared with the others in figure 80. The cheaper PIC18F24K20 has an operating voltage of 1.8V-3.6V which is too low [117], and the PIC18F24K22 has less RAM which reduces the space for further additions to the device in future.

6.5.5. Selected Microcontroller (Microchip PIC18F24K50)

This PIC microcontroller was chosen from the parametric search engine as it has a large amount of available pins for the large amount of sensors being used, and for future expansion, is USB compatible, and was priced low when comparing the others' pin counts and RAM. Table 20 shows the specifications of the selected PIC.



[118] Figure 81 - Microchip PIC18F24K50

Microchip PIC18F24K50 Specifications [118]	
Pin Count	28
Operating voltages	2.3V – 5.5V
Price	£2.04
Supplier	Microchip
Product Code	PIC18F24K50
Operating temperatures	-40 - +125°C
ADC Channels	14
I2C Channels	1

Data EEPROM	256 bytes
USB	1 x USB transceiver, USB V2.0 compliant.
USART	1 x USART module.
I2C/SPI	Master Synchronous Serial Port (MSSP) module Supporting 3-Wire SPI (all four modes) and I2C™ Master and Slave modes [119]
Program memory size	16KB
USB Interface	Compatible, FS Device, Universal Serial Bus 2.0 Module

Table 20 - Microchip PIC18F24K50 Specifications

6.6. Enclosure Selection

The dimensions of the PCB design once produced by JLCPCB [120] were 69.50mm x 59.00mm.

The dimensions of the batteries are 525 x 270 x 220mm.

PELI 1630 Large Transport Case With Wheels and Retractable Handle [121]

This case has superb robustness to protect the device, and is sealed to IP67 to prevent any water or dust ingress onto the PCB. The female connectors can be fitted to the outer case. The box is large enough to contain the two batteries, and the PCB, which will be held securely in foam.



[121] Figure 82 - PELI 1630 Large Transport Case With Wheels and Retractable Handle



[121] Figure 83 - PELI 1630 Large Transport Case With Wheels and Retractable Handle

Peli Case Specifications [121]	
External dimensions	79,45 x 61,49 x 44,4 cm
Internal dimensions	70,36 x 53,29 x 39,37 cm
Operating temperatures	-40 °C and 99 °C
Buoyancy	Up to 158.76kg
IP rating	IP67
Manufacturer	Peli
Model Number	1630-000-110E
ASIN	B001JQLH2E
Price	£557.99

Table 21 - Peli 1630 Transport Case Specifications

6.7. Quote from JLCPCB

The 3D PCB model that was produced from the schematic design in EasyPC, was sent to JLCPCB. JLCPCB are an online custom PCB manufacturer that can provide an instant quote when a design is provided to them. The quote that was provided for this device is shown in figure 84. The price was £30.03, with £20.57 shipping.

JLCPCB will keep producing during the Chinese New Year holiday. [Learn More about our production and shipping schedule >](#)

JLCPCB GBP Order now My file Sign in 9

Standard PCB/PCBA **Advanced PCB/PCBA** **SMT-Stencil** **3D Printing**

Your upload has finished processing. Enter the project details below and we'll move on to checking all the individual layers to make sure that they're correct.

[← Back to Upload File](#) ✓ Success

Base Material FR-4 Aluminum Copper Core

Layers 1 2 4 High Precision PCB 6 8 10 12 14 16 18 20

Dimensions 79.5 * 71 mm

PCB Qty 5

Product Type Industrial/Consumer electronics Aerospace Medical

PCB Specifications

Different Design 1 2 3 4

Delivery Format Single PCB Panel by Customer Panel by JLCPCB

PCB Thickness 0.4 0.6 0.8 1.0 1.2 1.6 2.0

PCB Color Green Purple Red Yellow Blue White Black

Silkscreen White

Surface Finish HASL(with lead) LeadFree HASL ENIG

High-spec Options

Outer Copper Weight 1 oz 2 oz

Via Covering Tented Untented Plugged Epoxy Filled & Capped Copper paste Filled & Capped

Confirm Production file No Yes

Remove Order Number No Yes Specify a location

Flying Probe Test Fully Test Not Test

Gold Fingers No Yes
HASL is chosen, the fingers will be tinned. If gold fingers are needed, please choose ENIG.

45°finger chamfered No Yes

Charge Details

Special Offer £ 1.85

Via Covering £ 0.00

Surface Finish £ 0.01

Standard PCBA Price

Setup Fee £ 20.68

Stencil £ 6.79

Components -

Feeders Loading fee -

SMT Assembly -

Hand-soldering labor fee -

Manual Assembly -

Build Time

PCB: 2-3 days £ 0.00

Calculated Price **£ 30.03**
Additional charges may apply for special cases

NEXT

Shipping Estimate £ 20.57

✓ DHL Express Worldwide 2-4 business days

Weight 0.27kg

Welcome back, may I help you?

Write a message...

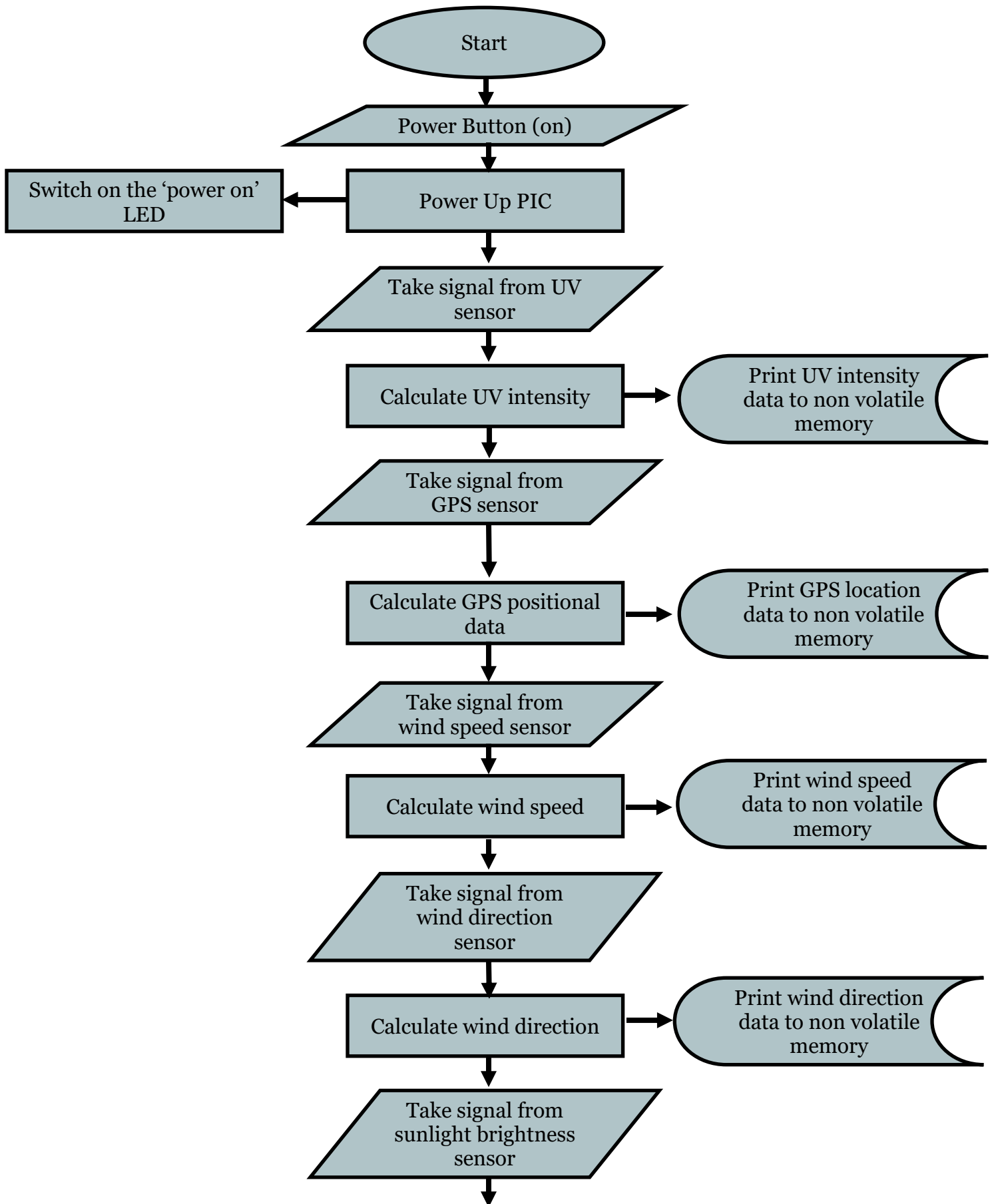
Figure 84 - JLCPCB Quote

6.8. Costings

Components	Costs	
	Price per Unit	Total Price
JLC PCB quote to build the circuit. (PCB board and full component assembly)	£30.03 + £20.57 shipping	£50.60
Raindao Pulse Output Integrated Wind Speed And Direction Sensor [13]	£156.04 + £19.56 shipping	£175.60
Amphenol Advanced Sensors T9602- 5-A Temperature and Humidity Sensor [24] [25] [26]	£47.57	£47.57
MLMLH PM2.5 Sensor - G5 PMS5003 PM2.5 Sensor [27] [28]	£28.29	£28.29
Rika 4-20mA 0-5V Analog Output Solar Light Sun Illumination Intensity Sensor [37] [38]	\$52 - £42.45	£42.45
Apogee Instruments SU-202-SS UV Sensor [53] [54] [55] [56]	\$925.98 - £755.91	£755.91
HOLYBRO- M8N - 2nd GPS Module #12014 [66] [67] [68]	\$49.00 - £40.00 + \$24.00 shipping - £19.59	£59.59
S+S Regeltechnik Multifunctional on- wall sensors and measuring transducers, for CO2 content and air quality (VOC) AERASGARD® ALQ-CO2- W [77] [78]	557,47 € - £493.17	£493.17
Male Connectors	£195.77	£195.77
Female Connectors	£131.28	£131.28
<i>High Power Wholesale Sealed Lead Acid Battery 12V 200Ah Gel 12V200Ah Battery</i>	£859.00	£859.00
Transcend TS4GSDHC4 4 GB SD Card	£14.11	£14.11
<u>PELI 1630 Large Transport Case</u>	£557.99	£557.99
	Total Projected Costs -	£3,411.33

Table 22 - Overall Costings

6.9. Flow Chart



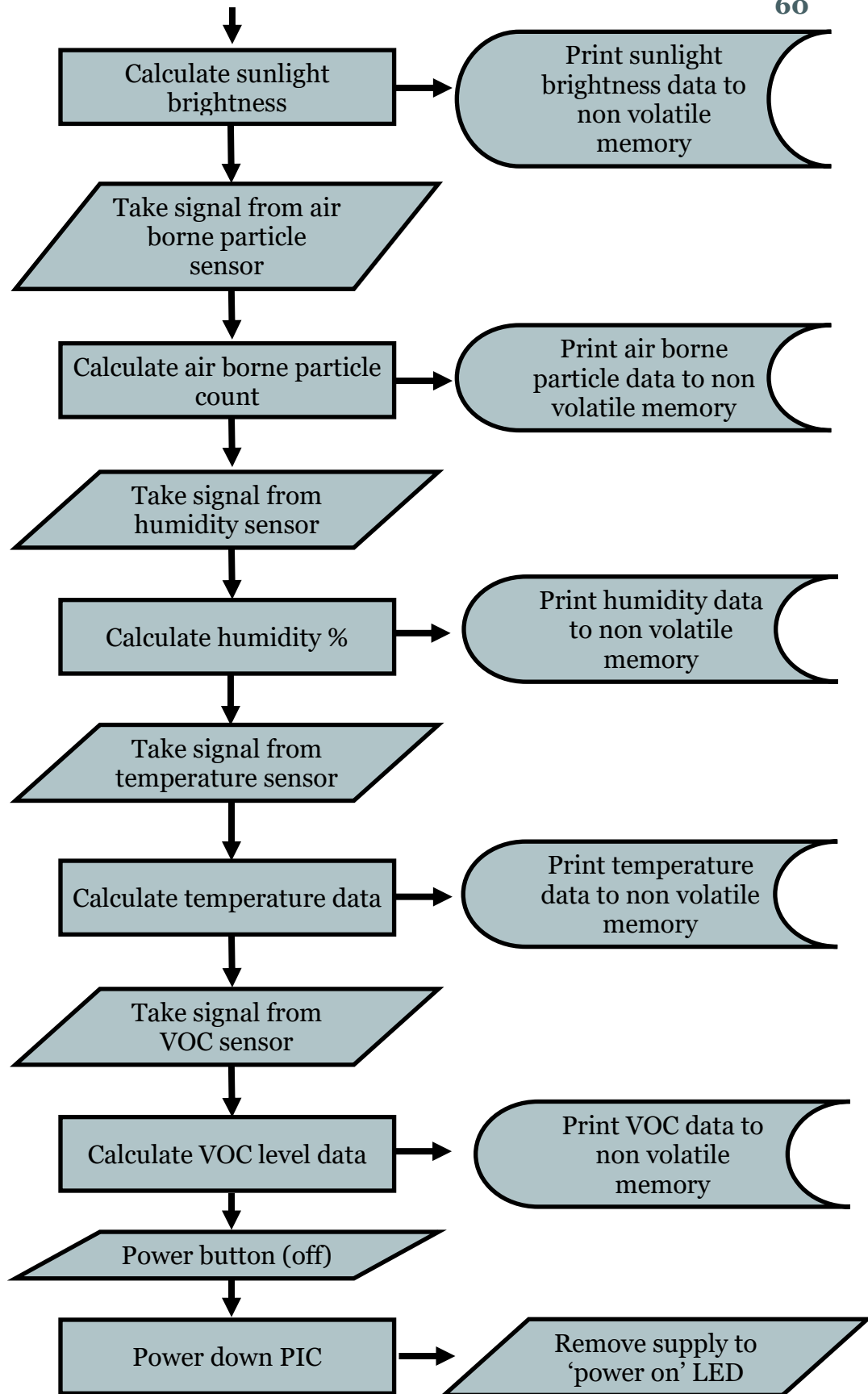


Figure 85 - Device Flow Chart

6.10. Software/System Structure Block Diagram

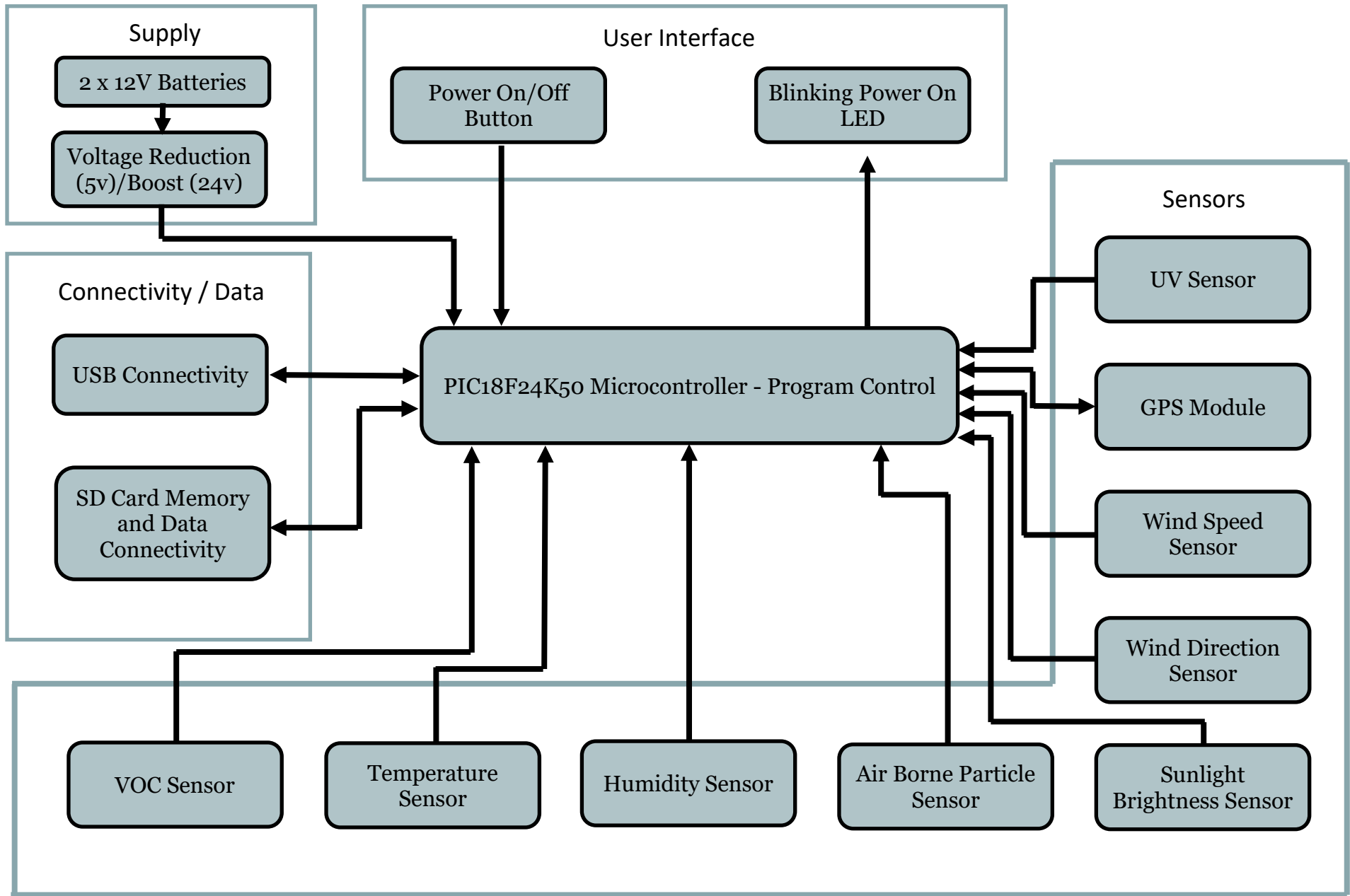
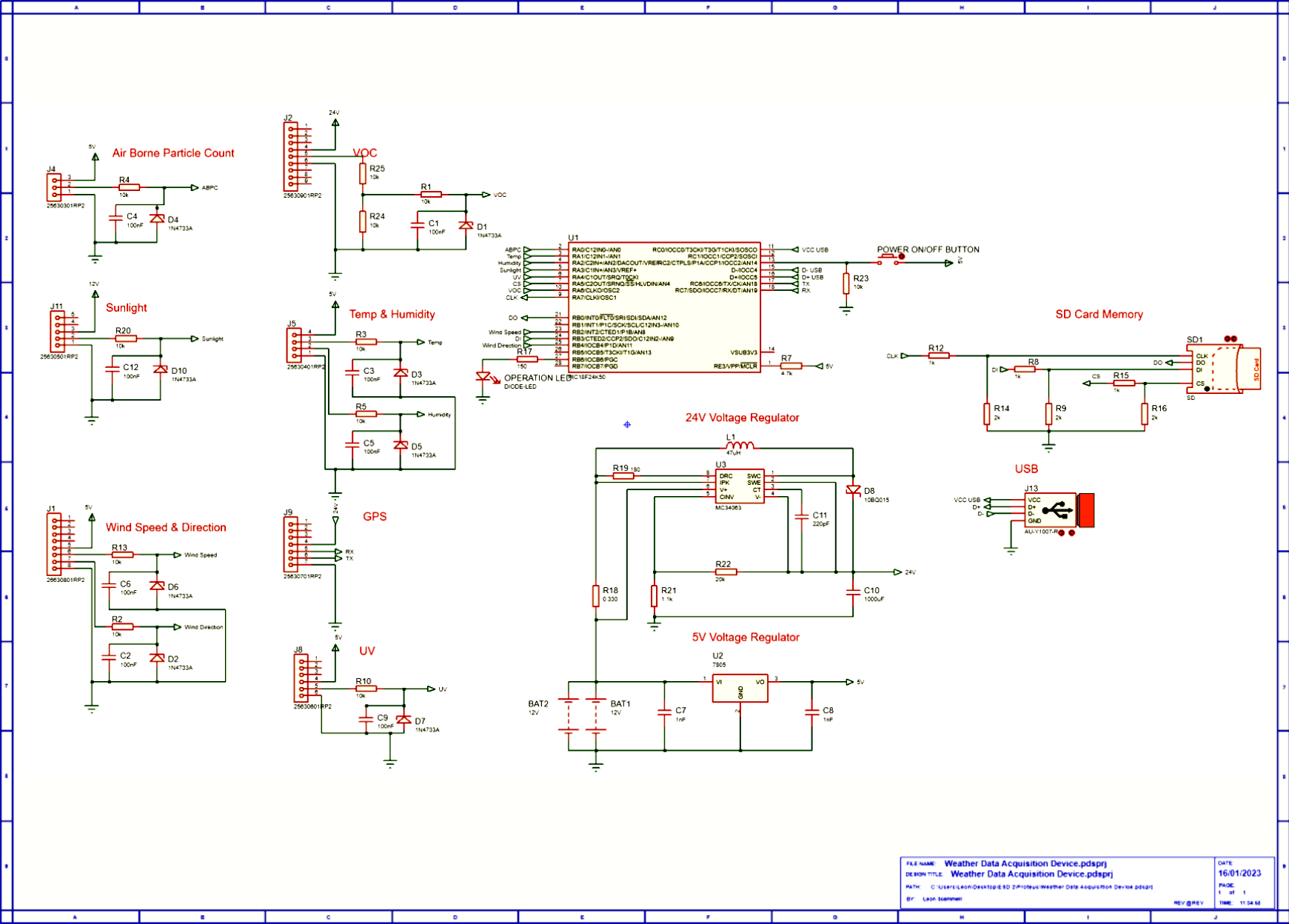


Figure 86 - Software/System Structure Block Diagram

6.11. Proteus Circuit Schematic Design



6.11.1. Explanation of Components

Batteries

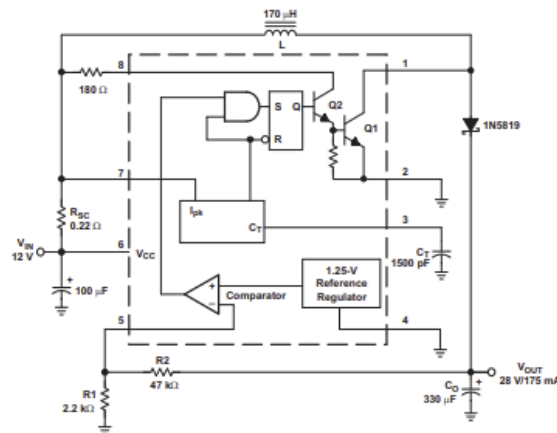
Two 12V rechargeable batteries were used as difficulty was encountered with finding batteries with smaller voltages that have sufficient charge capacity. Connecting two 100Ah batteries in parallel doubled the charge capacity.

5V Supply

The 12V supply was reduced to 5V to supply most of the sensors and the PIC microcontroller. This was done via an LM7805 voltage regulator by following the datasheet. [122] Two capacitors have been added to eliminate any voltage ripples in the DC supply.

24V Supply

In order to step up the voltage from 12V to 24V, an MC34063 Step-Up/Down/ Inverting Switching Regulator was implemented. To calculate the additional external components that were required, the datasheet includes the required calculations to determine the component values. Figure 87 shows the layout of the components around the converter, figure 88 shows the devices MC34063 implementation, and figure 89 displays the equations that were used to calculate the required components. The components with the nearest values were then implemented.



[123] Figure 87 - Example MC34063 Step - Up Converter

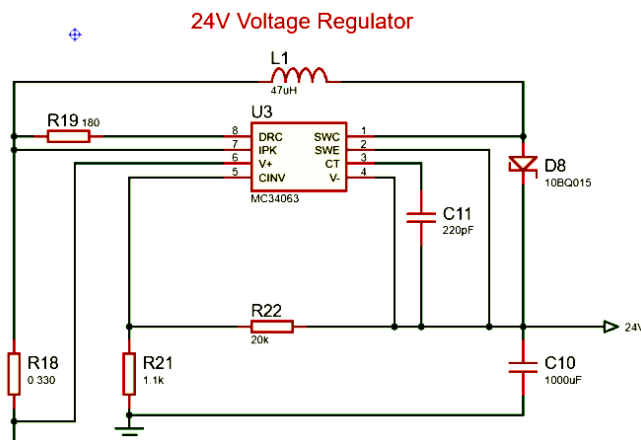


Figure 88 - Device's MC34063 Step-Up Converter

CALCULATION	STEP DOWN
t_{on}/t_{off}	$\frac{V_{out} + V_F}{V_{in(min)} - V_{sat} - V_{out}}$
$(t_{on} + t_{off})$	$\frac{1}{f}$
t_{off}	$\frac{t_{on} + t_{off}}{\frac{t_{on}}{t_{off}} + 1}$
t_{on}	$(t_{on} + t_{off}) - t_{off}$
C_T	$4 \times 10^{-5} t_{on}$
$I_{pk(switch)}$	$2 I_{out(max)}$
R_{SC}	$\frac{0.3}{I_{pk(switch)}}$
$L_{(min)}$	$\left(\frac{V_{in(min)} - V_{sat} - V_{out}}{I_{pk(switch)}} \right) t_{on(max)}$
C_O	$\frac{I_{pk(switch)} (t_{on} + t_{off})}{8 V_{ripple(pp)}}$
V_{out}	$1.25 \left(1 + \frac{R2}{R1} \right)$ See Figure 11

[124] Figure 89 - Design Procedure Calculation for MC34063

Sensors

All of the sensors were connected to the microcontroller via connectors with unique numbers of pins for each, which prevents connecting them in the wrong order, which will damage parts if voltages differ. Each sensor was connected via signal conditioning and clamps. The VOC output required a voltage divider to reduce the 0-10V output to 0-5V. The GPS connects to the UART pins (RX & TX) on the PIC.

SD Card

The SD card CLK was linked to the CLK1 pin on the PIC. And CS was linked to AN4, DI, and DO were connected to the PIC's SDI and SDO pins. The data transfer tracks were connected through voltage dividers to reduce the PIC's 5V outputs to 3.3V which the SD card works with.

USB

The USB was connected to the USB pins D+ and D- on the PIC.

Power On Button

A power on button was connected to pin AN14 via a switch and pull-down resistor.

Operation LED

The blinking operation LED was connected to a PIC output on pin 27.

6.12. Easy-PC Schematic

The Proteus schematic was then followed to produce another schematic on Easy-PC.

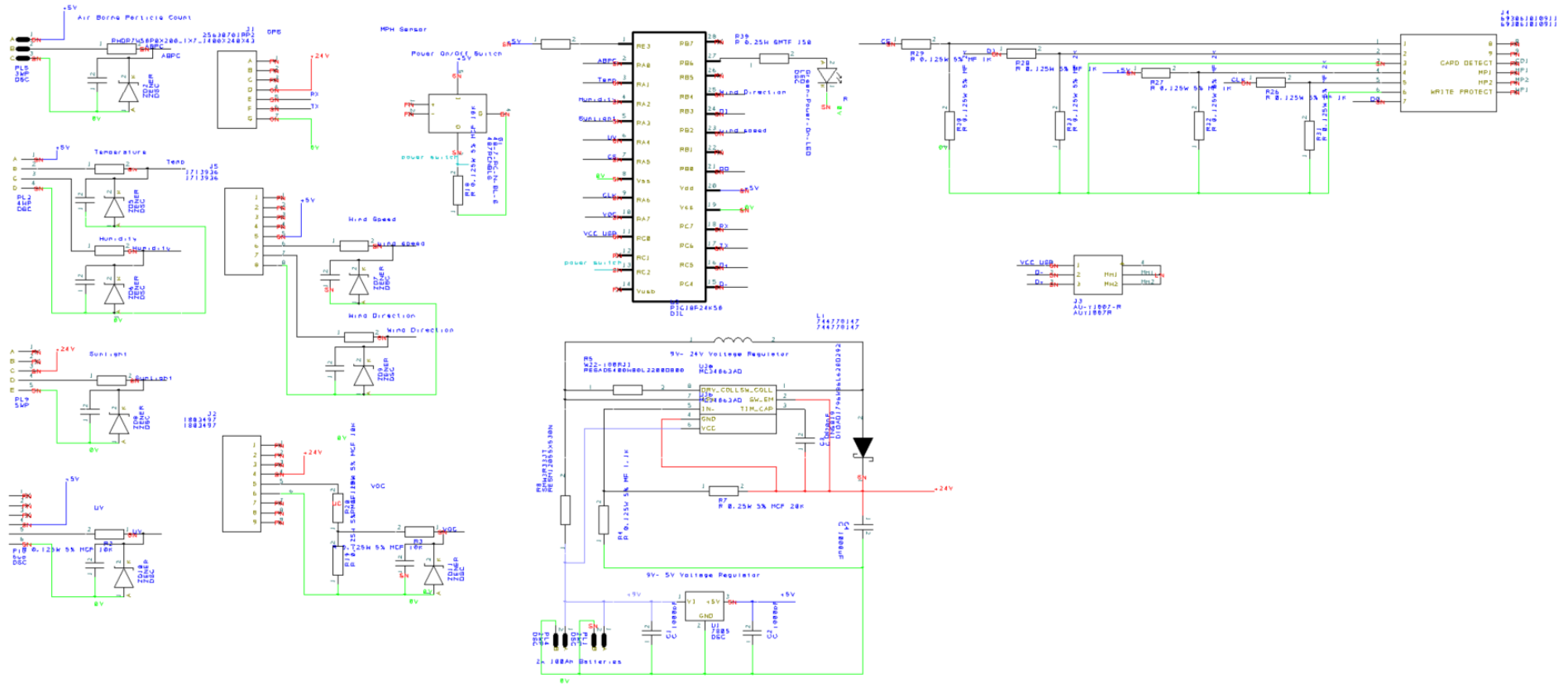


Figure 90 - Easy-PC Schematic Design

6.14. 3D View of the PCB Design

6.14.1. PCB Front

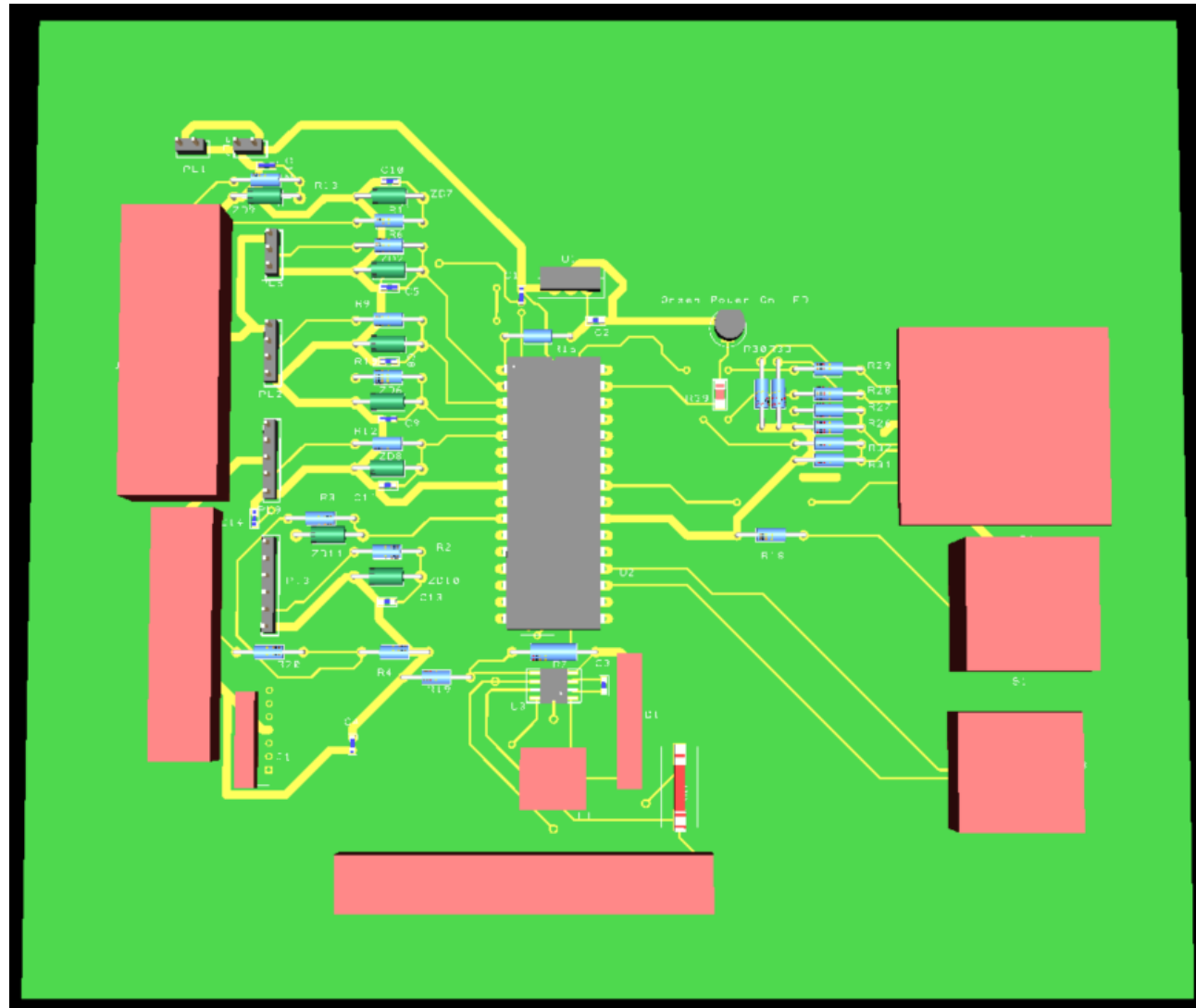


Figure 92 - 3D View of PCB (Front)

6.14.2. PCB Rear

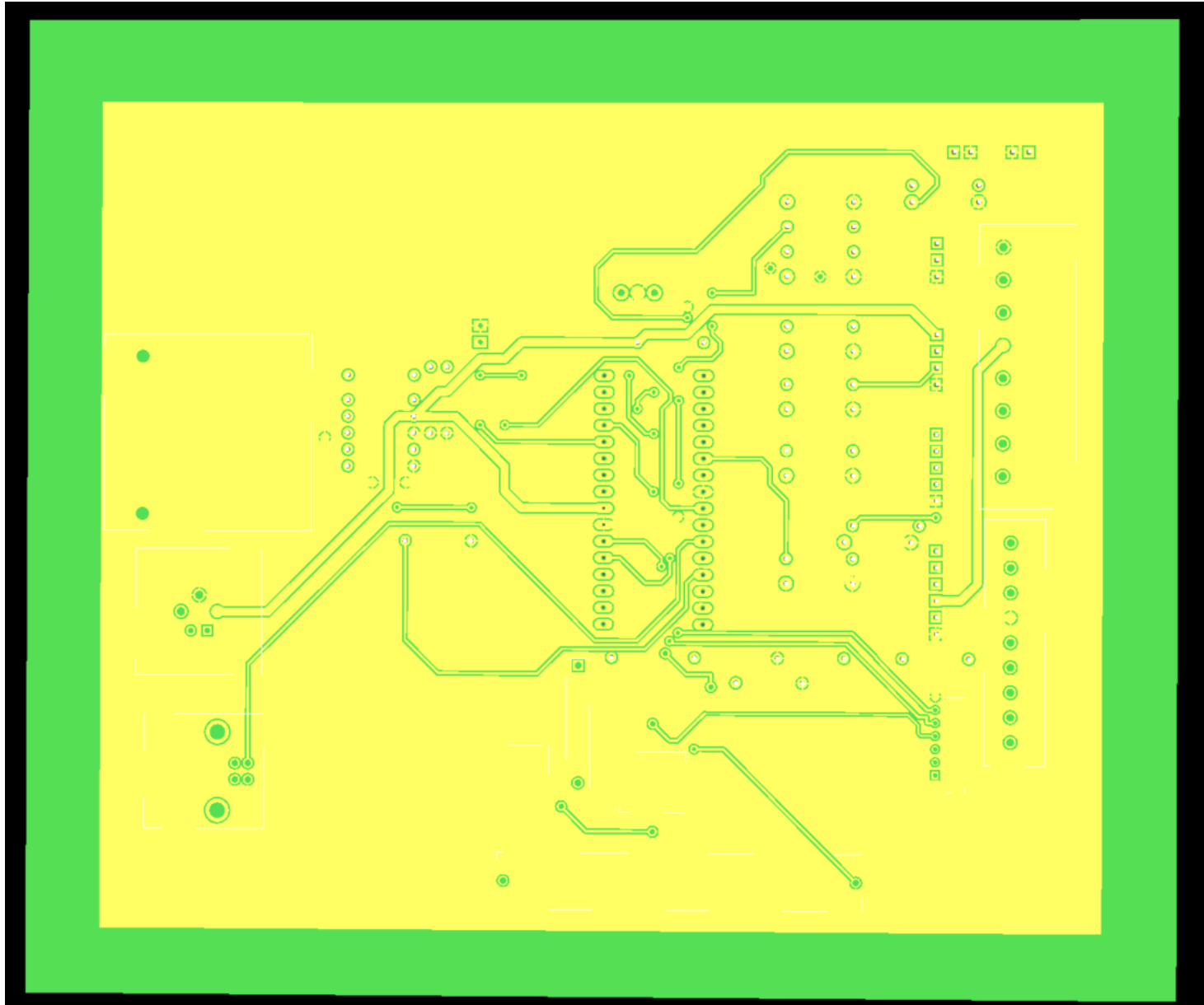


Figure 93 - 3D View of PCB (Rear)

7. Future Improvements

The potential future improvements include:

1. A display screen HMI to display the captured data live to the user, or to allow various sensors to be switched on/off if required to save battery charge.
2. Could include communication interfacing for multiple of these devices to be connected to each other whilst at different locations, allowing weather data to be recorded over a wide area.
3. Could include USB charging so the batteries can be left inside the unit.
4. Could include a rain volume sensor to track the amount of rain over the test period.
5. Larger memory and batteries to allow testing over several months.
6. Sensors could be connected via WIFI.

8. Conclusion

The research on similar devices aided with producing an effective design as it could be seen what variables other devices monitor, and what types of sensors are used. The device was designed in Proteus, which provided an easy to follow schematic that aided with producing the schematic and PCB design in Easy-PC. All of the components used were easily available at the time from online distributors. The PCB was designed and the software produced a 3D model that was compact and easy to fit in an enclosure. JLCPCB provided a quote that was affordable, and could provide a functional device in a short time.

9. Data Sheets



PIC18(L)F2X/45K50

28/40/44-Pin, Low-Power, High-Performance Microcontrollers with XLP Technology

Universal Serial Bus Features:

- USB V2.0 Compliant
- Crystal-less Full Speed (12 Mb/s) and Low-Speed Operation (1.5 Mb/s)
- Supports Control, Interrupt, Isochronous and Bulk Transfers
- Supports up to 32 Endpoints (16 Bidirectional)
- 1 Kbyte Dual Access RAM for USB
- On-Chip USB Transceiver

Flexible Oscillator Structure:

- 3x and 4xPLL Clock Multipliers
- Two External Clock modes, Up to 48 MHz (12 MIPS)
- Internal 31 kHz Oscillator
- Internal Oscillator, 31 kHz to 16 MHz
 - Factory calibrated to $\pm 1\%$
 - Self-tune to $\pm 0.20\%$ max. from USB or secondary oscillator
- Secondary Oscillator using Timer1 @ 32 kHz
- Fail-Safe Clock Monitor:
 - Allows for safe shutdown if any clock stops

Peripheral Highlights:

- Up to 33 I/O pins plus 3 Input-Only Pins:
 - High-current Sink/Source 25 mA/25 mA
 - Three programmable external interrupts
 - 11 programmable interrupts-on-change
 - Nine programmable weak pull-ups
 - Programmable slew rate
- SR Latch
- Enhanced Capture/Compare/PWM (ECCP) module:
 - One, two or four PWM outputs
 - Selectable polarity
 - Programmable dead time
 - Auto-shutdown and auto-restart
 - Pulse steering control
- Capture/Compare/PWM (CCP) module
- Master Synchronous Serial Port (MSSP) module Supporting 3-Wire SPI (all four modes) and I²C™ Master and Slave modes
- Two Analog Comparators with Input Multiplexing
- 10-Bit Analog-to-Digital (A/D) Converter module:
 - Up to 25 input channels
 - Auto-acquisition capability
 - Conversion available during Sleep

- Digital-to-Analog Converter (DAC) module:
 - Fixed Voltage Reference (FVR) with 1.024V, 2.048V and 4.096V output levels
 - 5-bit rail-to-rail resistive DAC with positive and negative reference selection
- High/Low-Voltage Detect module
- Charge Time Measurement Unit (CTMU):
 - Supports capacitive touch sensing for touch screens and capacitive switches
- Enhanced USART module:
 - Supports RS-485, RS-232 and LIN/J2602
 - Auto-wake-up on Start bit
 - Auto-Baud Detect

Extreme Low-Power Management with XLP:

- Sleep mode: 20 nA, typical
- Watchdog Timer: 300 nA, typical
- Timer1 Oscillator: 800 nA @ 32 kHz
- Peripheral Module Disable

Special Microcontroller Features:

- Low-Power, High-Speed CMOS Flash Technology
- C Compiler Optimized Architecture for Re-Entrant Code
- Power Management Features:
 - Run: CPU on, peripherals on, SRAM on
 - Idle: CPU off, peripherals on, SRAM on
 - Sleep: CPU off, peripherals off, SRAM on
- Priority Levels for Interrupts
- Self-Programmable under Software Control
- 8 x 8 Single-Cycle Hardware Multiplier
- Extended Watchdog Timer (WDT):
 - Programmable period from 4 ms to 131s
- Single-Supply In-Circuit Serial Programming™ (ICSP™) via Two Pins
- In-Circuit Debug (ICD) with Three Breakpoints via Two Pins
- Optional dedicated ICD/ICSP Port (44-pin TQFP Package Only)
- Wide Operating Voltage Range:
 - F devices: 2.3V to 5.5V
 - LF devices: 1.8V to 3.6V
- Flash Program Memory of 10,000 Erase/Write Cycles Minimum and 20-year Data Retention

Product Description

Parameters name	Wind speed and direction 2 in 1 sensor		
Parameters	Measure range	Resolution	Accuracy
Wind speed	0~45m/s (current and voltage output) 0~70m/s (pulse, 485, 232 output) (Other customizable)	0.3m/s	±(0.3+0.03V)m/s,V means speed
Wind direction	Measure range	Resolution	Accuracy
	0-359°	0.1°	±3°
Material	Aluminum alloy + ABS		
Features	It is assembled with aluminum alloy precision machined parts, with high strength, and a variety of installation methods are available.		
Technical parameter			
Start speed	≥0.3m/s		
Response time	Less than 1 second		
Stable time	Less than 1 second		
Output	RS485, RS232 MODBUS communication protocol Pulse output(NPNR/PNP) 4-20 mA 0-20 mA 0-2.5V 0-5V 1-5V		
Power supply	5VDC/9-30VDC		
Working environment	Temperature -30 ~ 85 °C, working humidity: 0-100%		
Storage conditions	-20 ~ 80 °C		
Standard cable length	2.5 meters		
The farthest lead length	RS485 1000 meters		
Protection level	IP65		
Wireless transmission	LORA/LORAWAN(868MHZ,915MHZ,434MHZ)/GPRS/4G/WIFI		
Cloud services and software	We have supporting cloud services and software, which you can view in real time on your mobile phone or computer		

Product Install



T9602 Humidity & Temperature Sensor for OEM Installation



Features

- Fully calibrated and temperature compensated
- Water resistant (IP 67 Certified)
- Digital or Pulse Density Modulated convertible to analogue
- Available in multiple flexible cable lengths
- Precision & accuracy ($\pm 2\%$ RH, $\pm 0.5^\circ\text{C}$, 14 bit resolution)
- Low current consumption
- Designed for reliability in harsh environments
- Flexible mounting options



Applications

- Energy saving HVAC Control – Air Conditioning, Refrigeration, Indoor Air Quality, Vent Fans, Home Appliances, Humi/Dehumidifiers
- Process Control & Instrumentation – Medical Instruments, Handheld Devices, Weather Stations, Food Processing, printers, RFID's

The T9602 offers the most advanced and cost effective humidity and temperature sensing solution for virtually any type of application.

Based on our own capacitive polymer sensor chip and ASIC integrated into an easy mount OEM package.

Each sensor is individually calibrated and tested. The T9602 is simple and ready to use without further calibration or temperature compensation.

The T9602 provides linearized output signals in one of two interfaces to meet customer requirements.

- I²C interface
- PDM output convertible to an analogue signal
- Refer to Application guide section for more detailed interfacing information

Amphenol
Advanced Sensors

Technical Index

Parameter	Index	unit
Range of measurement	0.3~1.0; 1.0~2.5; 2.5~10	Micrometer (μm)
Counting Efficiency	50%@0.3 μm 98%@ $\geq 0.5\mu\text{m}$	
Effective Range (PM2.5 standard)	0~500	$\mu\text{g}/\text{m}^3$
Maximum Range (PM2.5 standard) *	≥ 1000	$\mu\text{g}/\text{m}^3$
Resolution	1	$\mu\text{g}/\text{m}^3$
Maximum Consistency Error (PM2.5 standard data)*	$\pm 10\%$ @100~500 $\mu\text{g}/\text{m}^3$ $\pm 10\mu\text{g}/\text{m}^3$ @0~100 $\mu\text{g}/\text{m}^3$	
Standard Volume	0.1	Litre (L)
Single Response Time	<1	Second (s)
Total Response Time	≤ 10	Second (s)
DC Power Supply	Typ:5.0 Min:4.5 Max: 5.5	Volt (V)
Active Current	≤ 100	Milliampere (mA)
Standby Current	≤ 200	Microampere (μA)
Interface Level	L <0.8 @3.3 H >2.7@3.3	Volt (V)
Working Temperature Range	-10~+60	$^{\circ}\text{C}$
Working Humidity Range	0~99%	
Storage Temperature Range	-40~+80	$^{\circ}\text{C}$
MTTF	≥ 3	Year (Y)
Physical Size	50×38×21	Millimeter (mm)

Note 1: Maximum range means that the highest output value of the PM2.5 standard data is not less than 1000.

Note 2: "PM2.5 standard data" is the "data2" in the appendix.

RK210-01 Illuminance Sensor



RK210-01 Illuminance Sensor is very sensitivity and can detect weak light, has a wide measuring range, high accuracy, good waterproof performance, easy to use, easy to install. It's suitable for most applications, especially in agricultural greenhouses, urban lighting and other places.

FEATURES

- High sensitivity
- Applicable to various harsh environments
- High precision, wide measuring range
- Compact size
- Easy installation



ABS housing without display



ABS housing with display



Metal(aluminium alloy) housing without display

APPLICATIONS

- Agro-meteorological
- Intelligent buildings
- Greenhouse control
- Weather stations
- Crop monitoring

SPECIFICATIONS

Item	Specification	
Range	0-2000lux,0-20klux,0-200klux optional	
Spectral range	380-780nm	
Supply	5VDC, 12-24VDC	
Output	4-20mA,0-5V,0-10V	RS485
Accuracy	$< \pm 5\%FS$	$< \pm 4\%FS$
Response time	1s	
Temperature effect	$\pm 0.2\%/^{\circ}C$	
Repeatability	$< 1\%FS$	
Display	LCD optional(ABS housing)	
Operating temperature	$-40^{\circ}C \sim +75^{\circ}C$	
Weight(unpacked)	170g	
Shell material	ABS,metal shell can be customized	



INSTRUMENTS

OWNER'S MANUAL

ULTRAVIOLET-A SENSOR

Models SU-202 and SU-205

Rev: 4-Jan-2023



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#12012 #12013 #12014

M8N GPS

**Descriptions:**

The M8N GPS has an UBLOX M8N module, IST8310 compass, tri-colored LED indicator, and a safety switch. There are 3 different connectors options for different purposes. This module ships with a baud rate of 38400 5Hz

Features and Specifications:

- Ublox Neo-M8N module
- Industry leading -167 dBm navigation sensitivity
- Cold starts: 26s
- LNA MAX2659ELT+
- 25 x 25 x 4 mm ceramic patch antenna
- Rechargeable Farah capacitance
- Low noise 3.3V regulator
- Current consumption: less than 150mA @ 5V
- Fix indicator LEDs
- Protective case
- 26cm cable included
- Diameter 50mm total size, 32 grams with case.





 6000-3780-0000-1XX 37800-2021 V105 03./2021

AERASGARD® ACO2-W / ALQ-CO2-W / ACO2-SD
AERASGARD® AFTM-(LQ)-CO2-W / ATM-CO2-SD



D Bedienungs- und Montageanleitung

Multifunktionaler Aufputzfühler bzw. Messumformer, für Feuchte, Temperatur, CO₂-Gehalt und Luftgüte (VOC), kalibrierfähig, mit aktivem/schaltendem Ausgang

GB Operating Instructions, Mounting & Installation

Multifunctional on-wall sensors and measuring transducers, for humidity, temperature, CO₂ content and air quality (VOC), calibratable, with active /switching output

F Notice d'instruction

Sonde (transmetteur) en saillie multifonctionnelle, pour l'humidité, la température, la teneur en CO₂ et la qualité de l'air (COV), étalonnable, avec sortie active /tout ou rien

RU Руководство по монтажу и обслуживанию

Мультифункциональный датчик для открытой установки / измерительный преобразователь, для измерения влажности, температуры, содержания CO₂ и качества воздуха (VOC), калибруемый, с активным/релейным выходом

AFTM-CO2-W
 AFTM-LQ-CO2-W
 ATM-CO2-SD



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CARTONS
 ET EMBALLAGE
 PAPIER À TRIER

MIL-DTL-5015, Matrix®



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1630
Protector
Transport Case

Sensitive equipment needs protection, and since 1976 the answer has been the Peli™ Protector Case. These cases are designed rugged, and travel the harshest environments on earth. Against the extreme cold of the arctic or the heat of battle, Peli cases have survived. Made in the USA, these tough cases are designed with an automatic purge valve, that equalizes air pressure, a watertight silicone O-ring lid, over-molded rubber handles and stainless steel hardware.

- 4 strong polyurethane wheels with stainless steel bearings (wheel diameter is 5.3cm)
- Watertight, crushproof, and dustproof
- 3 level Pick N Pluck™ with convoluted lid foam
- Automatic Pressure Equalization Valve - balances interior pressure, keeps water out
- Easy open double-throw latches
- Fold down handles
- Note: Please consult a sales specialist for more details.
- O-ring seal
- Open cell core with solid wall design - strong, light weight
- Reinforced corners
- Retractable extension trolley handle
- Stackable
- Stainless steel padlock protectors
- Peli's legendary lifetime guarantee**
- * Where applicable by law



CONFIGURATIONS



DIMENSIONS

Interior (LxWxD)	27.70 x 20.98" x 15.50 (70.4 x 53.3 x 39.4 cm)
Exterior (LxWxD)	31.28 x 24.21" x 17.48 (79.5 x 61.5 x 44.4 cm)
Lid Depth	3.25" (8.3 cm)
Bottom Depth	12.14" (30.8 cm)
Total Depth	15.39" (39.1 cm)
Int Volume	5.21 ft³ (0.148 m³)
Padlock Hole Diameter	5/16" (12.7 cm)

MATERIALS

Body	Polypropylene
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