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BEng Electrical & Electronic Engineering

Electronic Systems Design

14 Day Weather and Air Quality Measurement and Logging System

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Project submitted as part of the requirements for the award of BEng (Hons) Electrical and Electronic Engineering

May 2021

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Introduction

This report will document the design of a microcontroller-based weather and air quality monitor/logger. The system will be designed to take measurements and log data over a 14-day period and will be intended for the use of weather predictions by amateur weather forecasters. The design will allow for the weather logger to be completely portable by having its own battery for remote work, making it adaptable to a range of test sites. In addition to this, the system will be able to store the collected data to non-volatile memory which may be externally read and cleared when connected to a computer via USB.

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

This report will reflect on the following: research and selection of relevant components along with calculations and specifications, a full circuit and PCB design, prototype software, design and structure, costs and conclusions

Literature Review

Generally, an automated portable weather system allows for a round the clock data collection of physical changes in the environment that can help to make weather predictions with minimal human intervention. Listed below is a collection of existing portable weather systems currently on the market: -

Vaisala
Weather Transmitter WXT530 Series [1]

The WXT530 is a cost-efficient series of all-in-one weather instruments. It provides six weather parameters: air pressure, temperature, humidity, rainfall, wind speed and wind direction. With multiple sensors available, you can choose the measurement parameter combination to fit various applications.

The latest version of these world-class weather instruments supports the modbus protocol, unlocking new industrial applications such as renewable energy, building and industrial automation, and manufacturing.

WXT530 is a simple system that utilises solid state technologies to minimise operating and maintenance costs. Integration is easy and flexible through the digital and analog interface. You can also connect third party sensors to WXT530 in order to create your own weather parameter hub. Additional parameters include: solar radiation, tipping bucket rain gauge, ultrasonic level sensor and external temperature sensor.

Omni
RWS-07 Portable Weather Station [2]

The RWS-07 includes the following sensors:

- Solid state weather station
- Data files in csv format
- Battery powered - lasts up to 6 months
- Rugged waterproof case
- Simple to deploy
- Wind speed
- Wind direction

There are also some additional sensors available:

- Temperature
- Humidity
- Rainfall
- Solar radiation
- Barometric pressure

Pegasus
FLX™ [3]

The Pegasus FLX weather station offers a complete weather monitoring solution for portable operations. For HazMat, pollution control, research, and other environmental monitoring requirements, the Pegasus FLX's wind sensor offers 2 degree wind direction resolution and up to 160mph wind speed range.

The met parameters monitored are:

- Temperature
- Barometric pressure
- Wind direction
- Wind speed
- Relative humidity

Weather Master software can also be used to calculate dew point, heat index, wind chill, density altitude and automatically integrate weather data into Cameo/Aloha HazMat software

BRESSER
5-IN-1 COMFORT WEATHER STATION [4]

The 5-in-1 outdoor sensor transmits measured values for wind speed, wind direction, humidity, temperature and rainfall to the base station. Current and historical values are displayed on the colour display of the base station. From the collected data, the weather station calculates a very reliable local weather trend forecast for the next twelve hours, depicted by six graphic symbols. The base station allows the internal storage and evaluation of measured data over a period of 24 hours. Alerts can also be programmed in order to notify the user if minimum of maximum values are exceeded. This includes a special frost/ice warning alert.

Comparison Table - Existing Portable Data Loggers

	Vaisala Weather Transmitter WXT530 Series	**Omni RWS-07 Portable Weather Station**	**BRESSER 5-IN-1 COMFORT WEATHER STATION**	**Pegasus FLX™**
Measured Variables	Air pressure Temperature Humidity Rainfall Wind speed Wind direction	Temperature Humidity Rainfall Solar radiation Barometric pressure	Air pressure Temperature Humidity Rainfall Wind speed Wind direction	Temperature Barometric pressure Wind speed Wind direction Relative Humidity
Cost	£2047.00	£2414.80	£109.99	£2519.00
Pros	Additional parameters include the solar radiation, tipping bucket rain gauge, ultrasonic level sensor and external temperature sensor	All data can be exported to Excel, CSV format. No external power or solar panels required. Up to 6 months battery life.	Includes additional sensors for: Wind chill Heat index Dew point Moon phase Selectable ice/frost alert Programmable alarms for weather extremes	LCD touch-screen displays weather data with two configuration screens. Capable of networking multiple weather stations with one centralised computer. Multiple alarm features mean that users can be alerted to critical weather conditions. Wireless transmission up to 2 miles.
Cons	No details of casing etc, may be less portable that other selections	Basic LCD screen	Smaller, more basic components. Wireless transmission range of only 30m	

Sensor Selection

Temperature Sensor Selection

1. Sensirion, SHT21, Band-Gap, Temperature sensor. [5]

The Sensirion SHT2x series of DFN digital humidity & temperature sensors are CMOSens® based. They are an industry standard, widely used humidity and temperature sensor. The humidity is measured using a capacitive sensor while temperature is measured using a band-gap sensor.
The SHT2x sensors also contain a version 4 silicon chip with an amplifier, A/D converter, OTP memory and a digital interface. They come in a plastic package which leaves the sensor area open, protecting the devices from external impact and providing long-term stability.
SHT2x sensors are ideal for both high and low volume applications.
The SHT21P has a PWM output and the SHT21S has a PDM output; these can be converted into analogue outputs by the use of suitable low-pass filters.

2. AM2303, DHT22, Negative Temperature Coefficient (NTC) Thermistor. [6]

Every sensor of this model is temperature compensated and calibrated in an accurate calibration chamber. The calibration-coefficient is saved in OTP memory and when the sensor is detecting, it will cite the coefficient from memory. A small size, low consumption and long transmission distance (20m) enables the AM2303 to be suited to all kinds of harsh application occasions.

3. A1227LUA-T Allegro Microsystems, Bipolar Hall Effect, Temperature Sensor. [7]

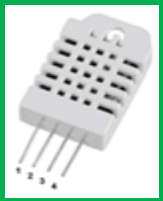
The A1225/7/9 High Temperature Hall Effect Latches are temperature-stable and stress resistant suitable for operation for temperatures up to 150°C. A Schmitt trigger circuit maintains operate and release point symmetry by compensating for temperature changes in the Hall element. Internal compensation provides magnetic switch points that become more sensitive with temperature, hence offsetting the usual degradation of the magnetic field with temperature.

4. RS PRO, Type K, IEC, PTFE, Exposed Welded Tip Thermocouple, Temperature Sensor. [8]

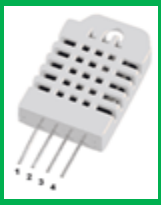
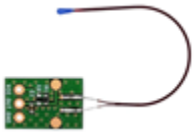
These Type K and Type T fine wire temperature sensors have a durable Teflon PTFE insulated class 1 twin-twisted 1/0.2 mm lead. The lead is terminated with a rewireable miniature flat pin plug for a quick and easy connection. These thermocouples have an exposed welded junction which enables them to operate with a fast response time.

A Table to Compare Different Types of Temperature Sensors

Sensor type	Band-Gap	(NTC) Thermistor	Bipolar Hall Effect	Thermocouple

Example sensor	Sensirion, SHT21	AM2303, DHT22	A1227LUA-T	RS PRO, Type K
Image				
Cost	£7.00	£9.30	£1.63	£7.22
Temperature range	-40°C to +125°C	-40°C to +125°C	-40°C to +150°C	-75°C to +250°C
Supply Voltage	3.8 V to 24 V.	3.3 V to 6 V DC	3.8 V to 24 V.	
Output	Digital output, I²C interface	Digital signal via single-bus	Voltage	Voltage

A Table to Compare Different Thermistor Models

Sensor Model	AM2303, DHT22	RS PRO Thermistor	Murata MTHMR-N-0002A	EPCOS B57541G1103F000
Image				
Cost	£9.30	£2.34	£30.84	£4.02
Temperature range	-40°C to +125°C	-40°C to +200°C		-55°C to +200°C
Supply Voltage	3.3 V to 6 V DC		3.3V or 5V DC	0.3 V DC
Output	Digital signal via single-bus	Resistance	Ratio metric analogue output	Resistance
Link	Next AM2302 / DHT22 Datasheet	RS PRO Thermistor 10Ω, 20 (Dia.) x 6mm	https://uk.rs-online.com/web/p/sensor-development-tools/1368800/	https://uk.rs-online.com/web/p/thermistor-ics/1527130/

Temperature sensor selected is the AM2303, DHT22, Negative Temperature Coefficient (NTC) Thermistor. This model has been selected due to its fair price, its suitable temperature range for the environment, and its digital output.

Humidity Sensor Selection

1. AM2303, DHT22, Capacitive Humidity sensor. [6]

AM2303 output calibrated digital signal. It utilises exclusive digital-signal-collecting-technique and humidity sensing technology, ensuring its reliability and stability. Its sensing element is connected with an 8-bit single chip computer.

2. Honeywell HIH-4602-C Thermistor Humidity Sensor. [9]

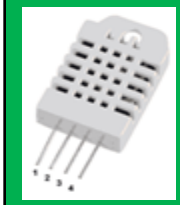
The HIH-4602-A/C series relative humidity sensors combine both relative humidity and temperature sensing in a TO-5 housing with a hydrophobic sintered stainless steel filter. The laser-trimmed thermoset polymer capacitive sensing element has on-chip signal conditioning.

3. ABS-300 Absolute Humidity Sensor. [10]

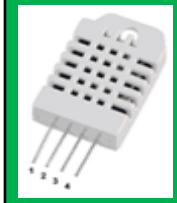
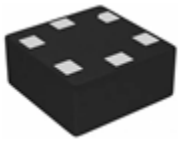
ABS sensors use two matched thermistors connected in a bridge circuit, located on a common stainless-steel heat sink. One thermistor is glass encapsulated in dry nitrogen while the other thermistor is exposed to the environment.

A Table to Compare Different Types of Humidity Sensors

Sensor type	Capacitive	Thermistor	Absolute Humidity

Example sensor	AM2303, DHT22	Honeywell HIH-4602-C	ABS-300
Image			
Cost	£9.30	£44.40	
Accuracy	-2 to +2 %RH	-3.5 to +3.5 %RH	
Supply Voltage	3.3 V to 6 V DC	4 V to 5.8 V DC	15 V DC
Output	Digital signal via single-bus	Voltage	Voltage

A Table to Compare Different Capacitive Sensor Models

Sensor Model	AM2303, DHT22	MK33-W	P14 SMD-G	HTS221TR
Example Image				
Cost	£9.30	£43.58	£28.86	£3.25
Accuracy	-2 to +2 %RH		-1.5 to +1.5 %RH	-3.5 to +3.5 %RH
Supply Voltage	3.3 V to 6 V DC	3v to 12 V	3v to 12 V	1.7 V to 3.6 V
Output	Digital signal via single-bus	Capacitance	Capacitance	16-bit humidity and temperature data output
Link	Next AM2302 / DHT22 Datasheet	https://uk.rs-online.com/web/p/temperature-sensors-humidity-sensors/1218002/	https://uk.rs-online.com/web/p/temperature-sensors-humidity-sensors/1699924/	https://uk.rs-online.com/web/p/temperature-sensors-humidity-sensors/1106598/

Humidity sensor selected is the AM2303, DHT22, Capacitive Humidity Sensor. The AM2303 has been selected again due to its fair price and suitable accuracy. Also, as this sensor will already be incorporated for temperature only one module is required to measure both variables.

Wind Speed Sensor Selection

1. Octopus Wind Speed Sensor Anemometer Three Aluminium Cups. [11]

An anemometer is a device used for measuring wind speed, and is a common weather station instrument. This well made anemometer is designed to sit outside and measure wind speed with ease.

To use, connect the black wire to power and signal ground, the brown wire to 7-24VDC (we used 9V with success) and measure the analog voltage on the blue wire. The voltage will range from 0.4V (0 m/s wind) up to 2.0V (for 32.4m/s wind speed). That's it! The sensor is rugged, and easy to mount. The cable can easily disconnect with a few twists and has a weatherproof connector.

2. 1405-PK-021 Wind Speed Sensor Anemometer. [12]

The Gill WindSonic is a low-cost anemometer, which utilises Gill's proven ultrasonic technology to provide wind speed and direction data via one serial or two analogue outputs. To confirm correct operation, outputs are transmitted together with an instrument status code.

With a robust, corrosion-free polycarbonate housing, this small, lightweight wind sensor is recommended for use in harsh environmental conditions and is particularly suited to marine & offshore (ships, data buoys) and land based installations. The WindSonic has no moving parts, offering maintenance-free operation in a wide range of applications.

3. SONIC-ANEMO-MICRO Ultrasonic Wind Speed Sensor. [13]

The sound (and ultrasound) is conveyed by the movement of the fluid in which it crosses. The electro acoustic transducers (1) communicate between themselves two by two using ultrasonic signals (2) to determine, following the orthogonal axes, the wave transit time differences induced by the air flow (3). CV7 Transducers communicate between themselves delivering four independent measures, while head wind measured vectors are preferably used for calculations. The measurements are combined in an integrated calculation to establish the wind speed and its direction in relation to a reference axis. The temperature measurements are used for calibration corrections. The sensor's design minimises the effect of heel angle (4) (the effect of an inclination of the wind sensor is partially corrected due to the shape given by the space).

A Table to Compare Different Wind Speed Sensor Models

Sensor type	Anemometer	Ultrasonic	Ultrasonic

Model	Octopus	1405-PK-021	SONIC-ANEMO-MICRO
Image			
Cost	£41.50	£684.00	£469.95
Wind Speed	0-70m/s	0-60m/s	0-40m/s
Supply Voltage	7 V to 24 V DC	5 V to 30 V DC	3.3 V to 3.6 V DC
Output	0.4V to 2V	analogue	ASCII format

Wind speed sensor selected is the 1405-PK-021 Ultrasonic Anemometer. This is due to its analogue output and its supply voltage of 12V.

Wind Direction Sensor Selection

1.1405-PK-021 Wind Speed Sensor Anemometer. [12]

The Gill WindSonic is a low-cost anemometer, which utilises Gill's proven ultrasonic technology to provide wind speed and direction data via one serial or two analogue outputs. To confirm correct operation, outputs are transmitted together with an instrument status code.

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3. BASIC magnetic Wind direction sensor. [14]

SMALL BUT IMPRESSIVE ...

and a particularly economical purchase are the sensors of the BASIC series. The slender, flow-optimised external geometry ensures certain and precise measurement. For optimum resilience and safe long-term use we rely on robust materials, such as the anodised aluminium housing. Additionally the compact sensors, with their simple mounting principles, provide a high degree of flexibility.

A Table to Compare Different Wind Direction Sensor Models

Sensor type	Ultrasonic	Ultrasonic	Magnetic

Model	1405-PK-021	SONIC-ANEMO-MICRO	BASIC
Image			
Cost	£684.00	£469.95	
Direction sensitivity	-2° to +2°	-1.5° to +1.5°	-3.5° to +3.5°
Supply Voltage	5 V to 30 V DC	3.3 V to 3.6 V DC	6 V to 28 V DC
Output	Analogue	ASCII format	0 V to 5 V

Wind direction sensor selected is the 1405-PK-021 Ultrasonic Anemometer. This is due to its analogue output, as well as it being the sensor selected for the wind direction. Reducing the overall number of sensors required.

Air Borne Particle Sensor Selection

1. TERA Sensor Next-PM, Particle Matter / Dust Air Quality Sensor Optical. [15]

Next-PM is the most advanced particle measurement solution available on the market. Its size and weight allows an easy integration into all systems. UART and / or Modbus connection.
The Next-PM sensor series has been designed to meet the highest standards. With 3 patents offering the best quality / size / price compromise, Next-PM provides real time PM1, PM2,5 and PM10 in number or mass (µg / m3 and pc / L.)
Thanks to its patented air flow control technology, Next-PM ensures years of maintenance-free measurements, even in a highly polluted and humid atmosphere.

2. SM-PWM-01C Infrared LED Dust Sensor. [16]

SM-PWM-01C is a dust sensor that detects the dust particle concentration in air by using optical sensing method. An infrared light emitting diode (IR LED) and a photo-sensor are optically arranged in the device. The photo-sensor detects the reflected IR LED light by dust particles in air.

The SMART Dust Sensor can detect the small particles like cigarette smoke and it can distinguish small particles like smoke from large house dust by pulse pattern of signal output.

3. SM-UART-04L Laser Dust Sensor, IR. [17]

SM-UART-04L Laser Dust Sensor is designed to operate in a moderate environment and provides excellent performance. It's embedded optical design leverages the strength from laser technology, which allows customers to achieve excellent performance with balanced reliability. SM-UART-04L is an ideal solution for industrial and consumer applications.

SM-UART-04L laser dust sensor detects dust particle concentration in air by using an optical sensing method. A laser light emitting diode (laser LED) and a photo sensor are optically arranged in the device. The photo sensor detects the reflected laser LED light by dust particles in air. The dust sensor can detect small particles such as, cigarette smoke and distinguish small particles, such as smoke from large house dust, by the pulse pattern of the signal output.

4. Particulate Matter Sensor SPS30 Laser Sensor. [18]

The MCERTS-certified SPS30 particulate matter (PM) sensor marks a new technological breakthrough in optical PM sensors. Its measurement principle is based on laser scattering and makes use of Sensirion's innovative contamination-resistance technology. This technology, together with high-quality and long-lasting components, enables precise measurements from the device's first operation and throughout its lifetime of more than ten years.

A Table to Compare Different Air Borne Particle Count Sensor Models

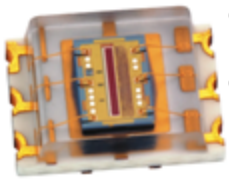
Sensor type	Optical	Infrared LED	Laser	Laser

Model	Next-PM	SM-PWM-01C	SM-UART-04L	SPS30
Image				
Cost	£81.82	£9.10	£21.53	
Mass concentration resolution	0.3 µg/ m³		1 µg/ m³	1 µg/ m³
Supply Voltage	5 V DC	-0.3 V to 7 V	0 V to 5.5 V	4.5 V to 5 V
Output	UART	Negative logic	UART 3.3V	UART, I²C

Air Borne Particle Count sensor selected is the optical laser SM-UART-04L. This is due to its fair price, UART output and suitable resolution of 1 µg/ m³.

Sunlight Brightness Sensor Selection

1. TSL2561T ams, Ambient Light Sensor. [19]



Cost: £2.83
Supply Voltage: 2.7V to 3.6V
Output: I²C

UV levels Sensor Selection

1. SEN0175. [20]

Cost: £11.46
Supply Voltage: 5V DC
Output: analogue

GPS position Sensor Selection

1. Garmin GPS Sensor. [21]

Cost: £145.48
Supply Voltage: 3.3VDC to 6VDC
Output: RS 232

VOC level Sensor Selection

1. Grove-VOC and eCO2 Gas Sensor (SGP30). [22]

Cost: £14.54
Supply Voltage: 3.3 V to 5 V
Output: I²C

Chosen sensors

	Sensor	Supply voltage	Output	Range	Storage

Temperature	AM2303, DHT22	5	Digital via single bus	-40°C to +125°C,	1 byte
Humidity	AM2303, DHT22	5	Digital via single bus	0%-100%	1 byte
Wind speed	1405-PK-021	12	Analogue	0m/s-70m/s	1 byte
Wind Direction	1405-PK-021	12	Analogue	0°-360°	2 bytes
Air Borne Particle Count	SM-UART-04L	5	UART	0µg/m³-999µg/m³	2 bytes
Sunlight Brightness	TSL2561T	3.6	I²C		2 bytes
UV levels	SEN0175	5	Analogue	280-390nm	2 bytes
GPS position	Garmin GPS Sensor	5	RS232		1 byte
VOC level	SGP30	5	I²C		1 byte

Non-Volatile Storage

Measurement Cycle Timings

Seconds									
0.0	Temp	Humid	W Speed	W Dir	ABPC	Sun	UV	GPS	VOC

0.5			W Speed	W Dir	ABPC				VOC
1.0			W Speed	W Dir	ABPC	Sun	UV		VOC
1.5			W Speed	W Dir	ABPC				VOC
2.0			W Speed	W Dir	ABPC	Sun	UV		VOC
2.5			W Speed	W Dir	ABPC				VOC
3.0			W Speed	W Dir	ABPC	Sun	UV		VOC
3.5			W Speed	W Dir	ABPC				VOC
4.0			W Speed	W Dir	ABPC	Sun	UV		VOC
4.5			W Speed	W Dir	ABPC				VOC
5.0			W Speed	W Dir	ABPC	Sun	UV		VOC
60.0	Temp	Humid	W Speed	W Dir	ABPC	Sun	UV		VOC

The table above shows the suggested measurement cycle of the weather logger. It shows the frequency at which each sensor records its respective variable. Temperature and humidity is recorded once every 60 seconds, this is due to the frequency and scale at which temperature and humidity generally changes, thus it makes sense to measure at this interval. Wind speed and direction can change much more frequently thus the air borne particle count and VOC levels will also change as a result, depending on the conditions it makes sense to measure these variables once every half second. Sunlight brightness and the UV levels are subject to change depending on winds and cloud coverage, therefore, these variables are measured once every second. Finally the GPS position, this variable only needs to be measured once as the weather logger is intended to be in one location, thus, it is measured only once when the recordings start.

14 days =	1,209,600	seconds	
	2,419,200	0.5s in 14 days	
	Number of times recorded	Number of bytes	Total number of bytes
Temperature	20,160	1	20,160
Humidity	20,160	1	20,160
Wind speed	2,419,200	1	2,419,200
Wind Direction	2,419,200	2	4,838,400
Air Borne Particle Count	2,419,200	2	4,838,400
Sunlight Brightness	1,209,600	2	2,419,200
UV levels	1,209,600	2	2,419,200
GPS position	1	1	1
VOC level	2,419,200	1	2,419,200
			19,393,921
			19.39Mb
	Non-volatile storage min		19.4Mb

Using the recommended measurement cycle table, the volatile storage was calculated, as shown in table to the left. Firstly, it shows how 14 days is represented in seconds, (1,209,600 seconds). This number is then multiplied by 2 to represent the number of half seconds in 14 days, (2,419,200 half seconds). This was calculated as the smallest time measurement recommended for this system is 0.5 seconds. Next, a list of each variable, the number of times each variable is recorded and the number of bytes required to store each record was made. Then the total number of bytes for each variable was calculated by multiplying the number of times a variable is recorded by the number of bytes required. Finally, the total number of bytes required for the non-volatile storage was calculated by adding all of the total number of bytes for each variable. This value was 19,393,921 bytes, when converted to megabytes and rounded up the minimum storage required for the non-volatile memory was 19.4 Mb.

Battery selection

To calculate the size of the battery required for the weather logger, the total number of watt hours needed to be calculated. The total number of watt hours was calculated in the table below by multiplying the power consumption of each sensor by the number of hours used. The power for each sensor was

calculated by multiplying its supply voltage by its current draw. As discussed earlier, the measurement cycles for each sensor is different, suggesting different amounts of useage. However, as the weather logger was intended to be used over 14 days (336 hours), this would be the time used to work out the battery size. This ensures that the battery will be large enough to cope with the demands of the sensors. The table below shows the calculator for the total watt hours.

I/O	Voltage (V)	Current (A)	Power (W)	Hours of use	W Hrs
Temperature & Humidity	5.0	0.0021	0.011	336	3.7
Wind speed & direction	12.0	0.0130	0.156	336	52.4
Air borne particle count	5.0	0.1000	0.500	336	168.0
Sunlight brightness	3.6	0.0006	0.002	336	0.7
UV levels	5.0	0.3000	1.500	336	504.0
GPS position	5.0	0.1000	0.500	336	168.0
VOC level	5.0	0.0500	0.250	336	84.0
					980.8

The total watt hours required by all of the sensors was 980.8 Whrs. To calculate the size of the battery the total watt hours was divided by 12, (the voltage size of the battery), giving a minimum size for the battery of 81.73 Amp hours.

The battery found was a RS PRO Lead Acid Battery [23]. This battery cost £277.55. It is a 12v 90AH battery, meaning it is large enough to accommodate the power demands of all the sensors.

Protective Casing

The weather logger system required a suitable package (casing) for the system that is both portable and suitable for the environment. As the system will likely be remote and subjected to the elements it was important that the case was secure and water tight.

The case found was the 1630 PROTECTOR CASE by Peli, costing £542.15 [24].

The chosen casing is made from a waterproof, crushproof and dustproof Copolymer Polypropylene, which is formed using an open cell core design and a solid wall construction. Internally there is base foam which is made up from three Pick 'n' Pluck layers, as well as a layer of Convoluted Lid Foam. This ensures maximum strength, durability and internal protection for delicate items. Other features include; seven double-step easy open latches, these latches are user friendly and allow easy access within the case, the placement and design of the latches also ensure the lid is securely sealed to the body of the case. The lip of the lid has an integrated rubber O-Ring seal, the latches and seal combined make this case fully waterproof with an IP rating of 67. The case has two Stainless steel padlock hasps, these allow the case to be locked when closed, preventing unwanted access. The case also has two easy grip fold down handles and one retractable handle combined with four strong polyurethane wheels that make this case very transportable.

Connectors

The connectors that will be used in the weather logger system are Lemo F CONNECTOR [25]. This model of connector by Lemo is perfectly suited for the weather logger as it is rated at IP67 making them fully waterproof. They incorporate a Push-Pull self-latching design making connection easy and secure. They come in 8 different sizes, enabling fast and easy connector identification and preventing incorrect connection between different sensors and voltage sources.
This connector has two mating parts, the first is a bulkhead connector which is attached directly to the case, internally the connector is then connected to the microprocessor. The partner connector is external and fixed to the cable that connects to the desired senor.

Micro Controller Specification

Volatile memory

Sensors	Times recorded per 60 seconds	no of bytes	Total no of bytes/60 seconds
Temperature	1	1	1
Humidity	1	1	1
Wind speed	120	1	120
Wind direction	120	2	240
Air borne particle count	120	2	240
Sunlight brightness	60	2	120
UV levels	60	2	120
GPS position	1*	1	1
VOC level	120	1	120
		(Volatile) Storage	963 bytes

*GPS is only recorded once during the 14-day period.

Pin requirements

I/O	Connection type	Pins	Digital or Analogue
Temperature & Humidity	Digital	1	Digital
Wind speed & direction	Analogue	2	Analogue
Air borne particle count	UART	2	Digital
Sunlight brightness	I²C	2	Digital
UV levels	Analogue	1	Analogue
GPS position	RS232	2	Digital
VOC level	I²C	2	Digital
USB		3	Digital
SD card	SPI	3	Digital
Start button		1	Digital
Digital ‘tell’		1	Digital
Power		1	
Ground		1	

PIC requirements

Program memory size KB: 16 or greater
SRAM (BYTES): 512 or grater
Pin Count: 28 or grater
Internal Oscillator (MHz): 16 or greater
ADC Inputs: 10 or greater
UART: 1 or grater
SPI: 1 or grater
I²C: 1 or grater
Number of USB Modules: 1 or grater

Using the parameters from the list and a Microchip 8-bit PIC MCU search tool, there were 3 potential PICs to choose from.

Product	5K Pricing	Program Memory Size (KB)	SRAM (Bytes)	Pin count	Internal Oscillator	ADC Input	UART	SPI	I2C	Number of USB Modules
[Reset] MTR6618 PIC10F200 PIC10F202 PIC10F204 PIC10F206 PIC10F220 PIC10F222 PIC10F320	[Reset] $0.33 $0.36 $0.38 $0.39 $0.42 $0.43 $0.44 $0.46	4 7 8 12 14 16 24 28 32 48	368 384 454 512 640 678 768 902 1024	18 20 28 40 44 48 64 80 100	11 MHz 12 MHz 13 MHz 14 MHz 16 MHz 16 MHz, 32 kHz 32 kHz 32 MHz, 32 kHz 4 MHz 4 MHz, 8 MHz	6 7 8 9 10 11 12 13 14 15	[Reset] 0 1 2 4 5	[Reset] 0 1 2	[Reset] 0 1 2	[Reset] 0 1
PIC18F24K50	$1.65	16	2048	28	16 MHz, 32 kHz	14	1	1	1	1
PIC18F25K50	$1.76	32	2048	28	16 MHz	14	1	1	1	1
PIC18F45K50	$1.99	32	2048	40	16 MHz	25	1	1	1	1

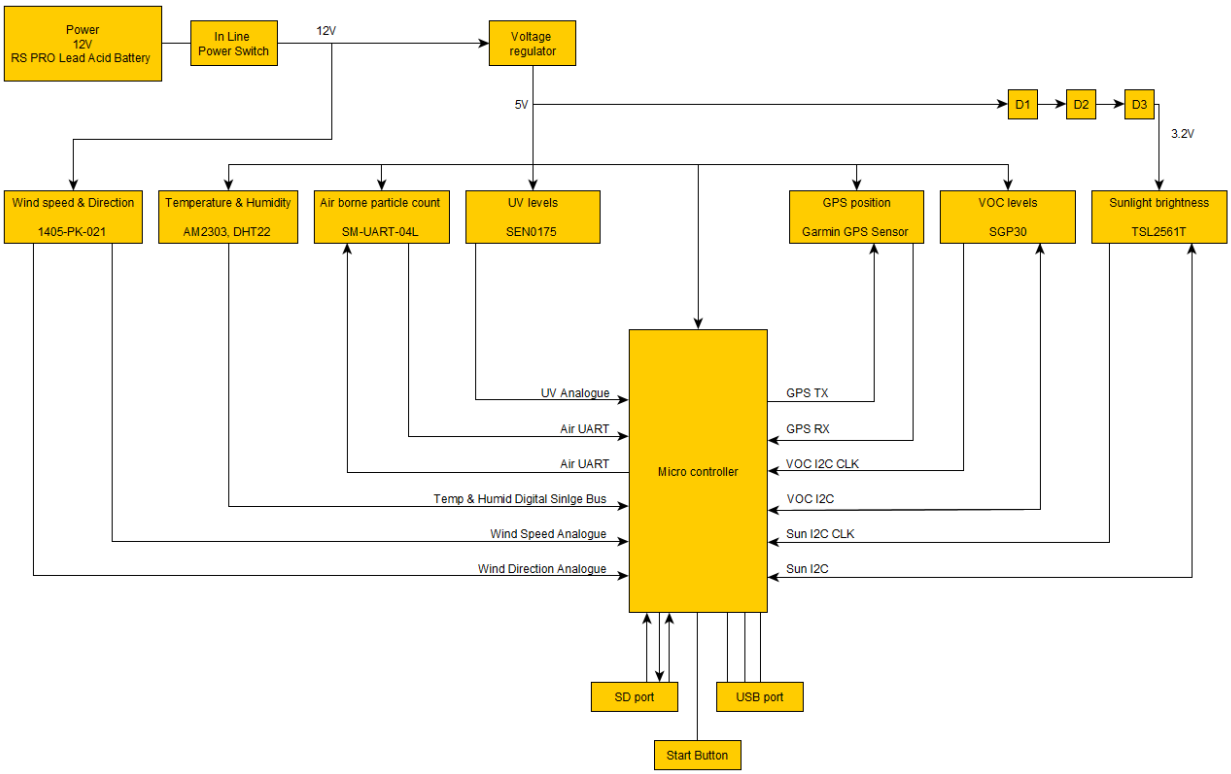
The main differences between these three PICs are: pricing, program memory size, pin count and ADC inputs. However, as all of these parameters meet or exceed the requirements any of these will be suitable. PIC18F45K50 has been chosen as the proposed microchip for this design based on the program memory and pin count. 32KB will ensure that any future firmware updates can be carried out. 40 pins allow for all sensor modules to be connected and leaves others free if future devices were to be added.

Parametrics

Name	Value
Program Memory Type	Flash
Program Memory Size (KB)	32
CPU Speed (MIPS/DMIPS)	12
SRAM (B)	2,048
Data EEPROM/HEF (bytes)	256
Digital Communication Peripherals	1-UART, 1-SPI, 1-I2C1-MSSP(SPI/I2C)
Capture/Compare/PWM Peripherals	1 ECCP,
Timers	2 x 8-bit, 2 x 16-bit
ADC Input	25 ch, 10-bit
Number of Comparators	2
Number of USB Modules	1, FS Device
Temperature Range (°C)	-40 to 125
Operating Voltage Range (V)	1.8 to 5.5
Pin Count	40
Low Power	Yes

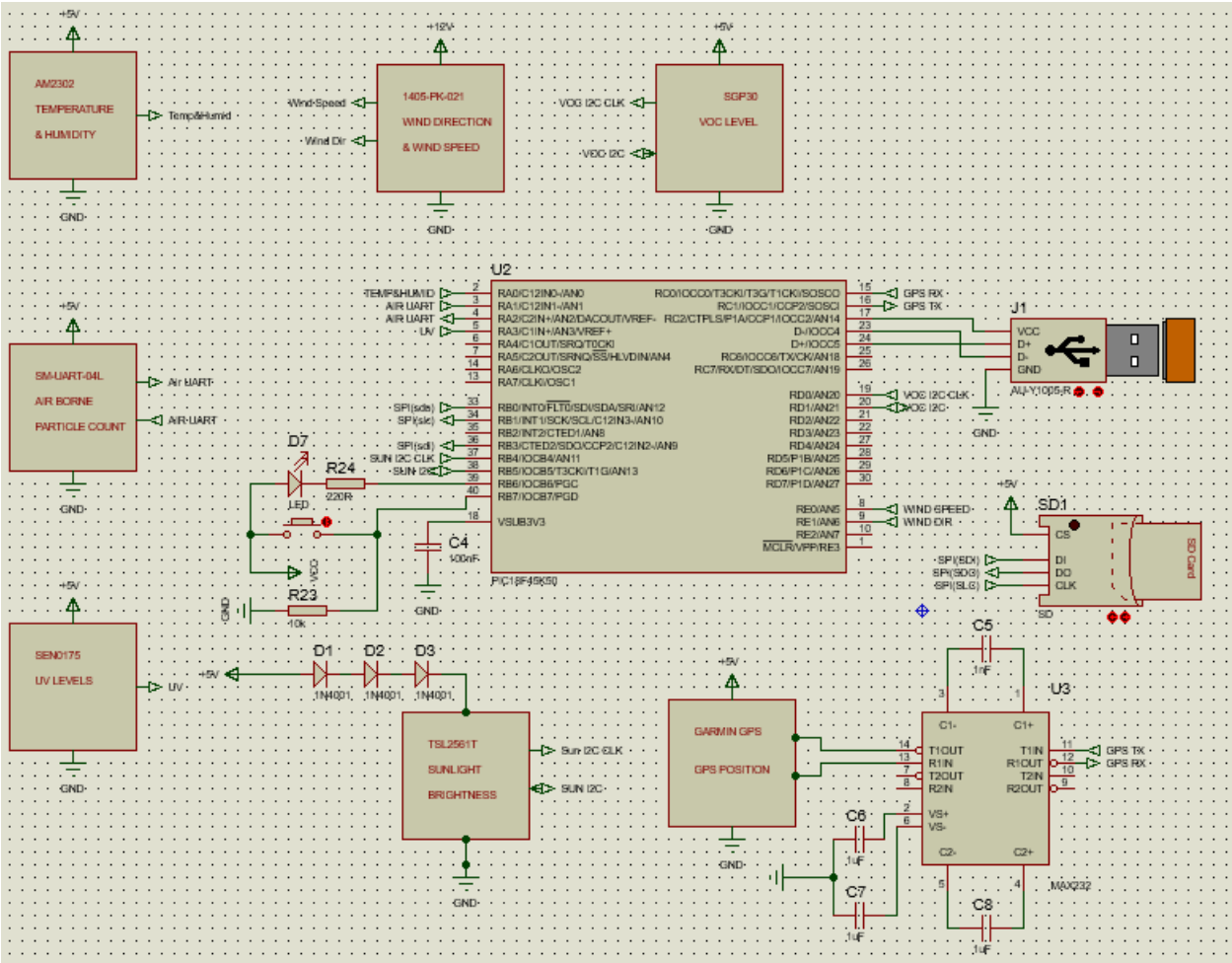
[26]

Circuit Block Diagram Design

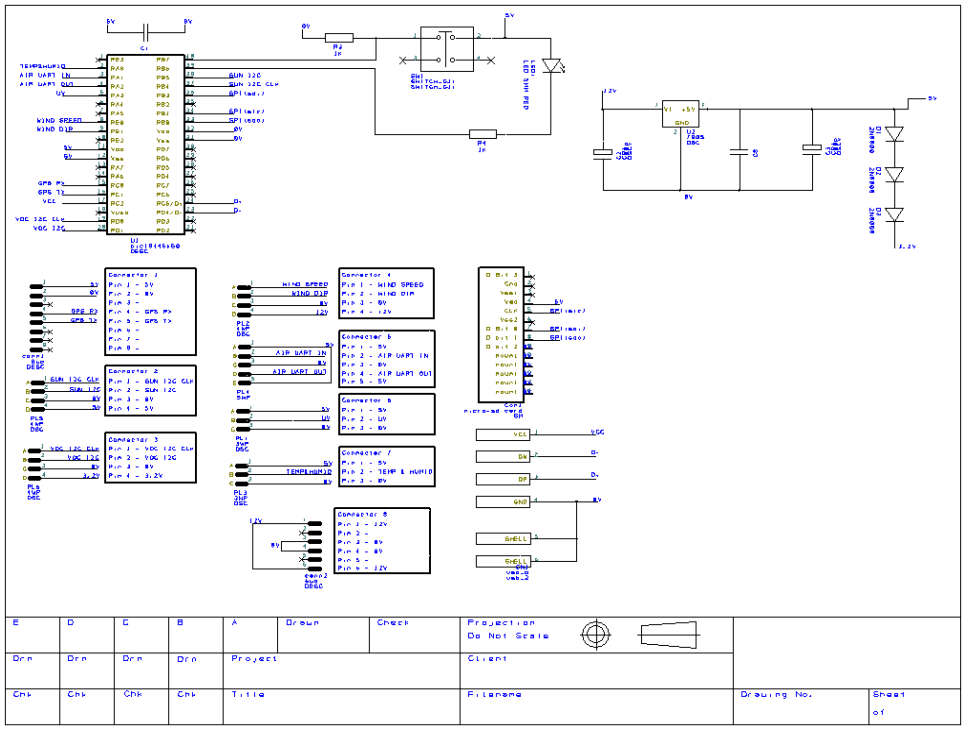


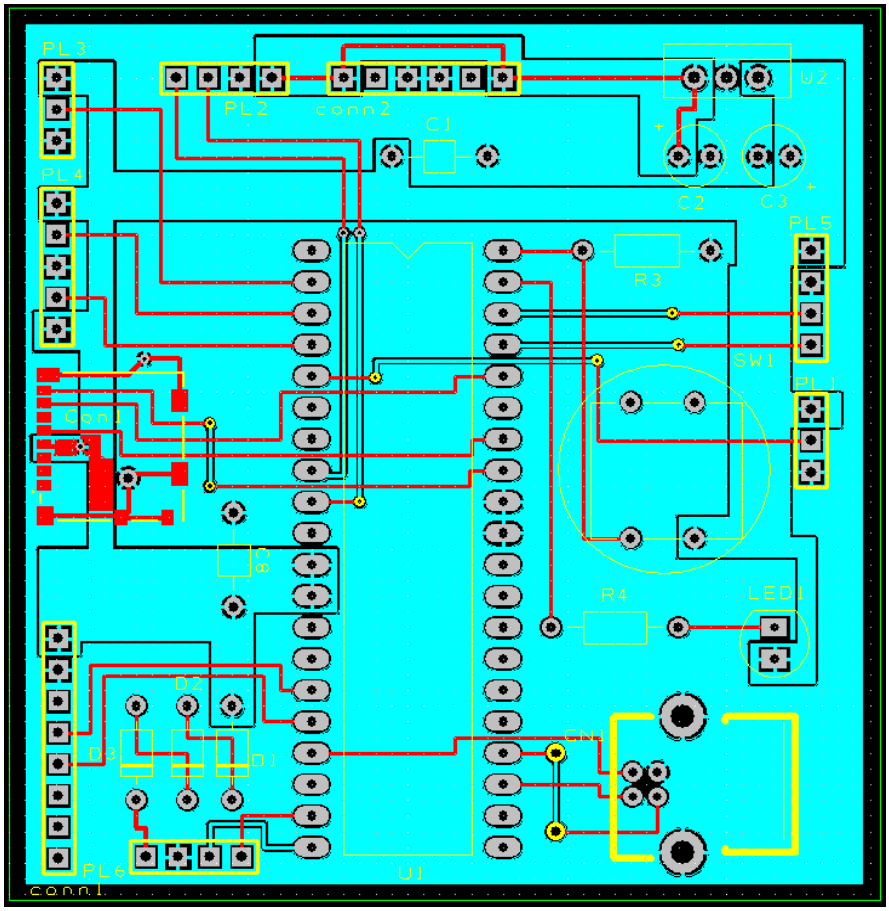
This circuit block diagram depicts the basic design of the hardware involved in the weather logger.

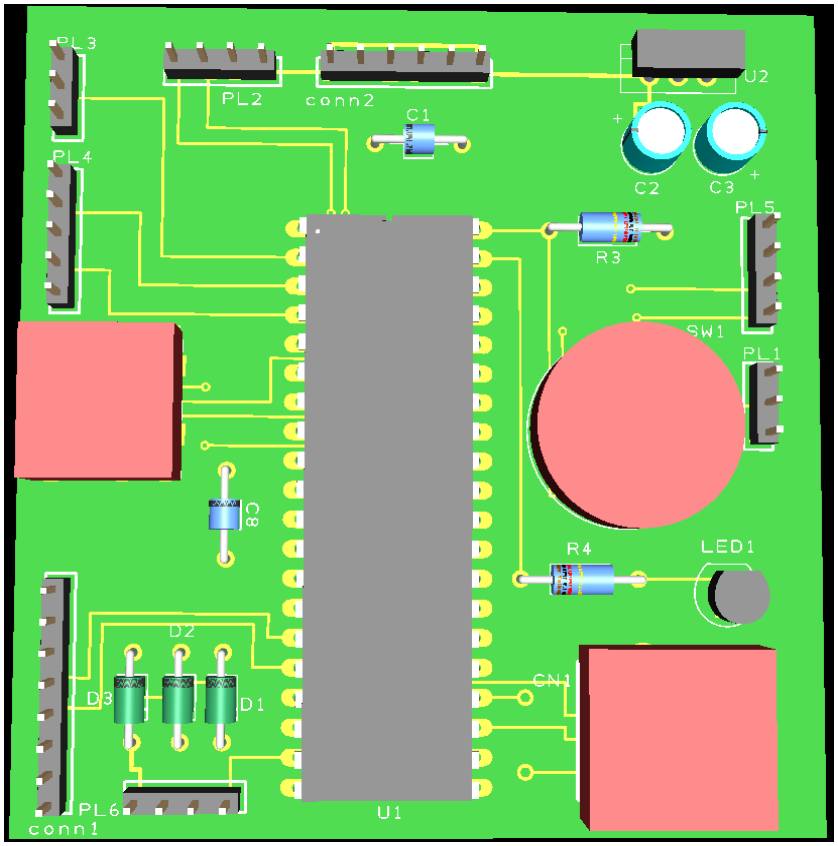
Proteus Schematic

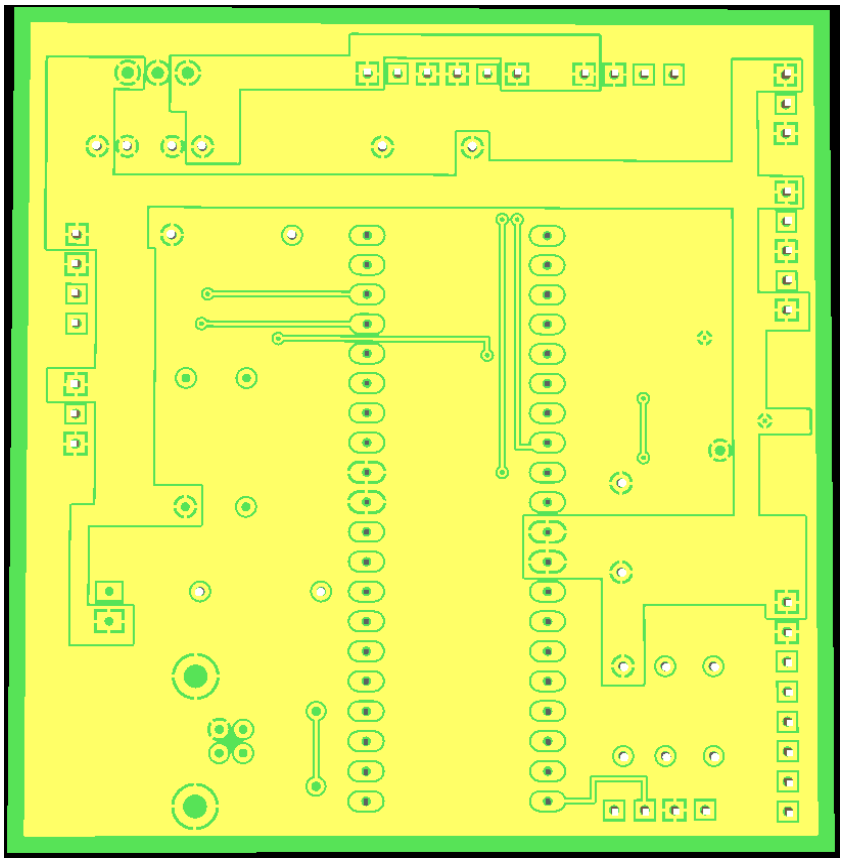


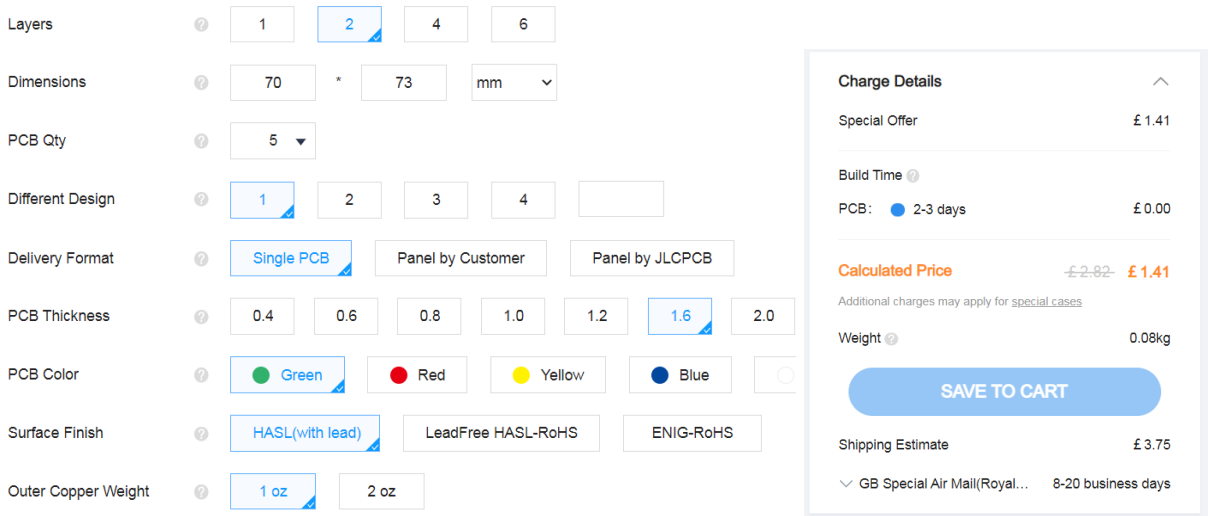
Easy PC


Drawn
Check
Projection
Do Not Scale
Drn
Project
Client
Chk
Title
Filename
Drawing No.
Sheet
of


PL3
PL2
conn2
C1
U2
C2
C3
PL4
PL5
R3
SW1
PL1
R4
LED
D2
D3
D1
PL6
U1
conn1


PL3
PL2
conn2
U2
C1
C2
C3
PL4
PL5
R3
SW1
PL1
C8
R4
LED1
D2
D3
D1
CN1
PL6
conn1
U1





Using the website JLCPCB, a cost for 5 PCB boards was found. The PCB was priced based on the features of the PCB designed using Easy PC. The features of the designed PCB taken into consideration were: its two layers, its dimensions (70mm by 73mm), its thickness (1.6mm), its colour and its copper pour weight (1 oz). The final cost for 5 PCBs including delivery was £5.16, meaning that 1 board would cost approximately £1.04.
[27]

Costs

Temperature & Humidity	£9.30
Wind speed & direction	£684.00
Air borne particle count	£21.53
Sunlight brightness	£2.83
UV levels	£11.46
GPS position	£145.48
VOC level	£14.54
Case	£542.15
Connectors	-
Microcontroller	£1.40
Battery	£277.55
PCB	£1.04
Total cost	£1,711.28

Discussions

There is a power switch in the battery feed line.

For the airborne particle sensor, software deals with the UART involved.

For both the sunlight brightness and VOC level sensors I2C is used, their SDA is connected to one pin and SCL is connected to another pin. Both are driven by software.

Conclusions

In considering conclusions and potential improvements, the selection of sensors is paramount. For example, in the case of a weather data logging system, finding a sensor that is multi-faceted - for example, the AM2303 DHT22 sensor that can measure both temperature and humidity, is far more valuable in terms of saving on costs and increasing the range of data that can be created. Having a sensor that is capable of measuring various parameters increases the product's useability, and can ultimately help to make the system more portable due to the saving of space. Another consideration concerning the sensors is potentially a secondary sensor for each variable that is to be measured. This would allow for cross-referencing of readings, as well as providing a back-up sensor in potentially harsh conditions.There is a wide range of additional sensors not included in this design that could also be added to allow for a wider range of applications throughout various industries and environments. A further potential improvement that could be made to this portable weather data logging system would be the incorporation of remote connection. This could be achieved through satellite connection, which would allow for access globally. This would allow real time access for weather monitoring and system status observation. Having access to the real time data could be beneficial in data assessment and research.

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