

Louise Caygill - ACDA6002 - Assignment 2

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UWTSD

14 Day Weather and Air Quality Measurement and Logging System

Electronic Systems Design ACDA6002

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Introduction

This report documents the research, design and development of a weather monitoring system. The system will measure the air quality, temperature, humidity, wind speed, wind direction, air borne particle count, sunlight brightness, UV levels, GPS position and Volatile Organic Compound levels. These parameters will be monitored over a 14-day period and logged to on-board memory, which will be able to be read and cleared by a connected PC.

Sections include a literature review on current weather monitoring systems, the specification and selection of a microcontroller and data storage, hardware, sensor and enclosure specification, circuit, PCB and prototype design, prototype build costs, and potential system improvements.

Literature Review

A weather monitoring station is used to measure meteorological parameters in real time [1] through a variety of sensors. They may be used by such groups as farmers, sailors, or outdoor enthusiasts, who need more locally accurate weather updates for safety or planning purposes [2]. This section of the report will compare 8 weather monitoring stations, 5 portable and 3 static; the Ecowitt WS6006 [3], Ecowitt Wittfield combo/suite [4], KestrelMet 6000 Wi-Fi [5], Kestrel 2500 Weather Meter [6], Kestrel 5000 Environmental Meter [7], Skywatch Windoo 3 Portable Weather Station [8], RK900-03 Portable Weather Station [9] and the Darrera HWS1000-PRO [10].

Below in Figure 1 is a quick look comparison table of the individual systems, it may be seen that the Darrera HWS1000-PRO is the most complete system, offering the most measurements in the smallest form factor. "O" and yellow below meaning an optional extra.

		Unit	Cost	Form		Power			Connectivity					Storage		Parameters											
				Portable	Handheld	Solar	Mains	USB	Headphone jack	Battery	Wi-Fi	Cellular/4G	RS232/RS485	Bluetooth/GPRS	USB	Headphone Jack	SD Card	Internal	Max Transmit Distance	Temperature	Humidity	Wind Speed	Wind Direction	Airborne Partical Count	Sunlight Brightness	UV levels	GPS Position
Weather Stations	Ecowitt WS6006	£310.00	N	N	Y	N	Y	N	N	N	N	N	N	Y	N	N	N	100M	Y	Y	Y	Y	N	N	Y	N	N
	Ecowitt Wittfield combo/suite	£340.00	N	N	Y	N	N	N	Y	Y	Y	N	N	N	N	N	N	100M	Y	Y	Y	Y	N	Y	Y	N	N
	KestrelMet 6000 Wi-Fi	£849.15	N	N	Y	N	N	N	Y	Y	N	N	N	N	N	N	N	304.8M	Y	Y	Y	Y	N	N	O	N	N
Handheld	Kestrel 2500 Weather Meter	£143.65	Y	Y	N	N	N	N	Y	N	N	N	N	N	N	N	N	N/A	Y	N	Y	N	N	N	N	N	N
	Kestrel 5000 Environmental Meter	£237.15	Y	Y	N	O	N	Y	N	N	N	O	N	N	Y	N	Y	30.48M	Y	Y	Y	Y	N	N	N	N	N
	Darrera HWS1000-PRO	£1,042.82	Y	Y	N	N	N	N	Y	O	N	N	Y	Y	N	N	N	N/A	Y	Y	Y	O	N	Y	Y	Y	N
Other	Skywatch Windoo 3 Portable Weather Station	£90.75	Y	Y	N	N	N	Y	N	N	N	N	N	N	N	N	N	N/A	Y	Y	Y	Y	N	N	N	N	N
	RK900-03 Portable Weather Station	£2,390.77	Y	N	O	Y	N	N	Y	N	N	Y	Y	Y	N	N	N	N/A	Y	Y	Y	Y	N	N	O	N	N

Figure 1: Weather Monitoring System Comparison Table

Firstly, the three static Weather Systems, seen below in Figure 2. These systems are designed to be set up on location and left to monitor their parameters indefinitely. All three have solar power as their main power supply, with the Ecowitt Wittfield (left in Figure 2) and the KestrelMET (right in Figure 2) also having a battery power back up, whilst the Ecowitt WS6006 (centre in Figure 2) has a USB power option. Of the three, the Ecowitt Wittfield is the most complete unit, measuring the most parameters.



Figure 2: Static Weather Stations

As mentioned, of the 3 handheld portable systems, the Darrera HWS1000-PRO (right in Figure 3) is the most complete unit, measuring the most parameters and including GPS positioning. Next is the Kestrel 5000 (left in Figure 3), with optional methods of connectivity available. Third, the Kestrel 2500 (centre in Figure 3) This model is fairly basic and as such is the least expensive of the three at £143.65, but for this reduction in cost there is also a reduction in parameters monitored, as well as methods of connecting to the device and reading the data, only being able to read in real time from the device itself, with no option to log the information.



Figure 3: Handheld Weather Monitors

Lastly are two weather monitoring systems that don't quite fit the previous two categories. The Skywatch Windoo Portable Weather Station (left in Figure 6) connects to a phone or tablet through the headphone jack, with the data being able to be read through an app on the device. This monitor doesn't have any wireless connectivity or external power supply, deriving everything from the connected device instead. Finally, the RK900-03. This weather monitor is designed to be portable rather than static, and as such has several power supply options, with an inbuilt mains or battery supply, and an optional extra of adding solar power. The RK900-03 is also able to measure multiple parameters and has the option to include UV level sensors and GPS position from the manufacturer.



Figure 6: Other Types of Weather Monitoring Systems

Microcontroller and Data

For this assignment the selected microcontroller needed to have a minimum of 15 pins, comprising of 4 analogue pins, with the rest being a mixture of GPIO for the I²C communications and digital inputs and items such as the system indication LED and Debug Rx and Tx.

- 8-bit family
- 15 I/O pins
- Minimum 16MHz clock speed
- 1 UART
- 1 USB
- I²C

For this assignment, as the quickest reading is wind speed and direction at 10 seconds, the clock speed needn't be that high. However, due to the types of connections specified, a PIC18F24K50 [11] was returned when using the Microchip Advanced Part Selector [12], which has a clock speed of 32MHz [11]. This PIC was selected despite the high clock speed, as it has a low power mode that it is able to enter between readings to conserve power. Additionally, it has 2048 bytes of RAM, making it a good choice for the amount of data it will capture over the 14-day monitoring period.

The data will be sent in packets of 209 bytes every 10 minutes, with an additional byte at the start and end for the GPS reading. Meaning the system will accumulate 421.344MB of data over the two-week monitoring period. Therefore, an SD card of 1GB was selected as it is more than sufficient to allow the system to save the data needed, whilst still having enough memory to be able to run at the appropriate speed. Figure 7 below demonstrates the structure of the first and last data packet to be sent, which also includes the GPS reading. Whilst Figure 8 is

	Start and End Packet														
0	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6	GPS
1	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6	GPS
2	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6	GPS
3	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6	GPS
4	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6	GPS
	210 Bytes														

Figure 7: Start and End Data Packet Structure

Regular Packet														
0	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6
1	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6
2	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6
3	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6
4	T&H1	T&H2	WS	WD1	WD2	APC	SL	UV	VOC1	VOC2	VOC3	VOC4	VOC5	VOC6
209 Bytes														

Figure 8: Regular Data Packet Structure

the data packet structure that will be sent at all other times, which does not include GPS readings.

Hardware

Power

The sensors have a common voltage of 5V, whilst the PIC and SD card require 3V3. It was decided to use a 12V solar panel and battery, as the next available voltage was 6V, which is not enough of a difference for the selected 5V regulator to work [13].



Figure 9: 100W Solar Panel and L110 12V Numax Leisure Battery

As the system would be running unattended for a fortnight, it needed a reliable power source that would be able to last for the two weeks without needing a mains connection. Therefore, a Sun Store 100W, 12V solar panel was selected [14], alongside a Numax 12V 110Ah leisure battery [15], both seen in Figure 9 above. This system would primarily get its power from the battery, with the solar panel charging it through a charge controller to protect the solar panel and circuitry from overvoltage [16] as needed. The solar panel will be mounted on the same pole that the wind sensors will use, using the mounting bracket specified in the build costs table. The current draw for the system sits at around 0.9W, 173mA, meaning that the battery will be more than sufficient to run it, with the solar panel to top it up.

Enclosure

As this system would need to be able to remain outside unattended for 14 days, it was decided to house the system inside a Pelicase Storm IM2750 [17], seen below in Figure 10. This case was selected as it is ruggedised, waterproof, IP67 rated and of a suitable size to fit the large leisure battery inside. It also has wheels and a handle for easy transportation, with rings for a padlock to be used to lock the lid closed to prevent theft or interference, plus a chain may be put through the handle to a stake. The system will make use of suitably IP rated panel mount connectors to pass through to the sensors.



Figure 10: Pelicase Storm IM2750

Sensor Selection

The weather station for this assignment needed to monitor the following:

- Temperature
- Humidity
- Wind direction
- Wind speed
- Sunlight brightness
- UV levels
- Airborne particle count (APC)
- GPS position
- Volatile organic compound count (VOC)

Temperature and Humidity

Table 1 and Table 2 below demonstrate the technologies available for temperature and humidity sensors and their advantages and disadvantages.

Technology	Infrared	Resistance Temperature Detector (RTD)	Thermocouple	Thermistor
Advantages	Non-contact, accurate	Accurate and stable	Cost, sensitive, simple, rugged and wide temperature range, self-powered	Sensitive, rugged, cost, long lasting
Disadvantages	Struggles with ambient temperature, can be affected by frost, moisture, dust, fog, smoke and close proximity to RF	Cost, self-heating, small size, requires current source	Not as accurate or stable as others	Slow, limited temp range
References	[18], [19]	[20], [21]	[20], [21]	[22], [23]

Table 1: Temperature Sensor Technologies

Technology	Capacitive	Thermal	Resistive	Hair Tension Hygrometer
Advantages	Wide temp and measurement range, stable, small, cost, resistant to chemicals, output near linear	Rugged, able to withstand high temps and corrosion, high resolution	cheap, small, able to be far from circuit board, interchangeable	Simple, easy to maintain, reasonable accuracy
Disadvantages	distance from sensor to circuit is limited, not as accurate under 5%RH, needs circuitry to convert capacitance to humidity	Affected by gasses with thermal properties	sensitive to vapours/contaminants, output may vary with water soluble things	Slow, easily affected by outside influences and contaminants
References	[24], [25]	[25]	[25]	[26]

Table 2: Humidity Sensor Technologies

Below in Table 3 are four sensor options for temperature and humidity monitoring. Of which the Amphenol Advanced T9602-5-A was chosen, as it was in the most rugged form factor with an IP67 rating, smallest current draw, with an analogue output.

	TE Connectivity Temperature & Humidity Sensor[27]	Honeywell HumidCon HIH6100 [28]	HYT 221[29]	Amphenol Advanced T9602-5-A [30]
Image				
Component or System	System	Component	Component	System
Output	Analogue	Digital	Digital	Analogue
Supply	5V	5V	5V	5V
Current Draw	1mA	1mA	850uA	750uA
IP Rating	None	None	None	IP67
Cost	119.08	11.42	41.21	45.26

Table 3: Temperature and Humidity Sensor Comparison

Wind Speed and Direction

As with the previous sensor, the wind speed and direction will both be measured from one sensor, in this case the MeteoWind IoT Sigfox from Barani Designs. Table 4 and Table 5 below compare the technologies available for measuring wind speed and direction, of which a sensor using a vane and cup combination was selected.

Technology	Rotating Cup	Pressure	Ultrasonic
Advantages	Simple, cost effective, can be rugged, easy calibration, wide application range	high stability, can measure air volume too, high wind speed/velocity, no moving parts, fast response	High accuracy and precision, less wear and tear as no moving parts, fast response, all weather operation
Disadvantages	No direction information, not as accurate, outdoor only, friction from moving parts can lead to result errors, may need recalibrating	need to be pointed towards wind flow, not appropriate for highly variable wind speed, not suitable for low air velocity	Expensive, consumes a lot of power, susceptible to environmental interference, small range
References	[31]	[32]	[33], [32]

Table 4: Wind Speed Sensor Technologies

Technology	Hotwire/Thermal	Vane Anemometer	Windmill
Advantages	long life as no rotation, low starting threshold, highly accurate, quick	durable, can withstand high winds,	heavy duty, lasts longer, handle high wind speeds, rugged

	response, small, can measure temp	outdoor/indoor use, compact, easy to use	
Disadvantages	not appropriate for highly variable areas, sensitive to large particles and dirt, expensive	vane has to be in wind direction, rotating parts wear over time, sensitive to freezing, high starting speed	moving parts degrade over time, can have high starting speed if blades are small, needs to be in right direction for readings, prone to bird landings affecting readings
References	[32]	[32]	[32]

Table 5: Wind Direction Sensor Technologies

The MeteoWind was selected due to its IP rating, low current draw and ability to run at 5V.

WIND	Davis Wind Speed and Direction Smart Sensor for HOBO Weather Station Loggers[34]	Weather Station Kit with Anemometer/Wind Vane/Rain Bucket[35]	WSD-V Wind Speed & Direction Sensor - Voltage Output[36]	MeteoWind IoT Sigfox MeteoWind Compact IoT wireless module[37]
Image				
Component or System	System	System	System	System
Output	UNSPECIFIED	UNSPECIFIED	Analogue	Digital
Supply	UNSPECIFIED	5V	24V	3.2-15V
Current Draw	UNSPECIFIED	UNSPECIFIED	30mA	50uA
IP Rating	None	None	None	IP67
Cost	470.04	132.50	5520.00	610.00

Table 6: Wind Speed and Direction Sensors

Sun Brightness

Technology	LDR	Phototransistor	Photodiode	Photovoltaic
Advantages	high light sensitivity, simple and compact design, affordable, high light-dark ratio, good linearity	higher current than photodiode, affordable, small, fast, produce a voltage	good frequency response, linear, less noise, highly sensitive, fast	various mounting panel
Disadvantages	limited spectral response, susceptible to temp and environment, slow response, poor linearity under strong light, susceptible to hysteresis effect	made of silicon so can't handle over 1000V, susceptible to energy surges, spikes and EMF, do not allow electrons to move as freely	small active area, rapid increase in dark current dependent on temp, poor temp stability, require amplification at low light level, current change may be too small to drive circuits	easily damaged, brittle, large, environmentally unfriendly, costly manufacture
References	[38]	[39], [40]	[41]	

Table 7: Sunlight Sensor Technologies

Table 7 above shows the pros and cons of the Sunlight sensor technologies [42], from which the photodiode technology was selected, due to its availability and cost effectiveness. Of the four photodiode sensors suitable for the purposes of this assignment the SEN0390 from DFRobot was selected. This was due to it being able to function at 5V with a negligible current draw. It also has a breakout board with the circuit required for the sensor, meaning that it wouldn't need any extra circuitry or components other than connecting lines. Additionally, it has a range of 0 – 200K lux, with the typical lux levels ranging from ~400 up to ~100K [43], this sensor is more than sufficient. This sensor is not IP rated as it is a component, therefore it will sit behind a fused quartz window behind a hole drilled in the lid of the Pelicase, which will be sealed with silicon sealant to retain waterproofing.

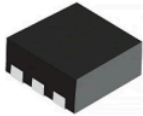
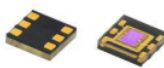
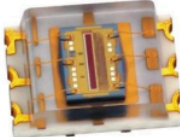
SUN BRIGHTNESS	OPT3001 Ambient Light Sensor, Texas Instruments[44]	SEN0390 DFRobot, Ambient Light Sensor[45]	VEML6035 Vishay, Light Sensor IC[46]	TSL2561T ams OSRAM, Ambient Light Sensor[47]
Image				
Component or System	Component	System	Component	Component
Output	Digital	Digital	Digital	Digital
Supply	1.6-3.6V	2.7-6V	1.7-3.6V	3V
Current Draw	1.8μA	0.7mA	170μA	0.6mA
IP Rating	NONE	NONE	NONE	NONE
Cost	1.50	6.49	1.25	2.35

Table 8: Sunlight Brightness Sensors

UV Levels

Technology	Photodiode	Albedometer	Pyrheliometer	Pyranometer
------------	------------	-------------	---------------	-------------

Advantages	good frequency response, linear, less noise, highly sensitive, fast	accurate, versatile, affordable	low power consumption, wide range of voltage supply, rugged, stable	temp coefficient is small, standardised to SIO, accurate
Disadvantages	small active area, rapid increase in dark current dependent on temp, poor temp stability, require amplification at low light level, current change may be too small to drive circuits	susceptible to errors from own shadow	expensive, difficult to operate	Longer response time to PV cell, high cost, complex data, not as accurate as Pyrheliometer doesn't observe complete spectrum of the sun causing errors
References	[41]	[48], [49]	[50]	[51]

Table 9: UV Sensor Technologies

The chosen sensor has a connector attached to the breakout board as standard. However, this connector itself is not standard and the mating part was unable to be found. Therefore, as it has a standard 2.54 pitch, it will be de-soldered and replaced by a Molex SL series connector with gold plated contacts [52]. As with the Sun sensor previously, this component is not IP rated and as such will also be situated behind a fused quartz window with silicon sealant to retain waterproofing.

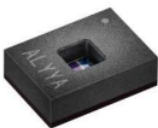
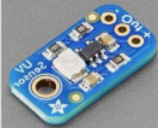
UV Levels	Digital LTR390-UV Ultraviolet Sensor[53]	AS7331-AQFM ams OSRAM, UV Light Sensor[54]	Analog UV Light Sensor Breakout - GUVAS12SD[55]	OSI Optoelectronics, UV-035EQ UV Si Photodiode[56]
Image				
Component or System	System	Component	System	Component
Output	Digital	Analogue	Analogue	Analogue
Supply	3-4.3V	5V	5V	5V
Current Draw	UNSPECIFIED	2mA	1mA	0.1mA
IP Rating	NONE	NONE	NONE	NONE
Cost	8.60	12.35	6.50	70.20

Table 10: UV Level Sensors

APC

The selected sensor is of the optical technology type due to its availability and cost. The component itself is not IP rated and as such will be placed inside the Pelicase directly behind the fan situated in the side, alongside the VOC sensor specified later. This will reduce the waterproofing of the unit, therefore, as with the glass windows, silicon sealant will be used around any edges, and the unit will be placed underneath the solar panel, which should provide a degree of rain cover.

Technology	Optical	Passive	Black Smoke
------------	---------	---------	-------------

Advantages	Portable, battery operated, can measure several sizes at once	Low cost, disposable	Simple, robust, cost, easy maintenance, long time span
Disadvantages	Runs on assumptions about characteristics of particle which could be incorrect	Need different types of plates for different pollutants, temperature dependent, delay in results due to time for bacteria to grow, not as accurate as it may not detect pollutants after the sample was taken, doesn't detect all types of bacteria	Time resolution limited to 24hrs, measures an index rather than concentration, not calibrated to current pollutants
References	[57]	[58]	[57]

Table 11: APC Sensor Technologies

AIRBORNE PARTICLE COUNT	TERA Sensor NextPS, Particle Matter / Dust Air Quality Sensor for Clean Rooms[59]	Gravity: Laser PM2.5 Air Quality Sensor[60]	Panasonic SN-GCJA5, Particle Matter / Dust Air Quality Sensor[61]	TERA Sensor Next-PM, Particle Matter / Dust Air Quality Sensor[62]
Image				
Component or System	System	System	System	System
Output	Digital	Digital	Digital	Digital
Supply	5V	5V	5V	5V
Current Draw	80mA	120mA	100mA	300mA
IP Rating	NONE	NONE	NONE	NONE
Cost	372.25	45	32	81.89

Table 12: APC Sensors

VOC Levels

VOCs are contaminants that are emitted from some liquids of solids [63] and are detrimental to the environment and human health. They are produced by many commonly used products, such as some paints and lacquers, cleaning supplies and adhesives [63].

Technology	Photoionisation Detector	Metal Oxide Semiconductor	Flame Ionisation Detector	Photo-Acoustic Infra-red
Advantages	accurate, small, continuous monitoring, instant feedback	Affordable, wide detectable range, widely available	Sensitive, fast response	smaller than traditional NDIR sensors, small, robust, highly sensitive, accurate at low readings
Disadvantages	lack of sensitivity, humidity can affect readings, can't measure all gas types	sensitive to environmental changes, sensor readings can drift off baseline over lifetime, short lifespan	need additional hydrogen gas cylinder, unable to analyse inorganic compounds, only sensitive to organic compounds that can be burned in the flame, less specific	Susceptible to environmental noise and vibrations
References	[64], [65]	[66], [67]	[68]	[69], [70]

Table 13: VOC Sensor Technologies

The MOS sensor type was selected due to its low cost and availability. From the sensor selection in Table 14 below, the Sensirion SVM30-J was selected, as it comes attached to a breakout board, meaning that the circuitry is extant, reducing the time spent creating the board and minimising the number of components needed on the created PCB. It also has a relatively low current draw, and a supply of 5V. As with the UV sensor previously, the connector attached to the sensor board will be swapped with an SL series Molex connector, and as with the APC sensor, this component is not IP rated and will sit inside the unit by the fan.

VOLATILE ORGANIC COMPOUND	SGX Sensors MICS-2714[71]	Sensirion SGP41-D-R4 [72]	Sensirion SEN54-SDN-T [73]	Sensirion SVM30-J[74]
Image				
Component or System	Component	Component	System	System
Output	Digital	Digital	Digital	Digital
Voltage	5V	3V3	5V	5V
Current Draw	26mA	3.2mA	110mA	49mA
IP Rating	NONE	NONE	NONE	NONE
Cost	10.10	4.28	18.80	14.54

Table 14: VOC Sensors

GPS

For the GPS module there is only one type of technology to choose from. However, it may be broken down further into whether a plug and play GPS antenna is used such as the Garmin 16x GPS sensor below, or if a component or module unit is used, such as the Quectel L80-M39 GPS receiver. As seen in *Table 15* below, the plug and play receiver is over three times the cost of the next expensive module. In order to save space, integrate more easily with the circuit and save costs, it was decided to go with an individual module that would be able to sit within the unit itself. As such the ADAFRUIT 746 GPS Module was selected, due to its ability to function at 5V with a low current draw, and that it comes attached to its own break out, meaning integration should be simplified and will not involve the inclusion of any external components such as resistors or capacitors. It is also able to have its own CR2032 battery supply as a backup should the main system fail. The specified enclosure is plastic, so the GPS shouldn't be affected by being inside the unit and so it doesn't need IP rating.

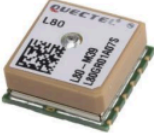
GPS	Quectel L80-M39 GPS Receiver[75]	ADAFRUIT INDUSTRIES 746 GPS Module[76]	Seeed Studio 113020003 GPS Module[77]	Garmin 16x GPS Sensor[78]
Image				
Component or System	Component	Component	Component	System
Output	Digital	Digital	Digital	Digital
Voltage Supply	3-4.3V	5V	5V	3V3-6V
Current Draw	25mA	20mA	40mA	90mA
IP Rating	NONE	NONE	NONE	NONE
Cost	12.70	48.74	19.82	145.94

Table 15: GPS Receivers

Connectors

For this assignment the Molex KK 254 range of PCB headers were selected, seen below in Figure 11 [79]. These are keyed, meaning that the user will not be able to plug them in the wrong way, and gold plated to reduce resistive losses, they are also a standard pitch of 2.54mm, which will make the design of the PCB simpler.

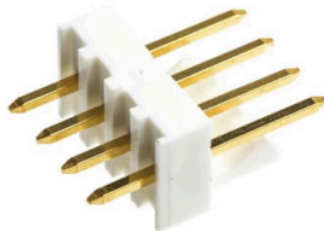


Figure 11: Molex KK 254 PCB Header

The external connectors are the RS Pro Industrial Circular Connectors, seen below in Figure 12 [80], [81], these are keyed, have a spring mechanism in place of a thread making set up easier, and are IP67 rated, with dust caps included as standard.



Figure 12: RS Pro Circular Panel Mount and mating Cable Mount Connectors

Circuit Design

A top-level block diagram of the circuit may be seen in Figure 13 below, the sensors generate the signal sources, with the temperature and humidity and wind sensors entering clamp circuits, before entering the PIC. The PIC will then write the data to the SD card.

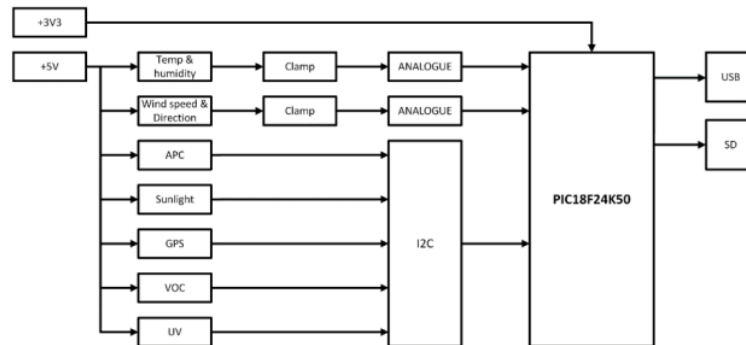


Figure 13: Schematic Block Diagram

The PCB and associated schematic diagram were both designed in Easy-PC [82] and function as so: A signal is created by the sensor on the external of the case, which then enters the board through the panel mount and Molex KK connectors, where they are read by the PIC and written to the SD card. The circuit diagram may be seen below in Figure 14, a larger version of which may be found in Appendix 1. Power in the form of 12V enters the board through the connector in the top left corner where it is stepped down to first 5V and then 3V3 by the two regulators. From which this power is distributed to the sensor headers, PIC, USB and SD card mount. It was decided to run the PIC from 3V3 instead of 5V so that less power is consumed, and it is able to write to the SD card efficiently, as that is powered by 3V3. As multiple sensors run on the same SCL/SDA lines, they will all need to be addressed differently so that the PIC

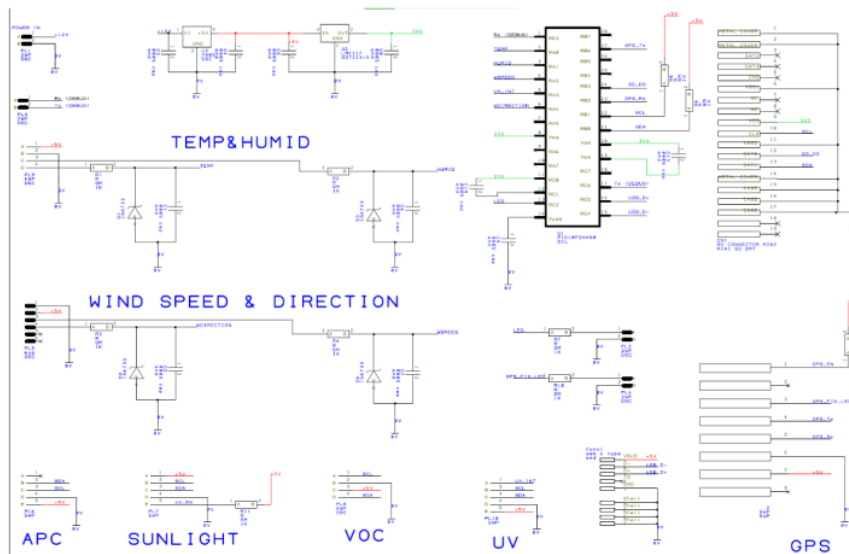


Figure 14: Circuit Diagram

is able to read them separately.

PCB Design

The proposed PCB design may be seen below in Figure 15 (a larger image may be found in Appendix 2), the three copper pours have been hidden so that the rest of the circuitry is visible. All of the headers are named so that the user may easily see where each connector plugs in. There are also dots by pin 1, and +/- symbols by 5V/3V3 and 0V, to align the pins and also to allow the user to quickly find positive and ground pins in the event of any fault finding. The board is designed around the central PIC, with the headers placed around the board to make connecting to them easier. It is 4 layers, with the internal layers used to route the +5V and +3V3 around the board through copper pours, reducing the number of tracks needed. The final copper pour is on the bottom layer and is used for ground/0V. The Design Rule Check (DRC) showed no errors aside from the pads for the SD card and the USB socket being too close to the edge of the board. However, these need to be situated at the edge to retain connectivity, and the manufacturer selected will be able to produce the board as designed.

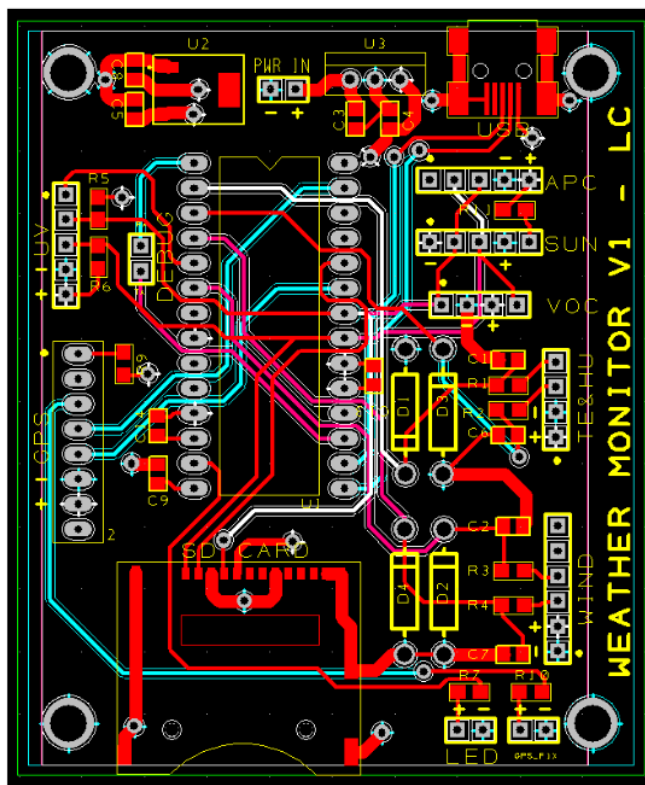


Figure 15: PCB Design

Once designed, the PCB was uploaded to JLC PCB for an online quote to add to the overall build costs. This board was quoted at £5.58 to produce and needed to be ordered in a minimum quantity of 5, contributing a total of £27.90 to the overall cost, an image of the quote may be seen overleaf in Figure 16.

JLPCB

GBP Order now My file Sign in

Standard PCB/PCBA

Limited Time Offer Advanced PCB/PCBA

SMT-Stencil

3D Printing/CNC

Back to Upload File

Detected 4 layer board of 76.6x63.64mm(3.02x2.51 inches).

Gerber Viewer

Base Material

FR-4

Flex

Aluminum

Copper Core

Rogers

PTFE Teflon

Layers

1

2

4

High Precision PCB

6

8

10

12

14

16

More

Dimensions

63.64

*

76.6

mm

PCB Qty

5

Product Type

Industrial/Consumer electronics

Aerospace

Medical

Charge Details

Special Offer

£ 5.58

Via Covering

£ 0.00

Surface Finish

£ 0.00

Build Time

PCB:

3-4 days

 £ 0.00

3 days

PCBA Only

 £ 0.00

Calculated Price

£ 5.58

Additional charges may apply for special cases

SAVE TO CART

Shipping Estimate

£ 16.02

UPS Express Saver

3-5 business days

Weight

0.20kg

Coupons

Save £ 23.92

Save £ 7.97

Figure 16: PCB Price Quotation

Software Design

The software will operate as shown in Figure 17, a larger image may be found in Appendix 3, it will perform two concurrent counts, one of which will run the sensor and flag timings, the other count the 14 days. Once this second count has reached the 2-week time limit, the system will take a final GPS reading and cease monitoring, shutting itself down. The user is able to connect to the system through a USB, where they will be able to read and clear the data logged.



Figure 17: Software Operation Flowchart

Below in Figure 18 are the total build costs for the prototype system, amounting to ~£1900. Included are all connectors, and extras such as mounting screws for the PCB, and a pole to mount the solar panel and wind sensors to, among others. The header for GPS is not included, as it comes with the board, and will be soldered directly to the PCB. Cabling will be sourced from existing lab supplies. It may be seen that the most expensive section is hardware, amassing to just under 1/3 of the total build cost. A larger image may be seen in Appendix 4.

[illegible]

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Future Improvements

In the future it may be prudent to add a cellular capability to the weather monitoring system, so that it may send an error message should the system fail. By enabling this the owner of the system is able to attend to the system when it fails, rather than waiting for the 14-day period to finish, to find that it failed and there is no data, rendering the two weeks wasted.

It may also be beneficial to add more parameters that the system monitors, such as a rain gauge or barometric pressure. This should increase the usefulness of the system and potentially add in a prediction factor based on these extra parameters, rather than simply monitoring.

With regards to the circuit design, the PCB may be laid out more efficiently using a surface mount PIC to reduce the length of tracks on the board and therefore introduced resistances. It also would be beneficial to utilise both sides of the PCB to reduce the final size. For example, the SD card being placed on the underside would enable the GPS header to be rotated 90°, and the two LED headers brought up into the freed-up space to reduce the size of the board.

It could be made so that the system uses either a USB or an SD card. As the SD card is removeable, it may simply be removed from the board and plugged into a PC negating the need for the USB. Alternatively, the system may make use of non-removeable storage and use the USB port, removing the SD card slot and allowing the PCB to be smaller.

In order to get more accurate readings for VOC, UV, APC and sunlight, larger, more expensive systems may be purchased with high IP ratings, so that the sensors may sit outside of the Pelicase.

Finally, the GPS sensor could be powered from its own regulator in order to use a switching regulator to provide a cleaner supply for the GPS.

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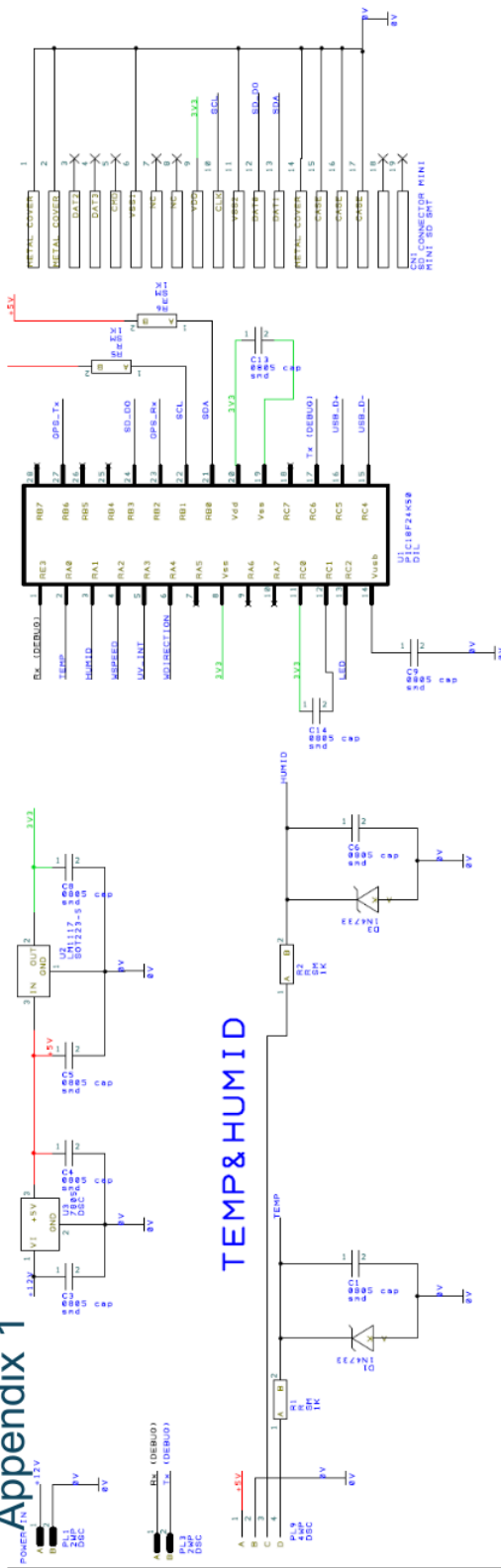
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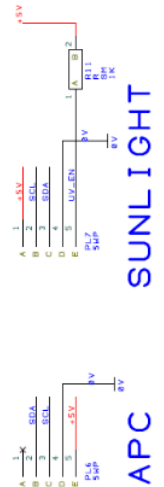
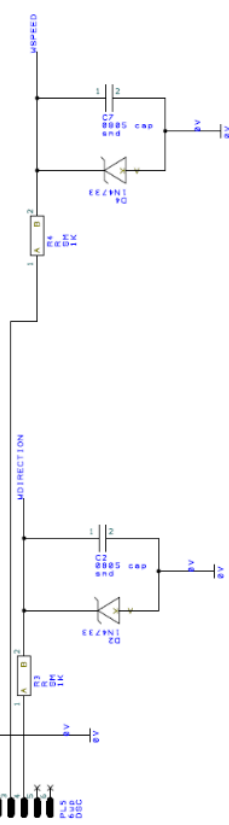
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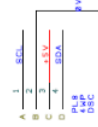
Appendix 1



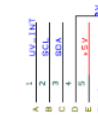
WIND SPEED & DIRECTION



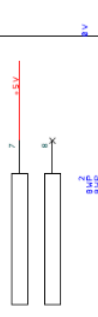
VOC



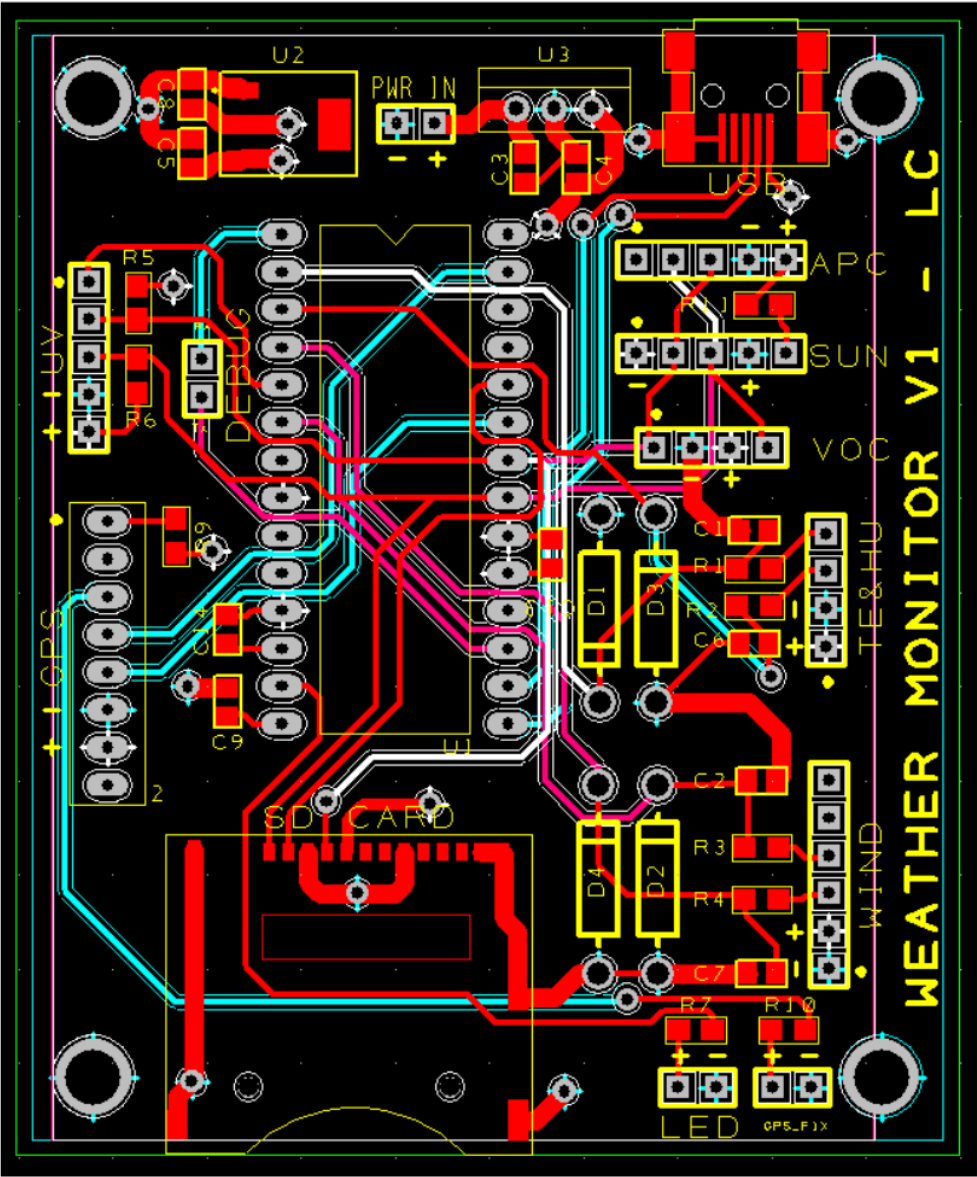
UV



GPS



Appendix 2



Appendix 3



Appendix 4

	Item	Cost (£)	Qty	Total (£)	Supplier Link	Section Total
POWER	Solar panel	131.400	1	131.40	https://www.sunstore.co.uk/product/12v	£280.75
	Leisure battery	91.990	1	91.99	https://www.gobatteries.co.uk/product/m	
	Charge controller	18.900	1	18.90	https://www.sunstore.co.uk/product/ep-s	
	3V3 Regulator	1.124	1	1.12	https://uk.rs-online.com/web/p/voltage-r	
	5V Regulator	1.630	1	1.63	https://uk.rs-online.com/web/p/voltage-r	
	Power switch	5.980	1	5.98	https://uk.rs-online.com/web/p/rocker-sw	
	Resistor 20ohm (0805)	0.049	100	4.90	https://uk.rs-online.com/web/p/surface-r	
	Resistor 330ohm (0805)	0.020	50	1.00	https://uk.rs-online.com/web/p/surface-r	
	Resistor 10kohm (0805)	0.475	10	4.75	https://uk.rs-online.com/web/p/surface-r	
	Resistor 820ohm (0805)	0.020	50	1.00	https://uk.rs-online.com/web/p/surface-r	
	Resistor 10Kohm (0805)	0.377	10	3.77	https://uk.rs-online.com/web/p/surface-r	
	Resistor 3.3Mohm (0805)	0.810	1	0.81	https://www.mouser.co.uk/ProductDetail	
	Capacitor 0.22uF (0805) (220nF)	0.097	10	0.97	https://uk.rs-online.com/web/p/mlccs-m	
	Capacitor 10uF (0805)	0.491	10	4.91	https://uk.rs-online.com/web/p/mlccs-m	
CONTROL	Capacitor 1nF (0805)	0.070	50	3.50	https://uk.rs-online.com/web/p/mlccs-m	£53.76
	Capacitor 100nF (0805)	0.047	25	1.18	https://uk.rs-online.com/web/p/mlccs-m	
	Diode 1N4733A	0.147	20	2.94	https://www.mouser.co.uk/ProductDetail	
	PIC	3.720	1	3.72	https://uk.farnell.com/microchip/pic18f2	
	USB Port	3.122	5	15.61	https://uk.rs-online.com/web/p/usb-conn	
SENSORS	SD Card Port	4.760	1	4.76	https://uk.rs-online.com/web/p/memory-y	£508.21
	SD Card	27.620	1	27.62	https://uk.rs-online.com/web/p/sd-cards	
	Green LED 10mm (System and GPS Fix)	0.410	5	2.05	https://uk.rs-online.com/web/p/leds/059	
	Temperature & Humidity combined	45.260	1	45.26	https://uk.rs-online.com/web/p/temperat	
	Wind Speed & direction	350.070	1	350.07	https://www.instrumentchoice.com.au/m	
	Airborne Partical Count	32.000	1	32.00	https://uk.rs-online.com/web/p/enviromn	
	Sunlight Brightness	9.000	1	9.00	https://uk.rs-online.com/web/p/colour-lig	
	UV Levels	8.600	1	8.60	https://thepihut.com/products/digital-ltr3	
HARDWARE	GPS Position	48.740	1	48.74	https://uk.rs-online.com/web/p/gnss-gps	£1,095.48
	VOC Level	14.540	1	14.54	https://uk.rs-online.com/web/p/enviromn	
	PCB	5.580	5	27.90	https://jlcpcb.com/	
	Enclosure	435.830	1	435.83	https://peliproducs.co.uk/collections/sto	
	Enclosure padlock	10.340	1	10.34	https://uk.rs-online.com/web/p/padlocks	
	PCB Mounting screws	8.770	1	8.77	https://uk.rs-online.com/web/p/machine	
	Nuts	12.710	1	12.71	https://uk.rs-online.com/web/p/hex-nuts/	
	LED mount	0.890	5	4.45	https://uk.rs-online.com/web/p/led-holde	
	Quartz Glass	12.500	2	25.00	https://www.uqgoptics.com/product/fuse	
	Fan for VOC sensor	6.530	1	6.53	https://uk.rs-online.com/web/p/axial-fans	
	Solar panel mount	40.750	1	40.75	https://www.sunstore.co.uk/product/heat	
	Pole for solar panel and wind sensors	172.300	1	172.30	https://www.weathershop.co.uk/davis-77	
	2 pin header	0.533	5	2.67	https://uk.rs-online.com/web/p/pcb-head	
	3 pin header	0.605	1	0.61	https://uk.rs-online.com/web/p/pcb-head	
	4 pin header	0.512	2	1.02	https://uk.rs-online.com/web/p/pcb-head	
	4 pin - VOC sensor	5.386	5	26.93	https://uk.rs-online.com/web/p/pcb-head	
	5 pin header	0.910	2	1.82	https://uk.rs-online.com/web/p/pcb-head	
	6 pin header	1.274	5	6.37	https://uk.rs-online.com/web/p/pcb-head	
	5 pin - UV sensor	4.090	2	8.18	https://uk.rs-online.com/web/p/pcb-head	
	2 pin plug	0.151	10	1.51	https://uk.rs-online.com/web/p/wire-hou	
	3 pin plug	0.287	10	2.87	https://uk.rs-online.com/web/p/wire-hou	
	4 pin plug	0.196	10	1.96	https://uk.rs-online.com/web/p/wire-hou	
	4 pin - VOC sensor	0.250	10	2.50	https://uk.rs-online.com/web/p/wire-hou	
	5 pin plug	0.179	10	1.79	https://uk.rs-online.com/web/p/wire-hou	
	5 pin - UV sensor	0.343	10	3.43	https://uk.rs-online.com/web/p/wire-hou	
	6 pin plug	0.308	10	3.08	https://uk.rs-online.com/web/p/wire-hou	
	Crimps KK	0.148	100	14.80	https://uk.rs-online.com/web/p/crimp-co	
	Crimps SL	0.175	100	17.50	https://uk.rs-online.com/web/p/crimp-co	
	3 pin panel mount	23.290	1	23.29	https://uk.rs-online.com/web/p/industrial	
	4 pin circle panel mount	23.290	1	23.29	https://uk.rs-online.com/web/p/industrial	
	5 pin panel mount	17.030	1	17.03	https://uk.rs-online.com/web/p/industrial	
	6 pin panel mount	17.110	1	17.11	https://uk.rs-online.com/web/p/industrial	
	3 pin cable mount	29.930	1	29.93	https://uk.rs-online.com/web/p/industrial	
	4 pin cable mount	29.890	1	29.89	https://uk.rs-online.com/web/p/industrial	
	5 pin cable mount	30.840	1	30.84	https://uk.rs-online.com/web/p/industrial	
	6 pin cable mount	26.450	1	26.45	https://uk.rs-online.com/web/p/industrial	
	Panel mount 2 pin	26.110	1	26.11	https://uk.rs-online.com/web/p/industrial	
	Cable mount 2 pin	29.930	1	29.93	https://uk.rs-online.com/web/p/industrial	
	Build Total			£1,938.20		

Louise Caygill - ACDA6002 - Assignment 2

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

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GRADING FORM: SMU GENERIC_GJ

LOUISE CAYGILL

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RESEARCH-INFORMED LITERATURE



Good literature review of available systems with a good comparison table of relevant information but a short section of the manufacturers specification would have improved it. 70%

7

KNOWLEDGE AND UNDERSTANDING



Good overall schematic design but a things to be kept in mind. When designing a complex board it is beneficial, from a understanding point of view, to limit the number of lines travelling around and instead use net names which you have done. All of your connectors are fitted around the perimeter of the board . Looking at your PSU, the 7805 requires a fairly large capacitor on its output to work as a tank for other components in case of large power call, maybe 20uF or more . On your next design, look for a 7805 switching regulator, it lowers the heat and the power wasted in a standard 7805 and its pin compatible.. Well done 75%

18.75

ANALYSIS



Good selection of microcontroller. Good selection of components well described and selected via the tables.. Good case selection. Good selection of connectors .75%

26.25

PRACTICAL APPLICATION AND DEP.



Costings were included in a table without an image but with the supplier's name and part number. Interesting attempt at future enhancements. 70%

14

SKILLS FOR PROFESSIONAL PRAC.



The report is well presented with a very good selection of references. 80%

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