

System design Curtis Rees

by Curtis Rees

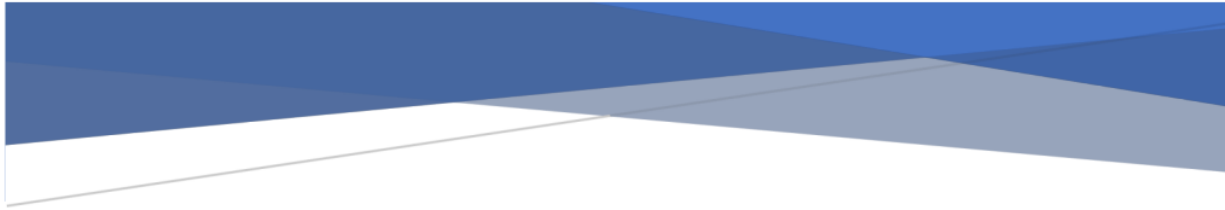
Submission date: 12-Jan-2024 12:38AM (UTC+0000)

Submission ID: 221654691

File name: 28930_Curtis_Rees_System_design_Curtis_Rees_547236_2004405318.docx (5.24M)

Word count: 4365

Character count: 25516



14 DAY WEATHER AND AIR QUALITY MEASUREMENT AND LOGGING SYSTEM

Electronic systems Design

University Of Wales Trinity Saint David
Electrical and Electronic Engineering

Curtis Rees (2003711)
2003711

Contents

Introduction	3
Requirements.....	3
Review of existing weather and air quality measurement and logging systems	3
AirVisual Outdoor Air Quality Monitor	3
Davis Vantage Pro2 Wireless Station with 24hr FARS, Solar and UV 6163UK.....	4
Wireless weather station with Wifi VIEW METEO 35.8000	5
Comparison Table Between Existing Weather and Air monitoring Devices	5
Sensor Selection.....	6
Temperature.....	6
Humidity.....	6
Wind Speed	7
Wind Direction	8
Air borne particle count	8
Sunlight Brightness	9
UV Levels.....	10
GPS Position	10
VOC Level	11
Microcontroller Selection.....	12
Storage Requirements.....	13
Connectors & Battery	14
RS232	14
USB.....	15
Input for sensors	15
Molex	15
Micro SD Card	16
Push Button Switch	16
LED	17
Battery.....	17
Voltage Regulator.....	17
Solar panel	18
Schematic Break down.....	18
Circuit Block Diagram	19
System On Start Up Switch.....	19
LED	20
Easy PC	20

.....	22
Structure Diagram	23
Systematic Diagram	24
Circuit Block Diagram	25
Cost of PCB Board	25
Final Build Cost.....	26
Improvements.....	26
Bibliography	27

Introduction

A data acquisition system design featuring a microcontroller is required, the system will be taking measurements and logging data of weather and air quality over a 14 day period. The data acquisition system is intended for use by amateur weather forecasters to aid in their weather predictions. It is required that this system will be portable and adaptable for a number of monitoring sites.

Requirements

The data acquisition system is required to obtain the following data throughout the 14 day period:

- 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 a non-volatile memory, which can be externally read and cleared when connected to a computer via USB.

Design must be portable, adaptable and suitable for operation in the intended environment. An LED flashing once every 10 seconds for 1 second is required to indicate operation.

System must have its own battery and be able to function off that battery so that its able to continue monitoring even when the site is remote or unpowered.

Review of existing weather and air quality measurement and logging systems

AirVisual Outdoor Air Quality Monitor



Figure 1

Figure 1 shows AirVisual Outdoor Air Quality Monitor which claims to be the ultimate air quality monitor. It provides a hyper-local, real-time air quality surrounding a home, school or business etc. 'Great for measuring air pollution exposure from traffic, industry, agricultural burning or wildfires. View real-time and historic air quality via the free mobile app.'

This air quality monitor can measure up to 8 environmental parameters:

- PM1
- PM 2.5
- PM 10
- CO2
- AQI
- Temperature
- Humidity
- Air Pressure

Designed to provide a reliable and sustainable power source for the AirVisual Outdoor air quality monitor, this solar panel kit enables the user to harness the power of the sun and ensure a consistent and uninterrupted power supply.

Davis Vantage Pro2 Wireless Station with 24hr FARS, Solar and UV 6163UK



Figure 2

Figure 2 is a wireless weather station with a versatile sensor suite that combines the rain collector, temperature and humidity sensors and anemometer into one package. This is a very advanced wireless weather station with one of its biggest selling points being that it can transmit weather data wirelessly up to 300m using frequency hopping spread spectrum radio technology.

Feature include:

- Large, backlit 3." X 6" LCD screen
- UV Radiation Screen
- Solar Radiation Sensor
- Fast 2.5 second updates

Wireless weather station with Wifi VIEW METEO 35.8000



Figure 3

The VIEW METEO wireless Weather Station with Wi-fi offers you all the functions of a classic wireless weather station and can also be used independently without a wi-fi connection or app. Outdoor temperature and humidity on site are determined by a radio transmitter and sent to the station with a range of up to 100 m (outdoors), an indoor sensor measures the room climate, the upcoming weather is displayed in the form of symbols and there are additional functions such as maximum and minimum values, dew point and alarm settings as well as a clock with date and day of the week written in full.

Comparison Table Between Existing Weather and Air monitoring Devices

AirVisual Outdoor Air Quality Monitor	Davis Vantage Pro2 Wireless Station with 24hr FARS, Solar and UV 6163UK	Wireless weather station with Wifi VIEW METEO 35.8000
		
5" colour display shows real-time and last 24 hours of air quality.	Large LCD screen	Dimensions (L)197 x (B)32 x (H)163 mm. Weight 343g
Displays outdoor data from paired AirVisual outdoor monitor or public air quality monitoring systems.	Solar radiation as well as UV radiation sensor.	Measuring range outdoor: -40... +60 degrees Celsius Measuring range indoor: 0... +50 degrees Celsius
Air quality forecast for the following 2 days.	Add wireless repeaters for distances up to 1.7miles.	12 hour continuously updates forecast.
Optional solar panel.	Solar panel	Batteries: 2 x AA 1.5 V
£305	£1775	£33

Sensor Selection

Temperature

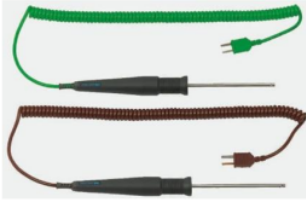
RS PRO NTC Air Temperature Probe [1]	RS PRO K Air Temperature Probe [2]	Calex EX-151-MT-C-25 mA Output Signal Infrared Temperature Sensor (Not suitable)
		
Best accuracy of $\pm 0.5^{\circ}\text{C}$	Best accuracy of $\pm 0.25^{\circ}\text{C}$	Response time 0.24s
Cable length of 1.5 m	Cable length of 2 m	Cable length of 25 m
Maximum temperature measurement of $+80^{\circ}\text{C}$	Maximum temperature measurement of $+750^{\circ}\text{C}$	Maximum temperature measurement of $+250^{\circ}\text{C}$
Probe diameter of 6 mm	Probe diameter of 4 mm	Probe diameter of 20 mm
Probe length of 41 mm	Probe length of 110 mm	Probe length of 500 mm
Air probe type	Air probe type	Surface temperature
NTC sensor type	Calibrated SYSCAL	Infrared temperature sensor
£14	£80	£936

Table above shows three different temperature sensors available online. I have decided to chose the RS PRO NTC Air temperature probe for the main reason being the price. As the specification shows this system is intended for amateur weather forecasters so ensuring the budget is reasonable is important. The infrared sensor would not be suitable for the specification.

Humidity

RS PRO Humidity Sensor [3]	RS PRO Temperature & Humidity Sensor [4]	TE Connectivity Humidity Sensor [5]
		
Accuracy $\pm 3\% \text{RH}$	Min operating supply voltage 2.15V to Max 5.5V	Suitable for 3 to 10 V dc supply voltage
Minimum operating temperature 0°C	Temperature & Humidity	Temperature & Humidity

Maximum operating temperature +60 °C	Accuracy: 1.5%RH	Accuracy 5%RH
Analogue output type	Digital output type	Analogue interface type
Humidity Sensor	Interface type: I2C	Dimensions: 11.4 x 59.3
Operating Humidity Range 20 - 90% RH	Dimensions: 2.5 x 2.5 x 0.9mm	Min operating temp -40 °C Max operating temp +60 °C
£2.49	Factory Calibrated	Resolution 0.4%RH
	£6.28	£62.82

For the humidity sensor, the RS PRO Temperature & Humidity sensor has been chosen. As the specification insists the system must incorporate a microcontroller, which runs approximately to 3V to 5V, which is adequate for this sensor. In comparison to the other two sensors the accuracy is very impressive as well as being fairly priced. Additionally, the interface type is I2C which will be useful for the communication between the different devices and sensors.

Wind Speed

Anemometer wind speed Sensor [6]	Anemometer Wind Speed Sensor w/Analog Voltage Output [7]	Anemometer & wind direction [Pro-D] [8]
		
0-5VDC	0.4-2V	
Range 0 - 30m/s	Range 0.5 - 50m/s	Range 1 to 67m/s
Material: aluminium alloy	Cable length 99cm	Cable length 13m
Working temp: -40 to +80 °C Working humidity: 35% to 85%	Not IP rated (requires additional gasketing or protection)	Converts wind speed into electrical signals, signals induced by Reed-contact, which closes through the effect of one magnet.
Waterproof	Max speed: 70m/s	Weight: 1.332kg
Resolution: 0.1m/s	Resolution: 0.1m/s	Resolution: 0.1m/s
£155	£44.80	£239

For the Wind speed measurement, the anemometer wind speed sensor has been chosen. Again due to the specification and it being stated that its designed for an amateur weather forecaster, price is an important factor. Despite have to add additional gaskets and protection I still believe this sensor is more cost effective. The range is impressive and supply voltage is sufficient to be compatible with the microcontroller.

Wind Direction

Anemometer & wind direction [Pro-D] [8]	Polycarbon Wind Direction Sensor [9]	GMX200 Wind Speed & Direction Sensor with Compass [10]
		
Wind direction: 0° to 360°, 360° = 20kOhm	Measuring 8 directions / 16 directions	Output rate: 1/s, 1/min, 1/hr
Accuracy: Wind Direction ±7°	Range 0 – 359.9 degrees	Range 0-359 degrees
Wind direction: 1° (0° to 355°), 22.5° between compasses	Working temperature: -20°C~+60°C 0%RH ~80%RH	Resolution: 0.01m/s Sampling Rate: 1Hz
Dimensions: 470 mm x 191 mm x 121 mm	Response time less than or equal to 0.5s	Power supply: 5 to 30VDC
12V DC	10 – 30VDC OR 5VDC	Compass
	IP65. Cable length 0.7 metres	Optional GPS
£239	£19.80	£1145

Polycarbon wind direction sensor has been chosen to record the wind direction measurements. It has a suitable range of 0~359.9 degrees meaning its suitable to record any possible wind direction making it sufficient and meeting the specification. It also has a suitable working temperature for any climate and a very fast response time. Finally its suitable for the microcontroller as its able to operate on a 5V supply.

Air borne particle count

Sensirion SPS30, Air Quality Sensor [11]	TERA Sensor Next-PM, Particle Matter / Dust Air Quality Sensor [12]	Sensirion SEN54-SDN-T, PM, RH, T, VOC Environment Sensor for Particulate Matter [13]
		
Air quality sensor	Particle Matter / Dust	Particulate Matter, Relative Humidity, Temperature, VOC Measurement

I2C, UART interface types	Response time: 10, 60, 900 seconds	Response time: 10s, 20s, 30s, 60s
Accuracy: +-10%	Accuracy: +-10%	Accuracy: 4.5%RH
Power supply: 5VDC	Power supply 5V	Power source: Battery, USB
Dimensions: 41 x 41 x 12mm	Dimensions: 61.85 x 52.55 x 23.72mm	Dimensions: 22.3 x 52.3 x 43.3mm
Max operating temp: -10 to +60 °C	Max operating temp: -20 to +70 °C	Max operating temp: -10 to +50 °C
£33.76	£93.16	£29.11

For the air borne particle count, a particle matter sensor has been chosen, the sensirion SPS30 air quality sensor. Several reasons this sensor has been chosen, firstly accuracy is similar to those more expensive. Secondly, the supply voltage being 5VDC means its compatible with the microcontroller selected. Finally a more than adequate operational temperatures.

Sunlight Brightness

Hamamatsu, S1223-01 Full Spectrum Si Photodiode [14]	NORPS-12 Luna Optoelectronics [15]	Seed Studio Grove SI1145 Sunlight Sensor [16]
		
visible and IR applications	Light dependent resistor with sensitivity in the visible light region	Detect UV light, visible light and infrared light
Min wavelength: 320nm Max wavelength: 1100nm	550nm peak response	Wide spectrum detection range: 280-950 nm
Operating temperature: -40 to +100 °C	Operational temperature: -60 to +75 °C	Easy to use: I ² C Interface (7-bit)
£19.80	Supply voltage 5VDC	£13.73
	£2.60	

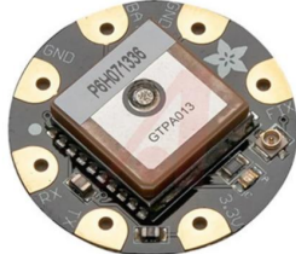
Its specified within the specification that a sunlight brightness sensor is required within the device. The NORPS-12 has been chosen because of its more than adequate operational temperatures and its supply voltage because suitable microcontroller that's been chosen.

UV Levels

Hamamatsu, S1223-01 Full Spectrum Si Photodiode [14]	ams OSRAM, BPX 65 Full Spectrum Si Photodiode [17]	OSI Optoelectronics, PIN-RD100 Visible Light Si Photodiode, Through Hole Ceramic [18]
		
visible and IR applications	Infrared, Ultraviolet, Visible Light	Detects Visible light
Min wavelength: 320nm Max wavelength: 1100nm	Min wavelength: 350nm Max wavelength: 1100nm	Min wavelength: 350nm Max wavelength: 1100nm
Operating temperature: -40 to +100 °C	Operating temperature: -20 to +120 °C	Operating temperature: -20 to +120 °C
£19.80	£6.74	£160

For the UV level measurement sensor, a ams OSRAM, BPX 65 Full Spectrum Si Photodiode has been chosen. Again due to its low price point and capabilities this was the most suitable UV level sensor. Its able to detect Infrared, Ultraviolet and Visible Light as opposed to the OSI Optoelectronics photodiode which would not be suitable due to detecting only visible light and not UV levels, not to mention the high cost.

GPS Position

Quectel L70B-M39 GPS Module	ADAFRUIT INDUSTRIES 1059 GPS Module [19]	ADL5601ARKZ-R7 Analog Devices, GPS Front End Module Linear [20]
		

GPS data for location, velocity, and time	Fix status LED	Max operating frequency: 4GHz
Power Supply 3.3V	Built-in datalogging	Surface mount
UART Port	-165 dBm sensitivity	Dimensions: 4.6 x 2.6 x 1.6mm
Compact size 10.1 x 9.7 x 2.5 mm	10Hz updates	Min operating temp: -40°C Max operating temp: +85°C
Tracking sensitivity: -165dBm	66 channels	Min operating supply voltage: 4.5V
Min operating temp: -40°C Min operating temp: +85°C	20mA current draw	Max operating supply voltage: 5.5V
£10.22	£48.78	£2.75

VOC Level

Sensirion SGP40-D-R4, VOC Air Quality Sensor for VOC Monitors [21]	Sensirion SEN54-SDN-T, PM, RH, T, VOC Environment Sensor for Particulate Matter [13]
	
Gases detected: VOC	Particulate Matter, Relative Humidity, Temperature, VOC Measurement
Response time: <10s	Response time: 10s, 20s, 30s, 60s
Power source: Battery, USB	Accuracy: 4.5%RH
Dimensions: 2.44 x 2.44 x 0.85mm	Power source: Battery, USB
Min Operating temp: -10 °C Min Operating temp: +50 °C	Dimensions: 22.3 x 52.3 x 43.3mm
£9.41	Max operating temp: -10 to +50 °C
	£29.11

Microcontroller Selection

A data acquisition system designed featuring a microcontroller is required, this section showcases the decision making process and requirements in which was needed from a microcontroller. Below is a table showing the calculations that were made in order to calculate the minimum required clock speed from the microcontroller. The clock speed of a microcontroller is an important factor to be considered in the design stage as it will determine the maximum rate at which the analog signal can be sampled. Clock speed will govern the conversion rate of any analog to digital operations, such as the potentiometer sensor for the suspension. Very slight and fine movement is likely to occur within the suspension travel and to enable this data to be recorded, a higher number of clock cycles will be required in comparison to the engine temperature where less is needed.

Parameter	Clock speed (Hz)	Testing frequency
Temperature	0.0166Hz	1min
Humidity	0.0166Hz	1min
Wind speed	1Hz	1second
Wind direction	1Hz	1second
Air borne particle count	0.0166Hz	1min
Sunlight brightness	0.0166Hz	1min
UV levels	0.0166Hz	1min
GPS position	0.000277Hz	1hour
VOC level	0.0166Hz	1min

In order to choose a microcontroller it is now necessary to set parameters for each of the sensors featured within the data acquisition system. After reading the specification the table below shows each parameter along with the amount of bytes. A max value expected from that sensor, the resolution necessary to record accurate but sensible data, number of possible values were all needed in order to calculate this.

Parameter	Max Value	Resolution	Number of Possible Values	Number of bits required	Bytes	Testing Frequency
Temperature	-10 to +50	1°C	60	6	1	1 min
Humidity	0% to 100%	1%	100	7	1	1 min
Wind speed	0mph to 300mph	1mph	300	9	2	1 second
Wind direction	0 to 359°	10°	36	6	1	1 second
Air borne particle count	1nm to 100µm	100nm	1000	10	2	1min
Sunlight brightness	0.0001 lux to 120,000 lux	1000	120	7	1	1 mins
UV levels	0UV to 11UV	1UV	11	4	1	1mins
GPS position	N/A	1m	N/A	24	3	1 hour
VOC level	0-100%	1%	100	7	1	1mins

Storage Requirements

$3 \times 60 = 180$ bytes per minute
 $180 \times 7 = 1260$ bytes per minute
 $1260 \times 60 = 75600$ bytes per hour
 $75600 \times 24 = 1814400$ bytes per day
 $1814400 \times 14 = 25401600$ bytes per 14 days
 25.4 Megabytes

Figure 5

Figure 5 shows the calculations that's been made for the storage requirements for the data acquisition system. The bytes for every second were combined and multiplied into bytes per minute, the bytes every minute were then added and so on. After calculating the bytes required per day, this was then multiplied by 14 because the specification states the data acquisition system is required to record and store data for 2 weeks.

	PIC18F97J94 Microchip delete	PIC18F87K90 Microchip delete	PIC18F44J50 Microchip delete
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)	64 MHz	64 MHz	48 MHz
FPU			
Operation Voltage	(2V-3.6V)	(1.8V-5.5V)	(2V-3.6V)
Temp Range	(-40 to 85)	(-40 to 125)	(-40 to 85)
Pin count	100	80	44
Program Memory Size (KB)	128 Flash	128 Flash	16 Flash
Error Correction Code Program Flash			
SRAM	3.771484375 KB	4 KB	3.7109375 KB
Data EEPROM/HEF (Bytes)		1024	
Internal DRAM Type			
Internal DRAM Amount (MB)			
Low Power	Yes	Yes	Yes
ADC Input	24	24	13
Max ADC Resolution (Bits)	12	12	10
DAC Outputs			
Number of Op Amps			
Hardware Touch Peripheral			
UART	4	2	2
SPI	2	2	2
I2C	2	2	2
I2S			
SSC			
Number of USB Modules	1		1
USB Interface	FS Device	None	FS Device
Number of CAN Modules			
Type of CAN module			
Ethernet			
Max 8-Bit Digital Timers	4	6	2
Max 16-Bit Digital Timers	4	5	3
Max 32-Bit Digital Timers			
Hardware RTCC/RTC	Yes	Yes	Yes
Max PWM outputs (including complementary)	19	19	
Number of PWM Time Bases			
Crypto Engine			
ARM TrustZone®			
Segmented LCD	480	192	
Graphics Controller/GPU			
Video Decoder			

An example of the comparison table in which I used to compare the different microcontrollers is shown above. Previously the parameters were decided so that the clock speed as well as the storage could be measured. This table shows all the information needed to choose a suitable PIC. Voltage, CPU type, ADC inputs, I2C and USB interface were all among the table and after comparing multiple microcontrollers, the PIC18F45K50 was chosen.

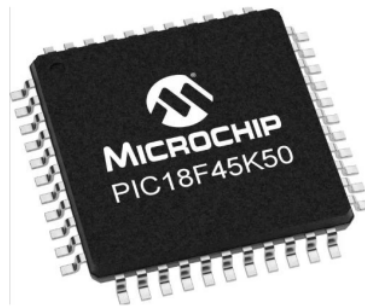


Figure 12

Figure 12 shows the chosen microcontroller PIC18F45K50 for vehicle acquisition system. The chip comes in various formats however, the surface mount package will ensure the design stays compact and as small as possible.

SD CARD STORAGE

Connectors & Battery

RS232



Figure 6

RS232 is simply a form of serial communications and a way in which to transmit data. It's the interface between data terminal equipment and data communications equipment using serial binary data exchange which is needed within my vehicle data acquisition system. Figure 6 shows the female DB9 socket chosen. [18] £7.49

USB

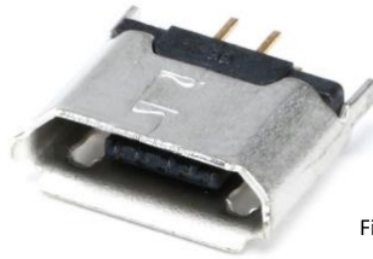


Figure 7

The USB connector shown in figure 7 is the micro USB socket. The USB can be used for storage, data backup and transferring of files between different devices that are USB compatible. For example this micro USB socket will enable the tester to withdraw the data from the data acquisition system and upload them onto a laptop/computer etc where the results are visible. [19] The micro USB has been chosen as its smaller and more compact than a traditional USB socket. £1.58

Input for sensors



Figure 8

Figure 8 is the 25-way right angle PCB female D socket connector that's will be used for the input/outputs. This socket has been chosen as it enables easier expansion of the input/outputs. It allows all sensors to be connected via the same connection which will be secure and highly vibration proof due to the metal screw on clamps. [20] £0.84

Molex



Figure 9

With their secure connections, flexibility and ability to withstand harsh environments, molex connectors have been selected. The data acquisition system is required to operate in harsh environments so these connectors are vital. They can accommodate different wire sizes and types. [21] £7.34

Micro SD Card



Figure 10

The system will feature a micro SD card which is used to expand the storage and allow the data that's been recorded via the multiple sensors to be stored and then later removed and downloaded onto a laptop or computer for the data analysis. A micro SD card is smaller and more compact making my design smaller and more suitable to be mounted to the vehicle. This SD card has 2GB of storage space available which is more than enough to run the data acquisition system for 14 days. £2.24

Push Button Switch



Figure 11

Figure 11 is an RS PRO Miniature Push Button Switch. The design consists of two of these push buttons, one will be the main on/off switch for the whole device, and the other will be positioned in a safe and convenient position for the driver of the vehicle to be able to access and start/stop the testing equipment from the driver's seat of the vehicle. [22] £3.57 for one

LED



Figure 15

Figure 14 is an Oxley OXL/CLH/80 Series Green Panel LED. It has a voltage rating of 5V which makes connectivity within the circuit easier and the chosen colour is green. The LED will be programmed to turn on when the device is switched on and recording data. Similarly to the push button switch, two of these will be required, one of the surface of the enclosure and one positioned next to the push button accessible from the drivers seat. It has an IP67 rating making it suitable for the harsh environments that might occur on the vehicle.



Battery



Figure 16

For the battery selection a RS PRO, 3.7V, Lithium Polymer rechargeable battery has been chosen. Its nominal voltage is 3.7V. It has a capacity of 1.8Ah. Lithium batteries are designed to last longer than normal aaa batteries. The intended goal of the acquisition system is to be as light and compact as possible making it as easy to be mounted or attached as possible. The enclosure will be adapted so the battery can be accessible to charging. £11.47



Voltage Regulator



Figure 25 [32]

The LF33CV is a fixed output very low dropout voltage regulator. This device is particularly suitable for battery powered systems, low noise and low power applications. It requires a 2.2uF capacitor for stability. Gives a fixed output voltage of 3.3V which ensures the voltage is suitable for the microcontroller used.

Solar panel



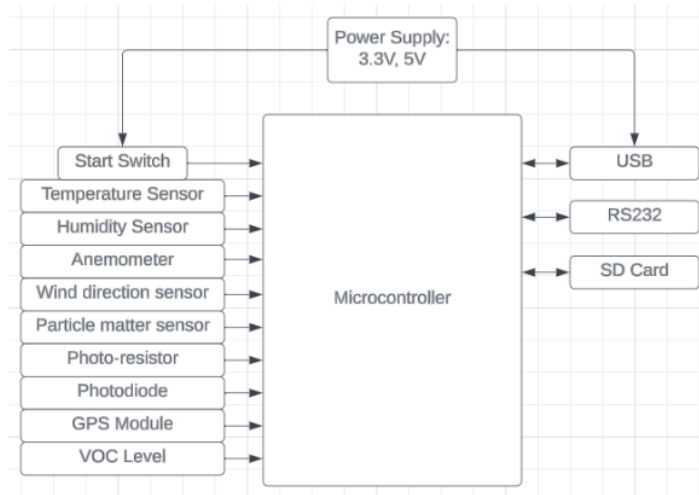
Figure 26 [32]

Figure 26 shows a 5V portable solar panel, water proof and suitable for outdoor environments. Despite the data acquisition system only being required to record data for 14 days, the design would benefit from incorporating a solar panel for more long term use.

Schematic Break down

This section of the report explains part of the schematic created in proteus, along with the schematic created in Easy-PC. As shown later on, some of the sensors were not included within the Easy-PC schematic as they were not to be constructed onto the PCB board.

Circuit Block Diagram



Circuit Block Diagram shows the simplified theory behind the circuit. As figure 17 shows, a power supply of 3.7V from the lithium Polymer rechargeable battery is fed into the circuit. The left hand side shows the input sensors from the different sensors each recording their relevant data that is then inputted into the microcontroller. In addition to these sensors, a start switch, fed by the power supply is inputting into the microcontroller turning it on/off. On the right hand side of the circuit block diagram are all the output sensors. For example the USB which will make the data transferrable from the microcontroller to another device compatible, such a laptop/computer.

System On Start Up Switch

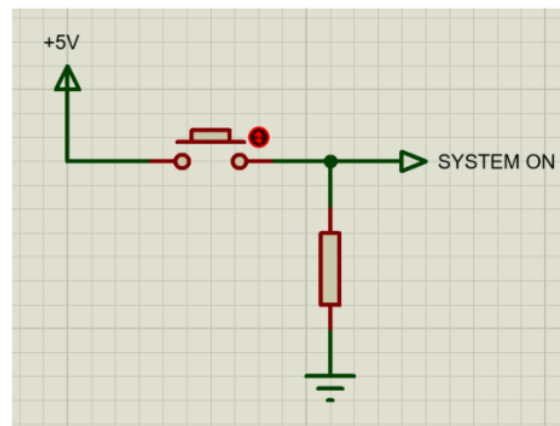


Figure 20

Figure 20 is the push button start up switch, this enables the device to be turned on/off saving battery.

LED

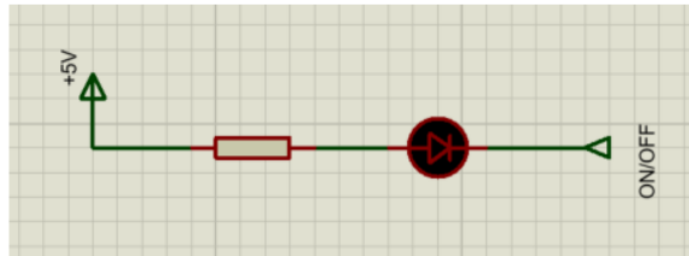


Figure 21

This LED design shown figure 21 is a simple design with the purpose of turning the LED when the microcontroller is turned on, therefore showing the user that its ready to record and store the data. The LED is green to showcase the vehicle acquisition system is on.



Easy PC

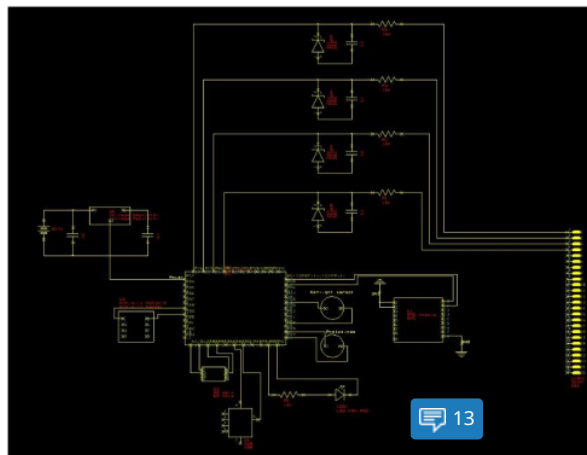


Figure 28

Figure 28 is the easy pc circuit design incorporating all the sensors, components and microcontroller for the weather and air monitoring data acquisition system.

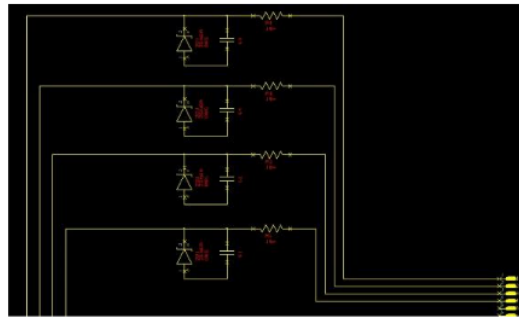


Figure 29

Figure 29 is the circuitry for the four sensors in which have sensors outside of the pcb board. These sensors will be connected via a 25 way connector but will not be mounted onto the pcb like the remaining sensors are. This is a simple low pass filter ensuring the microcontroller is protected against high voltages.

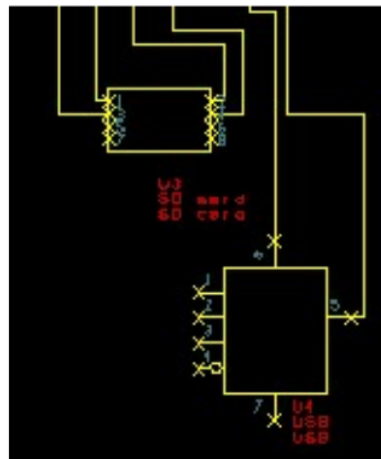


Figure 30

Figure 30 shows the USB as well as the SD card slot. The USB allows the data to be transferred onto a laptop or computer etc and the SD card allows the measurements taken from all the sensors, at their relevant frequencies, to be stored and accessible.

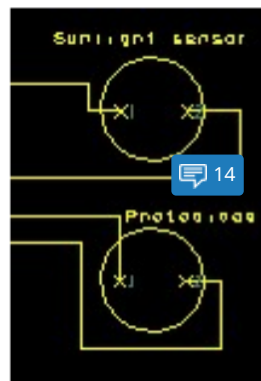


Figure 31

Figure 31 shows the sunlight sensor as well as the photodiode within the circuitry. Both sensors have two connectors and will be mounted onto the pcb board .

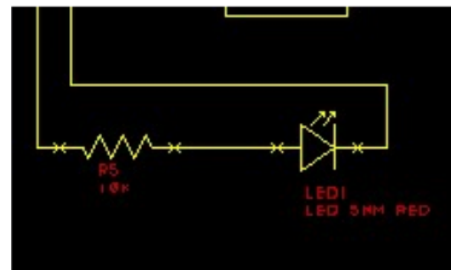


Figure 32

Figure 32 shows the LED design on easy pc to show device is switched on so that the user can see when the device is measuring and recording data.

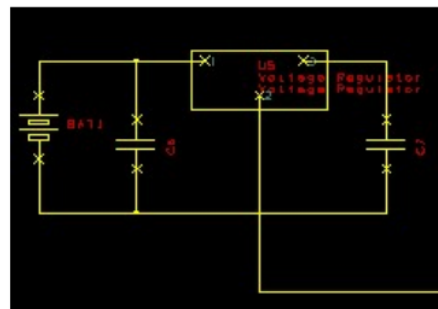


Figure 33

Figure 33 shows the voltage regulator circuit that's connected to the lithium ion battery previously chosen. The 2.2uF capacitor has been incorporated as the data sheet suggests for the voltage regulator chosen.

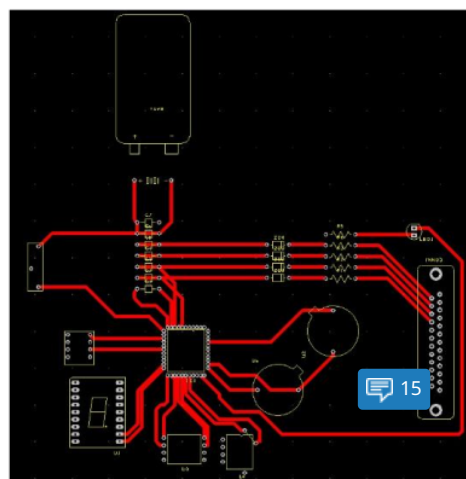


Figure 34

Figure 34 shows all the components being connected via trace lines to be transferred onto the pcb board.

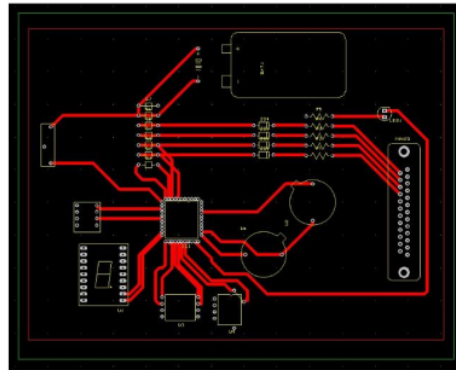


Figure 35

Figure 35 shows the pcb board area being represented by the green line and the copper pour area being represented by the red line.

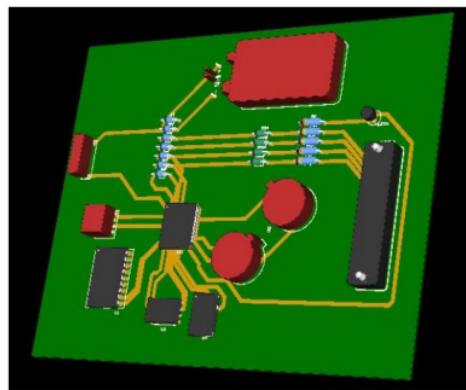


Figure 36

Finally figure 36 is a 3D view of the PCB board with all the parts and components mounted.

Structure Diagram

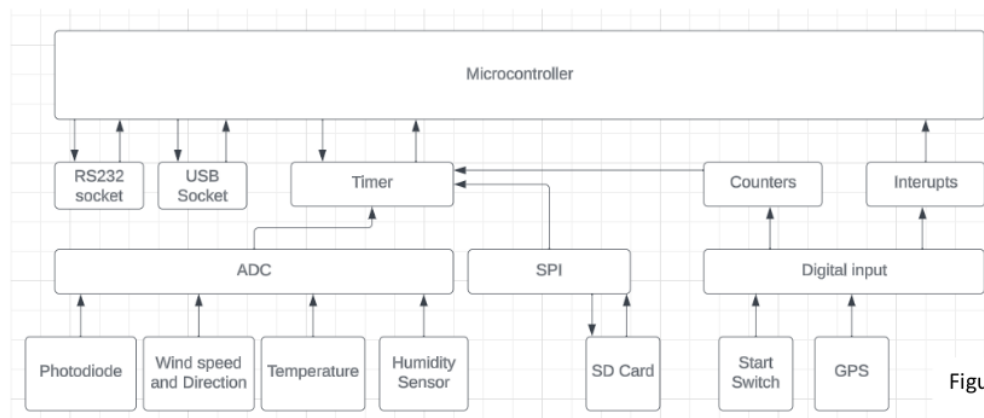
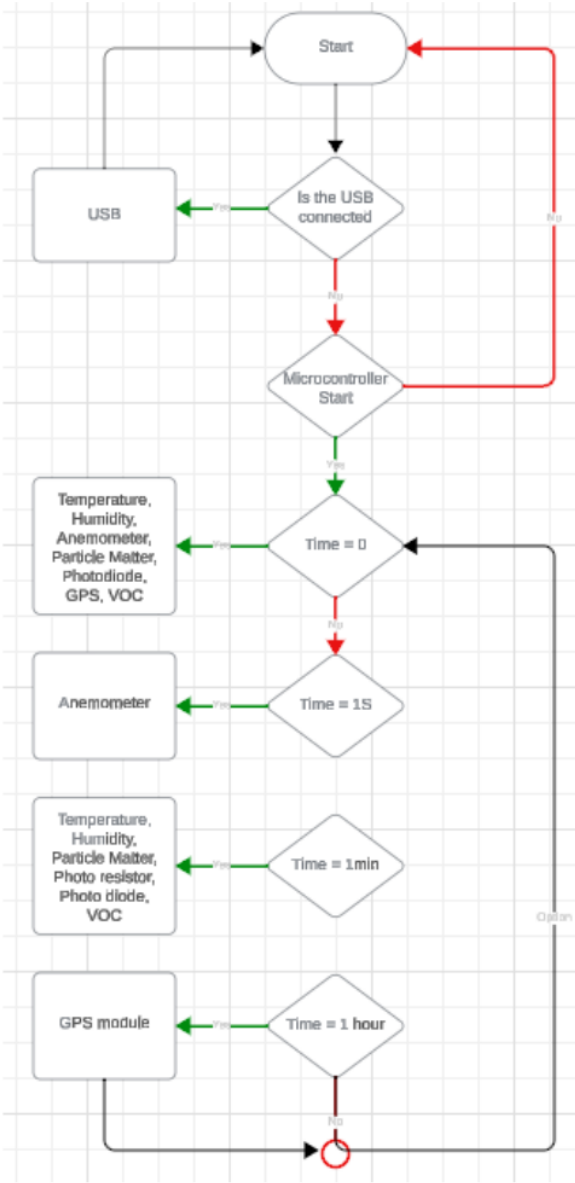
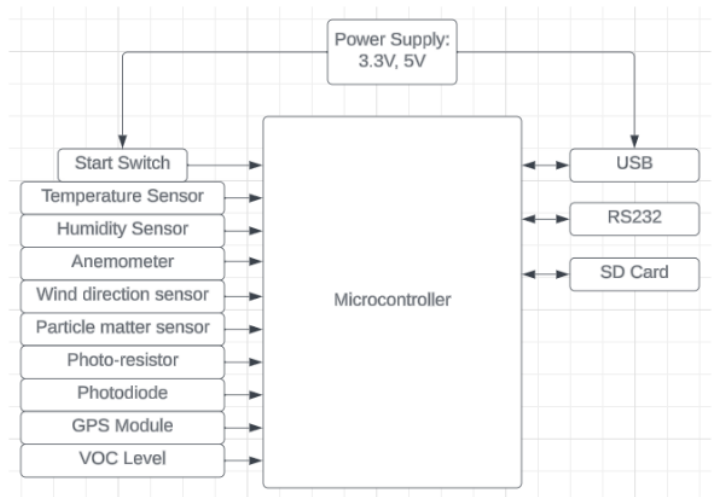


Figure 34

Systematic Diagram



Circuit Block Diagram



Cost of PCB Board

Reset Calculate

Speed
What's the difference between 'Standard' and 'Quick-Turn' PCB [Learn More](#)

PCB Specification Selection [Simple tutorial \(suitable for beginners\)](#) [Online Gerber Viewer](#)

PCB file (optional) [+ Add Gerber File](#)
Automatically sets the board size, hole, track/spacing only accept rar or .zip & Maximum 20M

Board type: ☒ Single pieces ☐ Panel by Customer ☐ Panel by PCBWay

Different design in panel: ☒ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ 6 ☐ 8 ☐ 9

* Size (single): 90 X 70 mm ☐ mm ☐ inch ☐ mm

* Quantity (single): 5 pcs

Layers: ☐ 1 Layer ☒ 2 Layers ☐ 4 Layers ☐ 6 Layers ☐ 8 Layers ☐ 10 Layers ☐ 12 Layers ☐ 14 Layers

Material: ☒ FR-4 ☐ Aluminum ☐ Rogers ☐ HDI (Buried/blind vias) ☐ Copper Base
*Material model can be remarked below. HDI is available for 4-layer or more.

FR4-TG: ☐ TG 130-140 ☒ TG 150-160 ☐ TG 170-180 ☐ S1000H TG150

Thickness: ☐ 0.2 ☐ 0.3 ☐ 0.4 ☐ 0.6 ☐ 0.8 ☐ 1.0 ☒ 1.2 ☐ 1.6 ☐ 2.0 ☐ 2.4 ☐ 2.6 ☐ 2.8 ☐ 3.0 ☐ 3.2
≥1.7-6.0 * Unit: mm

Min track/spacing: ☐ 3/3mil ☐ 4/4mil ☐ 5/5mil ☒ 6/6mil ☐ 8/8mil ☐ 10/10mil

Min hole size: ☐ 0.15mm ☐ 0.2mm ☐ 0.25mm ☒ 0.3mm ☐ 0.8mm ☐ 1.0mm ☐ No Drill

Solder mask: ☒ Green ☐ Red ☐ Yellow ☐ Blue ☐ White ☐ Black
☐ Purple ☐ Matte black ☐ Matte green ☐ None

Pricing And Build Time

PCB Price [Price Comparison Matrix](#)

Build Time	Qty	Total
☒ 24hours	5	\$ 5.00
☐ Extra Urgent	5	\$ 94.56

Final price is subject to our review.

Shipping Cost: US \$20.86
UNITED STATES OF AMERICA

DHL 2-4 business days, wt 0.11kg

Shipment Date: 2023/11/26 AM Delivery Date: 2023/11/29

PCB Cost: US \$ 5.00
Shipping: US \$ 20.86
Total: US \$ 25.86

[Save to Cart](#)

Final Build Cost

	A	B
1	Part	Price (£)
2	Temperature probe	14
3	Humidity sensor	6.28
4	Wind speed sensor	44.8
5	Wind direction sensor	19.8
6	Air quality sensor	33.76
7	Photoresistor	2.6
8	Photodiode	6.74
9	GPS	10.22
10	VOC level	9.41
11	Microcontroller	2.85
12	RS232	7.49
13	USB holder	1.58
14	Connector	0.84
15	Molex	7.34
16	Micro SD card	2.24
17	Push button switch	3.57
18	LED	8
19	Battery	11.47
20	Voltage regulator	0.62
21	Solar panel	11.5
22	PCB board	£5
23		
24	Final Build Cost	£210

Improvements

- Incorporating a smaller connector than the current 25 way connector, as a large proportion of the ports are not in use, this would make my design smaller and more compact and potentially reduce costs.
- Testing frequencies could be altered more specifically to the users needs, currently they are vague. For example, the gps module could sample less frequently to reduce the amount of storage required especially as its 3 bytes. Additionally, if more precise data for wind speed and direction was required increased sampling rate could be applied and the sensor could record data more frequently given more precise data.
- The enclosure could be specifically designed as some sensors are mounted onto the microcontroller and will need to be exposed to the air while still being safe and secure in potentially harsh weather conditions.
- Incorporate a switch with an LED to show when the device is switched on instead of having a separate LED. This making design smaller as well as avoiding more holes within the enclosure.

Bibliography



- ["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/temperature-probes/1241079?gb=s>. [Accessed 27 12 2023].
]
- ["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/temperature-probes/3430224?gb=s>. [Accessed 27 12 2023].
]
- ["RS," [Online]. Available: <https://uk.rs-online.com/web/p/temperature-humidity-sensors/2465635?gb=s>. [Accessed 28 12 2023].
]
- ["RS," [Online]. Available: <https://uk.rs-online.com/web/p/temperature-humidity-sensors/2465631?gb=s>. [Accessed 28 12 2023].
]
- ["RS," [Online]. Available: <https://uk.rs-online.com/web/p/temperature-humidity-sensors/8937247?gb=s>. [Accessed 28 12 2023].
]
- ["EBAY," sensors electronics and more, [Online]. Available:
6 https://www.ebay.co.uk/itm/254119722017?chn=ps&_ul=GB&mkevt=1&mkcid=28. [Accessed 28
] 12 2023].
- ["thepihut," [Online]. Available: https://thepihut.com/products/anemometer-wind-speed-sensor-7-w-analog-voltage-output?variant=27739587537¤cy=GBP&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&srsId=AfmBOooyQ5Xl6GGoQcRaRi3VNdBf20o_h4V8N46. [Accessed 28 12 2023].
]
- ["windlogger," [Online]. Available: https://www.windlogger.com/products/pro-d-anemometer?variant=1333095873¤cy=GBP&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&srsId=AfmBOoplWTZa9iDZ2LuuQlxOf9VYB0Dxdhejoi8tVbcbFI767aOrxKdgtEs. [Accessed 28 12 2023].
]
- ["Renke," [Online]. Available: <https://www.renkeer.com/product/polycarbon-wind-direction-sensor/>. [Accessed 29 12 2023].
]
- [[Online]. Available: <https://www.omniinstruments.co.uk/weather-stations-and-instruments/wind-speed-and-direction-sensors/gmx200-weather-station.html>. [Accessed 29 12 2023].
]
- ["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/environmental-sensors/1862298?gb=s>. [Accessed 29 12 2023].
]

1
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/environmental-sensor-ics/1953770?gb=s>. [Accessed 29 12 2023].

2
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/environmental-sensor-ics/2389413?gb=s>. [Accessed 29 12 2023].

3
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/photodiodes/4155722?gb=s>. [Accessed 29 12 2023].

4
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/colour-light-sensor-ics/9146714?gb=s>. [Accessed 29 12 2023].

5
]

["elektor store," [Online]. Available: <https://www.elektor.com/seeed-studio-grove-si1145-sunlight-sensor#:~:text=under%20the%20sun%3F-Grove%20Sunlight%20Sensor%20is%20a%20multi%2Dchannel%20digital%20light%20sensor,a%20new%20sensor%20from%20SiLabs..> [Accessed 29 12 2023].

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/photodiodes/4975677?gb=s>. [Accessed 29 12 2023].

7
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/photodiodes/1769787?gb=s>. [Accessed 29 12 2023].

8
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/gnss-gps-modules/9054637?gb=s>. [Accessed 29 12 2023].

9
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/rf-amplifiers-ics/1609927?gb=s>. [Accessed 29 12 2023].

0
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/environmental-sensor-ics/2047512?gb=s>. [Accessed 29 12 2023].

1
]

["omega," [Online]. Available: <https://www.omega.co.uk/temperature/z/rs232standard.html>. [Accessed 18 11 2023].

2
]

[h. (20958), "ebay," [Online]. Available: <https://www.ebay.co.uk/itm/263895372412>. [Accessed 18 11 2023].

3
]

["SWITCH ELECTRONICS," [Online]. Available: <https://www.switchelectronics.co.uk/products/25-way-right-angle-pcb-female-d-socket-connector>. [Accessed 19 11 2023].

4
]

["molex," [Online]. Available: <https://www.molex.com/en-us/products/connectors#:~:text=With%20their%20flexibility%2C%20secure%20connections,popular%20choice%20in%20many%20industries..> [Accessed 19 11 2023].

]

[[Online]. Available: <https://uk.rs-online.com/web/p/push-button-switches/7346704>. [Accessed 19 11 2023].

6
]

["RS online," [Online]. Available: <https://uk.rs-online.com/web/p/speciality-size-rechargeable-batteries/1449405?gb=s>. [Accessed 20 11 2023].

7
]

["iqair," [Online]. Available: <https://www.iqair.com/gb/air-quality-monitors>. [Accessed 22 12 2023].

8
]

["weatherspares," [Online]. Available: <https://weatherspares.co.uk/collections/complete-weather-stations-1/products/davis-vantage-pro2-wireless-station-with-24hr-fars-solar-and-uv-6163uk>. [Accessed 23 12 2023].

]

["tfa-dostmann," [Online]. Available: <https://www.tfa-dostmann.de/en/product/wireless-weather-station-with-wifi-view-meteo-35-8000/>. [Accessed 23 12 2023].

0
]

["amazon," [Online]. Available: https://www.amazon.co.uk/FlexSolar-Performance-Monocrystalline-Cellphone-Lanterns/dp/B09JFYPDNC/ref=sr_1_12?dib=eyJ2IjoiMSJ9.nrfmKh0o25YXvBnsgoHiQq2UDzgndy4YELsd0ptr7NfQqOanISlssA4WnxAn1beTbgBwB7trRtZZnEBzdJ7rXg.SE9G_YHqJEGd86tsYbFUeG1NN0XGbC_esiBYkJfb5E. [Accessed 08 01 2024].

["Farnell," [Online]. Available: <https://cpc.farnell.com/stmicroelectronics/lf33cv/v-reg-ldo-3-3v-to-220-3/dp/SC08293>. [Accessed 07 01 2024].

2

]

System design Curtis Rees

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

40/100

PAGE 1

PAGE 2

PAGE 3

PAGE 4

PAGE 5

PAGE 6

PAGE 7

PAGE 8



Comment 1

Each row in your comparison table is supposed to show the same data for each sensor, but this row you are comparing the type of the first sensor to the interface type of the second with the dimensions of the third. This does not make sense.

PAGE 9

PAGE 10



Comment 2

Will this be linear enough?

PAGE 11



Comment 3

Barely in the UV spectrum. You need a sensor sensitive to the parts of the UV spectrum you intend to measure.

You need to be able to measure both UVA and UVB bands

UVA = 315 - 400 nm (responsible for skin aging, wrinkling and skin cancers)

UVB = 280 - 315 nm (responsible for tanning, burning, and skin cancer)

UVC = 100 - 280 nm (completely filtered by atmosphere)

PAGE 12



Comment 4

Why have you chosen this sensor?

PAGE 13

PAGE 14

PAGE 15



Comment 5

This is not a connector, it is an adapter for connecting two male plugs together.



Comment 6

What are you using RS232 for? I asked for USB in the assignment brief.



Comment 7

This is for a weather station, not a vehicle data acquisition system.

PAGE 16

PAGE 17

PAGE 18



Comment 8

This is not meant to go on a vehicle



Comment 9

This voltage is too low for your system to run.



Comment 10

Is this big enough to allow the device to run for two weeks?



Comment 11

You haven't specified an enclosure.

PAGE 19

PAGE 20

PAGE 21



Comment 12

weather station



Comment 13

Too fuzzy to see detail

PAGE 22



Comment 14

unable to read the text in this diagram.

PAGE 23



Comment 15

Some issues:

1. The battery is not the one you chose in your component selection.
2. the components under the battery (resistors? capacitors? - too small to make out the text) have their pins connected together - short circuiting them
3. The footprint for your PIC is wrong. It should not have pin holes if it is a surface mount device.
4. The PCB is far too big for the number of components on it.
5. There is no board outline
6. There are no mounting holes

7. Why do you have a 7 segment display on your PCB?
8. The tracks going to the devices under the PIC (no idea what they are - the text is too small) the tracks look like they are all connected together because they are too close
9. The resistor from the LED only has one connection. The LED will never light up
10. The battery terminals are connected together. This will stop any current flowing in your circuit and damage the battery
11. There are no power connections to the external sensors on the 25 way D connector
12. Where does the solar panel connect?
13. Incorrect footprints used for LDR and photodiode

PAGE 24

PAGE 25

PAGE 26

PAGE 27

PAGE 28



Comment 16

References, not bibliography

PAGE 29

PAGE 30

PAGE 31

GRADING FORM: SMU GENERIC_SMOSEY

CURTIS REES

39.50

ENGAGEMENT WITH LITERATURE

including reading, referencing, academic conventions and academic honesty



Inclusion of a limited range of research-informed literature, including sources retrieved independently. Referencing conventions mostly consistently applied.

5

KNOWLEDGE & UNDERSTANDING

Knowledge of the basic underlying concepts and principles of a subject.



Your hardware design is missing any sort of battery management, even an on/off switch. You state that solar panels will be used to charge the batteries, but no connection details are given. Hardware design leaves questions - how will the sensors for light level and UV level be managed? Both leads of the sensors connect to the micro - so how will the micro drive them to make the measurements?
PCB design has many issues - see comment on Figure 34
Software structure is ok, although what controls the sample time?
Some diagrams are ok, but others are fuzzy and detail is too blurred to read.

9

COGNITIVE & INTELLECTUAL

Evaluate underlying concepts and principles of a subject and interpret qualitative and quantitative data in order to develop lines of argument and make sound judgements.



No thought is given to packaging the device at all. Memory sizing is ok. Some sensor justifications are questionable, but most are ok. Justifications not given for some components. No thought given to the power requirements for sizing the battery.

12.25

PRACTICAL APPLICATION SKILLS

Different approaches to solving problems in particular contexts.



Costing has components which are not in the device, and has some omissions - resistors, capacitors, diodes etc. from the PCB are not present in the costing. Suggested improvements are ok.

8.75

TRANSFERABLE SKILLS

Communicate the results of their study/work accurately and reliably, and with structured and coherent arguments; the qualities needed for employment requiring the exercise of some personal responsibility within a structured and managed environment.



Can communicate in a suitable format but with some room for improvement. Work lacks coherence in places and could be better structured.

4.5