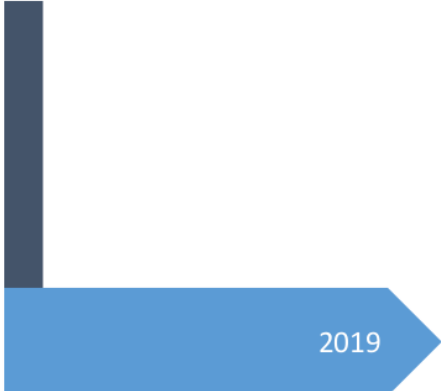


Assignment 1 - Vehicle Data Acquisition System

by Shaun Farthing

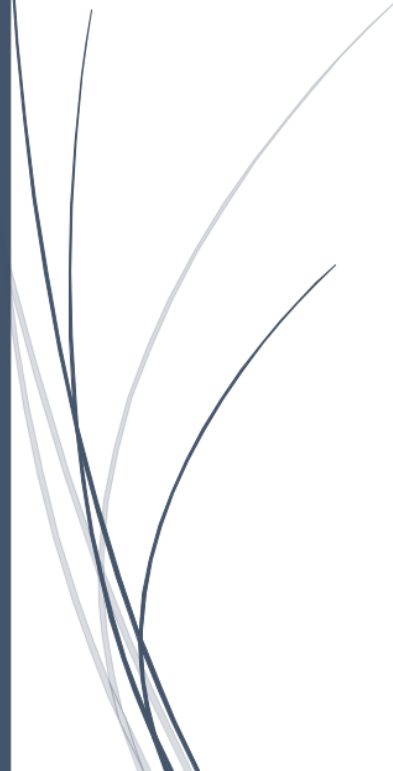
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2019

Electronics Systems Design

Vehicle Data Acquisition System



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Abstract

This report focuses on a portable vehicle data acquisition systems. The report firstly focuses on existing systems that are available. Then, it compares different sensor technologies. Sensor selection is then justified and chosen. Connector types are then explored and suitable connectors chosen. Power and storage requirements are detailed before microchip selection and justification. The report then focuses on schematic design and PCB construction. The article ends with a prototype cost and a list of improvements for future design.

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Introduction

This report details the tasks required to design a microcontroller based, portable, vehicle data acquisition system. Firstly, the report focuses on comparing what systems are currently available in the market. The report will contain an in-depth comparison of types of sensors available to measure a vehicles RPM, engine temperature, front and rear suspension travel, pitch, roll, yaw and vehicle speed. The report will also document suitable connector types for the selected sensors/ instruments. A suitable microcontroller will also be selected based on the data obtained through sensor selection and calculations. Data storage, data transfer, system power supply and transportation will all be designed and documented within this report. The circuit design will be carried out using the Proteus software, this will transfer to the Easy-PC software for the PCB design. The report concludes showing a table of prototype build costs and a full project review.

Literature review

Background research

Data acquisition (DAQ) is the process of measuring an electrical or physical phenomenon such as voltage, current, temperature, pressure, or sound with a computer. A DAQ system consists of sensors, DAQ measurement hardware, and a computer with programmable software. [1]

Data logging in its simplest form is a person recording data as they read it, this could be an operator measuring and recording the temperature of a furnace. As technology has evolved, data acquisition is becoming more common through electronic equipment as it is far more reliable, accurate and versatile. There is a vast array of data logging equipment available, ranging from simple data loggers to sophisticated computer systems. Data acquisition systems serve a very important part of many systems, they tie together a range of sensors measuring lots of different processes. Many have the ability to visually relay live data and/ or store data to be transferred elsewhere later. [2]

Current existing systems

The DL1 pro is a professional, highly configurable data logger. It has a rugged, IP54 rated, aluminium enclosure that houses the powerful data logger. There are a huge range of enhancement options and powerful live data processing. The data logger can process high quality driver and vehicle performance analysis using GPS, CAN, and ECU, accelerometer, frequency or analogue data. The DL1 pro has up to 12 analogue and 4 frequency inputs, USB port, SD card port, CAN and serial communication options. The DL1 pro costs from £1149. [3]



Figure 1 - DL1 Pro data logger

The VBOX 3i is a 100Hz, highly accurate vehicle data logger. It is a flexible solution to monitor vehicle performance and dynamics. The VBOX 3i consists of a number of analogue and digital inputs and outputs, it has CAN bus and RS232 connectivity as well as USB and Bluetooth. It also accepts CF cards up to 32 GB. The VBOX 3i also supports a separate inertial unit that measure roll, pitch and yaw. Unable to obtain cost at present. [4]



Figure 2 - VBOX 3i data logger

The OmnilightII RM1100 series is a portable data recorder that can be used in challenging environments. It benefits from data capture and play back functions alongside real time, memory and SD card storage modes. The unit can be powered using an AC source or DC battery supply. There are up to 8 input channels within this rugged, dust proof and splash proof data recorder. Cost for this unit is approx... £3495. [5]



Figure 3 - OmnilightII RM1100 series data logger

The Aim MXG 1.2 dash data logger is designed to acquire and display data coming from your ECU, the internal accelerometer and gyro, as well as from the GPS08 Module included in the kit. Analogue and digital inputs are gathered from predefined math channels. There is an option to add up to 8 expansion modules. This data logger is robust as it's built from aluminium, lightweight at 950g and suitable for harsh environments as its IP65 rated. This data logger costs £2310. [6]



Figure 4 - Aim MXG 1.2 dash data logger

Below is a table detailing key features of the existing systems mentioned above:

Data logger type	Input voltage	Inputs/ outputs	Data transfer/ storage	Sample rate	Storage / Memory	Durability	Web address
DL1 Pro	12v nominal input, minimum of 10v, max of 25v	12 external inputs analogue, 4 frequency inputs.	Serial ports x2, CAN port, USB.	100Hz optional 1000Hz	SD card up to 32GB.	IP54, aluminium enclosure.	http://www.systemaccess.com.tw/upload/web/Product/Velocimeter/3/(DL1_PRO)-Microsoft_Word_-_DL1_PRO-2.pdf
VBOX 3i	7 – 30 vdc	4x Analogue Inputs, 2x Digital Outputs, 2x Analogue Outputs	RS232, CAN bus, USB, Bluetooth.	100Hz	SD card up to 32GB.	Lightweight	http://m-techautomotive.co.uk/uploads/PDFs/VBox_3i_100hz_manual.pdf
Omnilight RM1100 series	0 - 5V (with logic cable: 0 - 24V)	8 channels, voltage/ temperature and logic	LAN, RS232, SD card.	1μS sampling rate	8GB	IP41	https://measurement.andonline.com/sites/default/files/documents/rm1100_manual.pdf
Aim MXG	9 – 15v	8x Analogue inputs, 2x digital inputs, 2x digital outputs.	RS232, CAN connection, Wi-Fi.	1000Hz	4GB	IP65, aluminium enclosure.	https://www.aimshop.com/collections/car-racing-loggers-displays/products/aim-mxg-dash-car-racing-datalogger

Figure 5 - Existing systems comparison table.

Sensors and associated equipment

RPM and speed measurement

There are many different types of sensors utilising different technologies. The table below details different sensor types that can be used to measure an engines RPM and a vehicles speed, and their level of compatibility with the headings. The data recorded for RPM and vehicle speed will be gathered in the same way, therefore, I feel that it would be sensible to use the same instrument for both.

Sensor type	Cost	Accuracy	Durability	Operating Range suitability	Installation suitability
Optical - reflective	High	High	High	High	High
Optical – Through beam sensor	Medium	High	High	Medium	Medium
Hall effect magnetic sensor	Low	Medium	High	Medium	High
Inductive magnetic sensor	Low	High	High	High	Medium

Of the different sensor types available, the option chosen is an optical sensor with reflective tape. The reasoning for this is that in comparison with an optical through beam sensor, the optical reflective would be an easier option to install as it does not require a receiver on the other side of the flywheel. The optical sensor is favoured over the magnetic options due to the accuracy of the optical sensor.

Optical sensors manufacturer's options.

Manufacturer	Model	Input	Power consumption	Output	Environmental protection	Connections	Operating range	Cost
Monarch	6180-057	3.3 to 15 VDC	40mA	TTL, same as source	Stainless steel, temperature up to 125degC	4 pins/cores	0.9m/1-250000 RPM	£146.40
Omni instruments	VLS5/T	5vDC	120mA	NPN pulse output	-	4 pins/cores, 1.5mm	50-1000mm/0-250000 RPM	£187.50 + £37.50 reflective tape
Compact instruments	MiniVLS 211	5vdc	30mA	NPN open collector	Stainless steel, IP67	4 pin, M12 plug.	0.1 – 250000 RPM	£285.00 + £25.00 reflective tape
ifm	OGP700	10-36VDC	15mA	PNP	IP67, -10 +60degC	4 pin, M12 plug	2000HZ switch frequency, 0.2 – 15m	£179.22 + £19.93 reflector

The Compact instruments MiniVLS 211 sensor has been chosen. Although it is one of the more expensive sensors available, it benefits from being stainless steel and IP67 which could be crucial in harsh environments. It also has a relatively low power consumption and low input voltage requirement. Reflective tape is included as a cost but a painted white surface could also be used. The outer body of the sensor has an M20 thread with locknuts that can be clamped in a bracket. [7]



Figure 6 - Compact instruments MiniVLS 211

Engine temperature

To measure the temperature of the engine, there are also multiple different technologies available that are suitable to monitor temperature. The table below details the sensor type and its level of compatibility.

Sensor type	Cost	Accuracy	Durability	Operating Range suitability	Installation suitability
Thermocouple	Medium	Low	High	High	High
Resistive temperature device	Medium	Medium	Medium	High	High
Infrared sensor	High	High	High	High	High
Thermistor	Low	High	Medium	Low	High

After evaluating the different sensor types that can be used for measuring the engine temperature, an infrared sensor has been selected. The reasoning for this is that they are a non-contact device which should make them less susceptible to damage. RTD's and thermocouples require surface contact to measure most accurately, maintaining contact would prove difficult given the vibration and movement of the vehicle without fixing permanently (welding/ drilling & pinning). Infrared devices are highly accurate and durable.

Manufacturer's options of infrared sensors.

Manufacturer	Model	Input	Power consumption	Output	Environmental protection	Connections	Operating range	Cost
RS Pro	Infrared temperature sensor	6 – 24VDC	30mA	Selectable, 0-5, 1-5, 0-10VDC	IP65, 0-70degC	4 pins/cores	0-1000 degC Up to 1m	£144.00 + 23.18 mounting bracket
Omega	OS136A-1-V1	12-24 VDC	50mA	0-5VDC	IP66, stainless steel	4 pins/cores	-18 + 202 degC Up to 9.1m	£170.00+£16.50 mounting bracket
Optris	RSCCSTCLT15K	5-7VDC	15mA	0-5VDC	IP65, stainless steel	4 pins/cores	-20 + 350degC Up to 800mm	£193.12
Calex	PC151MT-0	24VDC	20mA	4-20mA	IP65, stainless steel	2 pin/ cores	0 – 250degC Up to 1000mm	£195.12

On evaluation of the sensors detailed above. The sensor from Optris is most desirable for the application. Although all of the sensors are similarly rated with regard to environmental protection, given that most are stainless steel and IP65+ rated, and most have a relatively low power consumption. The Optris sensor is a good balance of cost and suitability as it has a 0-5vdc output with will not require any signal conditioning. [8]



Figure 7 - Optris RSCCSTCLT15K infrared temperature sensor

Front and rear suspension travel

To measure the front and rear suspension movement, as with the instruments for measuring RPM and temperature, there are various different technologies available. Detailed in the table below are the different types of sensors available to monitor suspension movement.

Sensor type	Cost	Accuracy	Durability	Operating Range suitability	Installation suitability
LVDT	Medium	High	High	High	Medium
Cable extension sensor	Medium	Medium	Medium	Medium	High
Optical (Laser)	High	High	Low	Low	High
Magnetic Sensors	Low	Medium	Low	Low	Low

A cable extension sensor has been selected out of the available options for measuring suspension travel. With a cable extension sensor, it gives flexibility of installation, unlike with an LVDT which would need to be relatively straight/ vertical to operate correctly, it also shouldn't be affected by dirt or debris like an optical laser sensor which may be affected by debris/ dirt that may be flicked from the road surface. Cable extension sensors are a good balance of durability, accuracy and cost.

Manufacturer's options of cable extension sensors.

Manufacturer	Model	Input	Power consumption	Output	Environmental protection	Connections	Operating range	Cost
TE Connectivity	SP1-25-3	30VDC max	2W	Voltage	IP67	4 pin, M12 plug	0-635mm	£173.94
Micro-epsilon	WDS-750-P60-SR-U	14-27 VDC	30mA	0-5vdc	IP65, aluminium	8 pin plug, 4 cores used	0-750mm	£395.00
ASM	WS31-750-R1K-L35-1	32VDC max	1W	1KΩ	IP50	3 pin/ cores, 4 pin socket M8	0-750mm	£161.70
Waycon	SX50-750-5VT	12-30VDC	22.5mA	0-5V	IP67, aluminium body, stainless steel rope	4 pin/ cores	0-750mm	£405.00

From the comparisons made above, the sensor from Waycon has been the picked as the best option for this application. It has an IP67 ingress rating, metal bodied construction with a stainless-steel rope, given the location that the instrument will be mounted in, durability is key, and the Waycon sensor is certainly the most robust. It also has a low input voltage and a teachable 0-5vdc output, allowing there to be no need for signal conditioning. [9]



Figure 8 - Waycon SX-50-750-5VT cable extension sensor

Pitch, roll and yaw

To measure the pitch, roll and yaw of the vehicle, the sensor type listed below have been compared.

Sensor type	Cost	Accuracy	Durability	Operating Range suitability	Installation suitability
Accelerometer	Medium	Medium	High	Medium	High
Gyroscope	High	High	High	High	High
Magnetometer	Medium	Low	High	Low	High

The gyroscope option has been chosen as the most suitable instrument to measure pitch, roll and yaw. An accelerometer can measure physical acceleration as it knows the vertical component (gravity direction) but cannot measure lateral orientation or 'yaw' as there is only a vertical reference to gravity. A gyroscope can sense rotation whereas an accelerometer cannot. A magnetometer can sense rotation due to its reference to magnetic north, but when changing direction is being measured, magnetometers are not as accurate.

Gyroscopes from different manufacturers.

Manufacturer	Model	Input	Power consumption	Output	Environmental protection	Connections	Operating range	Cost
Watson industries	DMS-E604	10-30VDC	3W	± 10VDC		25 pin male "D" sub miniature	±100°/s	£1,300.00
KA Sensors	Angular rate sensor - gyro	5V	25mA	0.5V-4.5V	IP65, aluminium	5 pin/cores	±200	£1,250.00
Texense	GYRN3-S-XC-YC-ZC	5 to 16v	16mA	0 – 5V	IP66, aluminium	6 pins/ cores	±150°/s	£1,395.00
Variohm	GYRN3	5 to 16v	28mA	0.4v – 4.6v	IP66	6 pins/ cores	±150°/s	£1,150.00

The options for the gyroscopes were very similarly matched. The reason that the KA sensors gyroscopes was selected over the other options was because it offered the largest operating range. All other aspects of the comparison were fairly closely matched. [10]

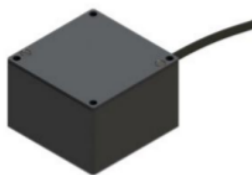


Figure 9 - KA sensors angular rate gyro

Connector selection

The connector styles chosen for this application are metal bodied to allow for the harsh environment that they are going to be used in. They also have a high IP rating to allow for adequate protection against dust and liquids. Connector pins are suitably coated to protect against corrosion.

RPM Connectors

There are 3 pins used on the RPM sensor, one for the +5v supply, one for the ground connection and one for the signal output. The chosen connector is made by Lumberg. The plug and socket are both metal bodied, IP68 rated and the connector pins have gold/ silver plating. They can be used in operating temperatures ranging between -40degC to and +85degC and are capable of voltages up to 250Vac, and currents up to 5A. The connectors are more than capable for use in this application.

[11]



Figure 10 - Lumberg plug



Figure 11 - Lumberg socket

MPH connectors

The sensor selected for measuring MPH is the same sensor used for RPM, therefore, as above, also uses 3 pins, , one for the +5v supply, one for the ground connection and one for the signal output. To minimise the chance of connecting the wrong sensor to the wrong input connector, the connector chosen for the MPH sensor is a 4 pin connector. The connector is made by Hirose. It is constructed using a brass zinc alloy for the body, it is IP67 rated, has gold plated contact pins and is capable of withstanding 150VAC, 200VDC and 2A. It can operate in temperatures of -25degC to 85degC. [12]



Figure 12 - Hirose plug



Figure 13 - Hirose socket

Temperature connectors

The sensor selected for monitoring the engine temperature is using 4 connections. One for the +5v supply, one for the 0-5v output, one for the ground connection and one for a shield connection. The connector chosen for the engine temperature readings is made by Bulgin. It is a 5 pin connector. It has a nickel plated brass body with an IP67 rating. Contacts are gold plated brass with a 4A 60V AC/DC rating. This connector more than meets the criteria required. [13]



Figure 14 - Bulgin plug



Figure 15 - Bulgin socket

Front and rear suspension connectors

For monitoring the suspension movement, the Waycon SX50 range of draw wire sensor has been chosen. This sensor requires a connector capable of at least 4 pins. One for the +12v supply, one for the signal, one for the signal ground and one for the ground. The connector chosen is manufactured by Harting. The connector is from the Han range. It has 5 pins, a zinc die-cast body and an IP65/67 rating. The connector is rated for 16A and 230V between conductors to earth, it can operate in temperatures ranging from -40 to +125degC. Another benefit of the Harting plug and socket is that it has a coding pin function, this prevents the incorrect mating to other connectors of the same type. The male pin should be omitted from the opposing cavity in the male insert. This would prevent the incorrect connection of the suspension sensors allowing confidence that the right sensor is connected to the right input. The sensors and plugs would also be numbered to eliminate confusion.

[14]



Figure 16 - Harting plug/ socket

Pitch, roll & yaw connectors

The sensor chosen to monitor the pitch, roll and yaw is from KA Sensors and requires a 5 pin connector, one for the +5v supply, one for the 0v supply, and one for each of the outputs for the X, Y and Z axis. The sensor chosen for this application is from Phoenix Contact. It has a zinc die-cast nickel plated body, IP67 rating. A voltage rating of 60V and a current rating of 4A. It can be used in temperatures ranging from -40 to +85degC. This connector achieves the standard required. [15]



Figure 17 - Phoenix Contact plug



Figure 18 - Phoenix Contact socket

LED's

Included on the system are two LED's. One of the LED's is to indicate that the 12v supply is present. The second LED, is to indicate that the PIC is running. [16]

12v supply red LED: 5mm, forward voltage = 1.8v, forward current = 20mA.



Figure 19 - 12v present indication

5v PIC running green LED: 5mm, forward voltage = 2.1v, forward current = 20mA.



Figure 20 - PIC running indication

Battery sizing & selection

The data acquisition system must be completely independent from the vehicle, so it must be battery powered. To determine a suitably sized battery, all of the components and sensors required for the system must be taken into consideration for their energy usage.

Component/ device	Quantity	Power consumption	Total power consumption
RPM sensor	1	30mA	30mA
MPH sensor	1	30mA	30mA
Engine temperature sensor	1	15mA	15mA
Front and rear suspension sensors	4	22.5mA	90mA
PRY gyroscope	1	25mA	25mA
LED's	2	20mA	40mA
Total			230mA

The total power consumption is 230mA. The specification states a data logging time of 2 hours.

Therefore, the total consumption is multiplied by 2 to give a total power consumption during the test drive of 460mA.

Although the data logger is required to only gather data during the 2 hour test drive, the system will have to be on outside of these times during any waiting time or during any delays. With this in mind, there has been an allowance made to have additional capacity on the battery.

The battery chosen is a 12v, 1.2Ah, sealed, lead acid battery. Dimensions are 97x43x58mm. [17]



Figure 21 - Battery

Enclosure selection

The enclosure that has been selected to house all components and the battery is the MAX235H155 by Max Case. It is waterproof and dustproof with an IP67 rating. The case is made from injection moulded polypropylene copolymer and is shockproof. It measures W 235mm x D 180mm x H 156mm internally, which will be enough space to house all components without being too large that it becomes hard to transport. The case weighs a manageable 1.06kg without any components or battery installed. The case also benefits from 'pick and pluck' foam inserts, meaning that the foam inside can be manipulated to keep all fragile components in place to ensure they do not move around during transportation. This case has a temperature rating of -30 to +90 degC. The case will be sufficient for the application required. [18]



Figure 22 - Enclosure MAX235H155



Figure 23 - Enclosure internal

Microcontroller selection

To select a suitable microcontroller, we have to build a specification. To do this, we have to take into consideration how many analogue and digital pins are required, resolution, how much program memory is required, how much RAM is needed, clock speed, and any other connectivity requirements such as USB and SD card.

Resolution calculations

RPM = Data logged every 100RPM, max 8000RPM on a saloon car, $8000 \div 50 = 160$. 8 bit will be suitable as that would allow 256 readings.

Engine temperature = Temperature logged every 0.5degC change, range of instrument is 330degC. So, $330 \div 0.5 = 660$. 10 bit will be suitable as that would allow 1024 readings.

Suspension travel = Suspension change logged every 1mm, range on sensor is 0-750mm. So, vehicle height is 400mm, so stationary under its own weight the voltage will be, $5 \div 750 \times 400 = 2.66v$. Movement could be up or down by 200mm. Upper limit of 600 will output $5 \div 750 \times 600 = 3.99v$ and lower limit could be $5 \div 750 \times 200 = 1.33v$. Voltage difference is 2.66v, so the voltage change per mm is $2.66 \div 400 = 0.00665v$. 10bit resolution would allow $5 \div 1024 = 0.0048v$ per mm, required is 0.00665v, so, 10 bit will be suitable.

Pitch roll & yaw = Logged 1 degree change. Sensor range is +/- 200 degrees with a 0.5 – 4.5v output. $4 \div 400 = 0.01v$ per degree. A positive change of 80 degrees would give $4 \div 400 \times 280 = 2.8v$ output. A negative 80 degree change would give 1.2v output. Voltage range is 1.6v, so $1.6 \div 160 = 0.001$ per degree/s. 10 bit resolution would allow $5 \div 1024 = 0.0048v$ per degree, required is 0.001v, 10 bit resolution is suitable.

Vehicle speed = Based on a 17inch diameter wheel. Circumference is $3.14 \times 17 = 53"$. 63360 inches in a mile, so, $63360 \div 53 = 1195$ revs per mile. 3600 seconds in an hour, so $1195 \div 3600 = 0.33$ pulses per second are required. This will not be possible, the data needs to be recorded at four points across the wheel, so $0.33 \times 4 = 1.32$ pulse per second. Given a top speed of 100mph, $100 \times 1.32 = 132$ bits. An 8bit counter would be suitable.

Below is a table detailing the signals that are required.

Signal	Pins	Analogue/ Digital	Log frequency	Resolution
RPM	1	Digital	1 s	8 bit counter
Engine temperature	1	Analogue	15 s	10 bit
Suspension travel	4	Analogue	0.1ms	10 bit
Pitch	1	Analogue	0.1 s	10 bit
Roll	1	Analogue	0.1 s	10 bit
Yaw	1	Analogue	0.1 s	10 bit
MPH	1	Digital	1 s	8 bit counter
SD card	4	Digital		
Start button	1	Digital		
Tell	1	Digital		
USB	2	D+/D-		
Power	3			
Total	21			

Figure 24 - Signal details

The table below forms the main criteria to be met when selecting a microcontroller.

Voltage	5v device
Digital signals	10 bits
Analogue signals	8 @ 10 bit resolution
USB	2 bits
SPI	Yes (1)
Program memory	16KB
RAM	0.5KB
Clock speed	16MHz

Figure 25 - PIC parameters

The data was entered into microchip.com 'parameter chart search' function which allows the selection to be narrowed down. The search narrowed down to a choice of 3 microcontrollers. They were PIC18F45K50, PICF24K50 and PICF25K50. PIC18F45K50 was ruled out as it has 40 pins, which is too large for this application. PIC18F25K50 was chosen over PIC18F24K50 as it has 32KB program memory compared to PIC18F24K50's 16KB program memory. [19]



Figure 26 - PIC18F25K50

Non-volatile memory

The specification asks for non-volatile memory, below is a table detailing requirement.

Signal	Signal type	Log frequency	Bytes	Total bytes
RPM	Digital	1 s	1	1
Engine temperature	Analogue	15 s	2	30
Suspension travel	Analogue	0.1ms	8	80000
Pitch, roll & yaw	Analogue	0.1 s	6	6000
MPH	Digital	1 s	1	1

The total number of bytes is 86.03KB's.

The specification has asked for the monitoring time to be over 2 hours.

$$86.03\text{KB/s} \times 60 = 5.16\text{MB/ min}$$

$$5.16\text{MB} \times 60 = 310\text{MB/ hour}$$

$$310\text{MB} \times 2 = 620\text{MB for the 2-hour test.}$$

The SD card chosen is 1GB by SanDisk, this will provide ample storage space for the application. [20]



Figure 27 - SD Card

Structure diagram

The figure below shows the structure of the design. The image details the elements required to create a system design.

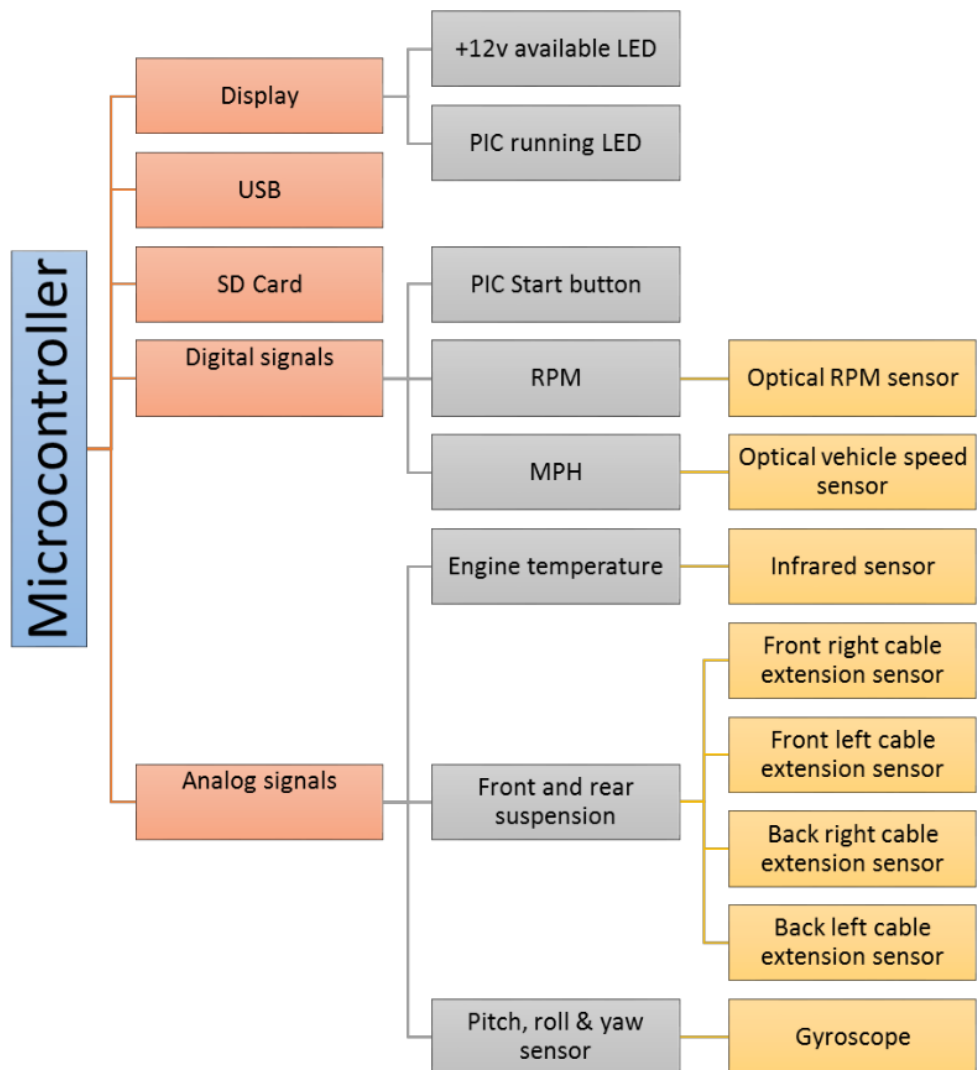


Figure 28 - Structure diagram

Data acquisition cycle

The figure below details how often each sensor logs the data acquired.

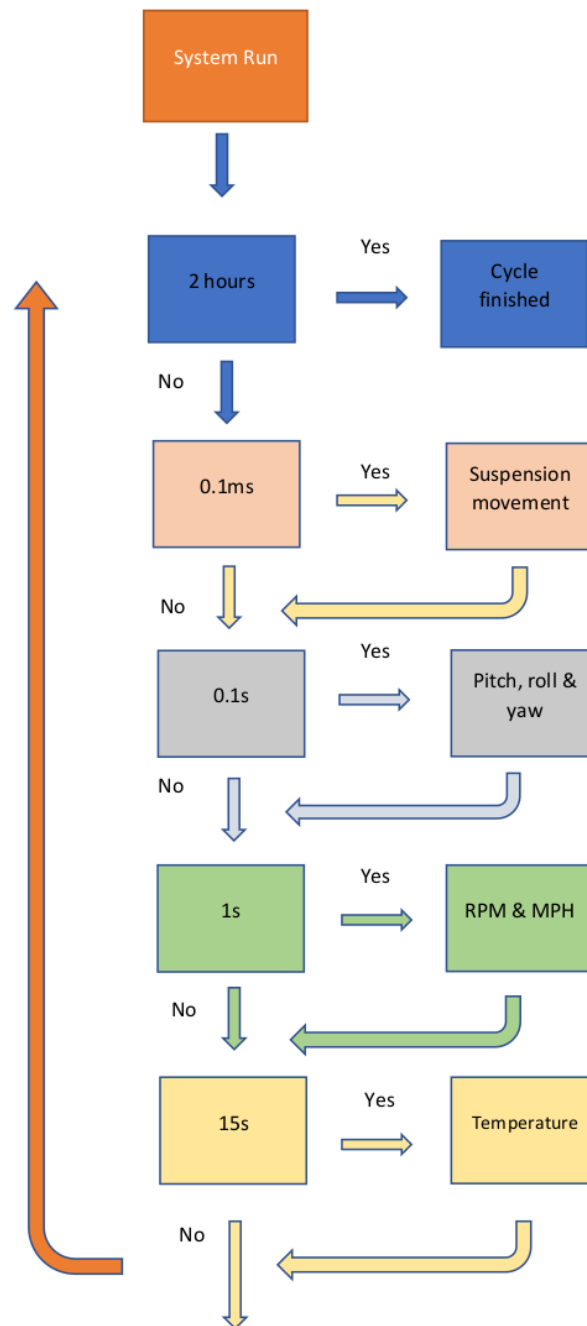


Figure 29 - Data logging frequency flow chart

Design

Below is the completed schematic for the vehicle data acquisition system. Proteus was the software that was used to build the schematic.

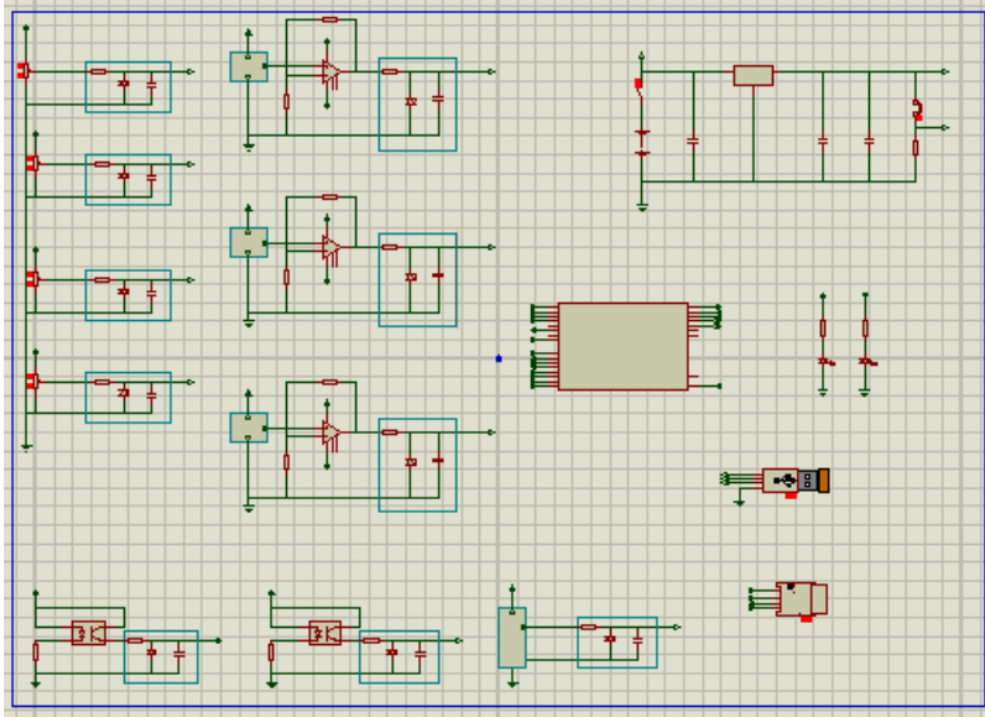


Figure 30 - Proteus full schematic

Power circuit

The figure below is of the circuit used for the power system. There is a 12v battery in the circuit. Immediately after the battery is a switch, when the switch is operated, it puts 12v onto all sensors requiring a 12v supply and also to an LED to indicate that there is 12v available. It also supplies 12v to the voltage regulator. The voltage regulator has a 5v output. From the voltage regulator, all the sensors and devices that require a 5v supply and fed. Capacitor C12 acts as a filter and capacitor C13 acts as a tank, this will store a small amount of energy in the event that power is lost. R17 is a de-coupler. There is also a start button that sends a run signal to the PIC and brings on a green LED to indicate that the PIC is running.

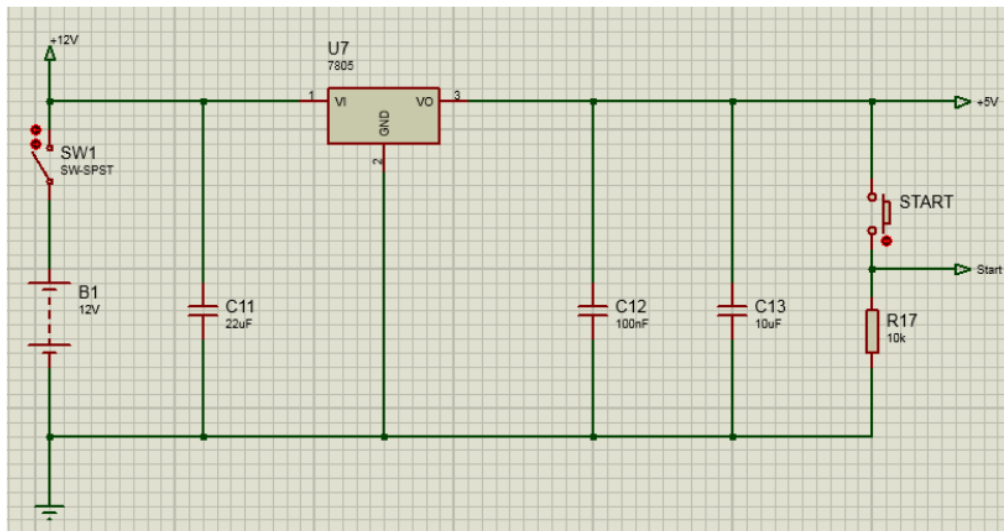


Figure 31 - Power supply circuit

RPM

The figure below shows the circuit for the RPM sensor. The sensor is a photo electric sensor. It has a +5v supply and a pulsed output. In the circuit there is a clamp, the clamp consists of a capacitor and resistor that form a filter and a Zener diode to protect against overvoltage.

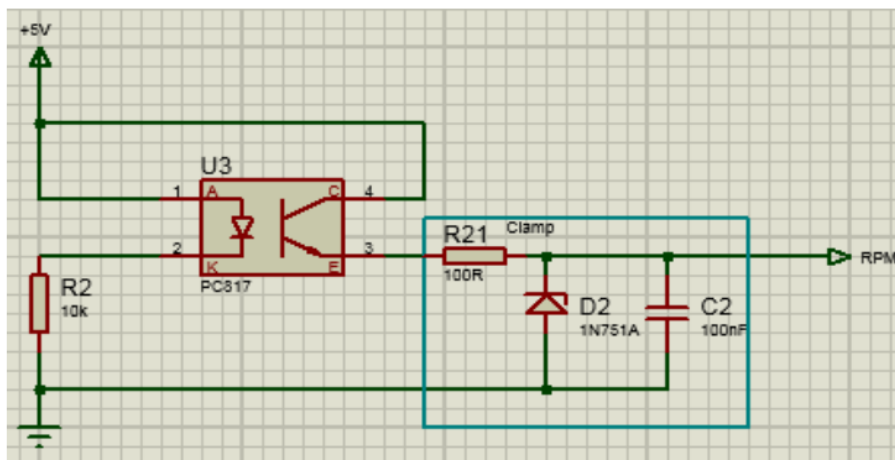


Figure 32 - RPM sensor circuit

Engine temperature

The figure below shows the circuit for the engine temperature. It has a +5v supply and a 0-5v output. Again, there is a clamp, the clamp consists of a capacitor and resistor that form a filter and a Zener diode to protect against overvoltage.

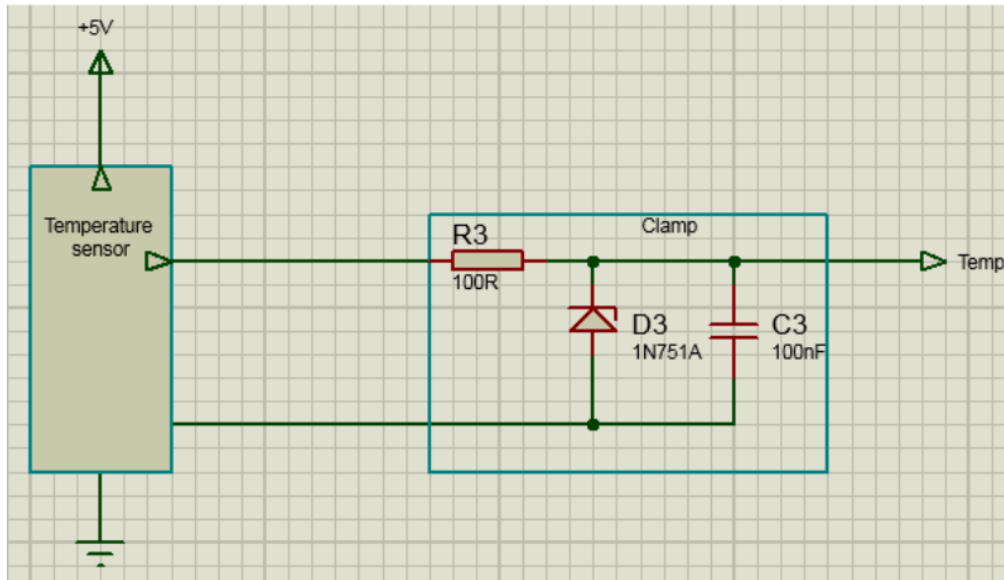


Figure 33 - Engine temperature sensor circuit

Front and rear suspension travel

The figure below shows the front and rear suspension circuits. They require a 12v supply and have a 0-5v output. The sensor is a draw wire sensor, it is depicted as a potentiometer on the schematic. Again, there is a clamp, the clamp consists of a capacitor and resistor that form a filter and a Zener diode to protect against overvoltage.

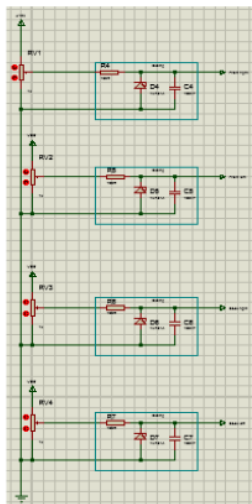


Figure 34 - Front and rear suspension circuits

Pitch, roll and yaw

The figure below shows the circuit for the gyroscope. It has a +5v supply and 3 outputs, X, Y and Z axis. Care needs to be taken when installing the gyroscope so that it is facing the correct orientation in relation to the axis. This circuit as above has a clamping arrangement consisting of a capacitor and resistor that form a filter and a Zener diode to protect against overvoltage. On this circuit, as the output is only +4.5v, there is a 741 amplifier to achieve the +5v signal.

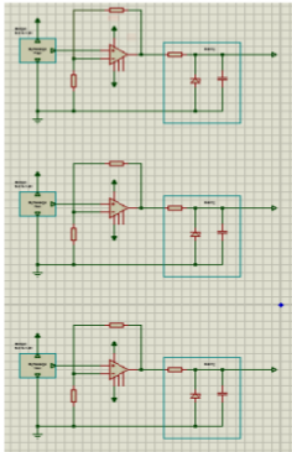


Figure 35 - Gyroscope circuit

Speed measurement

The figure below shows the circuit for the vehicle speed measurement. As with the RPM sensor, the sensor is a photo electric sensor. It has a +5v supply and a pulsed output. In the circuit there is a clamp, the clamp consists of a capacitor and resistor that form a filter and a Zener diode to protect against overvoltage

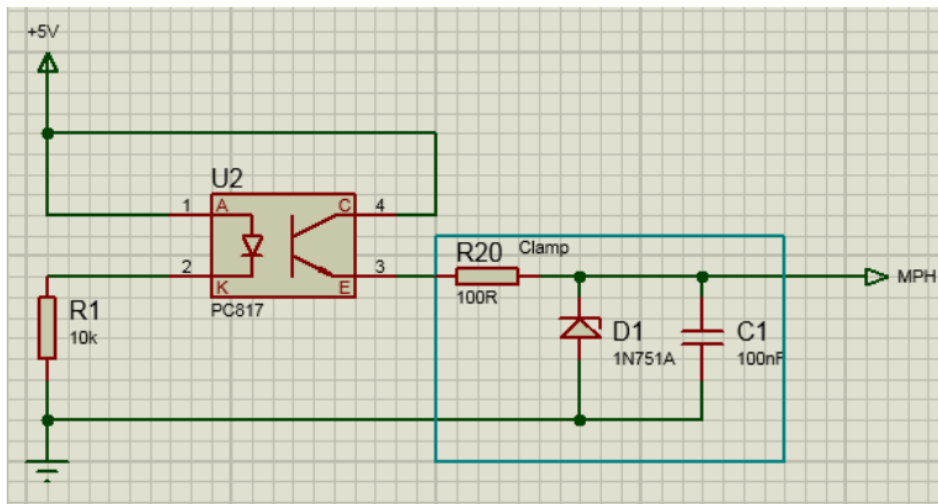


Figure 36 - Speed measurement circuit

USB

The figure below shows the circuit for USB connectivity. The USB is required to be able to connect the device to a computer. The VCC will be supplied from the computer when connected. The D and D- are bi-directional pins for data transfer.

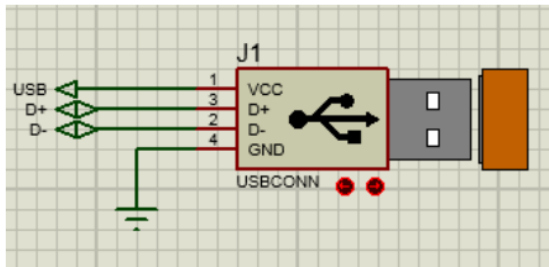


Figure 37 - USB circuit

Non-volatile memory

The brief states that suitable non-volatile memory is required, this is achieved using an SD card. The figure below shows the SD circuit. The SD card has a digital input from the PIC, a digital output to the PIC, a clock rate signal to allow the PIC to synchronise and a chip select signal so that the PIC can identify the device to write to as it's a BUS system, although, it is the only device on the BUS, the CS is connected.

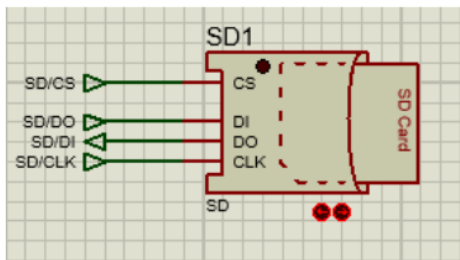


Figure 38 - Non-volatile storage circuit

LED's

The figure below shows the LED indication circuits. One red LED for the +12v availability and one green LED for a PIC running indication. The calculation for resistor sizing are below;

12v available, red LED.

$$V_{res} = 12v - 1.8v = 10.2v$$

$$R = \frac{10.2v}{0.020A} = 510\Omega$$

5v PIC running, green LED.

$$V_{res} = 5v - 2.1v = 2.9v$$

$$R = \frac{2.9v}{0.020A} = 145\Omega$$

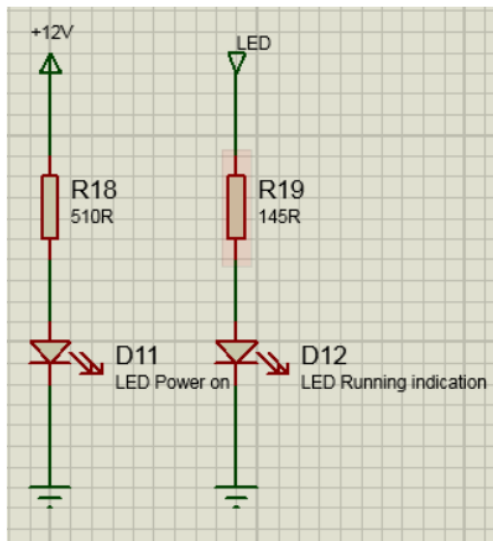


Figure 39 - LED circuits

PIC circuit layout

The figure below shows the PIC, with input and output circuit information.

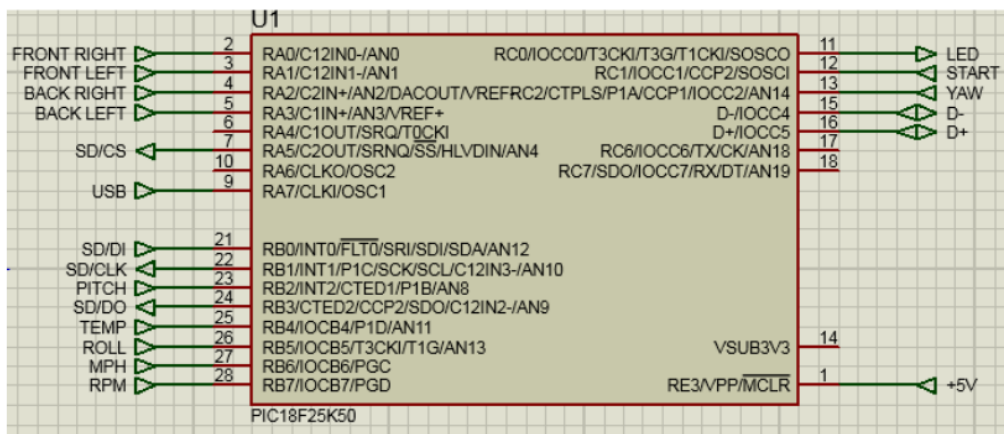


Figure 40 - PIC

The schematic that was produced on Proteus is then re-drawn onto Easy-PC to produce the PCB.

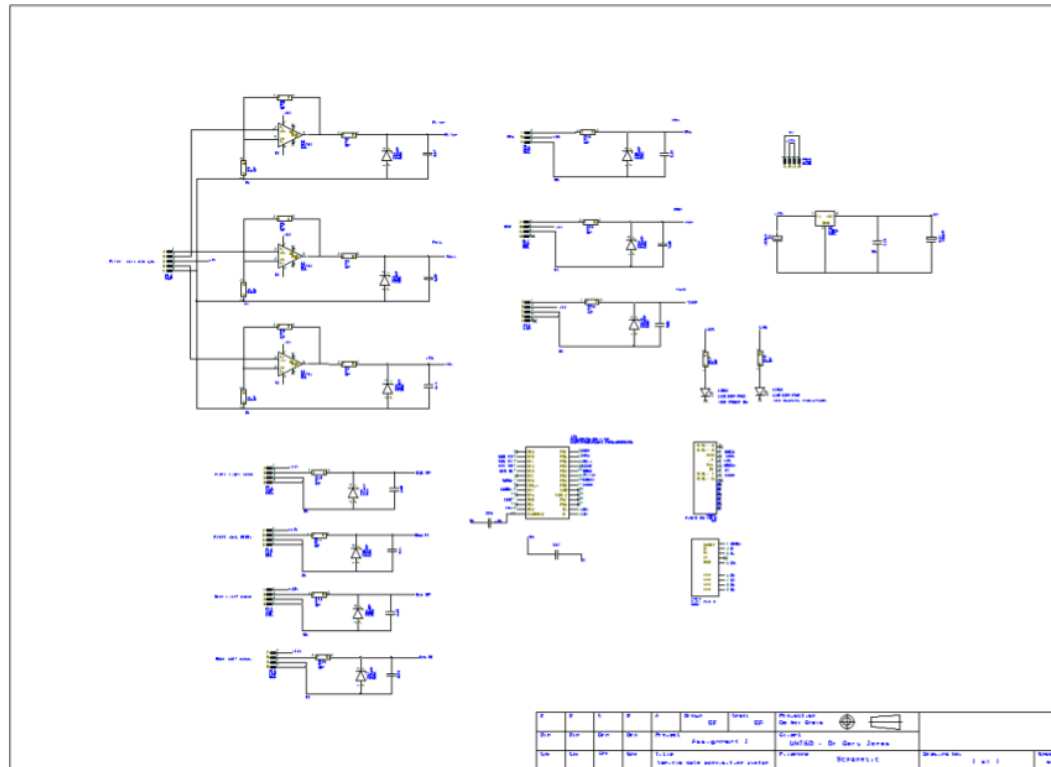


Figure 41 - Easy PC full schematic

The image below shows the top layer of the PCB after it has been translated to PCB. Using the optimise nets function, the PCB tracks were drawn onto the board.

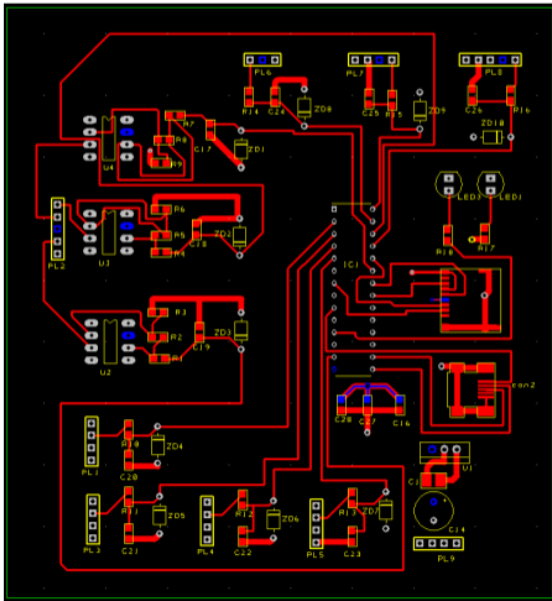


Figure 42 - PCB top layer

PCB after the bottom copper layer has been poured.

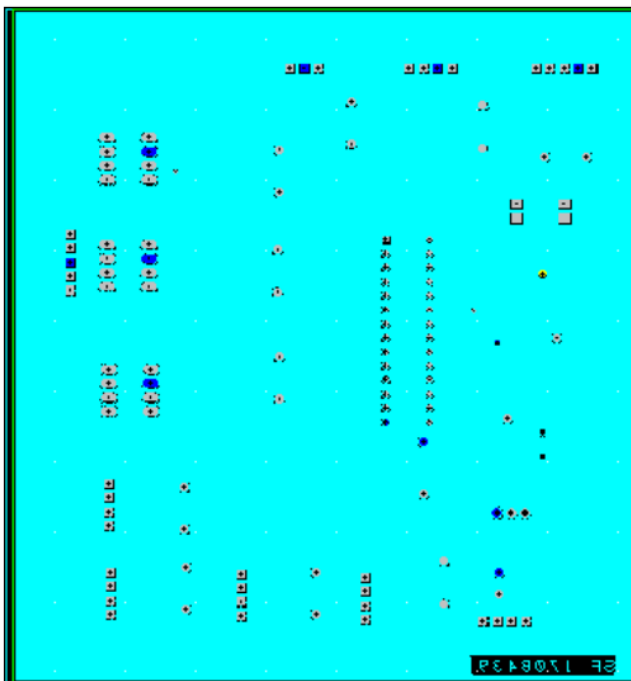


Figure 43 - PCB bottom layer

PCB with all layers visible.

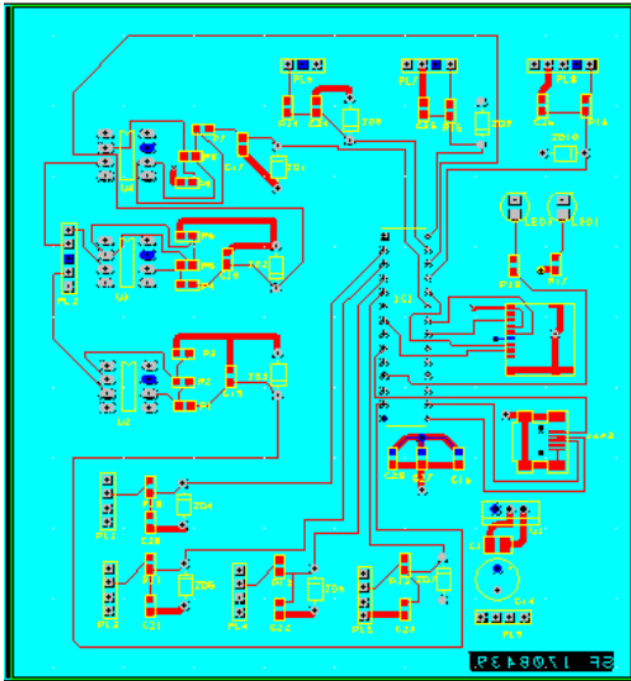


Figure 44 - PCB all layers

PCB in 3D view.

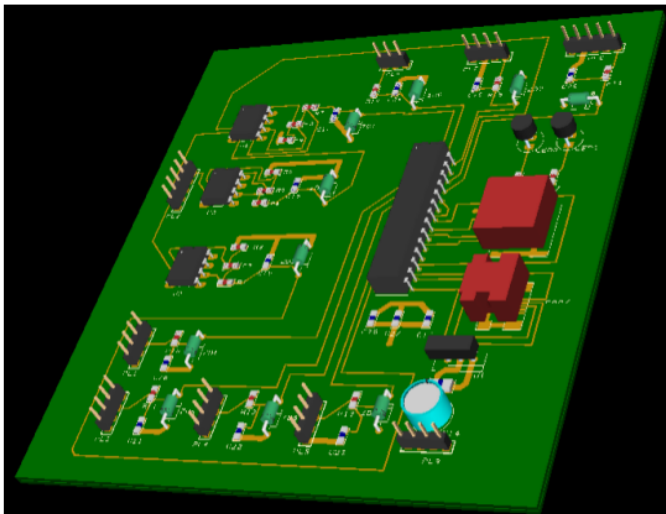


Figure 45 - Top of PCB 3D view

Bottom of the PCB in 3D view.

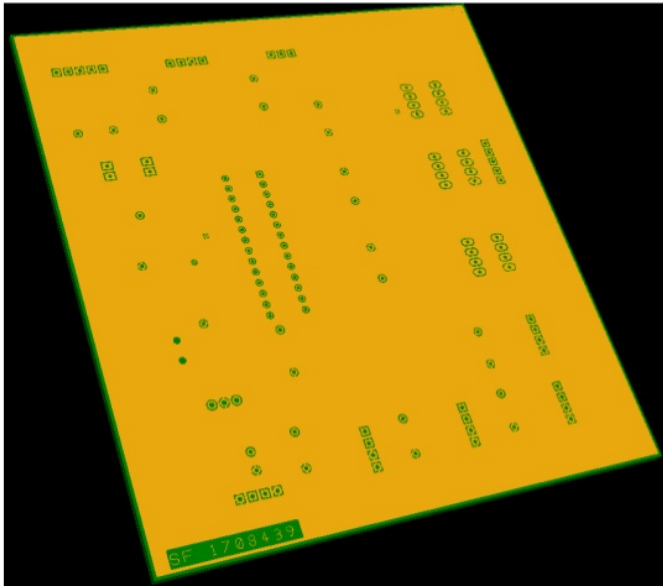


Figure 46 - Bottom of PCB 3D view

Design rule check with no errors.



Figure 47 - Design rule check

Prototype cost

Component	Manufacturer	Part.No	Quantity	Unit cost	Total cost
RPM	Compact instruments	MiniVLS111	1	£310.00	£310.00
MPH	Compact instruments	MiniVLS111	1	£310.00	£310.00
Engine temp	Optris	RSCCSTCLT15K	1	£193.15	£193.15
Suspension	Waycon	SX50-750-5VT	4	£405.00	£1,620.00
Gyroscope	KA Sesnors	Angular rate sensor - gyro	1	£1,250.00	£1,250.00
RPM plug	Lumberg	0322 03	1	£6.46	£6.46
RPM socket	Lumberg	30403	1	£3.28	£3.28
MPH plug	Hirose	HR10-7P-4P	1	£10.78	£10.78
MPH socket	Hirose	HR10-7R-4s	1	£7.80	£7.80
Temp plug	Bulgin	PXMBNI12FIM04ASCPG7	1	£16.43	£16.43
Temp socket	Bulgin	PXMBNI12RPF04APCPG9	1	£13.42	£13.42
Sus plug	Harting	Han A 4+	4	£22.36	£89.44
Sus socket	Harting	Han A 4+	4	£19.96	£79.84
PRY plug	Phoenix contact	1424678	1	£22.30	£22.30
PRY socket	Phoenix contact	1542761	1	£10.50	£10.50
LED red	Kingbright	L-56BHD	1	£0.64	£0.64
LED green	Kingbright	L-57EGW	1	£2.00	£2.00
Battery	Yucel	Y1.2-12	1	£7.20	£7.20
Enclosure	Maxcase	MAX235H155	1	£28.54	£28.54
PIC	Microchip	PIC18F25K50	1	£2.02	£2.02
SD Card	SanDisk	Micro SD 1GB	1	£14.00	£14.00
Voltage reg	ST microelectronics	L7805CV	1	£0.38	£0.38
741 op amp	Texas instruments	LM358P	3	£0.38	£1.14
100nF cap	Unbranded	MCRR25104X7RK0050	13	£0.08	£1.04
100nF electrolytic cap	Wurth elektronik	860010672001	2	£0.08	£0.16
3 pole connector	Phoenix contact	1725669	1	£1.90	£1.90
4 pole connector	RS Pro	790-1102	6	£0.82	£4.92
5 pole connector	Phoenix contact	1725685	2	£3.14	£6.28
Micro SD connector	Sparkfun electronics	BOB-00544	1	£3.59	£3.59
Mini USB	Molex	67503-1020	1	£0.74	£0.74
1K resistor	Unbranded	MF25 1K	18	£0.01	£0.23
Zener diode	Microchip/ Microsemi	1N751A	12	£2.61	£31.32
Prototype cost					£4,049.50

Figure 48 - Prototype cost

Improvements

Research at the beginning of this report of the existing systems showed that a lot of the existing systems have Bluetooth and Wi-Fi connectivity. This would be an improvement on the system designed within this assignment as it would allow wireless monitoring and transfer of the data being gathered. The systems available are a lot more compact than the system designed within this report. More focus on housing and connector types would improve the physical footprint of the system. LCD displays were also available on existing systems, this would be beneficial as this could display real time data. GPS was available, this would be beneficial as it would allow the vehicle location to be monitored. PCB design could be improved with more focus on the component layout and spacing. Cost savings could be achieved with more time being spent on sensor and connector selection.

Generally, the task was successful, although there are ways to improve.

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Assignment 1 - Vehicle Data Acquisition System

GRADEMARK REPORT

FINAL GRADE

GENERAL COMMENTS

Instructor

75/100

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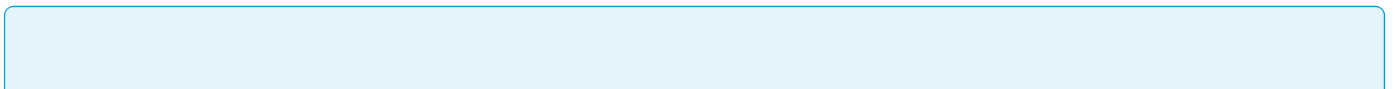
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GRADING FORM: SMU GENERIC_GJ



RESEARCH-INFORMED LITERATURE



Good literature review of available systems with a good comparison table of relevant information but a thumb nail image in the table would have been an improvement. 67%

6.7

KNOWLEDGE AND UNDERSTANDING



Good overall schematic design but a few 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. On C28 in the easy pc design you have connected the VUSB3v3 of the pic to 5V and connected c28 to it as well, be careful when copying parts that the connections taken with them are correct. Some of your clamp resistors are 100R others are 10R, they should be the same. Nice PCB design 76%

19

ANALYSIS



Good selection of microcontroller along with time calculations. Good selection of sensors with comparison table showing the other devices that

27.3

were researched, an image or illustration of each and a comparison table would have improved this section. Good case selection. Good selection of connectors with images but no comparison table. 78%

PRACTICAL APPLICATION AND DEP.

 Costings nicely put forward as a table with price including manufacturer part numbers but not supplier of component. Limited attempt at future enhancements. 70%

14

SKILLS FOR PROFESSIONAL PRAC.

 The report is well presented with very well presented tabled data and structure diagrams. A good selection of references. 80%

8