

assignment 2 1704018

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MARINE WEATHER MONITOR



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Task

Design a simple microcontroller based marine weather monitor which takes measurements and logs the data over a 7day period. The system is intended for use by amateur marine weather forecasters to aid in their predictions. The system must be portable and adaptable. The data it will be collecting or from; temperature, humidity, wave height, Wwnd speed, wind direction, sunlight brightness and GPS positioning sensors.

Data Acquisition Systems

Data Acquisition systems are devices that monitor their environment and store the data. DAQ systems can be used for monitoring almost anything. The DAQ systems can have many different sensors attached to it and they are flexible. During this report the process of developing the electronic side of a DAQ system will be documented. The DAQ system will be designed to be used as a marine weather station. Below is a comparison table of DAQ systems. These have been researched for background knowledge before the development begins.

					
Name	AWS430 [1]	CR1000 [2]	CR800 [3]	CR3000 [4]	CR300 [5]
Overview	Designed to withstand salty and wet conditions, freeze/thaw and can endure vibration and shock.	Rugged, can withstand extreme conditions. Reliable, used in applications all over the world.	Small, research-grade, standalone operations.	Supports complex applications with many sensors, designed for standalone operation in harsh and remote environments	Small, low-cost, fast communication, low power, USB, excellent analog input accuracy/ resolution.
Power	2.6 Ah / 12 V	9.6 to 16 Vdc	9.6 to 16 Vdc	10 to 16 Vdc	16 to 32 Vdc for charger input (CHG)
Analog Inputs	-	16 single-ended or 8 differential	6 single-ended or 3 differential	28 single-ended or 14 differential	6 single-ended or 3 differential
Digital I/O	-	8 I/Os or 4 RS-232 COM I/O ports can be paired as transmit and receive for	I/Os or 2 RS-232 COM I/O ports can be paired as transmit and receive for	3 SDM and 8 I/Os or 4 RS-232 COM I/O ports can be paired as transmit and	7 terminals (C1, C2, P_SW, and SE1 to SE4) configurable for digital input and output.

		measuring smart serial sensors.	measuring smart serial sensors.	receive for measuring smart serial sensors.	Includes status high/low, pulse width modulation, external interrupt, and communication functions.
Communication Ports	RS-232, RS-485 bus, LAN, ModBus, TCP/IP, and serial	CS I/O RS-232 Parallel peripheral	CS I/O RS-232	CS I/O RS-232 Parallel peripheral	USB Micro B RS-232
Battery-backed SRAM for CPU Usage & Final Storage	-	4 MB	-	-	CPU Drive/program 80 MB serial flash, Data storage 30MB serial flash

Wind speed/wind direction

Part of the criteria for the DAQ system was for it to be able to monitor wind speed and direction. Below is a comparison table containing five possible sensor options for the DAQ system to use.

					
Name	05103-L [6]	014A-L [7]	034B-L [8]	WMT700 [9]	WXT532 [10]
Description	This device is designed for measuring windspeed and direction. It is corrosion resistant.	This device measures windspeed.	Three-cup anemometer and vane into a single package. Measures wind direction and wind speed.	Robust, ultrasonic, measures wind speed and wind direction.	Ultrasonic wind sensor, lightweight, measures wind speed and wind direction.
Starting Threshold	Wind Speed: 1.0 m/s (2.2 mph) Wind Direction: 1.1 m/s (2.4 mph) at 10° displacement	0.45 m/s (1.0 mph)	Wind Speed (Anemometer): 0.4 m/s (0.9 mph)	Direction 0.1 m/s (0.2 mph), Speed 0 ... 75 m/s (168 mph): ± 0.1 m/s (0.2 mph) or 2 % of reading, whichever is greater 75 ... 90 m/s (201 mph): ± 5 % of reading	starting threshold are virtually zero
Accuracy	Wind Speed: ± 0.3 m/s (± 0.6 mph) or 1% of reading Wind Direction: $\pm 3^\circ$	0.11 m/s (0.25 mph) or 1.5%	Wind Speed (Anemometer): $\pm 1.1\%$ of true at > 10.14 m/s (22.7 mph) Wind Speed (Anemometer): 0.1 m/s (0.25 mph) at < 10.14 m/s (22.7 mph) Wind Direction (Vane): $\pm 4^\circ$	Direction $\pm 2^\circ$, Speed 0 ... 75 m/s (168 mph): ± 0.1 m/s (0.2 mph) or 2 % of reading, whichever is greater 75 ... 90 m/s (201 mph): ± 5 % of reading	Wind Speed: ± 3 % at 10 m/s (22 mph) Wind Direction: $\pm 3.0^\circ$ at 10 m/s (22 mph)

Range	Wind Speed: 0 to 100 m/s (0 to 224 mph)	0 to 45 m/s (0 to 100 mph)	Wind Speed (Anemometer) : 0 to 75 m/s (0 to 167 mph)	Wind speed: WMT701: 0 ... 40 m/s (89 mph) WMT702: 0 ... 65 m/s (145 mph) WMT703: 0 ... 75 m/s (168 mph) WMT704: 0 ... 90 m/s (201 mph)	Wind Speed: 0 ... 60 m/s (134 mph)
Resolution	Wind Speed: (0.0980 m s ⁻¹) / (scan rate in seconds) or (0.2192 mph) / (scan rate in seconds)	-	Wind Direction (Vane): < 5° Wind Speed (Anemometer) : (0.7998 m s ⁻¹) / (scan rate in seconds) or (1.789 mph) / (scan rate in seconds)	Direction 0.01°, Speed 0.01 m/s (0.0223 mph)	Wind Speed: 0.1 m/s (km/h, mph, knots) Wind Direction: 1°
Operating Temperature Range	-50° to +50°C (assuming non-riming conditions)	-50° to +70°C	-30° to +70°C	-55 ... +70 °C	-60 ... +70 °C

The wind speed and wind direction monitor 05103-L was chosen for the DAQ system. The 05103-L is corrosion resistant. The DAQ system is shore based so the sensor will be exposed to very wet and windy conditions. The corrosion resistant will help the sensor to last longer. Unlike some of the other sensors this sensor monitors both wind speed and wind direction so only one sensor is needed to meet the DAQ requirements. The 05103-L has the largest wind speed sensing range out of the five sensors.

Temperature and Humidity

The weather station that is being designed needs to be able to monitor temperature and humidity. Below is a comparison table of five sensors that are possible options for the DAQ system.

					
Name	HygroVUE10 [11]	HygroVUE05 [12]	EE181-L [13]	HMP3 [14]	HMP113 [15]
Description	Temperature and humidity elements, digital sensor	Temperature and Relative Humidity Sensor	Temperature and Relative humidity, long term unattended application	General purpose humidity and temperature application with exchangeable sensor	Temperature and humidity prob
Supply Voltage	7 to 28 Vdc	7 to 28 Vdc	7 to 30 Vdc (typically powered by the datalogger's 12 V supply)	15 ... 30 VDC	13.5 ... 16.5 VDC
Sensing Element	SHT35 modified by Campbell Scientific	SHT35 derivative (specially coated for reliability)		HUMICAPâ R2 sensor	-
Humidity Measurement range	0 to 100% RH	0 to 100% RH	0 to 100% RH (non-condensing)	0 ... 100 %RH	0 ... 100 %RH
Humidity accuracy	(at 25°C) ±1.5% (over the range 0 to 80% RH) ±2% (over the range 80 to 100% RH)	(at 25°C) ±1.8% (over the range 0 to 80% RH) ±3% (over the range 80 to 100% RH)	-40° to +60°C; ± (1.5 + 0.015 • RH reading) % RH	at +23 °C; ±0.8 %RH (0 ... 90 %RH)	(incl. Non-Linearity, Hysteresis and Repeatability):
Temperature Measurement Range	-40°C to +70°C	-40 to +70°C	-40° to +60°C	-40 ... +120 °C	-40 ... +60 °C
Temperature Accuracy	±0.2°C (over the range -40 to +70°C) ±0.1°C (over the range -20 to +60°C)	±0.4°C (over the range -40 to +70°C) ±0.3°C (over the range -20 to +60°C)	±0.2°C (at +23°C)	±0.1 °C	-40 ... 0 °C, +40 ... +60 °C ±0.4 °C

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The HygroVUE10 was chosen as the sensor for the weather station. The temperature and humidity probs all have very similar properties. The HygroVUE10 is the most up to date sensor.

Sunlight Brightness

The weather station needs to be able to monitor sun brightness. Below is a comparison table of potential sun brightness sensors.

					
Name	S-LIB-M003 HOBO-Solar Radiation Sensor [16]	SSR1D Solar Radiation Sensor [17]	SP-230 Sunshine Sensor (heated) [18]	SP-212 Apogee Precision Amplified Pyranometer [19]	SR15 Digital [20]
Description	Light Sensor	designed for constant outdoor use, full sight vision of 180°	eliminating the problem of snow, frost, and dew accumulating on the sensor	Measures solar radiation	General solar resource monitoring
Supply Voltage		3,3-15V DC	12 VDC with a nominal current draw of 15 mA	2.5-24 VDC with a nominal current draw of 300 µA	
Operating Temperature Range:	-40° to 75°C	-40 +65°C	-40 to 70 C, 0 to 100 % relative humidity	-40 to 70 C, 0 to 100 % relative humidity	-40 to +80 °C
Measurement range	0 to 1280 W/m2	0 ... 1500 W/m2		up to 1250 W m-2	
Resolution	1.25 W/m2	2mV per W/m2	0.20 mV per W m-2	2.0 mV per W m-2	10 x 10-6 V/(W/m2)
Spectral Range	300 to 1100 nm	300 – 1000 nm	360 nm to 1120 nm	360 nm to 1120 nm	285 to 3000 x 10-9 m
Accuracy	±10 W/m2 or ±5%, whichever is greater in sunlight.	+/- 5%	± 1%	< 1 %	< 1.8 %

	Additional temperature induced error $\pm 0.38 \text{ W/m}^2 / ^\circ\text{C}$ from 25°C				
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The SSR1D Solar Radiation Sensor was chosen for the sun brightness sensor. This sensor is designed for constant outdoor use, it has a full sight vision of 180° and the largest measurement range out of the five sensors.

Wave Hight

The weather station is marine based and is expected to be able to monitor wave height. Below is a comparison table with five potential sensors.

					
Name	CS451 [21]	LevelVUE™ B10 [22]	CS477 [23]	SR50A [24]	CRS456 [25]
Description	Pressure transducer, water level measurements	Water level based on a non-submersible pressure transducer system	Radar ranging sensor, monitors water level, non-contact	Non-contact, snow or water depth. Uses ultrasonic sound	Water level and water temperature sensor, own time clock, memory, battery
Power Requirements	6 to 18 Vdc	11.5 to 16.5 V	9.6 to 16 Vdc	9 to 18 Vdc	-
Operating Temperature Range	0° to 60°C	-40° to +60°C	-40° to +80°C	-45° to +50°C	0° to 60°C
Water-Level Resolution	0.0035% FS	±2.1 mm (0.007 ft) for 0 to 15 PSI	1 mm (0.04 in.)	0.25 mm (0.01 in.)	0.0035% FS
Output	SDI-12 (version 1.3) 1200 bps; RS-232 9600 bps	SDI-12 Protocol, SDI-12 Default "M" Measurement Response Time, RS-485 Protocol, RS-485 Baud Rate	SDI-12	SDI-12 version 1.3, RS-232, RS-485	micro USB

The CS451 was chosen as it was a contact-based sensor and it wasn't an independent device like the CRS456. For the wave height to be measured two of these sensors will be needed. One will measure the average wave height and will be put in a buoyancy float with small holes in it so that it resists the water flow. The second sensor will be in a buoyancy float that doesn't resist the water flowing in and out of it. The water volume in the second float will fluctuate at the same rate as the wave and that volume of water in the second float compared to the first float will give the wave height.

GPS Positioning

Below is a comparison table of three GPS models that could be used for monitoring the DAQ's location.

			
Name	GPS16X-HVS [26]	ANT895-6ML GPS - 6GK5895-6ML00-0AA0 [27]	GPS Receiver Antenna with NMEA 0183 output [28]
Description	GPS, provides positioning, velocity and timing information	GPS antenna is optimally suited for outdoor use	Built-in patch antenna 12 parallel tracking channels Fast TTFF and low power consumption
Operating Voltage Range	8 to 40 Vdc	-	-
Output	PSS, 1 Hz pulse; 1 μ s accuracy (Width factory set to 100 ms.)	0.3 m connection cable with N-female plug	Support RS-232 or RS-422 interface
Velocity Accuracy	0.1 knot RMS steady state	-	-
Operating Temperature Range	-30° to +80°C	-40-85 °C	-

The GPS16X-HVS was chosen as it had the most available information about it online. The other GPS models had very limited information and had no data sheet.

PIC Peripheral Needs

Now that the sensors have been selected the following table will lay out all the needs of the sensors and the peripherals that will be in the DAQ system that the PIC will need to support. This will give an idea of the PIC specifications.

	Pins	Type A/D	Resolution	Memory	Clock Speed	Power	Other
Wind speed/wind direction	1	Analog	0 to 224 mph (three pulses per revolution) 90 Hz (1800 rpm) = 8.8 m/s (19.7 mph)	10KB readings one week	1KHz (program reads data every 1second)		Measurements are typically processed for output with the Wind Vector instruction Pulse Counter
Wave Height	2	RS232	0.0035% FS SDI-12 (version 1.3) 1200 bps; RS-232 9600 bps	100KB	0.1s	6 to 18 Vdc	
Temperature/Humidity sensor	1	Digital	0.001°C ±0.1°C (over the range -20 to +60°C)	170B	1min	7 to 28 Vdc	standard M12 connector
Sunlight Brightness	1	Analog	Sensitivity 2mV per W/m ² Sensitivity range 300 – 1000 nm	170B	1min	3,3-15V DC,	
GPS Positioning	1	Digital	1 Hz pulse; 1 µs accuracy (Width factory set to 100 ms.)	10KB	1Hz	8 to 40 Vdc	
Button	1	Digital	0.25 seconds		Interrupt	5V	
USB2	1	Digital			480Megabits per second	3.3V	
RS232	2	Digital		10KB			
SD	4	Digital					
Total	10	6D, 2A		120KB			

PIC Selection

Now that demands of the peripherals have been calculated, it is time to choose a PIC. Below is a table that compares the top pic options. For each category the preferred value has been highlighted in orange.

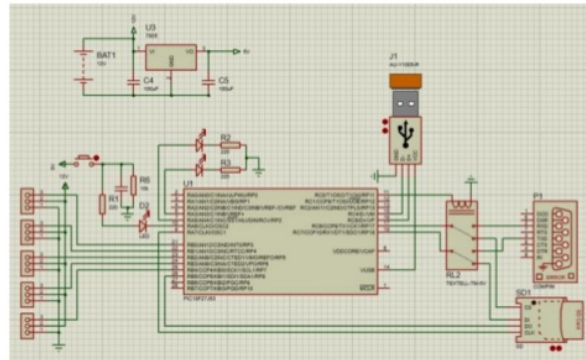
	PIC18F2550 [29] 	PIC18F25J50 [30] 	PIC18F26J53 [31] 	PIC18F27J53 [32] 	PIC32MK1024 GPD064 [33] 
Price \$	3.44	2	2.42	2.66	4.86
CPU Type	8-bit PIC MCU	8-bit PIC MCU	8-bitPIC MCU	8-bit PIC MCU	32-Bit MIPS MCU
Program Memory Size (KB)	32KB	32KB	64KB	128KB	1024KB
Program Memory Size (Kwords)	16	16	32	64	
SRAM	2048	3800	3800	3800	262144
Emulated EEPROM	256/HEF	0/HEF	0/HEF	0/HEF	4096 / True
Pin count	28	28	28	28	64
Internal Oscillator	8MHz, 32KHz	8MHz, 32KHz	8MHz, 32KHz	8MHz, 32KHz	8MHz, 32KHz
Max ADC Resolution (Bits)	10	10	12	12	12

Max ADC Sampling Rate (ksps)	100	100	100	100	500
UART	1	2	2	2	6
USB Modules	1	1	1	1	2
Temp Range	-40 to +85°C	-40 to +85°C	-40 to +85°C	-40 to +85°C	-40 to +125°C
Total No. of Preferred Features	1	3	3	5	5

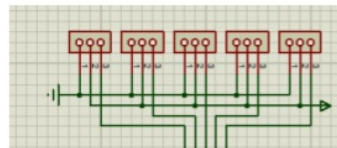
Above it show that there are two PIC's with 5 preferred features, PIC18F27J53 and PIC32MK1024GPD064. PIC32MK1024GPD064 is a large high power pic, it give the circlet developer freedom to implement a broad range of feature it they so wished. However this pick has way more capabilities than are needed for this weather station DAQ system, its physically larger so the PCB would need to be larger (which is not cost efficient) and the chip itself costs \$4.85. The PIC18F27J53 chip is better well suited for the DAQ systems purposes and it is physically small and costs less than the PIC32MK1024GPD064. For these reasons the PIC18F27J53 will be the main chip.

Circuit design and PCB

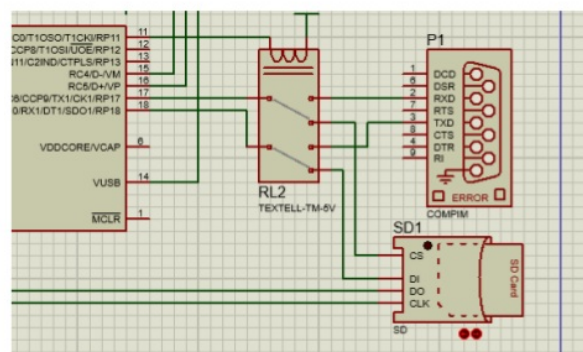
The circuit design process used two CAD programs, proteus and Easy-PC. The circuit was designed on proteus first. Below is a screen shot of the Circuit design.



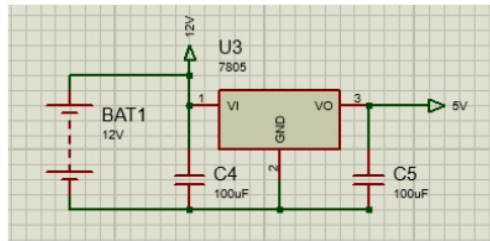
It has five sensor ports. Only four sensor ports are needed as the wave sensor is connected through the RS232 port but an extra one was added as a backup port in case one of the others failed.



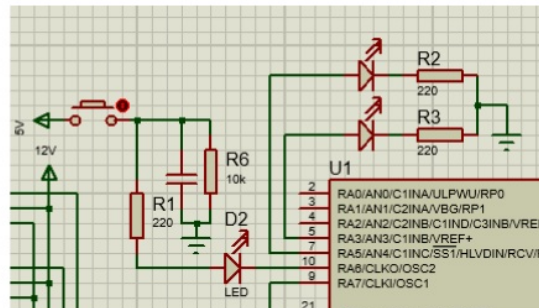
The circuit design also incorporates a low powered relay switch. This relay switch is powered by 5V so can be controlled straight from the PIC. As the PIC only have one set of TX RX ports but both the RS232 and the SD card was wanted in the final DAQ system a relay switch was added to allow both the ports contact with the chip one either one are ever in contact at the same time. This would mean if the PIC wanted to store data onto the SD card then it cannot read the incoming data from the RS232 at the same time. To over come this the sensory data would be stored onto the PIC SRAM and then every cycle the SRAM memory would be copied to the SD card and whipped from the chip.



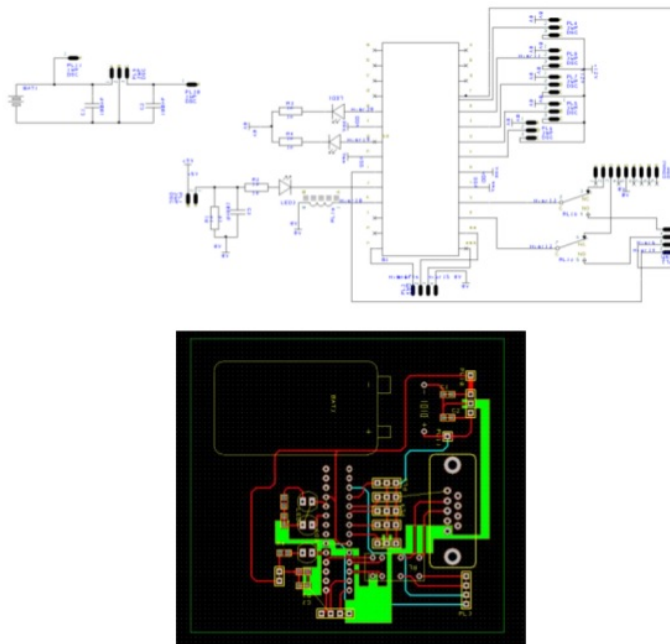
The Circuit is powered of a 12V battery as the sensors need a high voltage to work. The PIC runs of 5V so a step-down voltage module was introduced to supply the PIC.



The circuit has three LED's. One to show when the button is pressed, one to show when SD card is connected and one to show when the USB is communicating data.

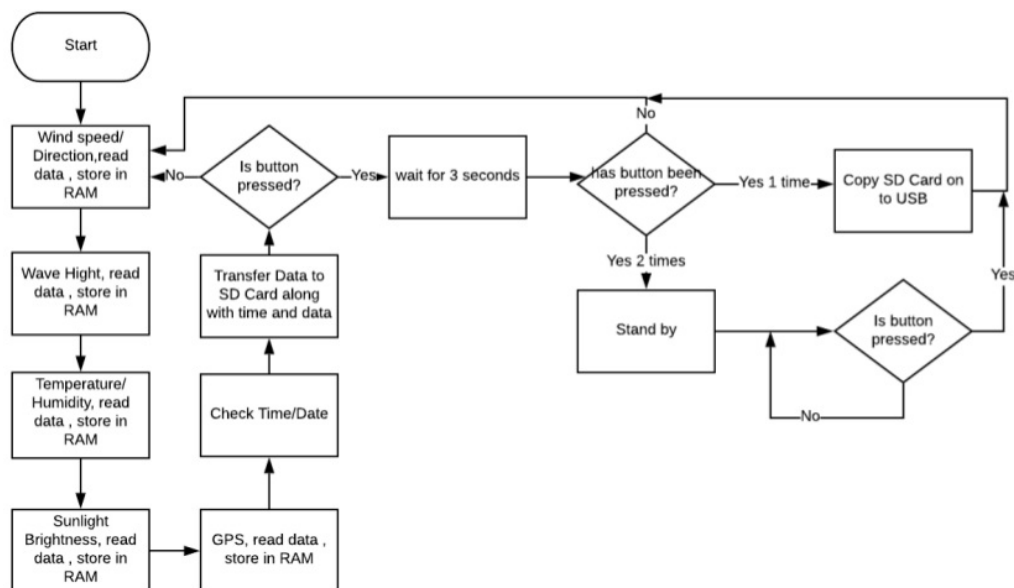
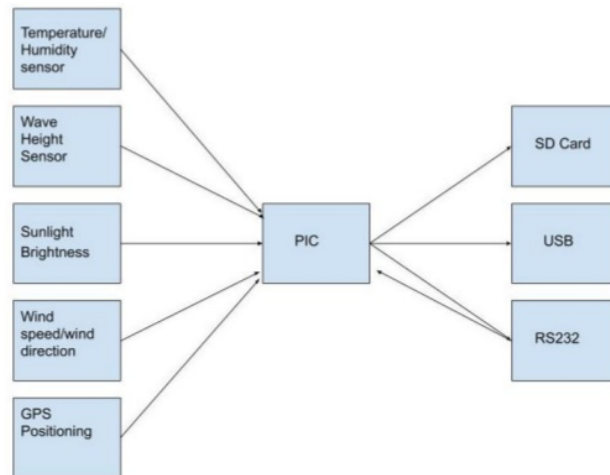


Below is a screen show of the Easy-PC circuit diagram and the PCB board design.



Flowchart

For the programmer to have an understanding of how the circuit is meant to function a block diagram and a flowchart have been made. The Block diagram show a simplified version of the data flow in the circuit were as the flowchart shows how the PIC would process and manage the data flow.



Battery Pack

In order to power the weather system monitor it needs a battery pack. Below are the workings out for the battery's current supply.

Wind Monitor - Quiescent 50 μ A, During Measurement 0.6 mA (takes 0.5 s)

Temperature and Humidity - Quiescent 50 μ A, During Measurement 0.6 mA (takes 0.5 s)

Sunlight Brightness - ?

GPS - 65 mA active (@ 12 Vdc)

Wave Hight – Quiescent < 50 μ A ,Measurement/Communication 8 mA (1 s measurement), Maximum 40 mA.

General connectors 0.6mA 0.0006

0.6mA 0.0006

0.6mA 0.0006

0.6mA 0.0006

(GPS) 65mA 0.065

(RS232) 8mA 0.008

(relay) 30mA 0.03

Button 20 mA 0.02A

Total = 125.4mA

Voltage 12V



Table of Battery Options

Battery Type	Rechargeable
Output Voltage	12 Vdc
Nominal Rating	24 Ah
Battery Cables Length	0.6 m (2 ft)
Dimensions	21.3 x 17.7 x 13.0 cm (8.4 x 7.0 x 5.1 in.) battery with mounting bracket
Weight	10.2 kg

Packaging

Below is the package that the DAQ system will be contained in. It's 245 x 162 x 215mm large so can fit the battery in with the brackets the secure it. The case is waterproof, shockproof and it is resistant to temperatures between -33°C and +90°C.



Costings Table

Item	£
Wind speed wind direction	1510.50
Wave height sensor	Estimate new 400
Temperature and humidity	Estimate 200
Sun brightness Sensor	175
GPS	20
Components and PCB (mass manufacture prediction)	Less than 10
PIC	2.66
Battery	50
Casing	60.22
Total	2428.38

Conclusion and Improvements

The DAQ system that has been designed meets the criteria that was required. There are changes that could be made in an updated version in the future. Those changes consist of more general sensor ports to give the DAQ user more flexibility. The DAQ system would benefit from three RS232 ports as quite a few sensors require one. This would again give the user more flexibility with the DAQ system. A later model would benefit from having the RS232 and the SD card totally separate at DAQ system would be able to perform faster and more efficiently. The DAQ system would benefit from the container being specifically designed and made for the DAQ system.

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assignment 2 1704018

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

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GRADING FORM: SMU GENERIC_GJ

**SARA
VONK****61.65****RESEARCH-INFORMED LITERATURE**

Good literature review of available systems with a good comparison table of relevant information.75%

11.25**KNOWLEDGE AND UNDERSTANDING**

2. 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 not done. I don't think you have read up enough about your pic and its abilities in so much as the programable pins once set to a specific function cannot be changed so there is a problem with having a relay switching the RX-TX lines to the SD card to act as CS and DI. Also the Vusb line on the pick is not inteded to be connected

17.5

to the 5V USB line. Your PCB has connectors inboard instead of around the perimeter. The sd card does not show as an onboard design item but as a 4 pin connector. 50%

ANALYSIS

 Good selection of microcontroller. Good selection of sensors showing details for each one with a table showing the selection of sensors to be chosen from with an image or illustration of each. Very good case selection. Good case selection selection of connectors with comparison table. No selection of connectors. 68%

20.4

PRACTICAL APPLICATION AND DEP.

 Costings put forward as a table with price including but missing manufacturer part numbers and supplier of component and incomplete. Fair attempt at future enhancements. 55%

5.5

SKILLS FOR PROFESSIONAL PRAC.

 The report is well presented with very well presented tabled data and diagrams. A good selection of references. 70%

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