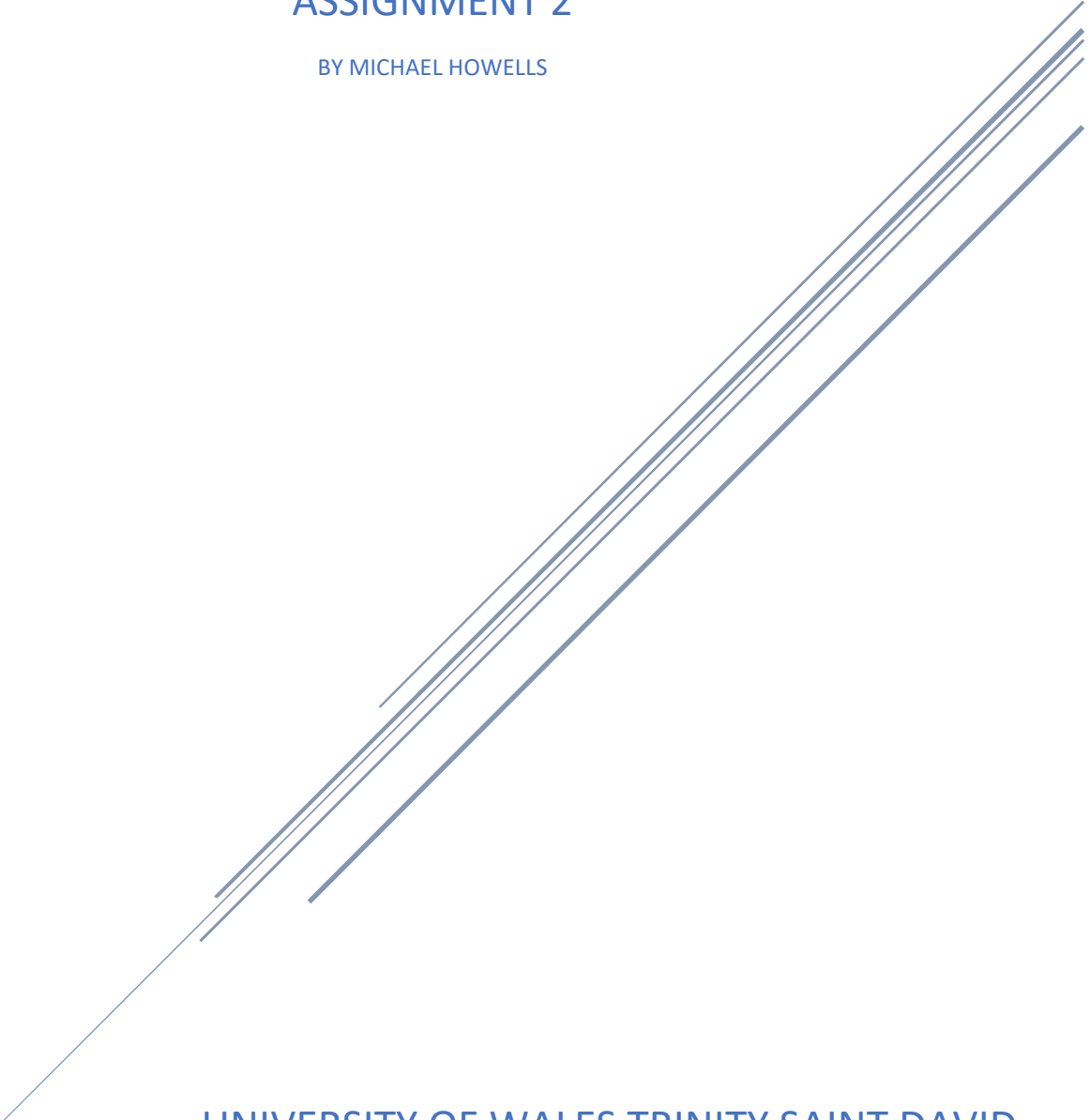


14 DAY WEATHER AND AIR QUALITY MEASUREMENT AND LOGGING SYSTEM

ASSIGNMENT 2

BY MICHAEL HOWELLS



UNIVERSITY OF WALES TRINITY SAINT DAVID
ELECTRONIC SYSTEM DESIGN – ACDA6002

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1 ABSTRACT

This report shows the process taken to design a weather station that has sensors used record environmental metrics.

Research into relevant technologies is shown and a full system is described in the report as well as supplementary documents. A PCB was also completed as part of the design.

2 DESIGN BRIEF

The design brief is as follows:

"You are required to design a simple microcontroller-based weather and air quality monitor / logger which

takes measurements and logs the data over a 14 day period

The data acquisition system is intended for use by amateur weather forecasters to aid in their predictions.

The system must be portable and adaptable for a number of monitoring sites.

The following data will be acquired during the 14-day cycle:-

- *Temperature*
- *Humidity*
- *Wind Speed*
- *Wind Direction*
- *Air borne particle count*
- *Sunlight brightness*
- *UV levels*
- *GPS position*
- *VOC level*

The system must:

Store the collected data to non-volatile memory which may be externally read and cleared when connected

to a computer via USB.

Have its own battery so that it may continue monitoring even when the site is remote and unpowered.

Ensure that your design is portable, adaptable, and suitable for operation in its intended environment. This

design does not require a display except for a LED which flashes once every 10 seconds for 1 second to indicate operation."

3 RESEARCH

3.1 EXISTING WEATHER LOGGING SYSTEMS

The table below shows 3 existing weather logging systems that are currently available. Where possible, measurement ranges are compared between products.

PRODUCT NAME	PSG04173	NE-MS1000	Tempest Weather System
IMAGE			
MEASURED VARIABLES	-wind speed -wind direction -air temperature -pressure sensor -rain sensor	-wind speed -magnetic north sensor -wind direction -air temperature -GPS positioning -humidity sensor	- light sensor -pressure sensor -lightning sensor -haptic rain sensor -sonic wind sensor -temperature sensor -humidity sensor -pressure sensor
TEMPERATURE MEASUREMENT RANGE(°C)	-40 to +60	-40 to +125	-40 to +60
WIND SPEED MEASUREMENT RANGE(m/s)	0 to 50	0 to 45	0 to 45
HUMIDITY MEASUREMENT RANGE	10 to 99%	0 to 100%	0 to 100%
PRICE	£79.95	Not available	£349.00
NOTE	-LCD display	-meets US military standards (MIL-STD 810 MIL-STD 461F MIL-STD 1275E)	-Works with google home hub and amazon alexa. -Has an app so the user can view data.
COMMUNICATION INTERFACE	WIFI	RS-422, RS-485, Ethernet, CAN-BUS	WIFI
POWER	5V DC, x3 AAA batteries for backup power	18-32V DC	4 solar panels, 1300mWh battery

REFERENCE	link	link	link
	link		link

Table 1 – EXISTING WEATHER SYSTEMS

4 MEASUREMENT TYPE

4.1 TEMPERATURE

The temperature sensor on the weather station should be able to measure temperature ranges that can be found on earth. The known air temperature range of earth is from -89.2°C to 56.7°C [1]. As the upper and lower values are very uncommon and extreme, it is not essential for the temperature sensor to match this range. The example products are not capable of measuring the extremely low temperatures; however the example ranges would be suitable for the majority of places on earth. This can be seen in Table 1.

PRODUCT NAME	EWSA-PT100	SEN-11050	R-10318-69
IMAGE			
SENSOR TYPE	RTD	IC	THERMOCOUPLE
MEASURE RANGE	-50 to $+100^{\circ}\text{C}$	-55 to $+125^{\circ}\text{C}$	-200°C to 350°C
COST	£152.11	£8.88	£98.98
REFERENCE	link	link	link

Table 2- TEMPERATURE SENSORS

From the temperature shown in Table 2, the EWSA-PT100 was selected as the most suitable. This was due to its temperature measurement range being comparable to the example products. It is also specifically designed to measure air temperature and it is housed within an 1P65 enclosure [2]. The sensor is an RTD type, which means that it contains a resistive element that changes its resistance properties in relation to the temperature of its environment [3].

4.2 HUMIDITY

Humidity is a value that represents the amount of moisture that is present in the air. Relative humidity is expressed as a percentage and shows the amount of water vapor that is in the air compared to the maximum water that the air can hold.

PRODUCT NAME	RS PRO Humidity Sensor	HPP809A031	HX93BC
IMAGE			
MEASURE RANGE	0 – 95%	0 – 100%	0-100%
COST	£2.49	£99.23	£437.44
NOTE		Also, a temperature sensor with range of -40 to 85°C	Also, a temperature sensor with a range of 30 to 75°C
REFERENCE	link	link	link

Table 3 - HUMIDITY SENSORS

The HPP809A031 was selected for its ease of use. The device simply outputs a voltage that can be used to calculate its relative humidity. It also has a secondary temperature sensor function.

4.3 WIND SPEED AND DIRECTION

A common measurement that is taken on weather station is wind speed and wind direction. The three sensors shown below are capable of both measurements. Implementing such a sensor will reduce the complexity of the design.

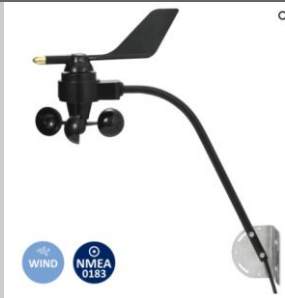
PRODUCT NAME	Anemometer Wind Speed Sensor	QK-AS06 Wind Sensor with NMEA 0183 output	Davis Sonic Anemometer 6415
IMAGE			
WIND SPEED MEASURE RANGE	0 – 100m/s	0 to 55m/s	0 to 40m/s
WIND DIRECTION MEASUREMENT RANGE	0 to 355°	0 to 359°	0 - 360°
COST	\$1,260 (£987.19)	£265.80	£640.76
REFERENCE	link link	link	link

Table 4 - WIND SPEED AND DIRECTION SENSORS

From the sensors in Table 4, the Anemometer Wind Speed Sensor, was selected as the most suitable due to its higher wind speed measurement.

4.4 AIR BORNE PARTICLE COUNT

An air borne particle counter sensor can be used to monitor the quality of the air around the weather station.

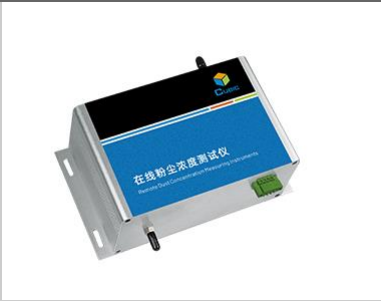
PRODUCT NAME	PM3003S	OPM-6303M	FLUKE 985 PARTICLE COUNTER
IMAGE			
MEASURE RANGE			
COST	Quote required	Quote required	£6,120.00
REFERENCE	link	link	link

Table 5 - AIR BORNE PARTICLE SENSORS

The most suitable particle sensor from Table 5 is the OPM-6303M. This is because it is a full unit that is designed to be used on meteorological stations [4]. The fluke 985 is designed to monitor clean rooms and the PM3003S required additional hardware to function.

4.5 SUNLIGHT BRIGHTNESS

To measure the sunlight brightness, illuminance values will be recorded. Illuminance describes the density of light energy present within an area [5].

Illuminance levels can range from 130,000 lux with direct sunlight overhead to as low as $1\text{E-}4$ on an overcast night lit only by starlight [6]. The sensor used must be able to detect a range comparable to these readings.

PRODUCT NAME	AHKF-I	LUX 34	SR65
IMAGE			
MEASURE RANGE	0...500 Lux / 1 kLux / 2 kLux / 5 kLux / 20 kLux / 60 kLux / 100klux	0...1000 lx* or 0...10000 lx	0..510 Lux, 0..1000 Lux (10 Bit), 0..1020 Lux, 300..30.000 Lux, 600..60.000
COST	£118.00	Quote required	£121
REFERENCE	link	link	link

Table 6 - ILLUMINANCE SENSORS

From Table 6, the AHKF-I was selected as the most suitable sensor as it has the widest illuminance range. The lux value can also be easily calculated from its output which is a voltage ranging from 0 – 10V and the illuminance measurement range can easily be selected from dipswitches on the module.

4.6 UV LEVELS

The weather station for this project must measure UV levels in the environment. This information is important as UV exposure has previously been connected to health issues such as cancer and immune suppression [7]. It could also be used to inform people of when to use sunscreen. For example, if the UV index is measured at 3 or above, then protection should be used [8].

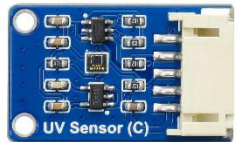
PRODUCT NAME	Digital LTR390-UV Ultraviolet Sensor	SKU 6490	UV Light Sensor
IMAGE			
MEASURE RANGE RADIATION DOSE		0 to 199 MEDs	
MEASURE RANGE UV RADIATION INDEX		0-16	
MEASURE RANGE UV RADIATION			0 to 200 $\mu\text{mol m}^{-2} \text{s}^{-1}$ Accuracy: $\pm 5\%$
INTERFACE	I2C		
COST	£8.60	\$425.00 (£332.59)	£462.61
NOTE			Specifically works with watchdog range of products.
REFERENCE	link	link link	link

Table 7 - UV SENSORS

The SKU 6490 was selected as the most suitable sensor in Table 7 as it is sufficiently capable of measuring UV radiation and has the best package to be readily installed and implemented in a system.

4.7 GPS POSITION

A GPS (Global Positioning System) module on the will be used to accurately determine the location of the weather station. GPS is a method of determining location by receiving signals from multiple satellites that contain, the satellite ID, timestamp, and location data. By receiving this data from multiple satellites, the position on earth can be calculated [9].

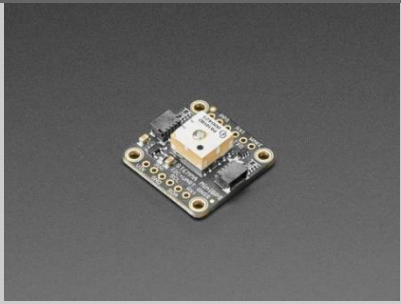
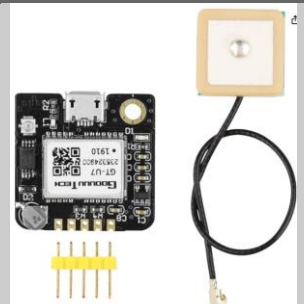
PRODUCT NAME	Mini GPS PA1010D - UART and I2C - STEMMA QT	QK-AS07-0183	GPS Module Receiver,Navigation Satellite Positioning NEO-6M
IMAGE			
INTERFACE	UART and I2C	USB	USB
COST	£31.99	£183.60	£12.99
REFERENCE	link link	link	link

Table 8 – GPS MODULES

From the GPS modules in Table 8, the MTK3339 was selected due to its ease of implementation and its wide operating temperature.

4.8 VOC (VOLATILE ORGANIC COMPOUNDS) LEVEL

A VOC sensor is used to monitor the environment to determine the quality of the air. The reading from these sensors, will show the concentration of numerous gasses, however it is unable to specifically define them beyond a range of gasses it can detect [10].

PRODUCT NAME	PPM WR VOC Gas Sensor	PS4-VOC-1000	PS1-VOC-10-MOD
IMAGE			
OUTPUT	Analog voltage response	Current generated response	UART
COST	Quote required	£66.46	£199.99
REFERENCE	link	link	link

Table 9 - VOC SENSORS

From VOC sensors in Table 9, the PPM WR VOC Gas Sensor was selected as the most suitable. This was due to its simplicity in design. It also had very good documentation, explaining how to implement it. It can also be used without the need for a pump as the air that is sampled can be diffused into it [11]. A separate module to hold this sensor may be required.

5 SELECTED SENSOR REVIEW

SENSOR NAME	MEASUREMENT	TYPE OF SIGNAL	TYPE OF SENSOR
<i>HTM2500LF</i>	Temperature	ANALOG	NTC THERMISTOR
<i>HTM2500LF</i>	Humidity	ANALOG	MODULE
<i>RMY-05106 Marine Wind Monitor</i>	Wind Speed	ANALOG	Centrally mounted stationary coil, 2K 0hm nominal DC resistance
<i>RMY-05106 Marine Wind Monitor</i>	Wind Direction	ANALOG	Precision conductive plastic potentiometer, 10K ohm resistance ($\pm 20\%$), 0.25% linearity, life expectancy 50 million revolutions, rated 1 watt at 40° C, 0 watts at 125° C
<i>OPM-6303M</i>	Air borne particle count	DIGITAL (RS485)	Laser scattering
<i>AHKF-I</i>	Sunlight Brightness	ANALOG	Light sensor with diffuser
<i>UV Sensor - SKU 6490</i>	UV Level	ANALOG	Semiconductor photodiode
<i>Mini GPS PA1010D - UART and I2C - STEMMA QT</i>	GPS	DIGITAL (I2C)	GPS
<i>PPM WR VOC Gas Sensor</i>	VOC LEVEL	ANALOG	photo-ionisation detection

Table 10 - SELECTED SENSORS

Table 10 shows the type of interface that each sensor will require. The microcontroller will require 7 analog inputs, 1 digital I2C interface and a way to communicate using an RS485 interface.

6 LOG DATA REQUIREMENTS REVIEW

SENSOR NAME	MEASUREMENT	MAXIMUM VALUE	RESOLUTION	NUMBER OF POSSIBLE VALUES	NO OF BITS REQUIRED	NO OF BYTES	SAMPLE RATE (HZ)	TOTAL BYTES IN CYCLE (14 DAYS)
HTM2500LF	temperature	85	0.1	1250	11	2	0.01666667	40320
HTM2500LF	humidity	100	1	100	7	1	0.01666667	20160
RMY-05106 Marine Wind Monitor	wind speed	100m/s	1	100	7	1	0.01666667	20160
RMY-05106 Marine Wind Monitor	wind direction	360	1	360	9	2	0.01666667	40320
OPM-6303M	air borne particle count (PM1)	1000	1	900	10	2	0.00027778	672
	air borne particle count (PM2.5)	1000	1	900	10	2	0.00027778	672
	air borne particle count (PM10)	1000	1	900	10	2	0.00027778	672
	air borne particle count (TSP)	1000	1	900	10	2	0.00027778	672
AHKF-I	sunlight brightness	60000	10	6000	13	2	0.01666667	40320
UV Sensor - SKU 6490	uv level	16	1	16	4	1	0.01666667	20160
MTK3339	gps position - latitude	na	na	na	na	51 bytes in header	NA	51
PPM WR VOC Gas Sensor	voc level	10000	10	1000	10	2	0.01666667	40320

Table 11 - MEMORY REQUIREMENTS FOR SENSORS

The GPS data will be recorded only once at the start of the cycle. This will be stored within a header at the top of the log file and will contain \$GPRMA data in the format “\$GPRMA,A,IIII.II,N,IIII.II,W,,,ss.s,ccc,vv.v,W*hh”. This includes, data status, latitude, longitude, speed over ground in knots, course over ground, variation, direction of variation E/W and a checksum. This data is 51 characters in length, each character is a byte in ASCII format.

Most sensors are samples at 0.01666667Hz. This is 1 recording per minute, and this was deemed to be a suitable sampling frequency. The exception to this sample rate is the air borne particle sensor with a sample frequency of 0.00027778Hz, which is 1 reading per hour. The reason for this is to reduce the power consumption of the unit as this sensor has a high-power usage.

The total memory required for the cycle is 224.499Kb. A micro-SD card will be used as non-volatile memory to store this data and the sizes that are available are more that suitable to meet the requirements of this design.

7 CONNECTOR SPECIFICATION

7.1 INTERNAL CONNECTORS

Connectors that will be used to connect devices internal to the enclosure have the following specification:

- Must satisfy the pinout requirements.
- Locking connector to reduce the risk of disconnect from vibrations during the record cycle.
- Must fit within the mechanical constraints of the PCB.

The selected connector for internal connections is the Molex KK254 series. This connector is a through hole part that can be soldered directly to the PCB. They have a friction lock which will ensure that the connection is maintained, even if vibrations are encountered. They are also polarized, so it is not possible to connect their respective wire backwards [12].



Table 12 - Molex KK254

7.2 EXTERNAL CONNECTORS

External connectors will be used to connect to a device that is external to the enclosure. They have the following specification:

- Locking connector to reduce the risk of disconnect from vibrations during the record cycle.
- High IP rating so moisture cannot compromise the electronics within the enclosure.
- Must satisfy the pinout requirements.

The 772-E SERIES D-sub has been selected for any external connections. This is a locking d-sub connector that has an IP rating of 67 so is suitable for use outside and will prevent any water damage.



Table 13 – 772-E SERIES D SUB CONNECTOR [13], SF67 SERIES PANEL SEAL [14], 967 IP67 BACKSHELLS [15]

8 HARDWARE REQUIREMENTS

8.1 BATTERY

The specification for the battery is as follows:

- Must have enough capacity to power the circuit for 14 days
- Rechargeable batteries are desirable.
- Must fit within enclosure

The battery that was selected for the project is the 24-100XTREME. This battery has a nominal voltage of 25.6V and can supply a current of 100Ah. This battery can supply more than double the current required for the system (calculated at 37.95Ah). Calculations for this can be found in appendices (POWER USAGE CALCULATION). This battery is rechargeable.



Figure 1 - 24-100XTREME [16]

8.2 ENCLOSURE

The specification for the project enclosure is as follows:

- Large enough to house all electronics.
- Have enough room on side for any connectors required.
- IP rating is required as this will house all electronics and will be left outside to be exposed any weather conditions.

A custom military grade case was selected as the enclosure for this system. The dimensions of the enclosure can be customized to fit the exact requirements of the project. The cases have an IP rating of 56 which will ensure that internal parts are protected from water. They can also be customized to have wheels so it can be transported easily [17].



Figure 2 - CUSTOM MILITARY GRADE CASE [17]

8.3 MICROCONTROLLER COMPARISON

Table 14 shows a comparison of 3 PIC microcontrollers that were reviewed for this project. Both the PIC18F66K80 and the PIC10F204 were deemed as unsuitable as they did not have a USB interface. This was specified in the design brief. The information in Table 14 was found using the microchip part selector tool [18].

The PIC18F46J50 was selected for use as the microcontroller in this project. It meets all hardware requirements. It has a USB interface which can be used to start the log cycle and retrieve the log data. The SPI interface can be used for the SD card interface. IT has enough digital IOs and analog inputs for each sensor and any other peripherals that may be required. It also has an RTC which can be used to timestamp all log data.

Chip Name	PIC18F46J50	PIC18F66K80	PIC10F204
Family	8-bit MCU	8-bit MCU	8-bit MCU
CPU Type	8-bit PIC MCU	8-bit PIC MCU	8-bit PIC MCU
Max CPU Speed (MHz)	48 MHz	64 MHz	4 MHz
Operation Voltage	(2V-3.6V)	(1.8V-5.5V)	(2V-5.5V)
Temp Range	(-40 to 85)	(-40 to 125)	(-40 to 125)
Pin count	44	64	6
Program Memory Size (KB)	64 Flash	64 Flash	0.375 Flash
Error Correction Code Program Flash			
SRAM	3.7109375 KB	3.5625 KB	16 Bytes
Data EEPROM/HEF (Bytes)		1024	
Low Power	Yes	Yes	
ADC Input	13	11	0
Max ADC Resolution (Bits)	10	12	
UART	2	2	
SPI	2	1	
I2C	2	1	
Number of USB Modules	1		
USB Interface	FS Device	None	None
Number of CAN Modules		1	
Type of CAN module		CAN	
Max 8-Bit Digital Timers	2	2	1
Max 16-Bit Digital Timers	3	3	
Max 32-Bit Digital Timers			
Hardware RTCC/RTC	Yes		
Max PWM outputs (including complementary)		8	

Table 14 - PIC MICROCONTROLLER COMPARISON TABLE

9 WEATHER STATION DATA LOGGER BLOCK DIAGRAM

Figure 3 shows a block diagram of the weather station system.

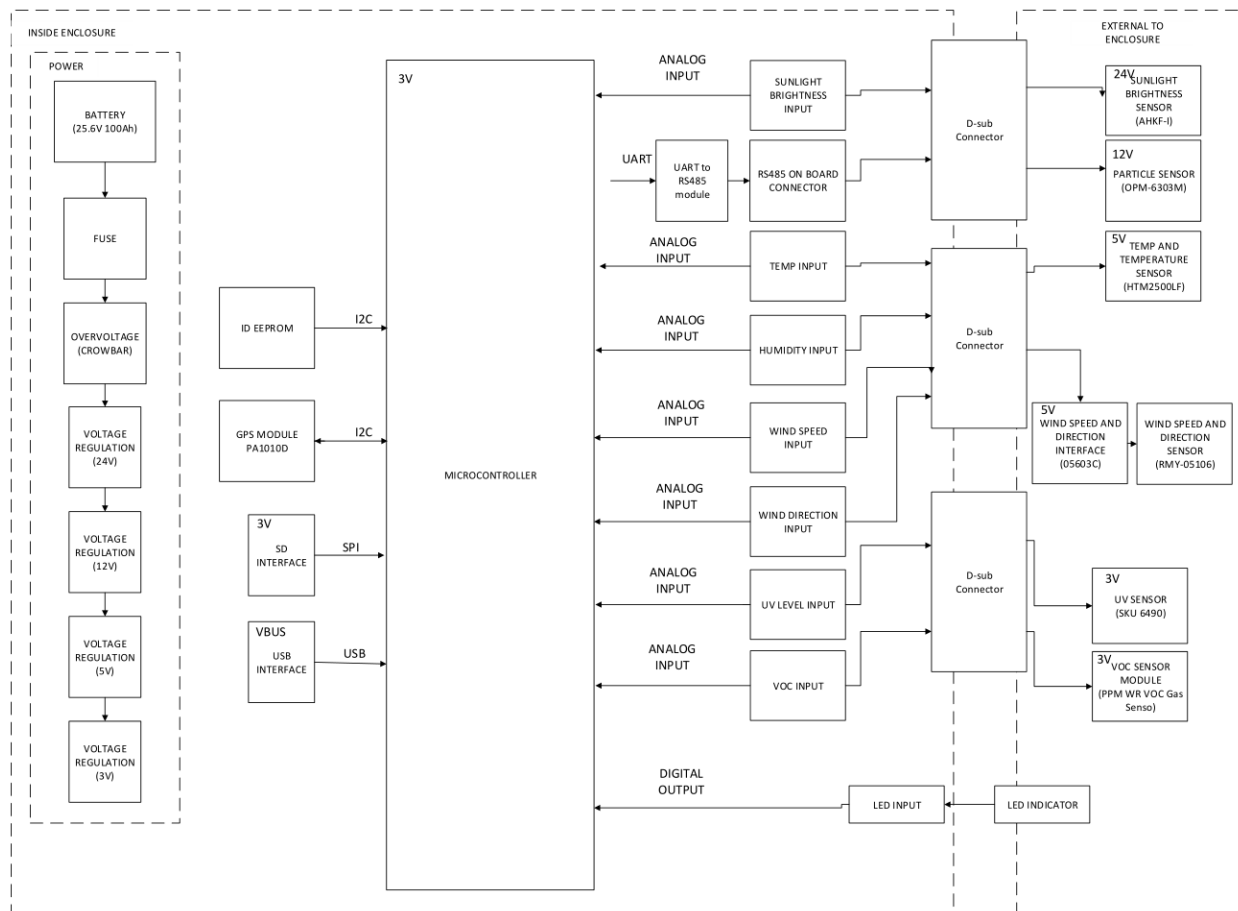


Figure 3 - WEATHER STATION DATA LOGGER DESIGN BLOCK DIAGRAM

The system is powered from a 25.6V 100Ah battery. The supply from the battery is connected to the circuit and goes through a simple protection stage providing overvoltage and overcurrent protection.

The voltage is then regulated to 24V, 12V, 5V and 3V to supply power to the circuit and its external sensors.

The selected microcontroller has several communication interfaces that are connected to the circuit. The USB interface is connected to a USB type B connector. This connector is to be used for connecting to an external computer that will be used to start the logging cycle and retrieve the log data. The SPI interface is used to write the log data to an SD card. The I2C interface used to communicate to the GPS module and an external EEPROM IC used to uniquely ID each board. A UART interface is used to communicate to the particle sensor through an RS485 interface board.

7 analog inputs are used to record data from sensors. 1 digital output is used to control the indicator LED.

D-sub connectors are used to interface the circuit to sensors that are external to the enclosure.

10 PCB DESIGN

10.1 SCHEMATIC OVERVIEW

The circuit design will be explained in this section.

10.1.1 BATTERY INPUT AND PROTECTION

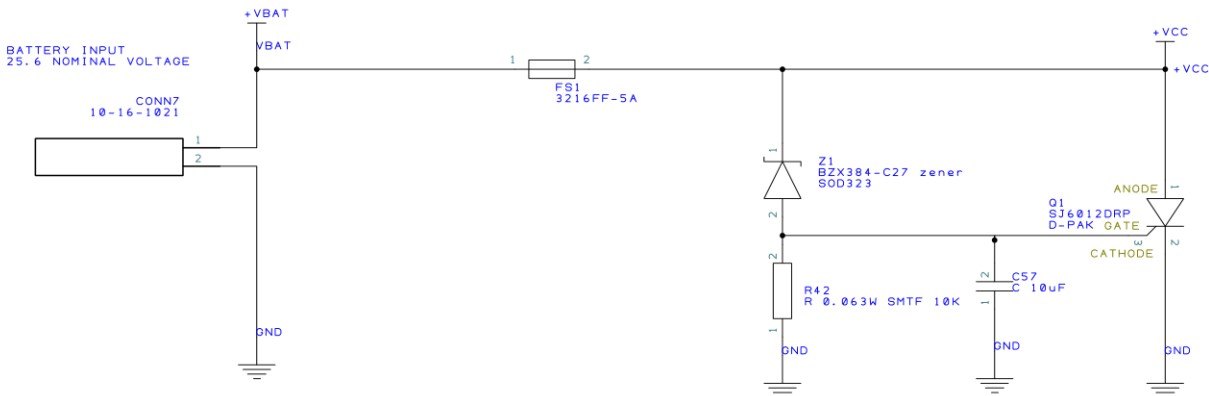


Figure 4 – BATTERY INPUT AND PROTECTION

The battery is connected to the circuit using a locking 10-16-1021 connector. The circuit is protection used on this part of the circuit is a fuse for overcurrent protection. The fuse is rated for 5A. A crowbar circuit is used for overvoltage protection. IF the 27V threshold for Z1 is met, the SCR will trigger and will sink a large current. The large current will cause the fuse to break the circuit. C57 is used to prevent any short transient events from triggering the SCR.

10.1.2 24V VOLTAGE REGULATOR

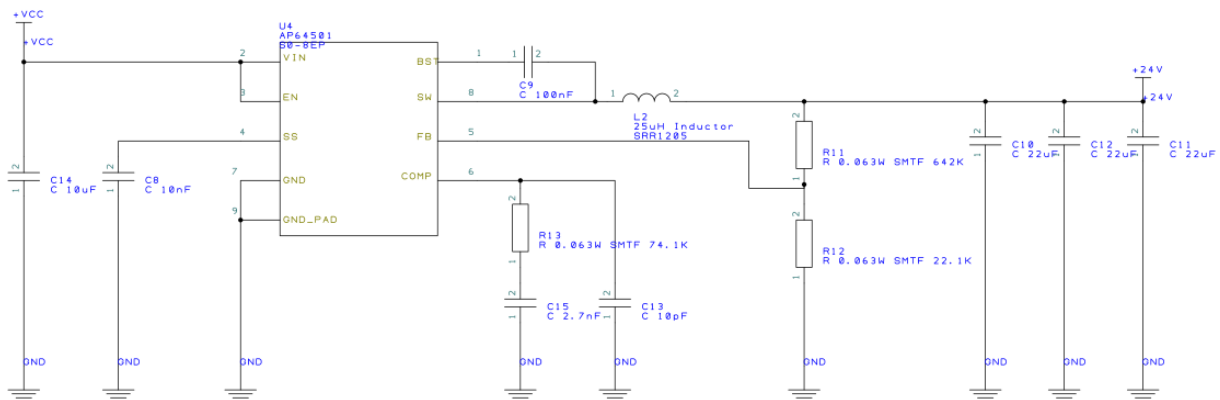


Figure 5 - 24V VOLTAGE REGULATOR

The circuit above shown a switch mode power supply circuit used to regulate 24V from VCC. A switch mode regulator was selected due to its higher efficiency than linear ones such as a 7805. The AP64501 can be used with a wide range of input voltages, ranging from 3.8 – 40V. The AP64501 IC has built in

overvoltage protection, overcurrent protection and a thermal shutoff if the chip gets hotter than its specified shutoff temperature.

The circuit above is an implemented reference circuit from the AP64501 datasheet with components selected to product a 24V output.

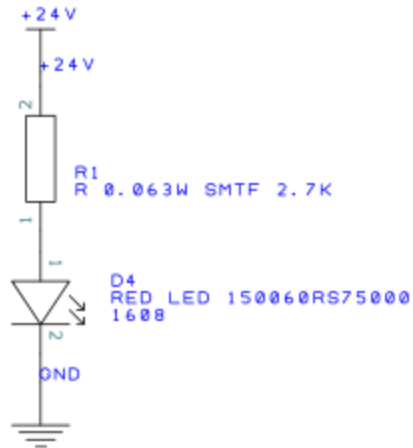


Figure 6 - 24V INDICATOR LED

An indicator LED included to shown then 24V was present in the circuit.

10.1.3 12V VOLTAGE REGULATOR

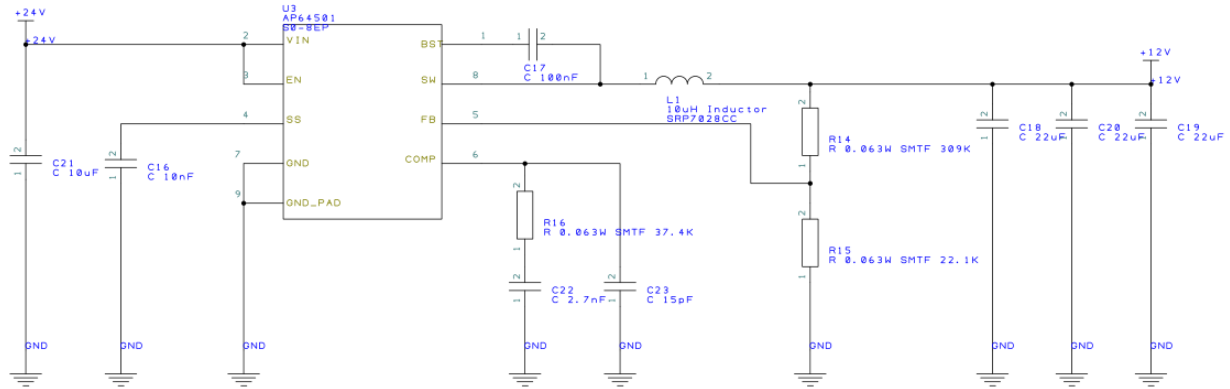


Figure 7 - 12V VOLTAGE REGULATOR

The circuit above shows another implementation of a AP64501 voltage regulator, like the one shown in Figure 5. The components have been selected to output 12V, as per the datasheet.

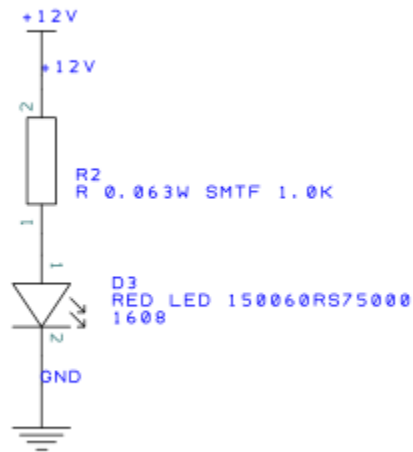


Figure 8 - 12V INDICATOR LED

An indicator LED included to shown then 12V was present in the circuit.

10.1.4 5V VOLTAGE REGULATOR

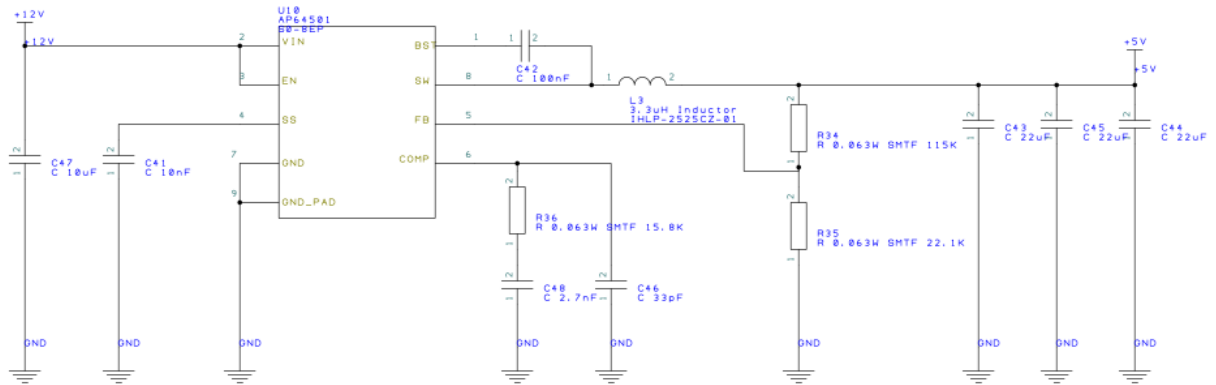


Figure 9 - 5V VOLTAGE REGULATOR

The circuit above shows another implementation of an AP64501 voltage regulator, like the one shown in Figure 5. The components have been selected to output 5V, as per the datasheet.

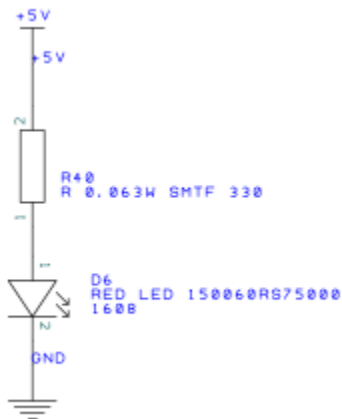


Figure 10 - 5V INDICATOR LED

An indicator LED included to shown then 5V was present in the circuit.

10.1.5 3V VOLTAGE REGULATOR

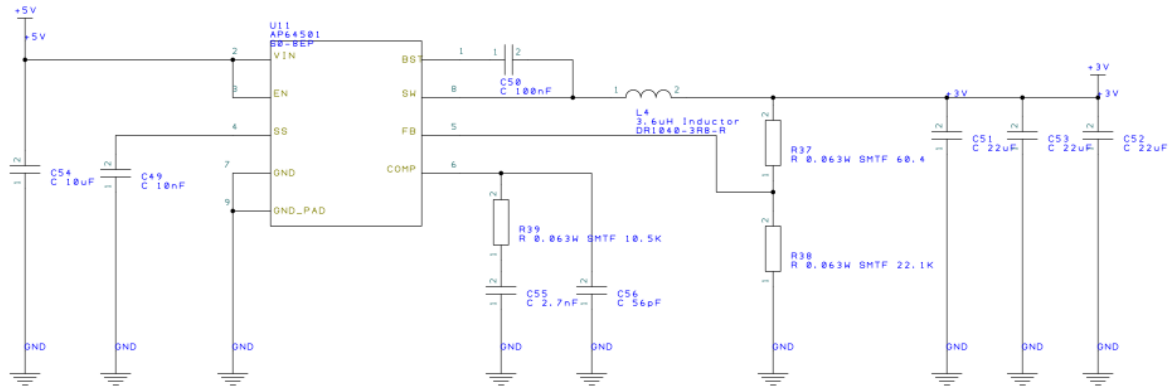


Figure 11 - 3V VOLTAGE REGULATOR

The circuit above shows another implementation of an AP64501 voltage regulator, like the one shown in Figure 5. The components have been selected to output 5V, as per the datasheet.

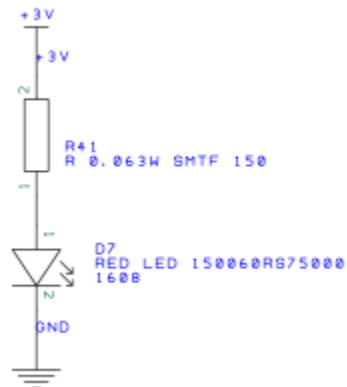


Figure 12 - 3V INDICATOR LED

An indicator LED included to shown then 3V was present in the circuit.

10.1.6 PIC18F46J50

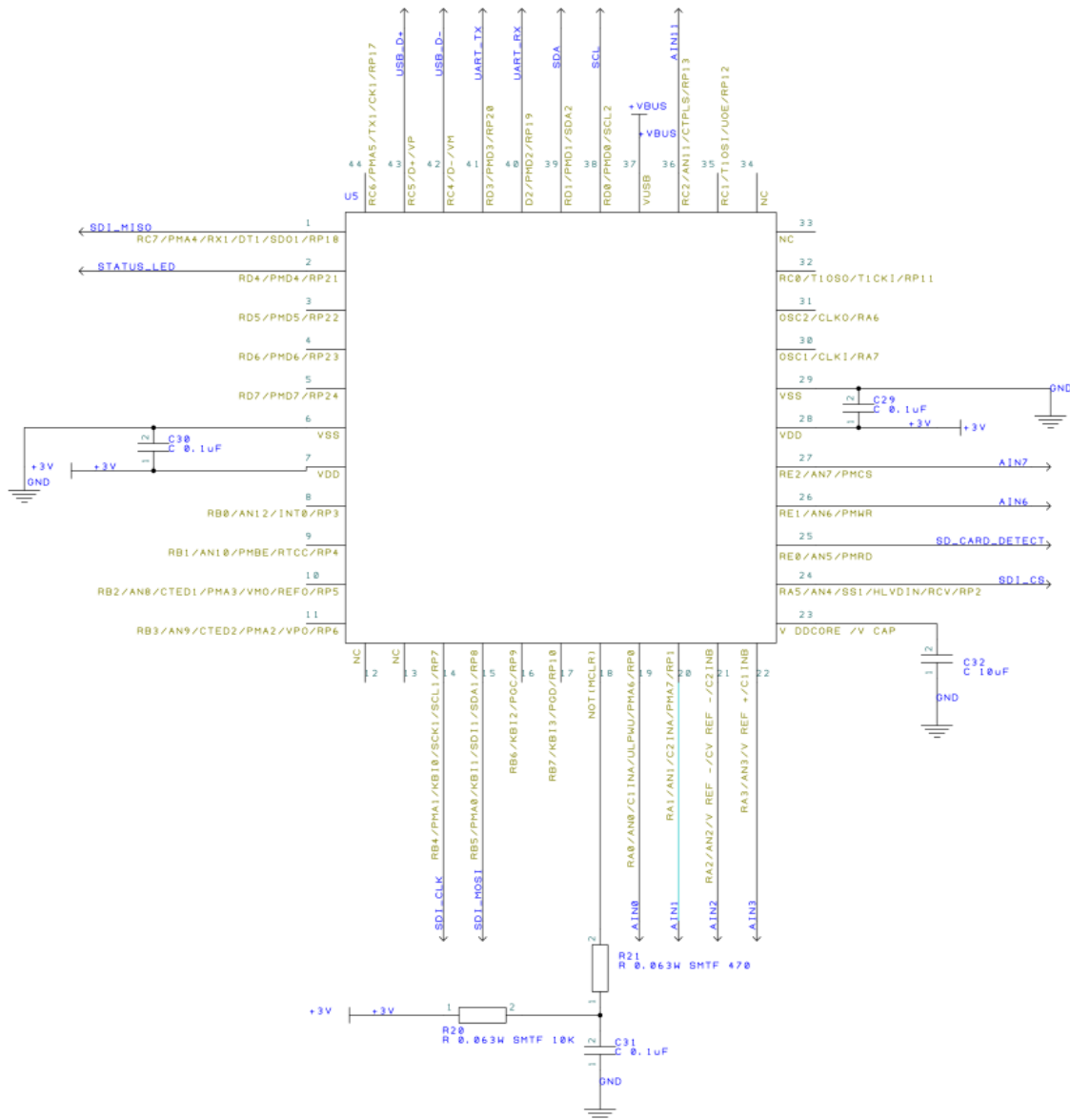


Figure 13 - PIC18F46J50 CIRCUIT

The circuit above, shows an implementation of the recommended minimum connection circuit shown in the datasheet for the PIC18F46J50. C29 and C30 are decoupling capacitors used to filter out and high frequency noise at the power input pins of the IC. R21, R20 and C31 required for device reset, device programming and debugging. The values used are recommended values from the PIC18F46J50 datasheet [19].

10.1.7 HUMIDITY INPUT CIRCUIT

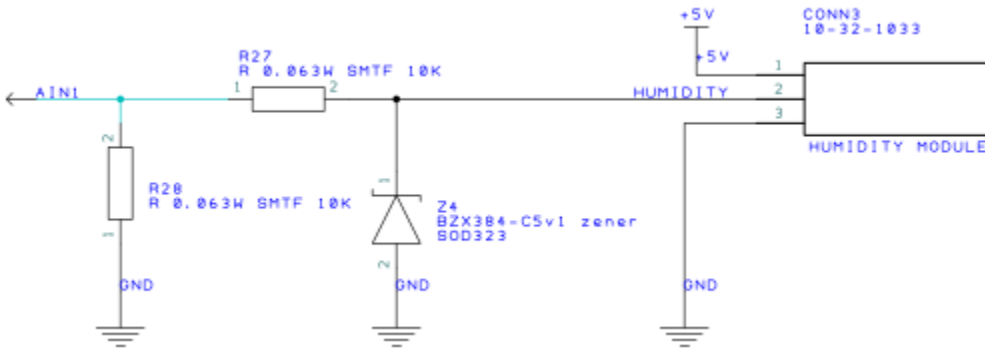


Figure 14 - HUMIDITY INPUT CIRCUIT

The humidity module is connected to CONN3, which is a 3 pin Molex header. The humidity voltage input ranged from 0 – 5V. The input voltage is halved using a voltage divider network. Overvoltage protection is provided by the 5.1V Zener diode.

10.1.8 TEMPERATURE INPUT CIRCUIT

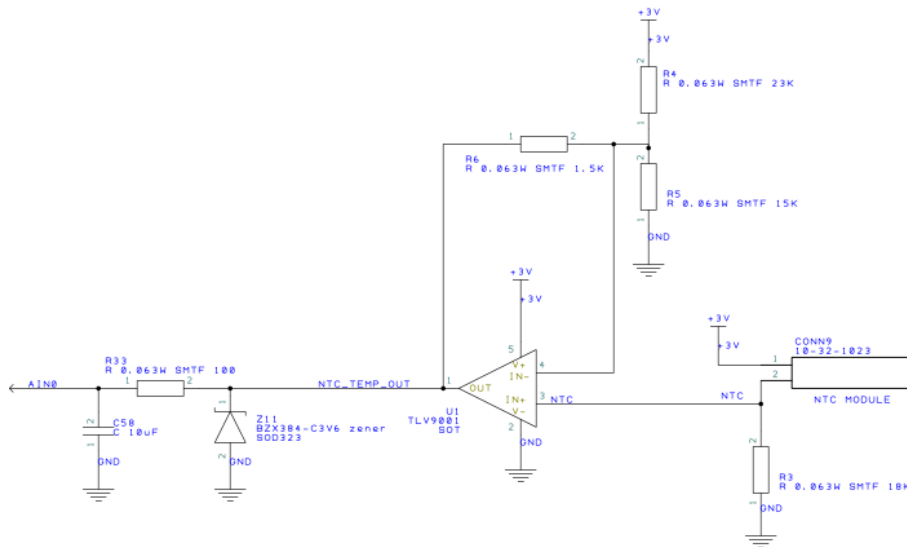


Figure 15 - TEMPERATURE INPUT CIRCUIT

The temperature sensor used on the system is an NTC. The circuit above was designed by following the steps in the Texas Instruments NTC circuit design guide [20]. The NTC forms a voltage divider with R3. The output voltage is input into a non-inverting amplifier which has its gain set to match the input requirements of the ADC. Overvoltage protection is provided by the Zener diode and R33 and C50 form a low pass filter.

A low pass filter was added to filter out any high frequency noise. The cutoff frequency was calculated to be 159Hz.

10.1.9 VOC MODULE INPUT CIRCUIT

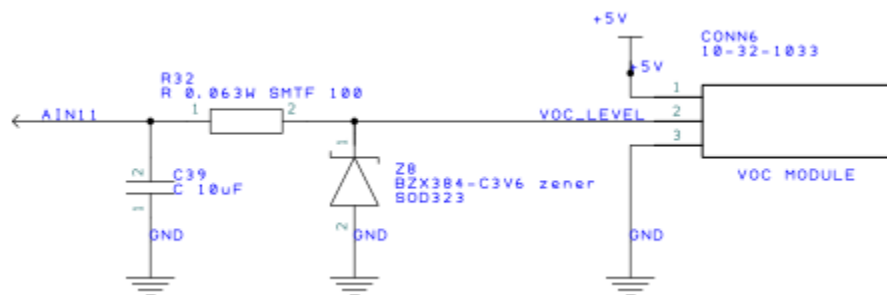


Figure 16 - VOC MODULE INPUT CIRCUIT

A low pass filter was added to filter out any high frequency noise. The cutoff frequency was calculated to be 159Hz.

10.1.10 UV MODULE INPUT CIRCUIT

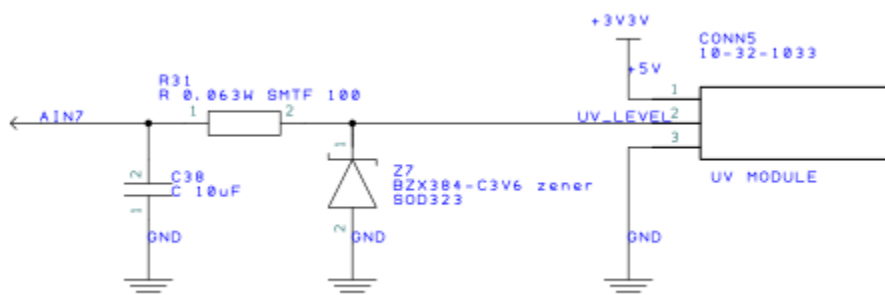


Figure 17 - UV MODULE INPUT CIRCUIT

The UV Module outputs a voltage that correlates to the UX index measured. The input is protected by a low pass filter and a Zener diode for overvoltage protection.

10.1.11 WIND SPEED SENSOR INPUT CIRCUIT

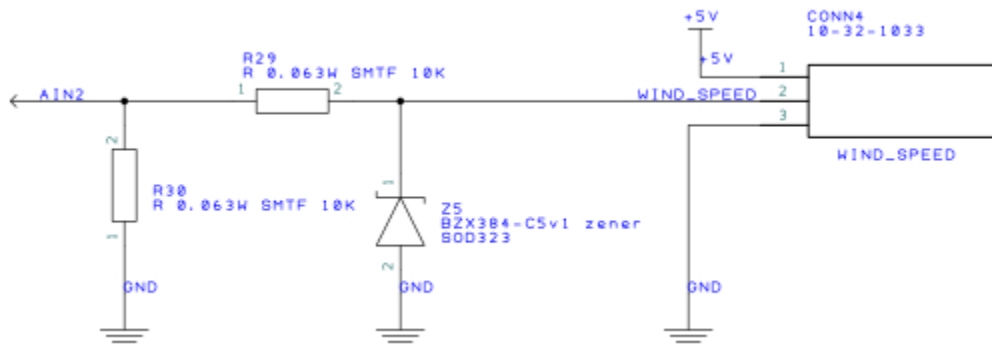


Figure 18 - WIND SPEED INPUT CIRCUIT

The wind speed module outputs a voltage that correlates to the speed measured. The input is protected by a zener diode for overvoltage protection.

10.1.12 WIND DIRECTION INPUT CIRCUIT

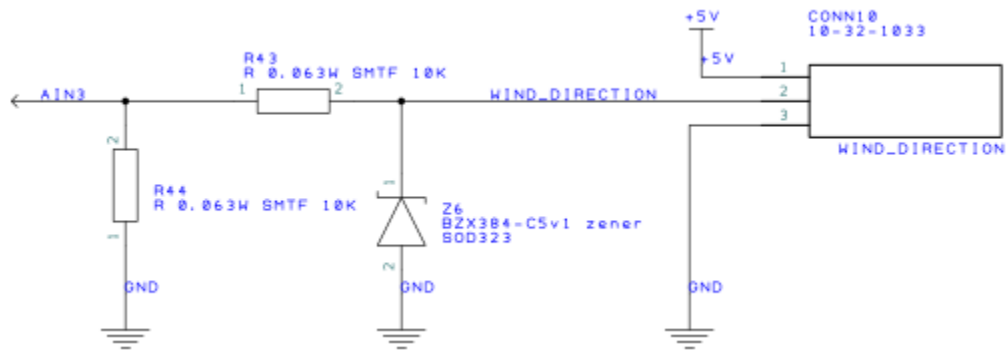


Figure 19 - WIND DIRECTION INPUT CIRCUIT

The wind direction module outputs a voltage that correlates to the direction of the wind. The input is protected by a Zener diode for overvoltage protection.

10.1.13 GPS MODULE CIRCUIT

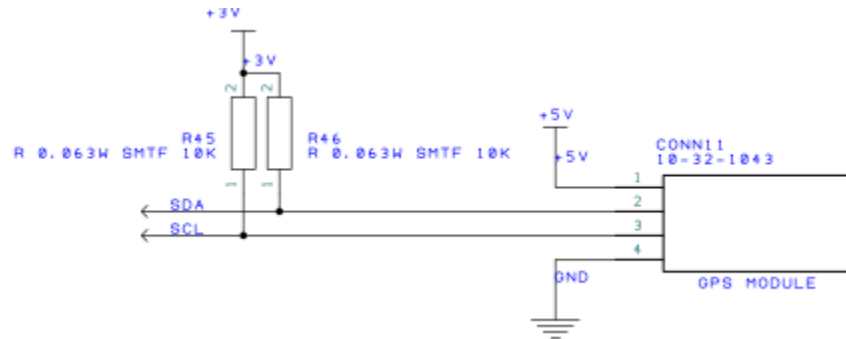


Figure 20 - GPS MODULE CIRCUIT

The GPS module circuit is simply a connector with I2C, clock and data lines.

10.1.14 BRIGHTNESS MODULE INPUT CIRCUIT

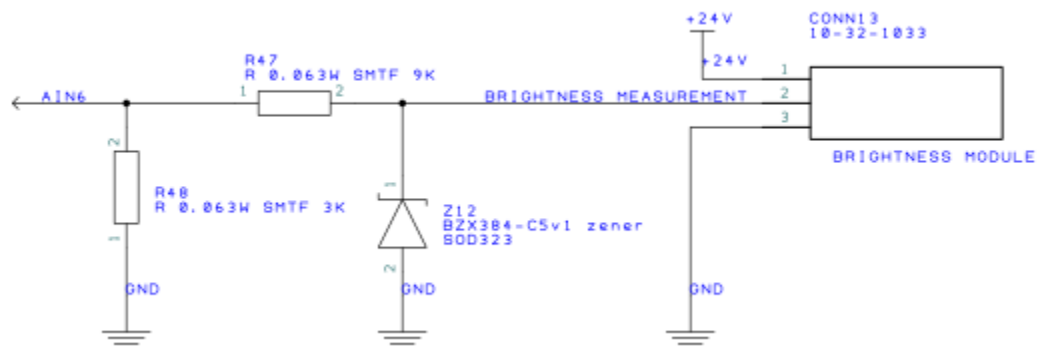


Figure 21 - BRIGHTNESS MODULE INPUT CIRCUIT

The brightness module outputs a voltage between 0-10V, depending on the measured brightness. The voltage divider above will quarter the brightness measurement so that it does not damage the analog input pin.

10.1.15 AIR PARTICLE SENSOR INTERFACE

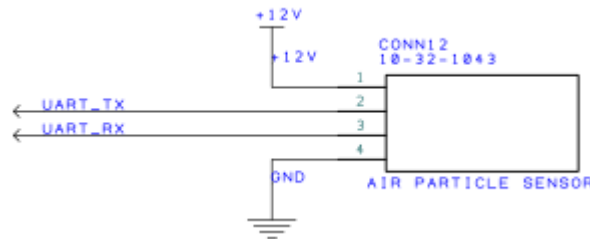


Figure 22 - AIR PARTICLE INTERFACE

The air particle interface is an RS485 connection. CONN12 has UART connections, and these will be connected to a UART to RS485 interface board.

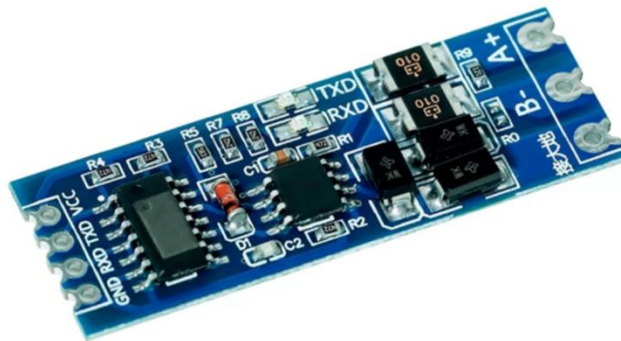


Figure 23 - UART TO RS485 INTERFACE MODULE [21]

The interface board is shown above. It will be housed within the enclosure.

10.1.16 SD INTERFACE

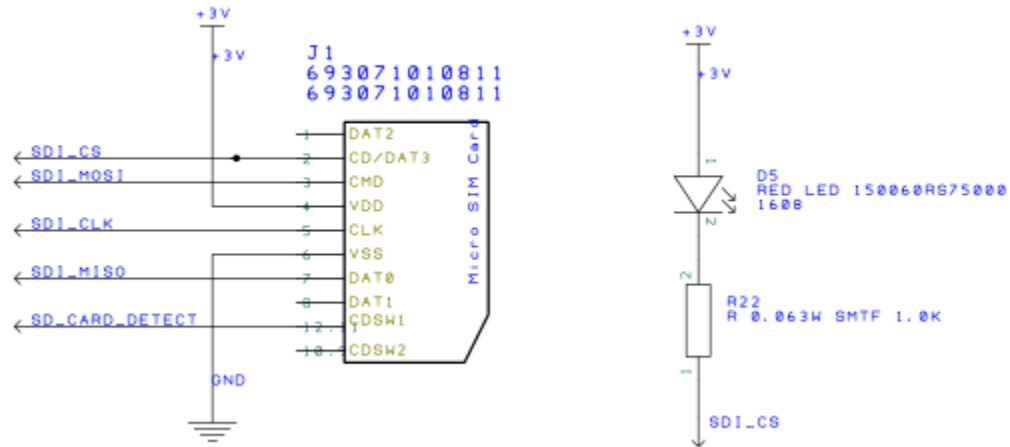


Figure 24 - SD INTERFACE

The SD card will be connected to J1 and a SDI interface will be used to control it.

10.1.17 USB INTERFACE

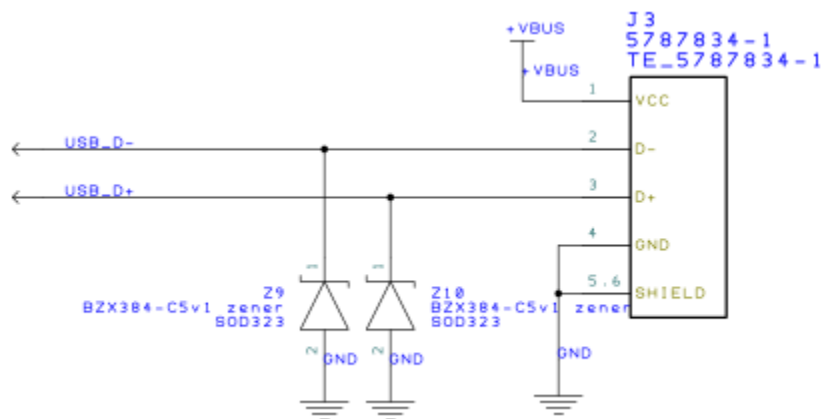


Figure 25 - USB INTERFACE CIRCUIT

A USB type B connector is fitted and is connected to the USB data lines of the PIC. Zener diodes provide overvoltage protection to the data lines.

10.1.18 UNIQUE EEPROM IC

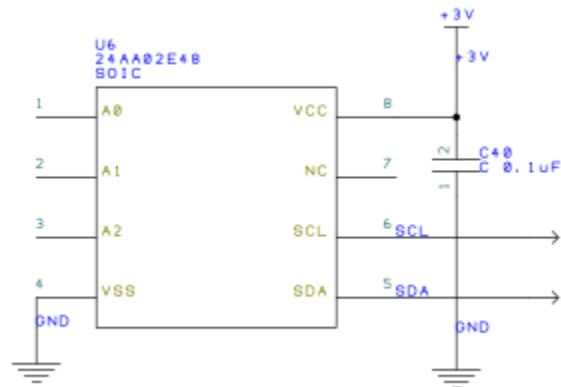


Figure 26 - UNIQUE EEPROM IC [22]

The unique ID eeprom has been connected as per the recommended circuit in the datasheet [22].

10.1.19 INDICATOR LED CONNECTION

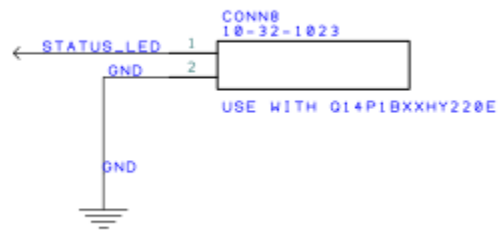


Figure 27 - INDICATOR LED CONNECTION

The connector above is used for an LED that is visible on the enclose to show the device is recording data. A APEM Q14P1BXXHY220E is used as the LED [23]. The LED does not require a current limiting resistor and can be connected to a digital output.

10.2 PCB OVERVIEW

10.3 BOARD STACKUP

The PCB that was designed is a 4 layer board. It contains, 2 signal layers, 1 ground later and a power layer.

10.4 PCB DIMENSIONS

180mm x 180mm

10.5 POWER DISTRIBUTION

10.5.1 SPLIT POWER PLANE

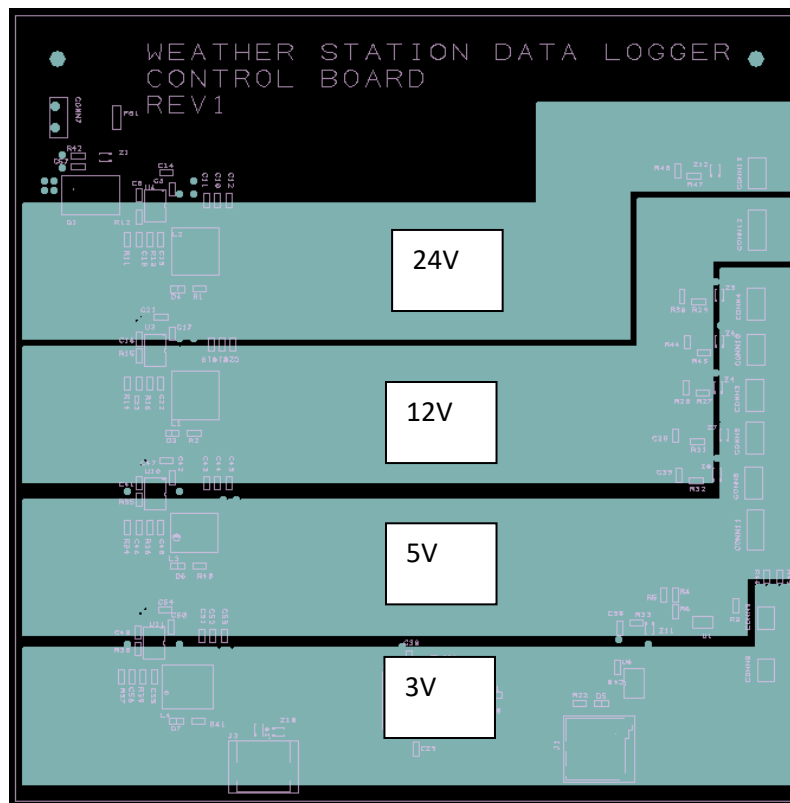


Figure 28 - SPLIT POWER PLANE

Figure 28 shows the split power plane on the PCB design. There is a polygon pour on the power plane for each required voltage. This makes routing the PCB on the signal layers much simpler. Components have been placed in a way so that the power plane is below them. A via can then be used to easily connect them.

10.5.2 GND PLANE

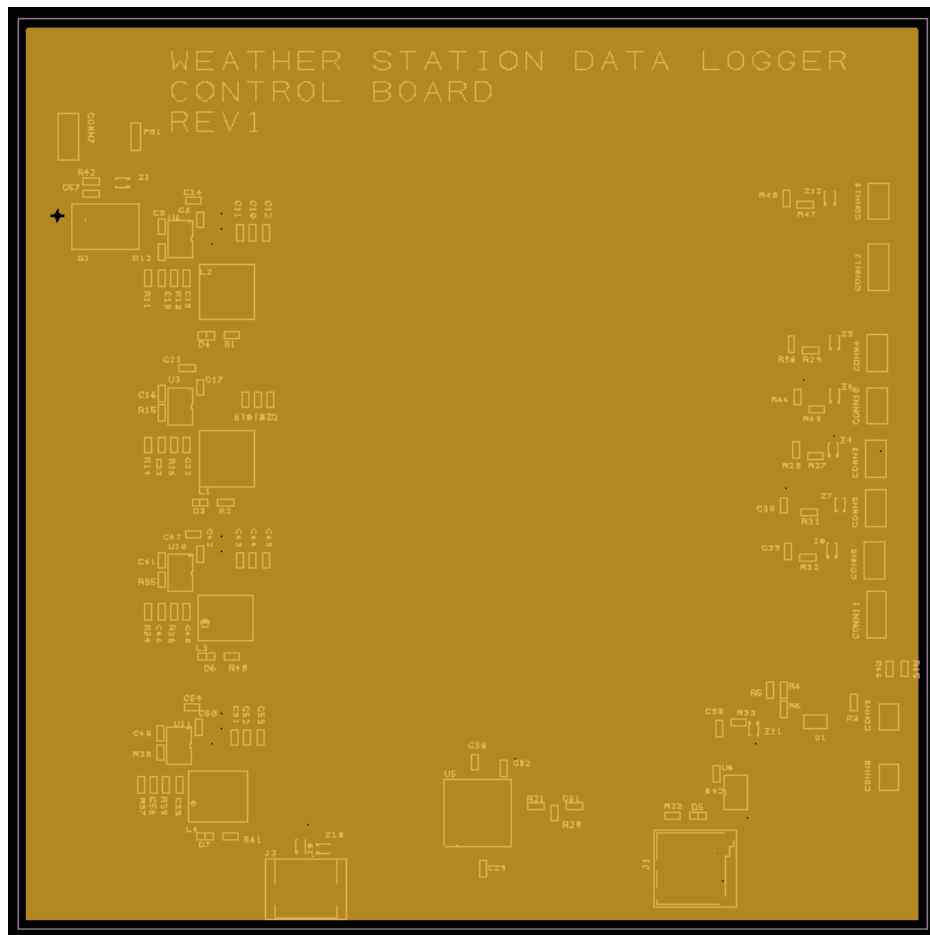


Figure 29 - GROUND PLANE

A full ground plane was inside the board. This largely reduces any ground routing on the top and bottom layers and simplifies routing.

10.6 3D VIEW

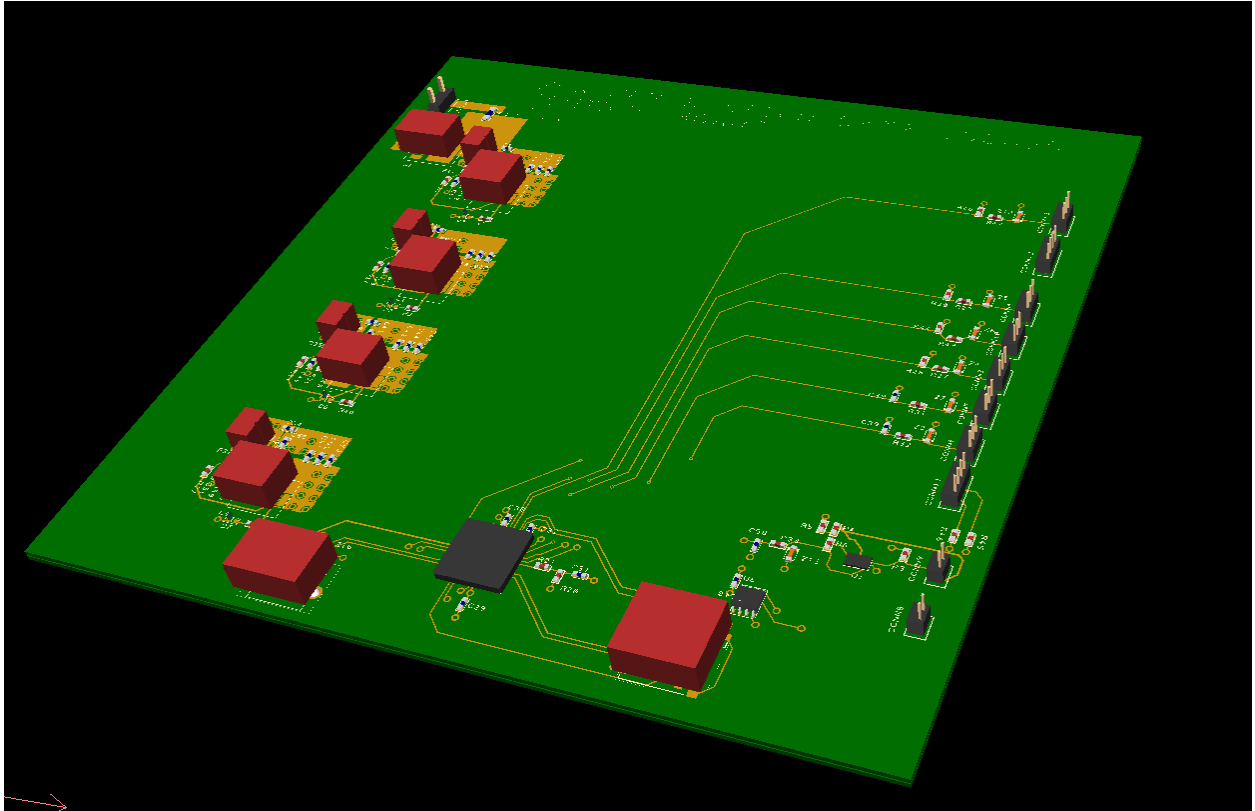


Figure 30 - PCB 3D VIEW

Figure 30 shows a 3D view of the designed board.

11 COST BREAKDOWN

Sensor Name	COST (£)	QTY	TOTAL
HTM2500LF	91.536	1	91.536
RMY-05106 Marine Wind Monitor	986.52	1	986.52
WIND SENSOR INTERFACE (for use with Model 05106)	404	1	404
OPM-6303M	NA - QUOTE REQUIRED	1	
AHKF-I	118	1	118
UV Sensor - SKU 6490	430.76	1	430.76
PPM WR VOC Gas Sensor	NA - QUOTE REQUIRED	1	
Mini GPS PA1010D - UART and I2C - STEMMA QT	31.99	1	31.99
UART TO RS485 MODULE	0.78	1	0.78
CUSTOM MILITARY GRADE CASE	NA - QUOTE REQUIRED	1	
BOM COST	41.86228	1	41.86228
PCB COST	9.2	1	9.2
IP67 D SUB CONNNECTOR (15 POS) MALE	NA - QUOTE REQUIRED	3	
IP67 D SUB CONNNECTOR (15 POS) FEMALE	NA - QUOTE REQUIRED	3	
24-100XTREME	1600	1	1600
SD CARD	8.79	1	8.79

Figure 31 - COST BREAKDOWN

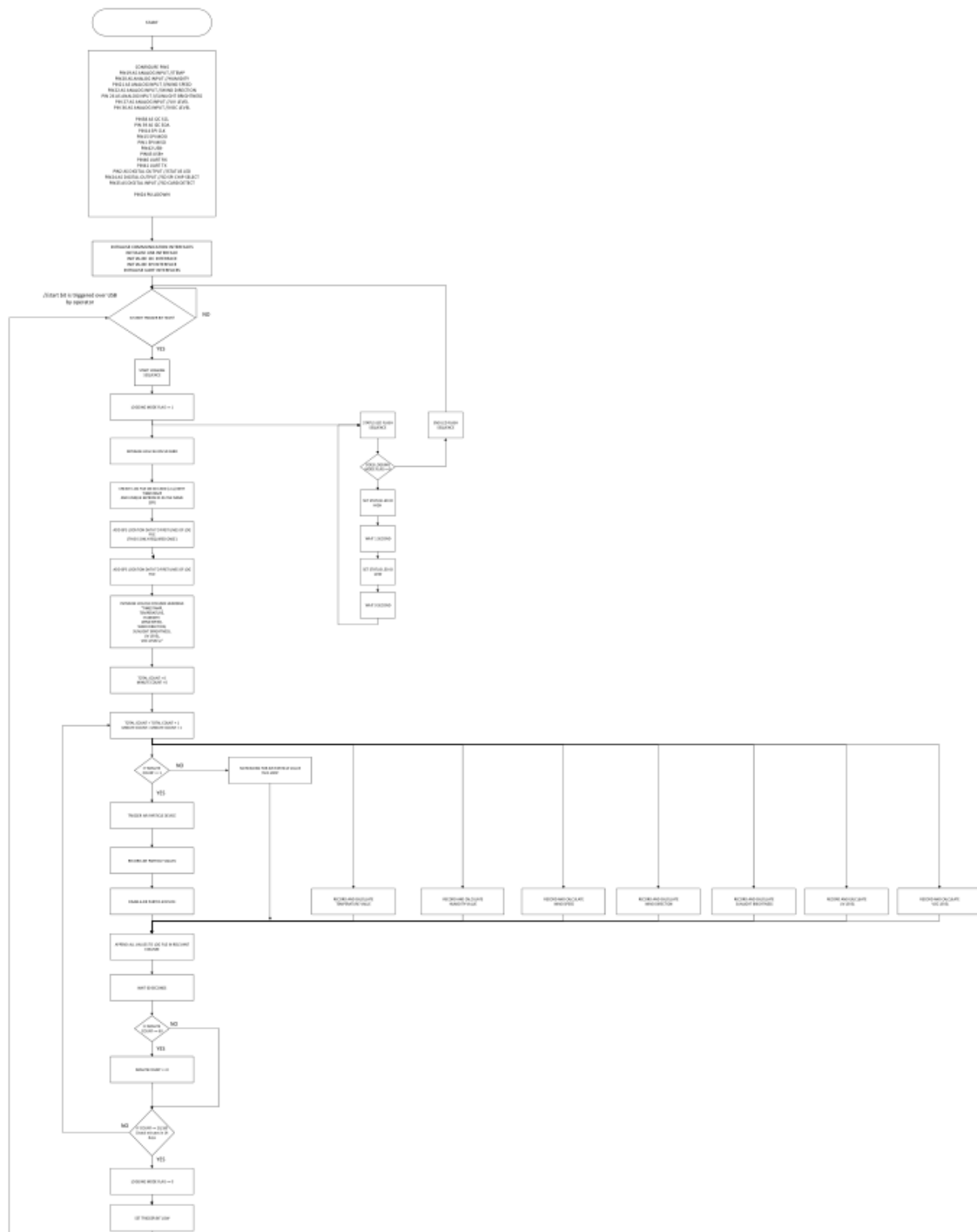
*wiring costs not included

The total known cost for the project is £3723.44. However, the actual cost may be much higher due to the unknown price of certain parts.

12 BOM

A full BOM can be found in the appendices.

A download link to the full flow chart can be found in the appendices.



14 SUGGESTED IMPROVEMENTS

The following improvements could be made to improve the design:

- Review sensors and find ones with common supply voltages. The sensors selected for this project require 4 different supply voltages. The circuit cost, simplicity and size could be significantly reducing the amount of voltage regulators on the circuit.
- A solar panel circuit could be implemented to increase the battery life of the system.
- Adding wireless functionality so that the system can remotely upload data to a server using a cellular network would be a good addition. This would allow it to be monitored without the need to physically retrieve the SD card or connect to the PICs USB interface.

15 APPENDICES

15.1 POWER USAGE CALCULATION

COMPONENT	SUPPLY VOLTAGE (V)	MAX CURRENT USAGE	POWER USAGE (W)	QTY OF PART	TOTAL POWER USAGE	Required watt hours
HTM2500LF	5	1.2mA	0.006	1	0.006	0.006
HTM2500LF	5					
RMY-05106 Marine Wind Monitor	5	5ma	0.06	1	0.06	0.06
RMY-05106 Marine Wind Monitor						
OPM-6303M	12	4.5A	54	1	54	0.9
AHKF-I	24	42mA	1.008	1	1.008	1.008
UV Sensor - SKU 6490	3	2.4mA	0.0072	1	0.0072	0.0072
MTK3339	3	45mA	0.135	1	0.135	0.135
PPM WR VOC Gas Sensor	3	3mA	0.1	1	0.1	0.1
AP64501	24	0.000025	0.0006	2	0.0012	0.0012
AP64501	12	0.000025	0.0003	1	0.0003	0.0003
AP64501	5	0.000025	0.000125	1	0.000125	0.000125
PIC	3	0.000728	0.002184	1	0.002184	0.002184
R1 (24v LED resistor)	24	0.02	0.48	1	0.48	0.48
R2 (12v LED resistor)	12	0.01	0.12	1	0.12	0.12
R40 (5v LED resistor)	5	0.009090909	0.0454545	1	0.0454545	0.0454545
R41 (3v LED resistor)	3	0.006666667	0.02	1	0.02	0.02
R22 (active LED resistor)	3	0.001	0.003	1	0.003	0.003
GPS MODULE	5	0.025	0.003	1	0.003	0.003

Total power usage in watt hours is 2.891463545Wh.

Total watt hours required for recording cycle of 14 days is 971.5317513Wh.

Amp hours required for recording cycle (calculated using nominal battery voltage of 25.6V) is 37.95045903Ah.

15.2 FULL SCHEMATIC PDF

WEATHER_STATION_SYSTEM_BATTERY_AND_PROTECTION – Schematic

https://www.dropbox.com/scl/fi/ib4lx06x3embh4q84qw3v/WEATHER_STATION_SYSTEM_BATTERY_AND_PROTECTION-Schematic.pdf?rlkey=9ra52ocz69dmfyh0cxthgmiy&dl=0

WEATHER_STATION_SYSTEM_VOLTAGE_REGS_1 – Schematic

https://www.dropbox.com/scl/fi/q80nfy5gh213nzukwh4oh/WEATHER_STATION_SYSTEM_VOLTAGE_REGS_1-Schematic.pdf?rlkey=lz3o1n5818n28n0outor8r1bm&dl=0

WEATHER_STATION_SYSTEM_VOLTAGE_REGS_2 – Schematic

https://www.dropbox.com/scl/fi/04423hxdjhslgms4f34ou/WEATHER_STATION_SYSTEM_VOLTAGE_REGS_2-Schematic.pdf?rlkey=d0sxqlh87mymiofovpya6rj32&dl=0

WEATHER_STATION_SYSTEM_MICROCONTROLLER_IO_ADC_OTHER – Schematic

https://www.dropbox.com/scl/fi/2sjrx0glohcg95tchvy58/WEATHER_STATION_SYSTEM_MICROCONTROLLER_IO_ADC_OTHER-Schematic.pdf?rlkey=eprs7050r20nr56dvrqps2hx&dl=0

15.3 FULL PCB BOM

Component	Qty	Ref Name	Manufacturer Part Number	Supplier	Cost (£)	Total Cost (£)
3.3uH Inductor	1	L3	IHLP2525CZER3R3M01	Digikey	0.9	0.9
3.6uH Inductor	1	L4	DR1040-3R8-R	Mouser	0.76	0.76
10-16-1021	1	CONN7	10-08-5021	Mouser	0.52	0.52
10-32-1023	2	CONN8,CONN9	22232021	Digikey	0.17	0.34
10-32-1033	6	CONN3,CONN5,CONN6,CONN4,CONN10,CONN13	22232031	Digikey	0.22	1.32
10-32-1043	2	CONN11,CONN12	22232041	Digikey	0.28	0.56
10uH Inductor	1	L1	SRP7028CC-100M	Farnell	0.48	0.48
25uH Inductor	1	L2	SRR1205-250ML	Digikey	0.44228	0.44228
24AA02E48	1	U6	24AA02E48T-E/OT	Digikey	0.31	0.31
3216FF-5A	1	FS1	TR/3216FF5-R	Digikey	0.7	0.7
5787834-1	1	J3	5787834-1	Digikey	2.47	2.47
693071010811	1	J1	693071010811	Mouser	2.49	2.49
AP64501	4	U4,U3,U10,U11	AP64501SP-13	Digikey	1.9	7.6
BZX384-C3V6 zener	3	Z7,Z8,Z11	BZX384-C3V6,115	Digikey	0.17	0.51
BZX384-C5v1 zener	6	Z4,Z9,Z10,Z5,Z6,Z12	BZX384-C5V1,115	Digikey	0.17	1.02
BZX384-C27 zener	1	Z1	BZX384-C27,115	Digikey	0.16	0.16
C 0.1uF	4	C29,C30,C31,C40	CL10B104KB8NNWC	Digikey	0.08	0.32
C 2.7nF	4	C15,C22,C48,C55	2211Y4K00272KXT	Digikey	1.4	5.6
C 10nF	4	C8,C16,C41,C49	C0603C103K4REC7867	Digikey	0.09	0.36
C 10pF	1	C13	GRM0335C1E100JA01D	Digikey	0.08	0.08
C 10uF	9	C57,C14,C21,C47,C54,C32,C38,C39,C58	CL10A106MQ8NNNC	Digikey	0.09	0.81
C 15pF	1	C23	GRM0335C1E150JA01D	Digikey	0.08	0.08
C 22uF	12	C10,C11,C12,C18,C19,C20,C43,C44,C45,C51,C52,C53	GRM188R60G226MEA0D	Digikey	0.15	1.8
C 33pF	1	C46	C0603C330J5GAC7867	Digikey	0.12	0.12
C 56pF	1	C56	600S560FT250XT	Digikey	1.54	1.54
C 100nF	4	C9,C17,C42,C50	CL10B104KB8NNWC	Digikey	0.08	0.32
PIC18F46J50	1	U5	PIC18F46J50-I/PT	Digikey	4.15	4.15
R 0.063W SMTF 1.0K	2	R2,R22	RMCF0603FT1K00	Digikey	0.08	0.16
R 0.063W SMTF 1.5K	1	R6	WR06X1501FTL	Digikey	0.08	0.08
R 0.063W SMTF 2.7K	1	R1	RMCF0603FT2K70	Digikey	0.08	0.08
R 0.063W SMTF 3K	1	R48	ERA-3AEB302V	Digikey	0.25	0.25
R 0.063W SMTF 9K	1	R47	RMCF0603FG49K9	Digikey	0.08	0.08
R 0.063W SMTF 10K	10	R42,R20,R27,R28,R29,R30,R43,R44,R45,R46	RMCF0603FT10K0	Digikey	0.08	0.8
R 0.063W SMTF 10.5K	1	R39	RMCF0603FT10K5	Digikey	0.08	0.08
R 0.063W SMTF 15K	1	R5	WR06X15R0FTL	Digikey	0.08	0.08
R 0.063W SMTF 15.8K	1	R36	RMCF0603FT15K8	Digikey	0.08	0.08
R 0.063W SMTF 18K	1	R3	RG1608P-183-B-T5	Digikey	0.16	0.16
R 0.063W SMTF 22.1K	4	R12,R15,R35,R38	RMCF0603FT22K1	Digikey	0.08	0.32
R 0.063W SMTF 23K	1	R4	RMCF0603FT23K2	Digikey	0.08	0.08

R 0.063W SMTF 37.4K	1	R16	RC0603FR-0737K4L	Digikey	0.08	0.08
R 0.063W SMTF 60.4K	1	R37	RMCF0603FT60K4	Digikey	0.08	0.08
R 0.063W SMTF 74.1K	1	R13	RN73R1JTTD7412B25	Digikey	0.16	0.16
R 0.063W SMTF 100	3	R31,R32,R33	RMCF0603FT100R	Digikey	0.08	0.24
R 0.063W SMTF 115K	1	R34	RMCF0603FT115K	Digikey	0.08	0.08
R 0.063W SMTF 150	1	R41	RC0603FR-07150RL	Digikey	0.08	0.08
R 0.063W SMTF 309K	1	R14	RMCF0603FT309K	Digikey	0.08	0.08
R 0.063W SMTF 330	1	R40	CR0603-JW-331ELF	Digikey	0.08	0.08
R 0.063W SMTF 470	1	R21	ERA-3AEB471V	Digikey	0.26	0.26
R 0.063W SMTF 642K	1	R11	RN73H1JTTD6423B50	Digikey	0.25	0.25
RED LED 150060RS75000	5	D4,D3,D6,D7,D5	150060RS75000	Digikey	0.12	0.6
SJ6012DRP	1	Q1	SJ6012DRP	Digikey	1.49	1.49
TLV9001	1	U1	TLV9001IDBVR	Digikey	0.37	0.37

15.4 JLC PCB FULL QUOTE

The screenshot displays the JLCPCB website's quote interface. At the top, navigation links include 'USDShip to', 'Order now', 'My file', 'Sign in', and a shopping cart icon. Below the navigation bar, four service categories are shown: 'Standard PCB/PCBA' (selected), 'Advanced PCB/PCBA', 'SMT-Stencil', and '3D/CNC'. Two images of green PCBs are displayed. Below the images, a status message reads 'Detected 6 layer board of 180x180mm(7.09x7.09 inches)'. A 'Gerber Viewer' link is also present. The main configuration area includes: 'Base Material' (FR-4 selected, with options for Flex, Aluminum, Copper Core, Rogers, and PTFE Teflon); 'Layers' (1, 2, 4 selected, with options for Precision PCB, 6, 8, 10, 12, 14, 16, 18, and 20); 'Dimensions' (180 x 180 mm); 'PCB Qty' (5); and 'Product Type' (Industrial/Consumer electronics selected, with options for Aerospace and Medical). On the right, a 'Charge Details' table lists: Engineering fee (\$24.00), Via Covering (\$18.26), Surface Finish (\$0.00), and Board (\$16.50). Below this, a 'Build Time' table shows: PCB (4-5 days, \$0.00), 3-4 days (\$0.00), 3-4 days PCBA Only (\$0.00), and 2-3 days (\$62.90). The 'Calculated Price' is \$58.76, with a note that additional charges may apply for special cases. A 'SAVE TO CART' button is located below the price. At the bottom right, a 'Shipping Estimate' section shows 'Charge: Choose destination country first' and 'Weight: 0.68kg'.

Charge Details	
Engineering fee	\$24.00
Via Covering	\$18.26
Surface Finish	\$0.00
Board	\$16.50

Build Time	
PCB:	4-5 days \$0.00
	☐ 3-4 days \$0.00
	☐ 3-4 days PCBA Only \$0.00
	☐ 2-3 days \$62.90

Calculated Price **\$58.76**
Additional charges may apply for special cases

Shipping Estimate
Charge: Choose destination country first
Weight 0.68kg

Figure 32 – FULL JLC PCB QUOTE

15.5 SOFTWARE FLOW CHART PDF DOWNLOAD LINK

<https://www.dropbox.com/scl/fi/8k0amt045wuejbihd0t7v/OPERATIONAL-FLOW-CHART.pdf?rlkey=s1x97o0q5435x78eebpbj1r&dl=0>

16 REFERENCES

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