

SL_ESD1

by Sam Lloyd

Submission date: 30-Jul-2024 03:07PM (UTC+0100)

Submission ID: 238080510

File name: 32801_Sam_Lloyd_SL_ESD1_523682_1954420203.docx (1.24M)

Word count: 4901

Character count: 25993

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Introduction

The following brief was given:

“You are required to design a microcontroller based automotive data acquisition system.

The data acquisition system is intended to be fitted to a production prototype car. In this case the vehicle is targeted for the family saloon market, however the system must be re-usable, portable and adaptable for any class of vehicle.

The data will be gathered to establish that the vehicle design both operates within safe limits and provides a comfortable means of transport. The following data will be acquired during a 2-hour test track run.

- *RPM*
- *Engine temperature*
- *Front and rear suspension travel*
- *Pitch, roll and yaw (PRY)*
- *Vehicle speed (MPH)."* [1]

The aim of a task like this is to collect data for a vehicle so that issues with as car can be found or any additional improvements can be made [2]. With the brief given, the Aim will be to research and select products for the following key components of the build:

- PIC micro controller:
This will have considerations for memory size, pin out, analogue and digital and more.
- Memory sizing:
This will be a calculation on the memory size required for a 2-hour period using the relevant data size for each sensor.
- Sensors:
This will involve selecting appropriate sensors with an appropriate data read rate and data range.
- Circuit design:
In this part of the planning a circuit diagram and PCB will be designed and ready in a state to print. The circuit will include any required power regulators, clamps, signal conditioning and anything else required.
- Enclosure:
Sized appropriately to include the PCB, connectors and the PSU.
- Software structure
This will be a flow chart on how the system will operate and handle data when working.
- Power supply
For the Supply voltage this will be 12V, using the values from data sheets from each component the required battery will be selected.

Research

Component research

PIC requirements

For selecting an appropriate PIC for the project it's important to consider the requirements that will be required. Some considerations are pins requirements, which if these require to be analogue and digital, processing speed, operational voltage, memory size, UART output and

a SD card connection. For the required pins this can be easily set when all the required sensors are selected.

The required memory can be calculated by deciding on reading rate for each sensor, and the bytes per reading, then using this data to determine the max data in a 2-hour period. First a decision on appropriate time per reading, for some of these it's how frequent data needs to be read, for example on Temperature this is not regularly required, so 15s was used. Next RPM and MPH which should be displayed every second as anything faster than this is unnecessary but slower would not give the user enough data. For PRY this requires a high frequency, it was decided to do every 0.05 seconds, this allows data to be recorded if a spin was to happen. Finally, Suspension, this requires a very high frequency to see any bump, after calculation it was decided that 0.00005 seconds was appropriate, this means that any little bump/pothole would be recorded as the wheel moves every 0.2mm while traveling at 85mph, the calculations for this can be seen in Table 1.

Formula used	Value	Data
B1		85 M/H
$B1 / (60 * 60) * 1609$	37.99027778	m/s
$B2 * 0.00005$	0.001899514	m/read
$B3 * 1000$	1.899513889	mm/read

Table 1: Suspension Accuracy Calculation

Once all worked out, the next step is to calculate that amount of data that will be produced, calculation for this can then be seen in

Table 2, this shows that in a 2-hour period there will be approximately 1.15 GB of data produced meaning a SD card greater than this will be required.

Sensor	Bytes Per Reading	Time Per Read (s)	Record (bytes over 15s) $Bx * Cx$
RPM	1	1	15
MPH	1	1	15
Temp	2	15	2
PRY	6	0.05	1800
Suspension	8	0.00005	2400000
		Record Total	2401832
		total (2hrs)	1152879360

Table 2: Memory calculations

Next to calculate the frequency required, to do this take the lowest "time per recording" from

Table 2 and then do the following calculations seen in Table 3. This shows that a 32MHz frequency is required to complete all operations in the required time.

	Value	Formula
Time per recording	0.00005	B2
Number of operations	400	B3
Time per operation	0.000000125	$B2 / B3$
Frequency	8000000	$1 / B4$

Table 3: CPU speed calculations

The operating voltage will 5 volts unless there is a requirement for more and the pin requirements will be decided after the sensors are selected. The Final pic will be selected later.

Sensor requirements

For each type of data there are multiple ways to record these, bellow is a shit list of options:

RPM

- Magnetically – This would be done by attaching a small magnet to the cam belt then measuring how frequently this completes a rotation. This has a major negative that the cambelt would have to be altered which is undesired.
- Optical
 - Reflective – [3] this can be done by making a reflective mark on the cam belt that then is counted every time a rotation is completed, seen in Figure 1. This has a positive that it would require low level of intrusion and no physical alteration on the cam belt.

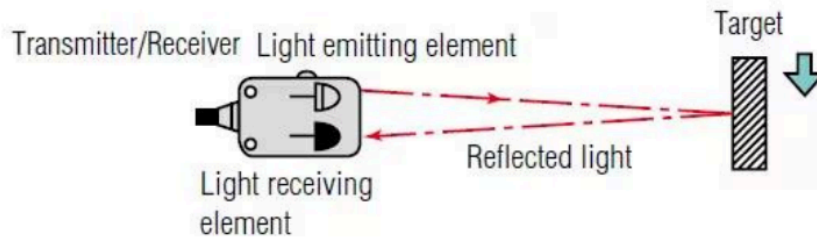


Figure 1: Reflective sensor example [4]

- Beam break – [3] with the beam break this works by having a hole in the cam belt and counting every time the laser can pass through, seen in Figure 2. This has multiple negatives such as having to alter the cam belt by putting a hole in it, also this would mean having to connect this component very close to the belt which would likely be hard to do.

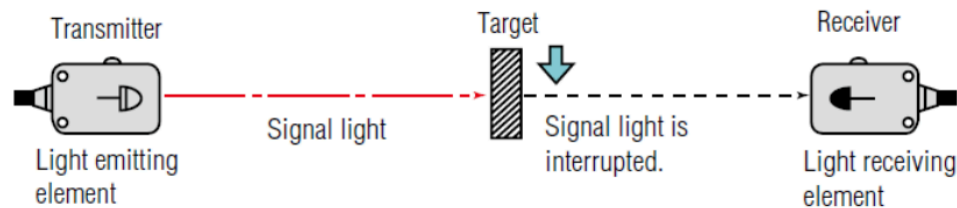


Figure 2: Beam break example [4]

Vehicle speed (MPH)

With the MPH this would be all the same options as done for RPM but instead done on the wheel, placing a magnet or reflective object on the wheel. To ensure the accuracy for these multiple points would be used as when the car is moving slowly this could cause an error as no highs could be reported within the second causing an error.

Engine temperature

- Resistance

- Thermistor – [5] this would be connected to the engine block and would create an analogue output; this has the advantage that it's a cheap and simple component to connect to the circuit but would require a physical connection to the engine block.

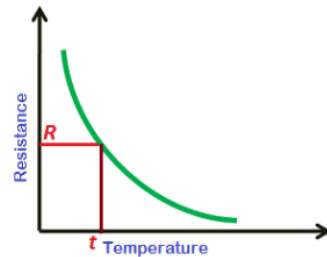


Figure 3: thermistor graph [5]

- Thermocouple – [6] this uses 2 metals which when at different temperatures will pass different levels of voltage between the 2. This will provide a varying analogue output depending on the temperature. This is very similar to the thermistor but has the same negative of requiring contact to the engine block.

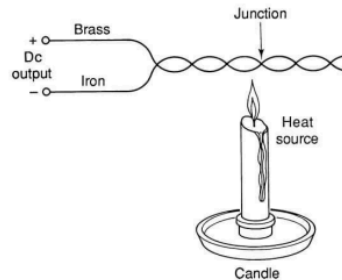
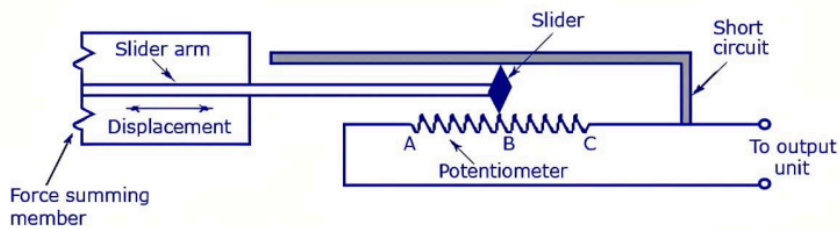


Figure 4: Thermocouple example [6]

- Optical – an infrared sensor can be used and would have minimum to no difficulty with connections and would be able to display a live temperature with an analogue output.

Suspension travel

- Resistance
 - Linear pot - [7] this device works by moving a slider up and down a potentiometer wire and creating a varied resistance providing a varying analogue value at the output, this can be seen in Figure 5. This has the advantage of being simple and easy to set up, but the negative of being a large device.



Linear Potentiometer

www.InstrumentationToday.com

Figure 5: Linear Potentiometer example [8]

- String/ Wire Potentiometer - [9] this works as the wire is pulled out the resistance decreases, and this changes the voltage received on the output at an analogue pin.

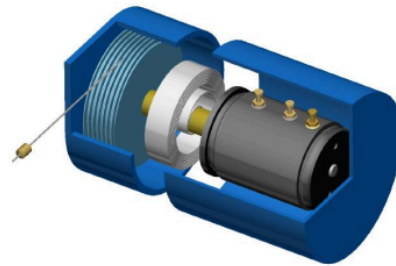


Figure 6: String/ Wire potentiometer example [10]

- Optical – [11] using a reflective laser would be very accurate for this job as are able to constantly output a distance which is very precise but has the key negative that its will be affected by any water or other material sprayed up in the wheel arches.

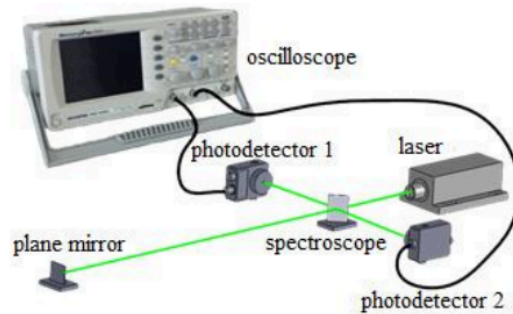


Figure 7: Optical distance measurement device [11]

Pitch, roll and yaw (PRY)

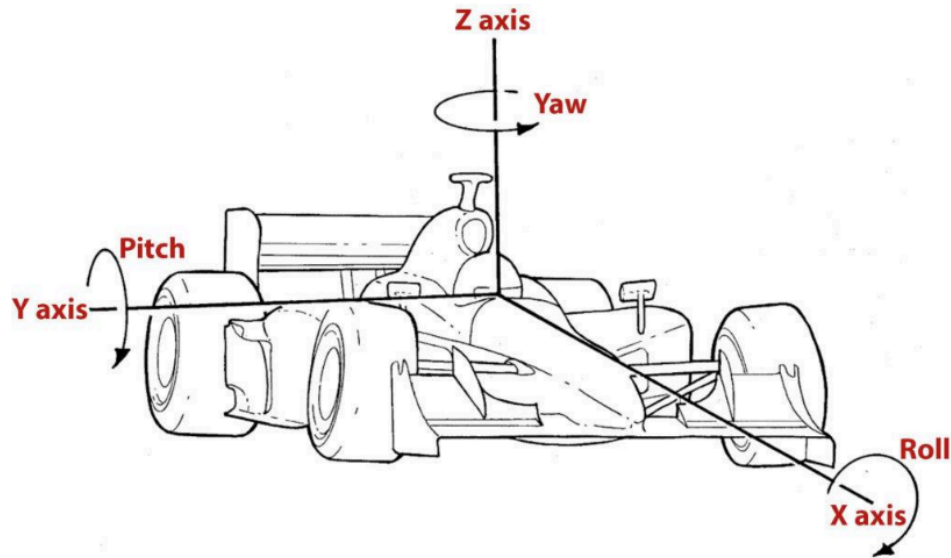


Figure 8: PRY on car

- Accelerometer - [12] this measures the acceleration in one direction so for recording the Pitch Roll and Yaw of the car this is not optimal as would involve a precise setup which could be done incorrectly.
- Gyro - [13] a sensor that measures the change in angular velocity, in the case of pitch, roll and yaw, this will be a singular chip with 3 data output which is perfect for the task. compared to the accelerometer this would be a much simpler setup to get the data required.

Final Design

Chosen components

Chosen sensors

Firstly, for RPM and MPH the chosen technique will be optical reflective sensor, the reason for this decision is compared to the other techniques used it is the least intrusive as nothing apart from a reflective mark needs to be altered to the cam belt or the wheel. Additionally, this does not need to be as close to either part to create an accurate measurement meaning finding appropriate spot for the housing similar. The chosen sensor is "OPB720B-06Z Optek, Reflective Optical Sensor, Open Collector Output" [14]. this sensor has an operating voltage of 4-7 which means it can be powered on the same power connection as the PIC, this additionally is a digital output which will be ran on the interrupt's pins of the pic, this will allow for a count to take place monitoring how many times this is triggered within the second period, this data can then be read to set to the SD card.

Next for the Engine temperature the decision is to use an optical option using the infrared sensor, this means it doesn't have to be connected to the engine block like the resistance options. This can easily be connected to somewhere appropriate in the car engine and be pointed at the engine block so the temperature can be read. The chosen sensor is "Optris CATCSLT15SFCB3K Temperature Sensor USB Infrared Temperature Sensor, 3m Cable, -50°C to +1030°C" [15]. The sensor is perfect for this job as the working range is well within the requirements of the job while still having an appropriate power consumption. This device is an analogue output with a power supply of 5 – 30 volts meaning this to can be powered on the 5-volt line, then using the software this can be programmed to have an output voltage from 0-5 volts which can be read on an analogue pin.

For Suspension travel the best option is the String/ Wire potentiometer, this is due to the optical options being affected if anything is thrown in the wheel well and the linear potentiometer would require a large amount of space as discussed in the research section. The chosen sensor is "TE Connectivity 10kΩ Linear Potentiometer Bracket Mount, SP1-25" [16]. This is a wire pot that comes in many sizes but the one selected is 25 inches/ 625mm which should be more than enough range for movement on a salon vehicle that this is being built for. This will have an analogue output which can be read onto the PIC using the ADC pins and then data can be read from there.

Finally for pitch, roll and yaw the simplest choice was to choose an analogue gyro as already discussed. The chosen sensor was the "ADXL335 - 5V ready triple-axis accelerometer (+/-3g analogue out)" [17]. This could be read on an analogue pin as desired and could be supplied through 5V which is what was desired from a sensor, this also would be able to give the data at the speed desired. Due to the Gyro having a 3.3V output this will require signal conditioning, this will take the voltage from the max 3.3V output of the Gyro and convert this to a Max of 5V, this is done using an op amp, the setup for this is seen in Figure 9 and the calculations required for the resistor values can be found using Equation 1.

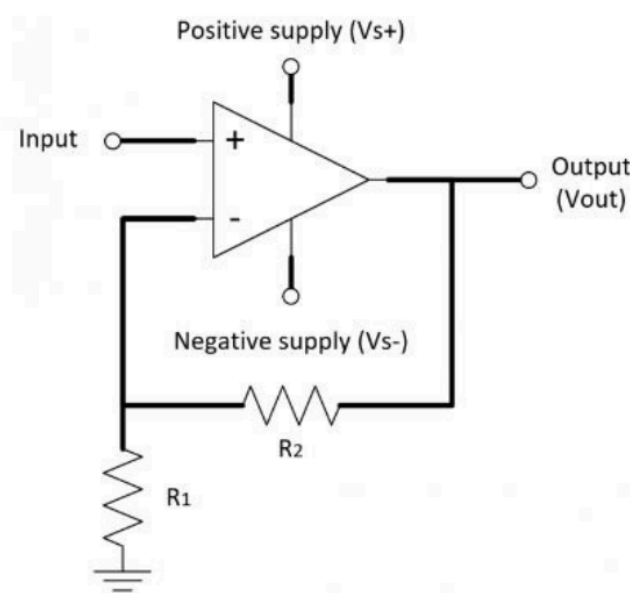


Figure 9: noninverting amplifier [18]

$$\frac{V_{out}}{V_{in}} = Gain = 1 + \frac{R_2}{R_1}$$

Equation 1: Gain of Amplifier [18]

V_{out} - voltage output

V_{in} - voltage input

R_1 - Resistor 1

R_2 - Resistor 2

For this we will have a V_{in} of 3.3V and V_{out} desired of 5V, giving us a Gain value of approximately of 1.5, then using the resistor values of $R_1=10K$ and $R_2 = 5.6$ this will create a final gain of 1.56, converting the 3.3V to 5.1V. This means that the data from the Gyro can be read to as higher degree of accuracy.

Chosen PIC

Once all sensors have been selected the final pin requirements are known, the requirements are the following:

- 8 for analogue sensors
- 2 for digital sensors (interrupt pins)
- 4 for micro-SD
- 1 for start
- 1 for tell
- 2 for debug

Then the using the following requirements a search can be carried out using the website "MICROCHIP ADVANCED PART SELECTOR" [19], this is a search engine for all Pics, using this it's possible to search a data base of 2240 pics to find one that fits the requirements. The requirements entered can be seen below:

- Family = 8-bit MCU
- CPU type = 8-bit PIC MCU
- Max CPU speed (MHz) = 32 min
- Operating voltage (V) = 5 min
- Pin count = 16 min, 40 max
- Program memory size (KB) = 32 min, 64 max
- ADC input = 8 min
- UART = 1 min
- Number of USB modules = 1 min

These requirements left 6 PICs remaining, with the chosen pic being the PIC18F45K50 [20]. This was selected as it meets all the requirements and had an advantage that there was prior experience using this device.

Circuit diagrams

Before creating any circuit diagrams the first thing done was a block diagram top understand the basics of what needed to be done, this can be seen in Figure 10. This shows how the data will be passed through the system from start to finish, in this case the only data that will be altered in the signal processing [21] is the data from the Gyro as all other data does not

need to be altered, the clamp [22] is used to protect the PIC processor, then the data is passed through to the SD card where it will be later read.

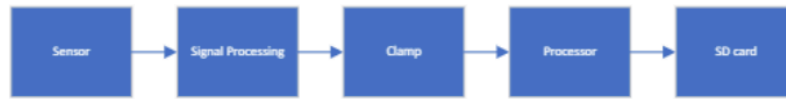


Figure 10: Block Diagram

The Circuit diagram will be created in "PROTEUS DesignSuit" [23] and then transferred to "EasyPC" [24], once completed a PCB will be made.

Within this circuit the bellow components will be required:

- PIC18F45K50.
- SD card for memory storage.
- USB connector to read the data.
- Debugging connection.
- 7805 regulator – This will convert the 12-Volt input to 5-Volt, this is required for the PIC and some sensors.
- 7806 regulator – This will convert the 12-Volt input to 6-Volt, this is required for a sensor.
- LEDs for power tell and PIC operation tell.
- Range of values of resistors used for the clamps, LED protection.
- Range of values of capacitors used for the clamps, regulator setups and PIC to ground.
- Diodes for the clamp.
- When creating the connectors aim to use different headers for each type of connection. Using a 4 pin for Power, 5 Pin for MPH ect as seen in Figure 12. This is done in the aim to prevent errors when being assembled, preventing damage to be caused to the sensors or PIC.

The Proteus circuit diagram can be seen in Figure 11 and EasyPC in Figure 12.

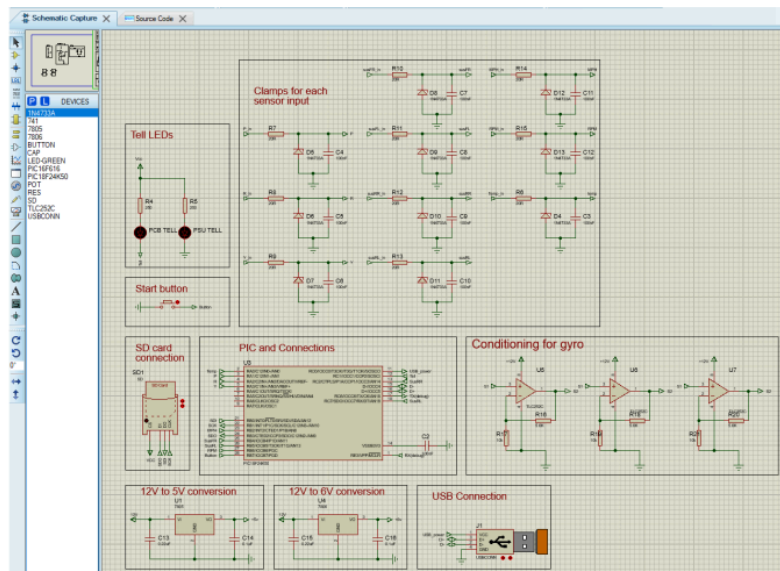


Figure 11: Proteus Circuit Diagram

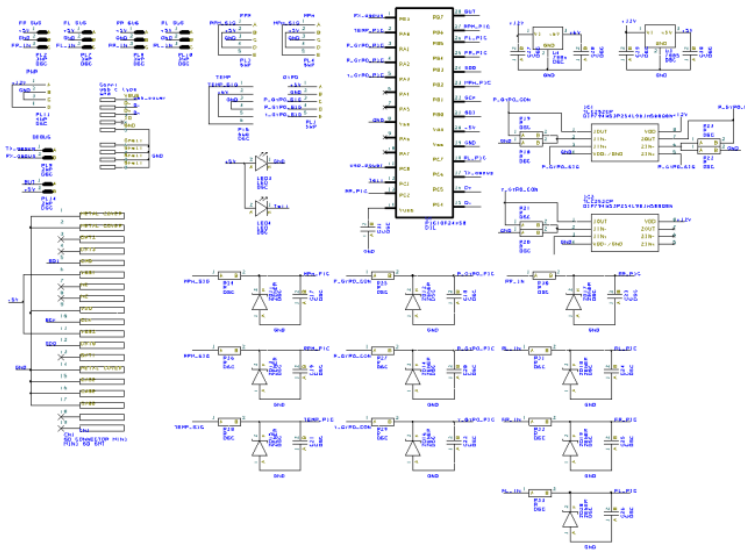


Figure 12: EasyPC Circuit Diagram

PCB Design

Using the Circuit Diagram created in “EasyPC” the design can be converted to PCB, this means all the components will be moved into a “component bucket” and placed to create the board.

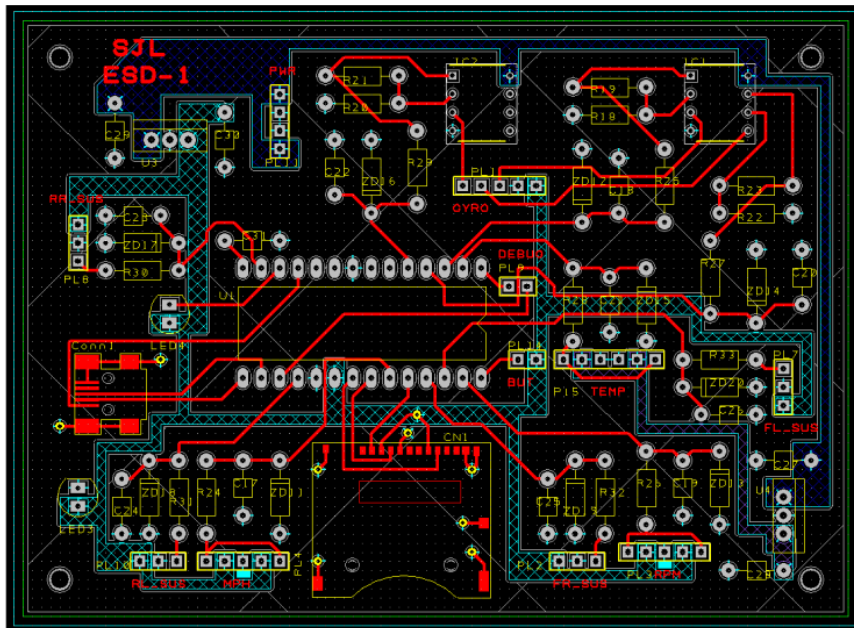


Figure 13: Final PCB

Once all components are placed, they then need to be connected, the final product can be seen in Figure 13. All connections are made on the top layer and then using a copper pour to connect the +5V, +6V, +12V and Ground nets on the base. To ensure the PCB has no errors a design rule test is ran, the setting seen in Figure 14 and the results in Figure 15. Once completed using the "Plotting and Printing" tool a Gerber file can be created and then uploaded to a website of choice to receive a quote on Pricing for the PCB, JLCPCB was used due to their low costing making 5 PCBs for £2. The final simulated product can be seen in Figure 16 and Figure 17, the Final product has the measurements of 115mmx83mm

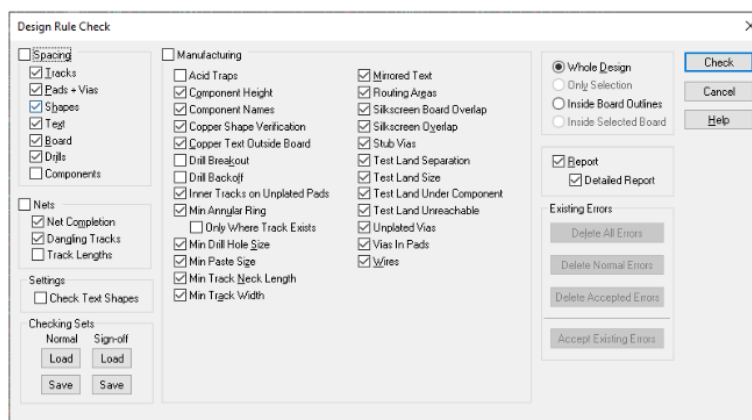


Figure 14: Design Rule Check

Design Rule Check Report

Report Written: Friday, July 19, 2024
Project Path: C:\Users\ISA0609210\Desktop\ESD\ESD-assignment1\easy-PC\ESD-A.prg
Design Path: C:\Users\ISA0609210\Desktop\ESD\ESD-assignment1\easy-PC\ESD-A.pcb
Design Title:
Created: 17/07/2024 10:07:56
Last Saved: 19/07/2024 11:24:37
Editing Time: 503 min
Units: thou (precision 0)

Results

No errors found

Accepted Errors already in the design

No errors found

Settings

Spacings

Tracks	Yes
Pads and Vias	Yes
Shapes	Yes
Text	Yes
Board	Yes
Drills	Yes
Components	No

Manufacturing

Acid Traps	No
Drill Breakout	No
Drill Backoff	No
Silkscreen Overlap	Yes
Silkscreen Board Overlap	Yes
Wires	Yes
Component Height	Yes
Component Names	Yes
Copper Text In Board	Yes
Mirrored Text	Yes
Routing Areas	Yes
Min Track Width	Yes
Neck Length	Yes
Min Annular Ring	Yes
Min Paste Size	Yes
Vias In Pads	Yes
Unplated Vias	Yes
Unplated Pads With Inner Tracks	Yes

Nets

Net Completion	Yes
Dangling Tracks	Yes
Net Track Length Differences	No

Figure 15: Design Rule Check Report

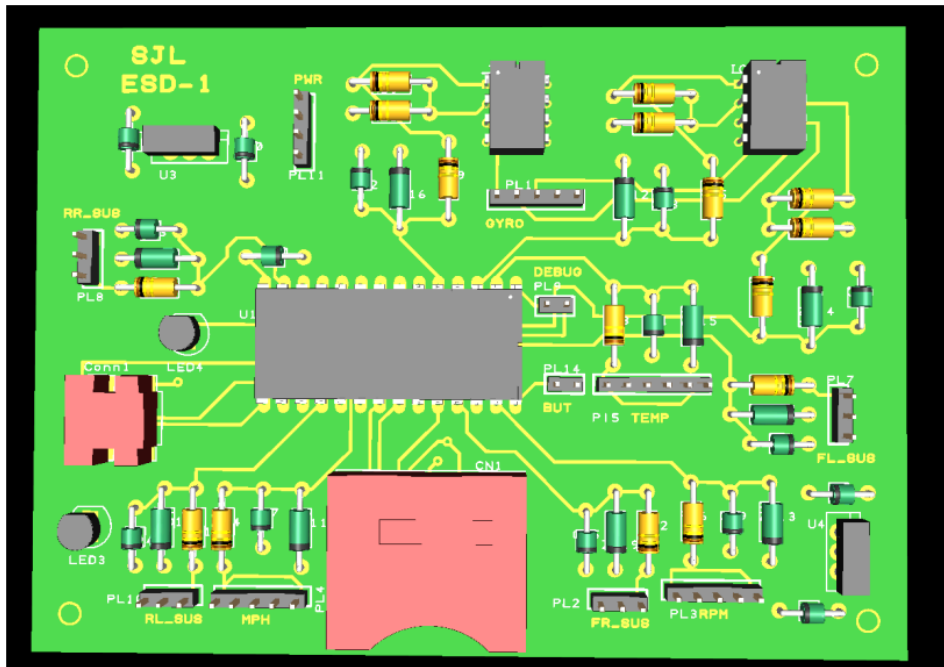


Figure 16: PCB Top View

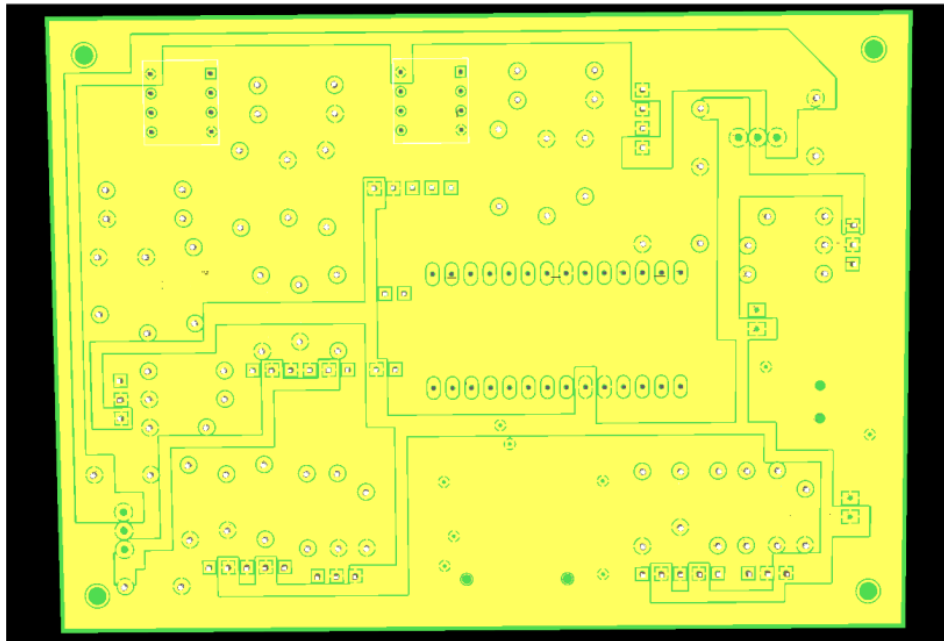


Figure 17: PCB Base View

Software & Data Structure

For the software structure this is planned out using a Flow chart [25] seen in Figure 18, showing how the code will flow, and Figure 19, showing how the interrupts will operate. This helps when it comes to producing the software as will allow to see how the flow of information.

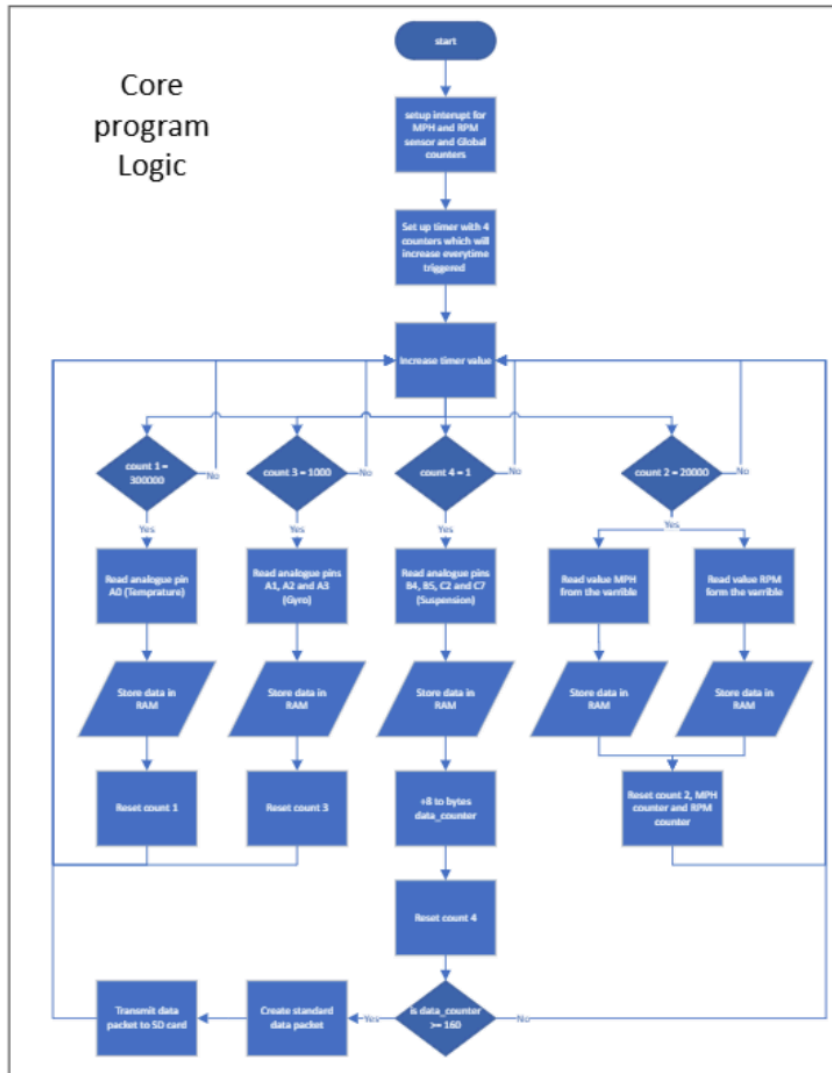


Figure 18: Main Program Flowchart

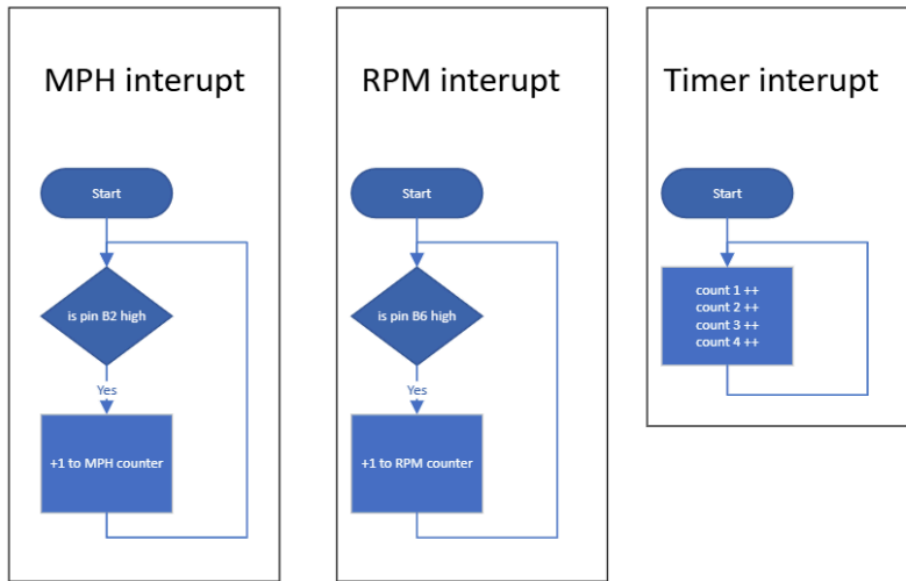


Figure 19: Interrupt Flowcharts

Figure 19 shows the 3 interrupts that are required, 1 core timer interrupt, 2 for each digital count. When programming the chip, the time for the interrupt can be set, for this it will be set to 50us meaning that the counts will equal the values as shown below when triggered:

- Count 1 = 300000
- Count 2 = 20000
- Count 3 = 1000
- Count 4 = 1

For the data, initially the data will be stored in the ram when collected, then when 160 bytes of suspension data or more are stored in the buffer this will be transmitted to the SD card using SPI [26]. Before transmission a packet will be created, creating a standardised form transmission, this will be 160 bytes of suspension data, including space which may be left on 0 if there is no data to transmit for the gyro data, temp, RPM and MPH, the final packet will have the split as seen in Figure 20, containing 160 bytes of suspension data, 6 bytes of Gyro, 2 bytes of Temp and 1 byte of RPM and MPH.

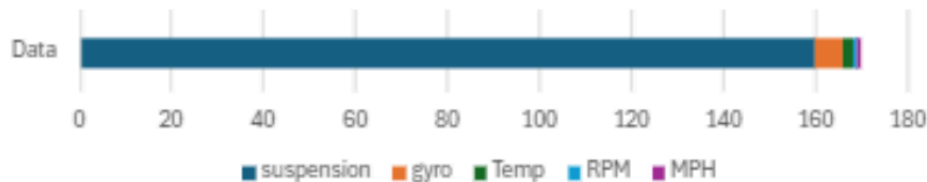


Figure 20: Packet Split

This will mean when the SD card is read at the end of the job the data should be organised into packets and can be read simply by looking at the packets of 170bytes of data. Due to doing this this means I will require a larger SD card than originally calculated in

Table 2, this can be seen in Table 4 as 1.224GB. For the final product a 4GB SD card was selected just to be safe and ensure no data is ever lost, seen in Table 6.

	Value	Formula
suspension data (bytes)	8	B2
suspension data per packet (bytes)	160	B3
time to record (s)	0.00005	B4
additional sensor data (Bytes)	10	B5
time to record 160 bytes (s)	0.001	B3/B2* B4
packets created	7200000	2* 60* 60/ B6
total bytes	1224000000	B7* (B3+B5)

Table 4: New Memory Calculation

Power, Enclosure, Cables and Connectors

The power supply the requirements are below:

- 12 Volts
- A greater than 0.793 AH, calculations seen in table 5

5V component	current required	number of components	required current (A)
RFM/MPH	0.05	2	0.1
PRY	0.0003	1	0.0003
SUS	0.0005	4	0.002
PIC	0.025	1	0.025
op amp	3E-10	2	6E-10
		5V current	0.127300001
6V component	current required	number of components	required current (A)
TEMP	0.004	1	0.004
		6V current	0.004
component	component efficiency	current required out	required current in
8705	41.66666667	0.127300001	0.305520001
8706	50	0.004	0.008
		current (A)	0.313520001
		power (W)	3.762240017
		+1Wfor passive components (W)	4.762240017
		2 hrs (W/h)	9.524480035

Table 5: Battery Calculations

The calculations above take the current requirements found for each component, convert the current in the 5V line and 6V line, convert them to 12V to find the final required current and then charge this to Watts for the final power use for the battery. From these requirements the best fitting device is a "Yuasa 12V Faston 4.8mm Sealed Lead Acid Battery, 1.2Ah" [27], the details for this can be found in Table 6.

The enclosure requirements are as followed:

- Fit the PCB (115x85mm), Gyro (20x20mm) and 12V battery (100x45x55mm).
- Fit 6 3 pin connectors (27x27mm).
- Start button (17.5x17.5mm).
- The IP 66 [28] standards or above, preventing damage from water and Dust.

After deciding on these requirements this enclosure was selected, "Rittal JB Series Grey Carbon Steel Junction Box, IP66, 250 x 250 x 150mm" [29], the details can be seen in Table 6. This enclosure will provide plenty of space for the required components and connectors on the external faces of the box. All the sensors came with housings meaning nothing additional is needed.

The cabling requirements are as followed:

- 3 cores.
- 1A supply rating.

The selected cable can be seen in Table 6. Additionally on top of the 3-core wire there will be a requirement for some single core wires for the inside of the box to create the connections between the PCB and the connectors on the box. This can be found in the Lab and will not be included in this bill of materials.

For the connectors military standard will be used to additionally reduce any possible effects from water and dust ingress. 3 pin connectors are required for power, ground and signal connections for each external sensor. Additionally for the button required to start the operating system this will also be to a high standard.

For all the above the components decided upon can be seen within the "Total Bill of Materials", these can be seen within Table 6.

Total Bill of Materials

Component	Manufacturers number	Supplier	Quantity	Price per unit (£) (inc VAT)	Total Price (£)
Sensors					
OPB720B-06Z Optek, Reflective Optical Sensor, Open Collector Output	OPB720B-06Z	RS	2	16.42	32.84
Optris CATCSLT15SFCB3K Temperature Sensor USB Infrared Temperature Sensor,	CATCSLT15SFCB3K	RS	1	210.02	210.02

3m Cable, -50°C to +1030°C					
ADXL335 - 5V ready triple-axis accelerometer (+-3g analog out)	ADXL335	Pihut	1	14.10	14.10
TE Connectivity 10kΩ Linear Potentiometer Bracket Mount, SP1-25	SP1-25	RS	4	337.28	1349.12
PCB/components					
PCB, pack of 5	N/a	JLCPCB	1	2.00	2.00
Microchip PIC18F45K50-I/P, 8bit PIC Microcontroller, PIC18F, 48MHz, 32 kB Flash, 40-Pin PDIP, pack of 5	PIC18F45K50-I/P	RS	1	3.19	3.19
RS PRO 250Ω Metal Film Resistor 0.6W ±0.5% pack of 50	174-2772	RS	1	5.30	5.30
Kingbright 2 V Green LED 5mm Through Hole, L-53GD, pack of 5	47334-0001	RS	1	1.07	1.07
20Ω resistor pack of 5	YR1B20RCC	RS	2	2.60	5.20
KEMET 100nF Multilayer Ceramic Capacitor MLCC, 50V dc V, ±10%, Through Hole, pack of 5	C322C104K5R5TA	RS	3	1.13	3.39
Taiwan Semi 1000V 3A, Rectifier Diode, 2-Pin DO-201AD FR307G, pack of 20	FR307G	RS	1	4.24	4.24
Molex, 47337 8 Way Right Angle Micro SD Memory Card Connector with Solder Termination	47334-0001	RS	1	1.07	1.07
Würth Elektronik Right Angle, Surface Mount, Through Hole, Socket Type C 3.1 USB Connector	632723100021	RS	1	6.78	6.78
Panasonic ECQE(F) Polyester Film Capacitor, 630V dc, ±5%, 220nF, Through Hole, pack of 5	ECQE6224JF	RS	1	4.12	4.12
RS PRO 10kΩ Carbon Film Resistor	707-7745	RS	1	1.41	1.41

0.25W ±5%, pack of 10					
TE Connectivity 5.6kΩ Metal Film Resistor 0.6W ±1% LR1F5K6, pack of 10	LR1F5K6	RS	1	0.40	0.40
TLC252CP Texas Instruments, Op Amp, 1.7MHz, 3 → 15 V, 8- Pin PDIP	TLC252CP	RS	2	6.20	12.40
Texas Instruments LM7805CT/NOPB, 1 Linear Voltage, Voltage Regulator 1A, 5 V 3-Pin, TO-220, pack of 5	LM7805CT/NOPB	RS	1	8.15	8.15
onsemi MC7806CTG, 1 Linear Voltage, Voltage Regulator 2.2A, 6 V 3-Pin, TO- 220, tube of 50	MC7806CTG	RS	1	16.60	16.60
Box and cabling and connectors					
Rittal JB Series Grey Carbon Steel Junction Box, IP66, 250 x 250 x 150mm	JB101006HC	RS	1	109.33	109.33
RS PRO Data Cable, 0.22 mm², 3 Cores, 24 AWG, Screened, 100m, Grey Sheath	812-4725	RS	1	60.37	60.37
Amphenol Industrial, MS3102A 3 Way Box Mount MIL Spec Circular Connector Receptacle, Pin Contacts, Shell Size 10SL	MS3102A-10SL-3P	RS	6	9.86	59.16
Amphenol Industrial, MS3106A 3 Way Cable Mount MIL Spec Circular Connector, Pin Contacts, Shell Size 10SL, Screw	MS3106A-10SL-3P	RS	6	14.03	84.18
ITW Switches 59 Series Miniature Push Button Switch, Momentary, Panel Mount, 13.65mm Cutout, SPST, Clear LED, 125V ac,	59-115	RS	1	7.82	7.82

Transcend 4 GB SDHC SD Card, Class 10	TS4GSDHC10	RS	1	14.69	14.69
PSU					
Yuasa 12V Faston 4.8mm Sealed Lead Acid Battery, 1.2Ah	Y1.2-12	RS	1	24.31	24.31
				Final Cost (£)	2041.185

Table 6: Bill of Materials

In total cost to complete this design would costs £2,041.19 as seen in Table 6. All components' data sheets can be found in the "Appendix" section below.

Future upgrades

For the design requirements given this will carry out the job required, but for future upgrades some things that could be considered are:

- Testing a range of sensors ensuring their accuracy and seeing which perform best at the task. To achieve this, purchase a selection of 5-10 sensors for each job and creating a test to see if the which sensor has the best accuracy while outputting data at an appropriate rate. The rate of data is just as important as the accuracy as if the data can only be sourced every second for gyro this could mean a large amount of data would be missed if a spin was to occur, whereas with a rate of 0.05 seconds this would catch a much larger amount of data if a spin was to occur which could be very beneficial.
- Another future endeavour could be to create a build for racing vehicles, this would involve worrying about a greater speed and RPM recording, less suspension movement, likely higher engine temperatures and consideration of other types of data recording not done in this build [30].

Appendix

Components datasheet links

OPB720B-06Z Optek, Reflective Optical Sensor, Open Collector Output - [0900766b813e4537.pdf \(rs-online.com\)](#)

Opttris CATCSLT15SFCB3K Temperature Sensor USB Infrared Temperature Sensor, 3m Cable, -50°C to +1030°C - [A700000009186419.pdf \(rs-online.com\)](#)

ADXL335 - 5V ready triple-axis accelerometer (+-3g analog out) - [adx1377.pdf \(analog.com\)](#)

TE Connectivity 10kΩ Linear Potentiometer Bracket Mount, SP1-25 - [0900766b8142cde6.pdf \(rs-online.com\)](#)

Microchip PIC18F45K50-I/P, 8bit PIC Microcontroller, PIC18F, 48MHz, 32 kB Flash, 40-Pin PDIP - [0900766b813835fd.pdf \(rs-online.com\)](#)

Molex, 47337 8 Way Right Angle Micro SD Memory Card Connector with Solder Termination - [0900766b813c3daf.pdf \(rs-online.com\)](#)

Wurth Elektronik Right Angle, Surface Mount, Through Hole, Socket Type C 3.1 USB Connector - [0900766b814ff8e4.pdf \(rs-online.com\)](#)

TLC252CP Texas Instruments, Op Amp, 1.7MHz, 3 → 15 V, 8-Pin PDIP - [tlc25l2a.pdf \(ti.com\)](#)

Texas Instruments LM7805CT/NOPB, 1 Linear Voltage, Voltage Regulator 1A, 5 V 3-Pin, TO-220 - [lm7800.pdf \(ti.com\)](#)

onsemi MC7806CTG, 1 Linear Voltage, Voltage Regulator 2.2A, 6 V 3-Pin, TO-220 - [0900766b8154f52c.pdf \(rs-online.com\)](#)

Rittal JB Series Grey Carbon Steel Junction Box, IP66, 250 x 250 x 150mm - [0900766b813e8de8.pdf \(rs-online.com\)](#)

Amphenol Industrial, MS3102A 3 Way Box Mount MIL Spec Circular Connector Receptacle, Pin Contacts, Shell Size 10SL

Amphenol Industrial, MS3106A 3 Way Cable Mount MIL Spec Circular Connector, Pin Contacts, Shell Size 10SL, Screw & ITW Switches 59 Series Miniature Push Button Switch, Momentary, Panel Mount, 13.65mm Cutout, SPST, Clear LED, 125V ac - [0900766b8148892b.pdf \(rs-online.com\)](#)

Transcend 4 GB SDHC SD Card, Class 10 - [0900766b816b6fe4.pdf \(rs-online.com\)](#)

Yuasa 12V Faston 4.8mm Sealed Lead Acid Battery, 1.2Ah - [A700000006472950.pdf \(rs-online.com\)](#)

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FINAL GRADE

GENERAL COMMENTS

68/100

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SAM LLOYD

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RESEARCH-INFORMED LITERATURE



No literature research. 0%

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KNOWLEDGE AND UNDERSTANDING



The circuit diagram is complete with nice use of single sided amplifiers. All of your connections go

17.5

to suitable pins. Your PCB is complete and shows no errors. A 100nf cap should be placed between the power lines as close to the micro-controller as possible to try to contain noise. 85%

ANALYSIS

 Good selection of microcontroller, and of the enclosure. Good selection of sensors but without an image or short spec to back-up the choices. A 100nf cap should be placed between the power lines as close to the micro-controller as possible. Your connectors are good .78%

27.3

PRACTICAL APPLICATION AND DEP.

 your costings are nicely tabulated and carry supplier, manufacturer and part numbers. Reasonable attempt at future enhancements. 70%

15

SKILLS FOR PROFESSIONAL PRAC.

 The report is well presented with some good explanations of choices and images. Excellent selection of references. 77%

7.7