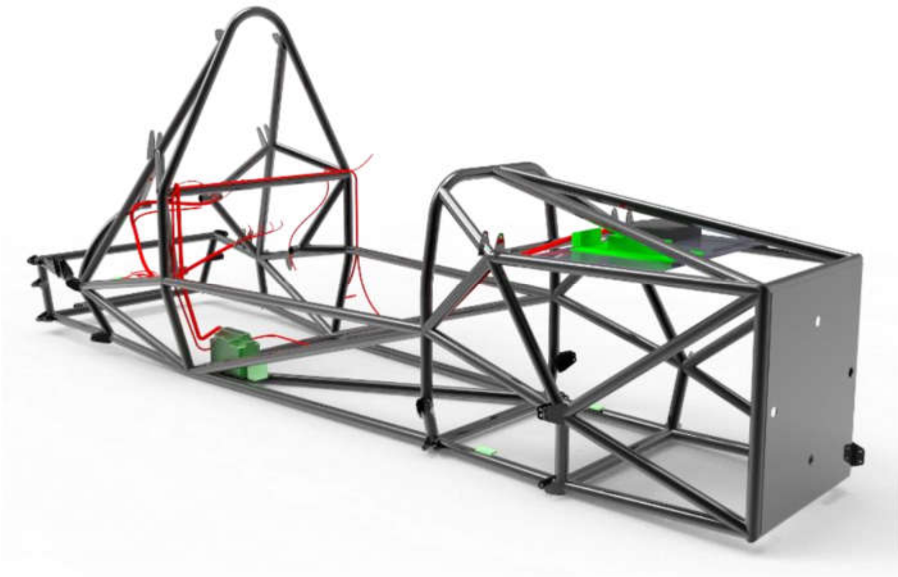
PRAVEGA RACING



ELECTRICAL

FORMULA STUDENT AUSTRALASIA

2018

The Electrical department is engaged in both fundamental and applied research in creating and understanding Electrical control systems. The department's strength lies in practical and reliable electrical system designs and their implementation in race car systems.

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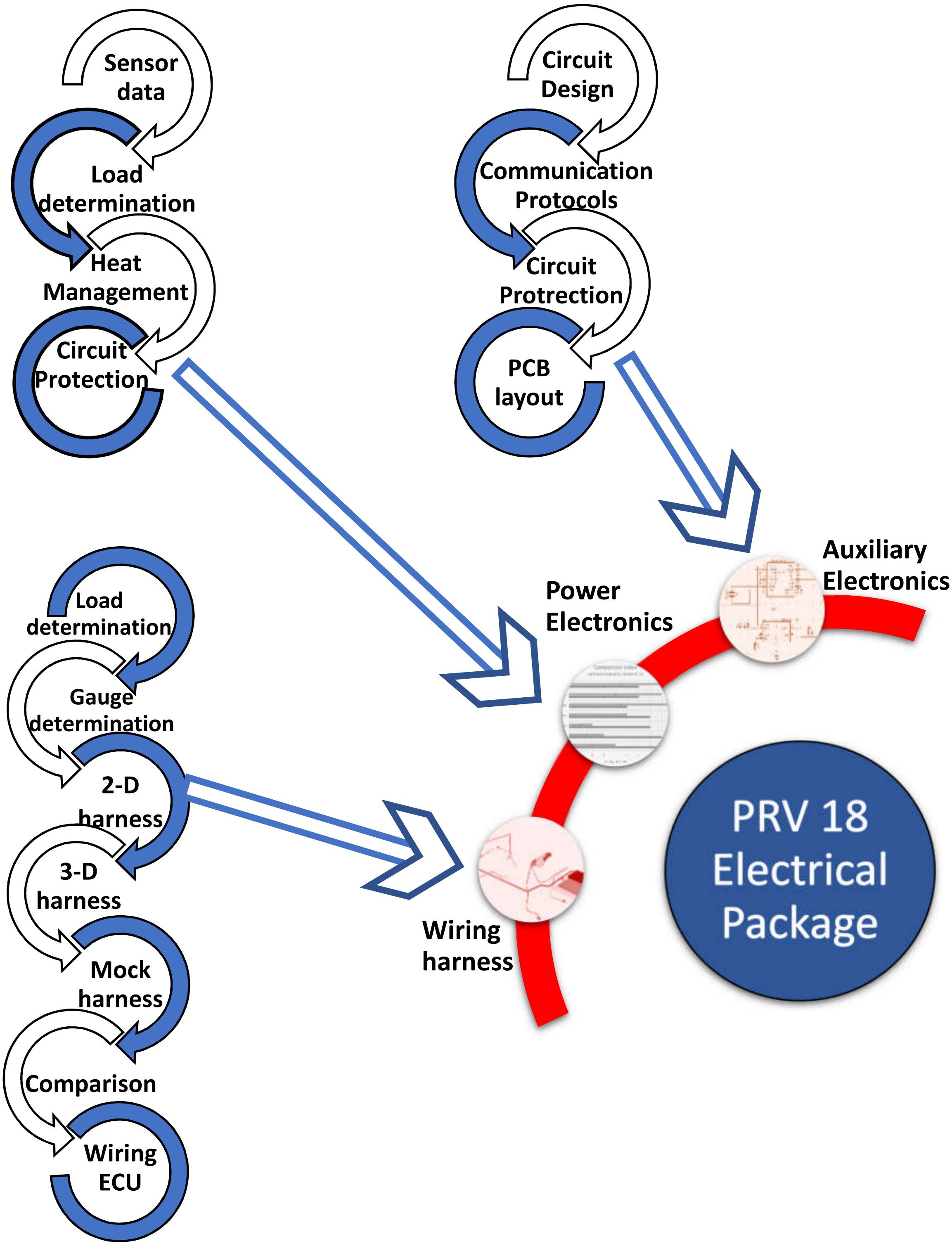
Department Preview

We at Pravega racing seek to enhance the learning experience of the student community by implementation of engineering fundamentals within the context of building a formula inspired Race car.

Following the same aspiration, the Electrical Department has evolved from ground zero, and is focused on developing robust and fundamentally applied Electrical Control Systems. From incorporating technical expertise and practical knowledge, the department has given in everything in creating a compact, reliable Electrical System.

Preceding season, the department had incorporated some major changes, which faced major troubleshooting and research failures. This season, the department has not only amended previous year's problems, but has also integrated necessary modules in designing driver assistance and wiring harness system.

Design Process



Sub- Systems

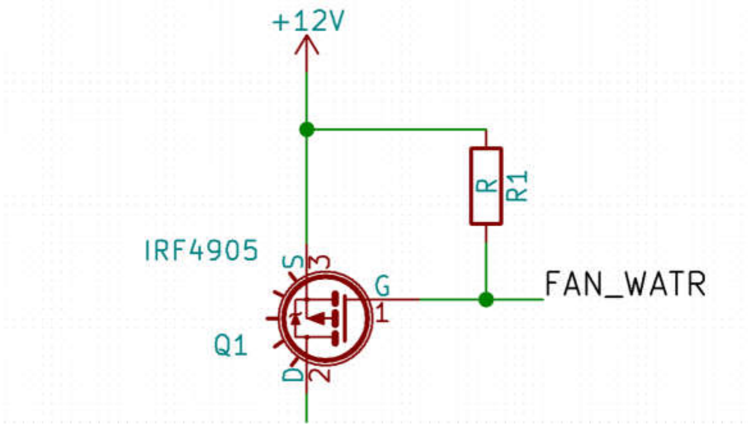
POWER ELECTRONICS:

1. **Power switching.**

- Heavy current drawing components need a reliable source of power with minimal execution time
- In fuel injected Internal Combustion Engines, such factors play a key role, when it comes to designing Electrical Power Systems
- Most of the power components, such as fuel pump, work on inductive principle, because of which they generate heavy Transient Voltage, and draw large amounts of current
- Based upon the need for faster switching and performance, Power Mosfets were chosen as the primary switching component

(fig 1.1)

- The gates of the all the Mosfets are to be isolated from any floating signal, which may trigger them unexpectedly

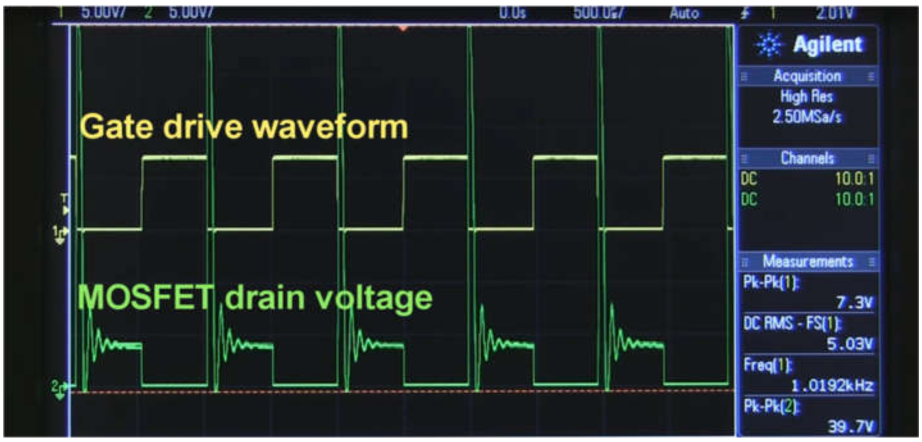


(fig 1.2. Here resistor R1 serves as the pullup resistor in isolating the gate.)

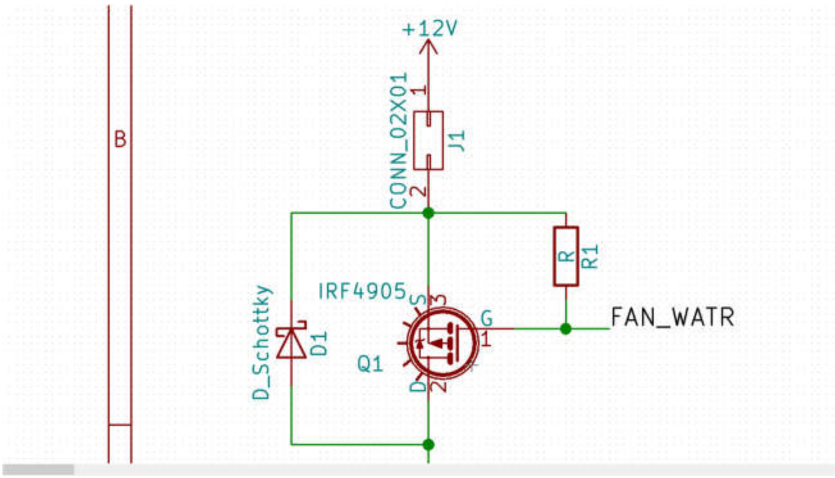
- In order to ensure back EMF protection schottky diodes were incorporated based on the decision matrix given below

Serial No.	Factor	Schottky diode	PN junction diode
1.	Reverse DC voltage	High	Low
2.	Forward DC voltage	Low	High
3.	Reverse recovery time	Shorter	Longer
4.	Application	High voltage protection	Steady breakdown voltage

- Figure given below shows the Voltage spikes due to inductive load, as seen on oscilloscope

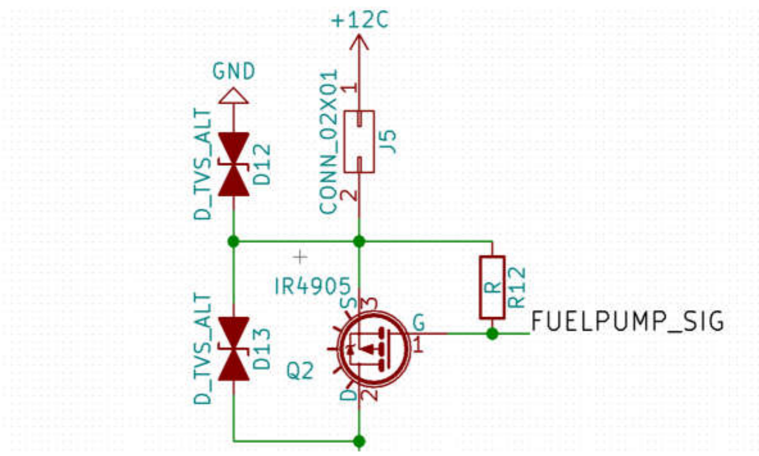


(Fig 1.3)



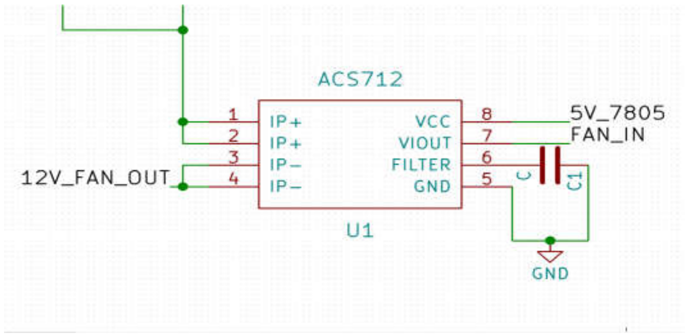
(fig 1.4, the circuit gives the design stage after integrating Schottky diodes.)

- For power component such as fuel pump, due to heavy inductive spikes and high transient voltages, the temperatures of the Mosfets were very dangerous and Transient Voltage Suppression diodes (littlefuse 1.5KE15A) were incorporated for this purpose

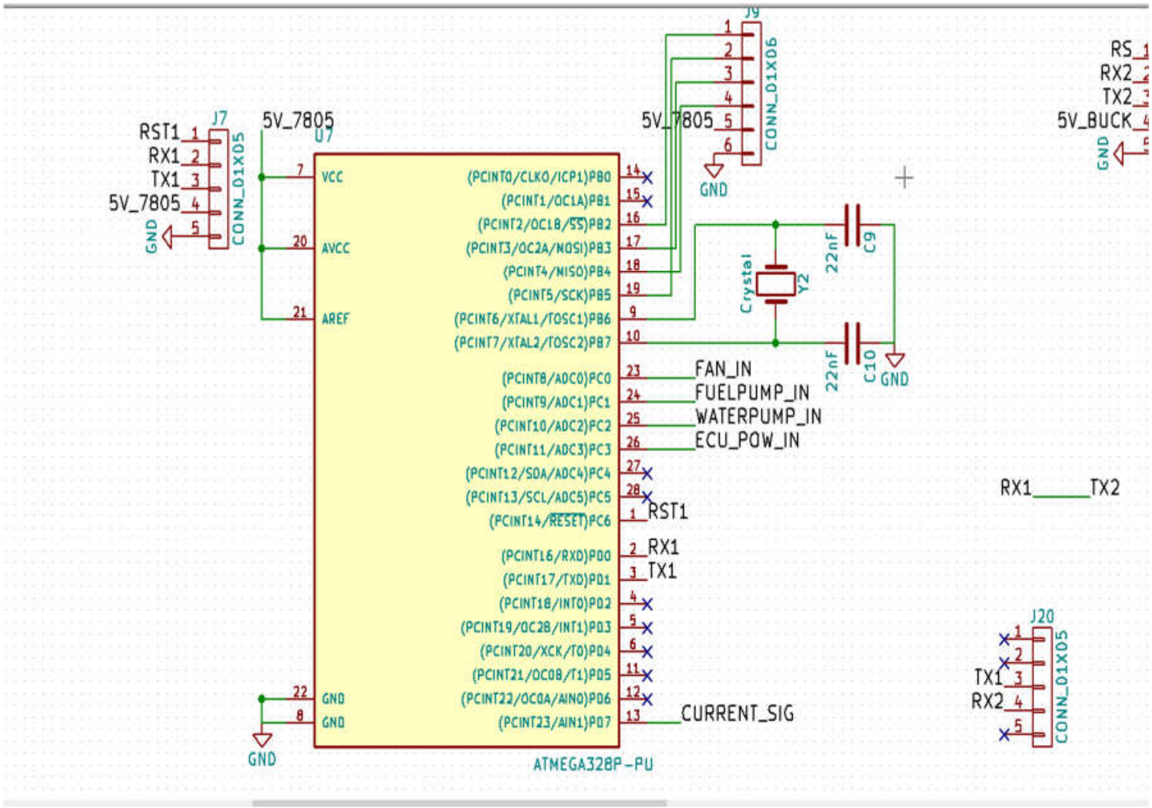


(fig 1.5)

- In case of undesired cases such as over current, logic level protection circuit was designed using current sensor(ACS 712) and Atmega 328p microcontroller(in fig 1.6a and 1.6b)



(1.6a)

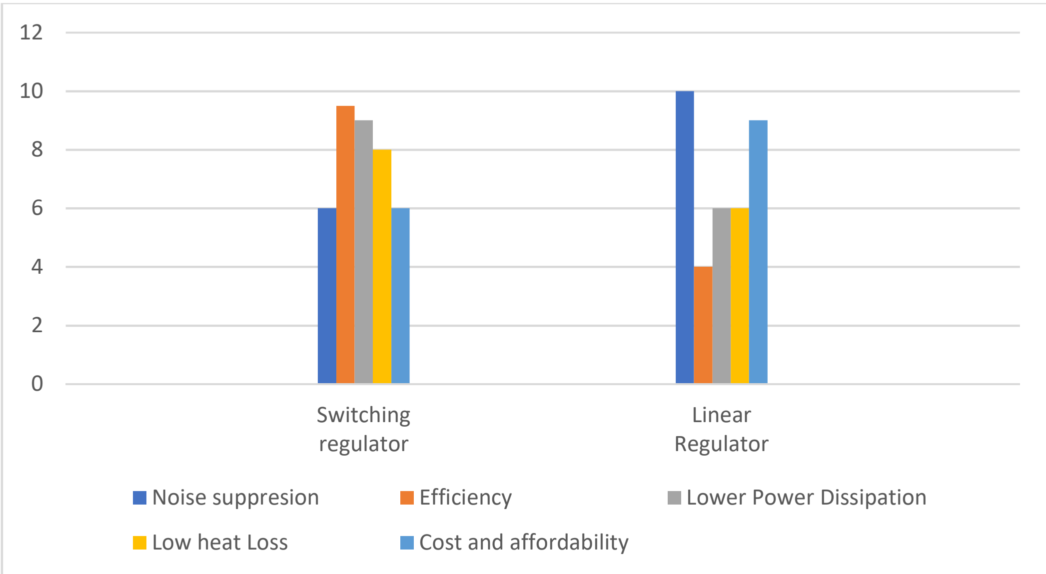


(1.6b)

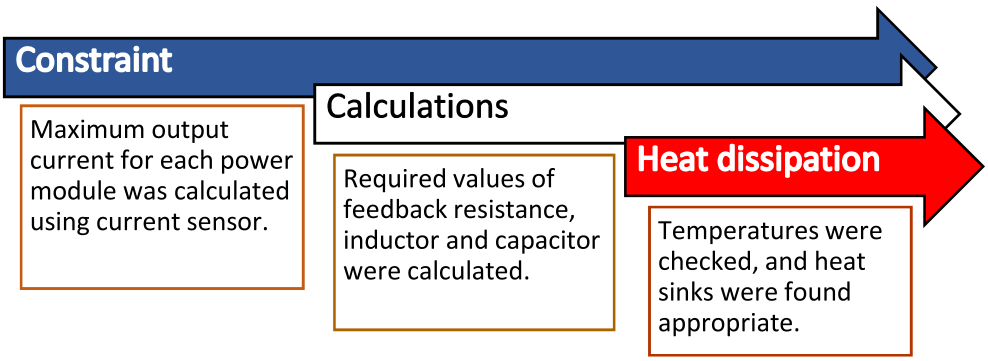
- The output from the microcontroller labelled as CURRENT_SIG in fig 1.6b is fed to the shutdown system

2. Voltage Regulation.

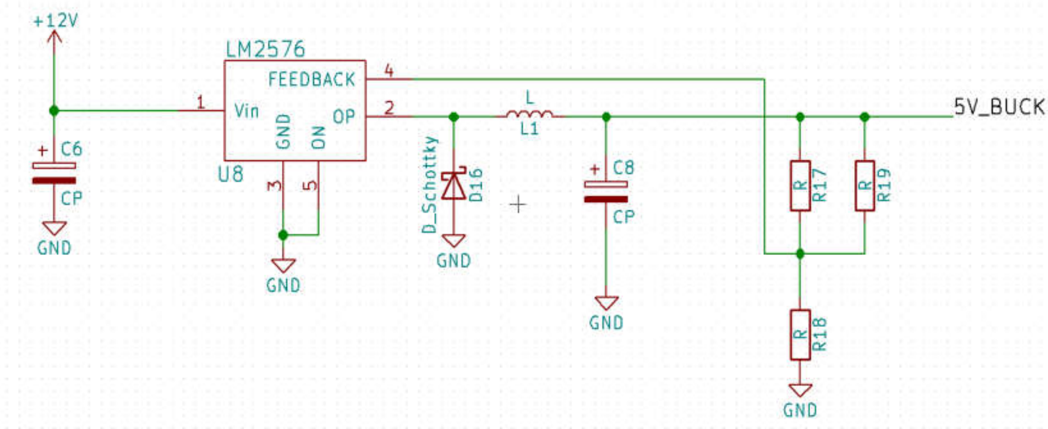
- For IC's, sensors and other LV components, a separate power supply of 5V would not only remove the load from a single power supply unit(like ECU), but will also keep it well distributed and effective
- Switching regulator was incorporated for this purpose. A comparison between switching and linear regulators is given in fig 1.7(factors were scaled for comparison)



(fig 1.7, here LM2576 was used as the switching regulator.)



(fig 1.8 shows the steps followed in designing the power supply.)



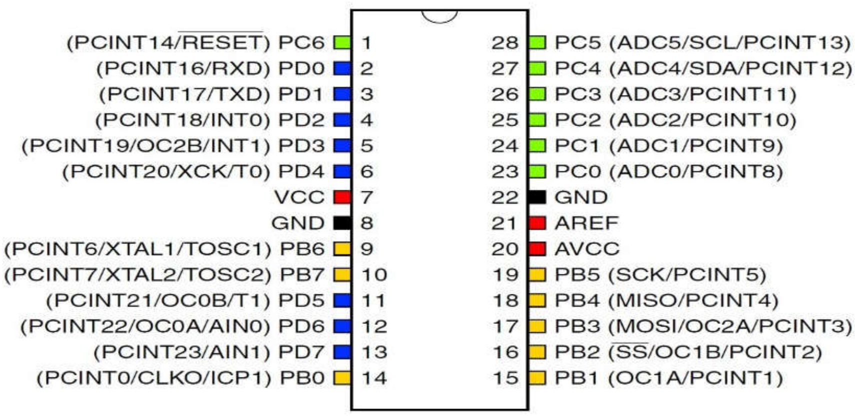
(fig 1.9 shows the circuit for 5V power supply based on the methodology followed.)

AUXILIARY ELECTRONICS:

MICROCONTROLLER SELECTION:

- The auxiliary Electronics System requires signal processing and communication standards to quickly and reliably receive and transmit data throughout
- For this purpose, Atmega 328P was chosen as the desired microcontroller based on the decision matrix given below

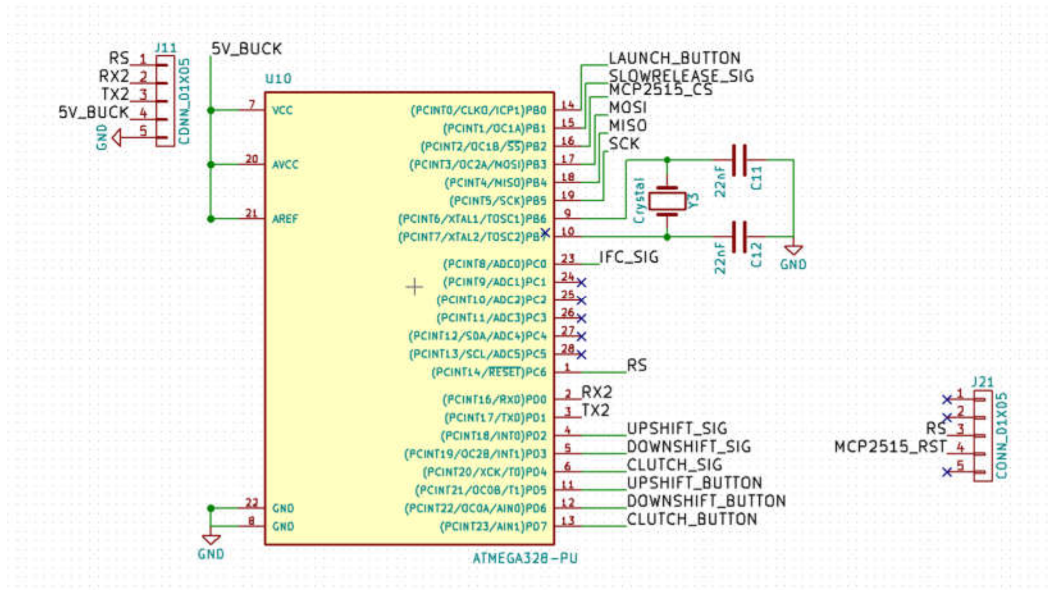
Serial No.	Factor	Atmega 328P	MSP 430	TM4C129
1.	Easy of interface	Yes	Yes	No
2.	Sufficient I/O pins	Yes	Yes	Yes
3.	Multiple Peripheral Support	Yes	No	Yes
4.	SRAM(min 2KB)	Yes	Yes	Yes
5.	Affordability	Yes	Yes	No



(fig 2.1 given above shows the pinout for Atmega 328p.)

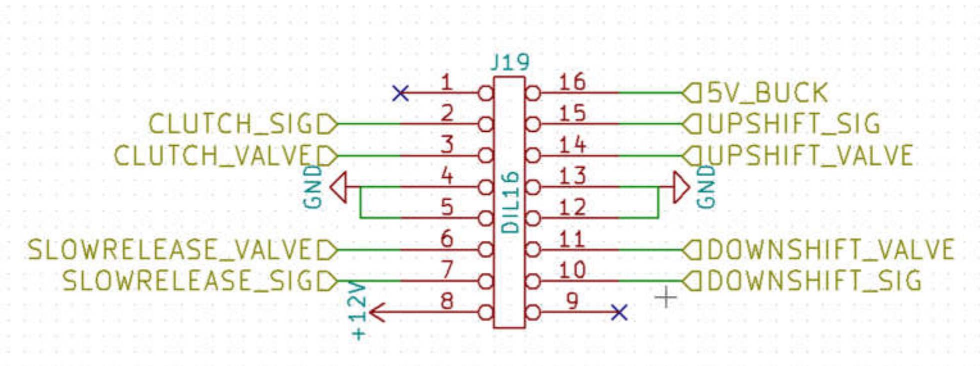
1. **Electro-pneumatic Gear Control Unit.**

- Electronically controlled shifting system has always been the preferred mechanism in Race Car Systems because of their faster actuation time and ease of use

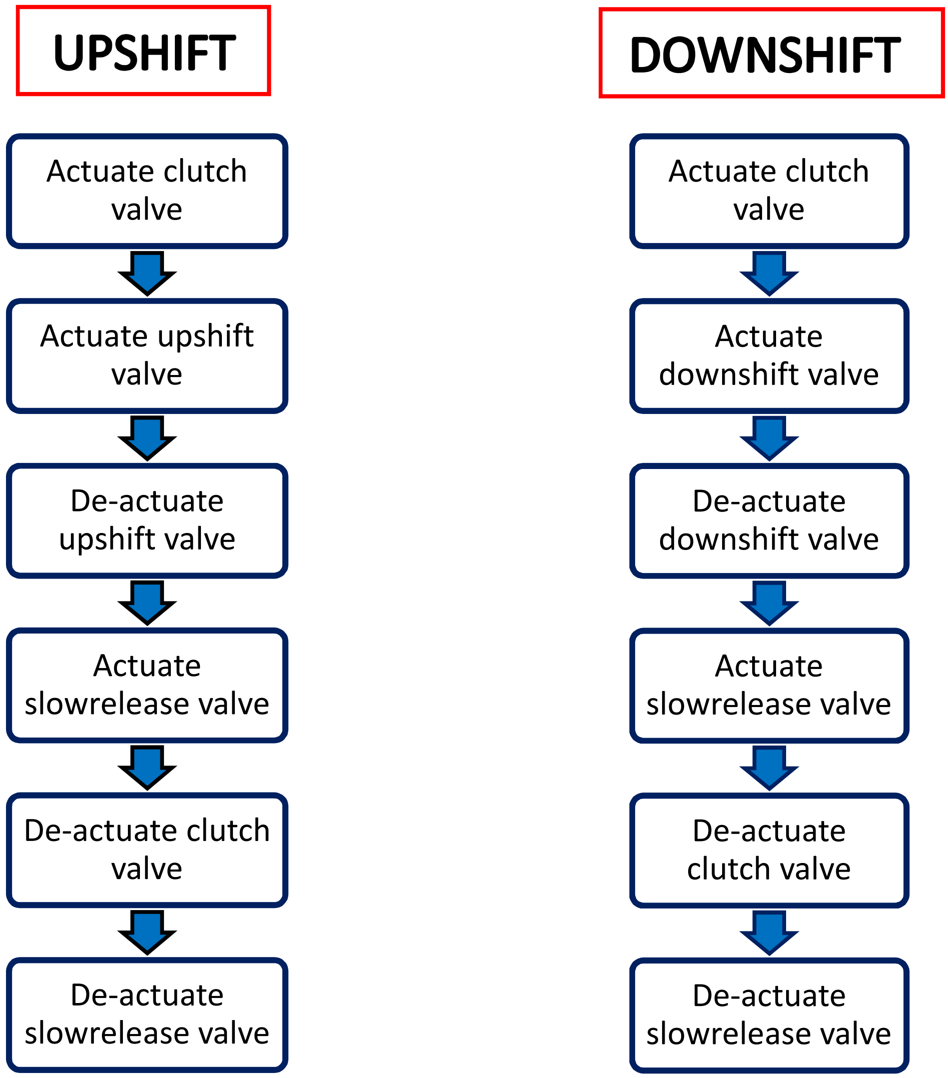


(fig 2.2 given above shows the Control Unit.)

- The microcontroller executes via H-bridge (L293d IC) for actuating the corresponding valves for pneumatic shifting as shown in figure 2.3



(fig 2.3)

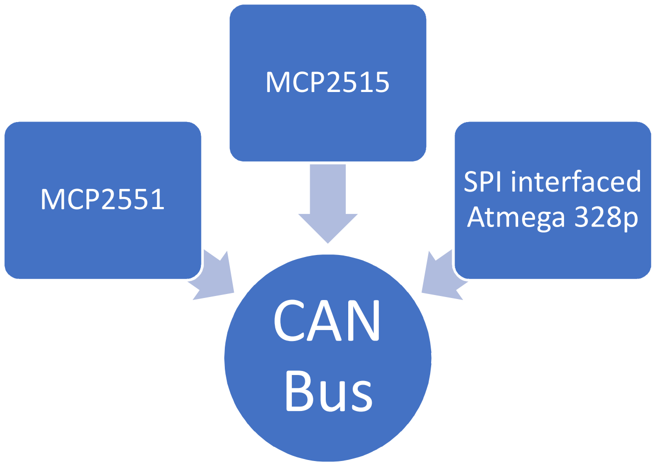


(The delay between each of the steps was iterative and different for both upshift and downshift.)

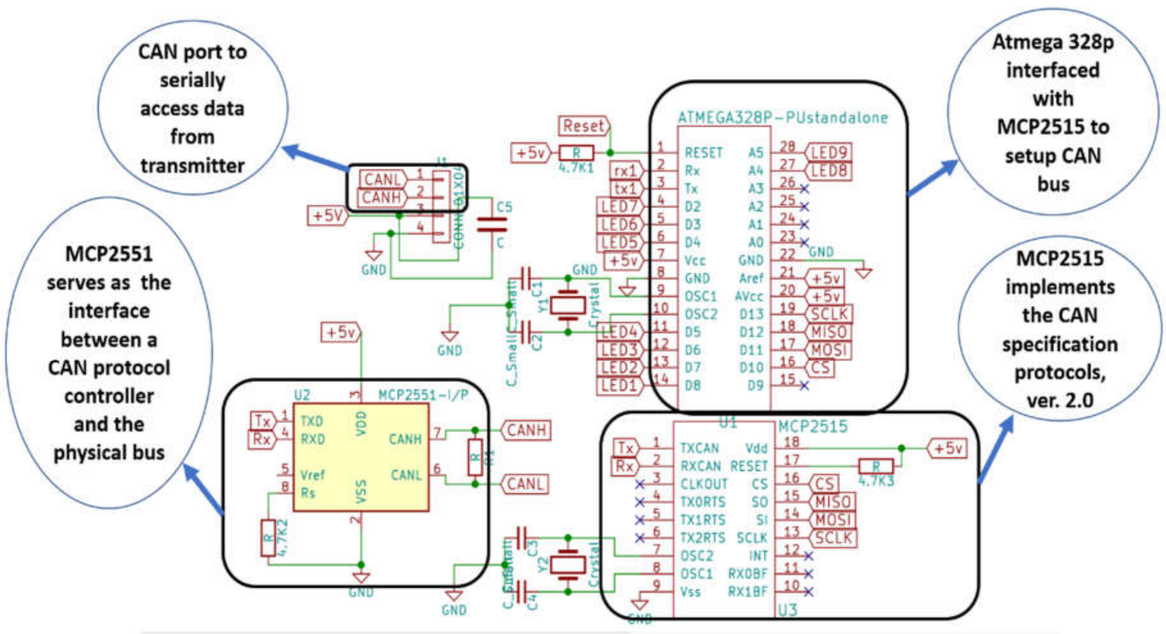
- The system is also integrated with IFC(Ignition Fuel Cut), to eliminate the use of clutch

2. Embedded CAN.

- CAN(Controller Area Network) is a robust vehicle bus standard designed to allow microcontrollers and devices communicate with each other



- The detailed schematic for the CAN bus is given below in figure 2.4

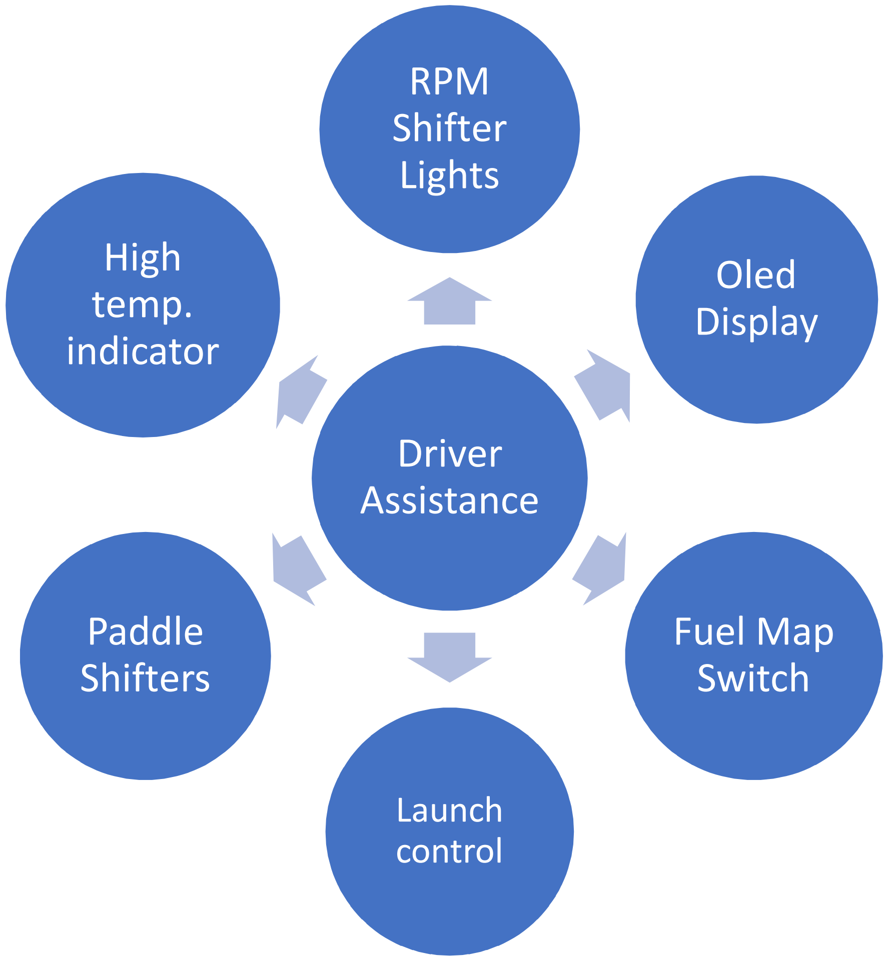


(fig 2.4)

- The CAN bus, operating at 16 MHz clock frequency, helps in channelling data of different sensors as well as engine data from ECU to the required port

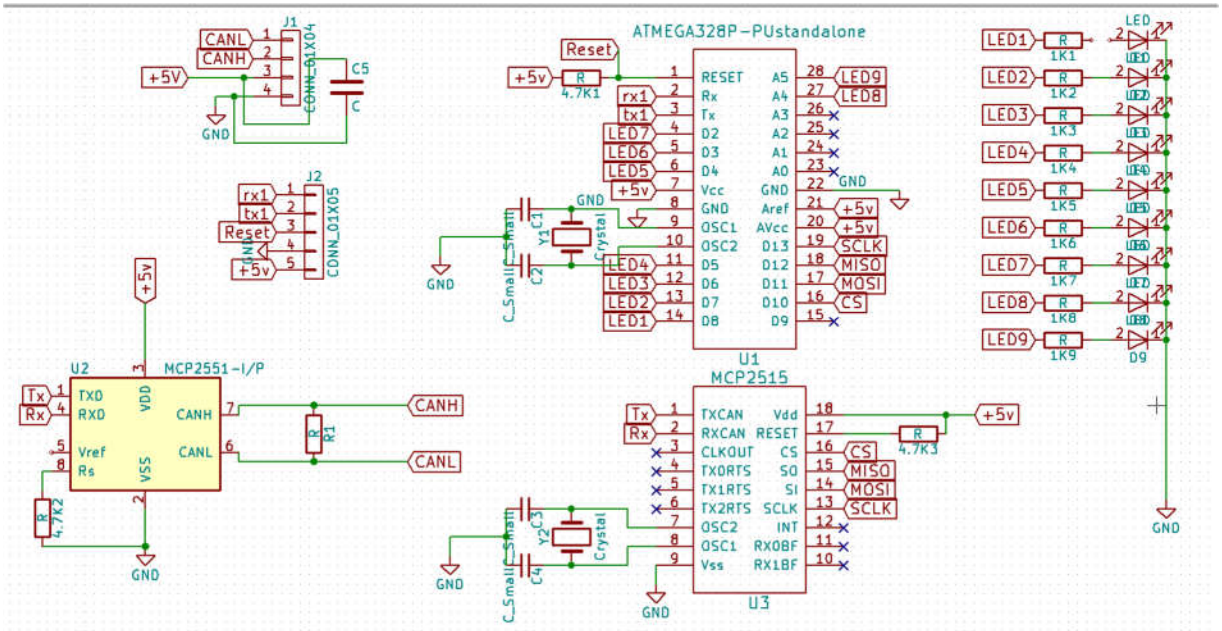
3. Driver Assistance.

- In modern era of Race Car Systems, electronics are designed keeping driver aid and safety in mind. This helps the driver with proper feedback of the necessary data

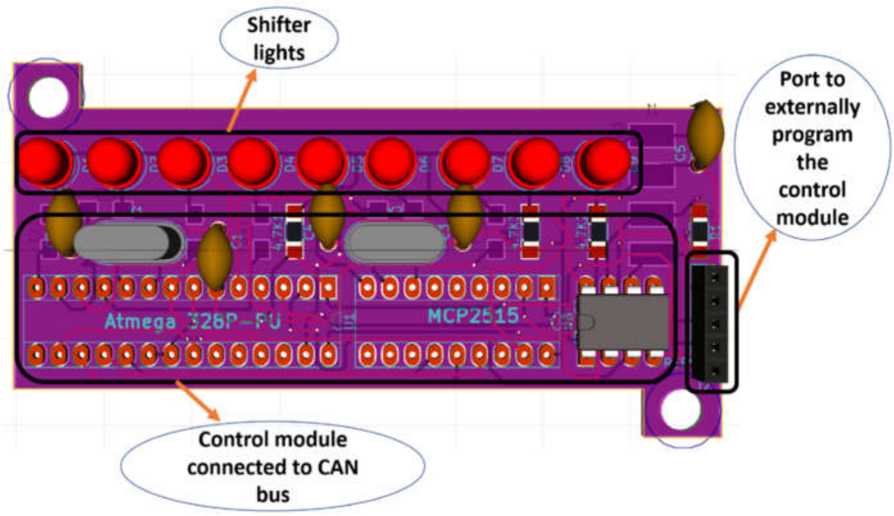


- RPM shifter lights and paddle shifters are integrated in the steering wheel, whereas High temperature indicator, Oled display and Fuel map switch are incorporated in the dash board
- The microcontrollers (Atmega 328p) are connected to CAN (Controller Area Network) interface using SPI protocol

- **Steering wheel**
    - The RPM shifter lights PCB, along with paddle shifters and Launch Control switch has been integrated in the steering wheel
    - The Shifter lights control module gets wheel RPM data, through the CAN bus, which is then coded accordingly
    - Complete schematic and 3-D view of the PCB are given below (in figure 2.5 and 2.6)

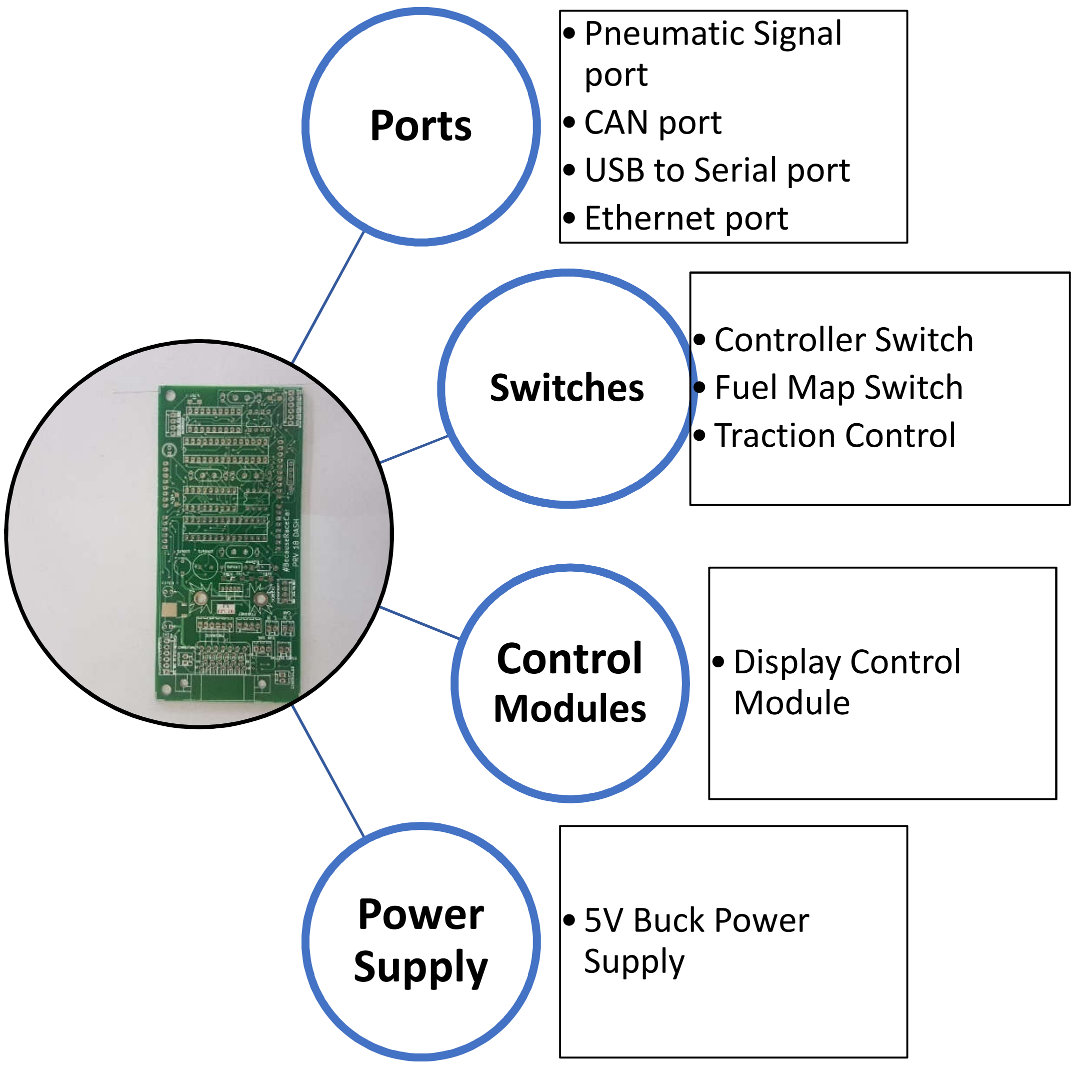


(fig 2.5)



(fig 2.6)

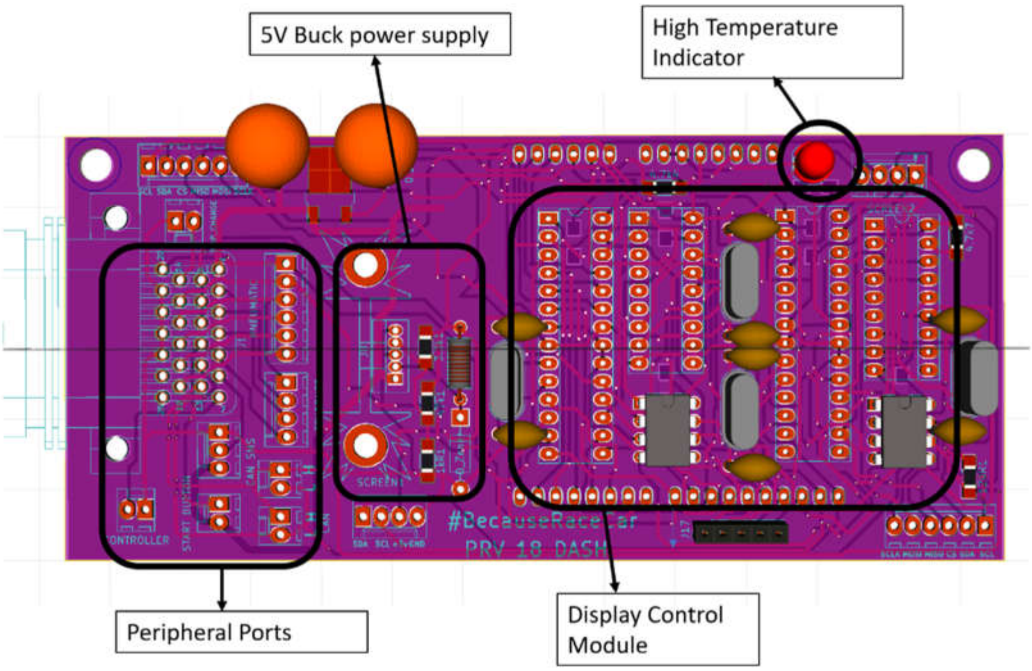
- **Dash Board**
    - It acts as the central hub for main signal distribution and the power shutdown system



The CAN module is integrated in the dashboard acting as a receiver. It broadcasts:

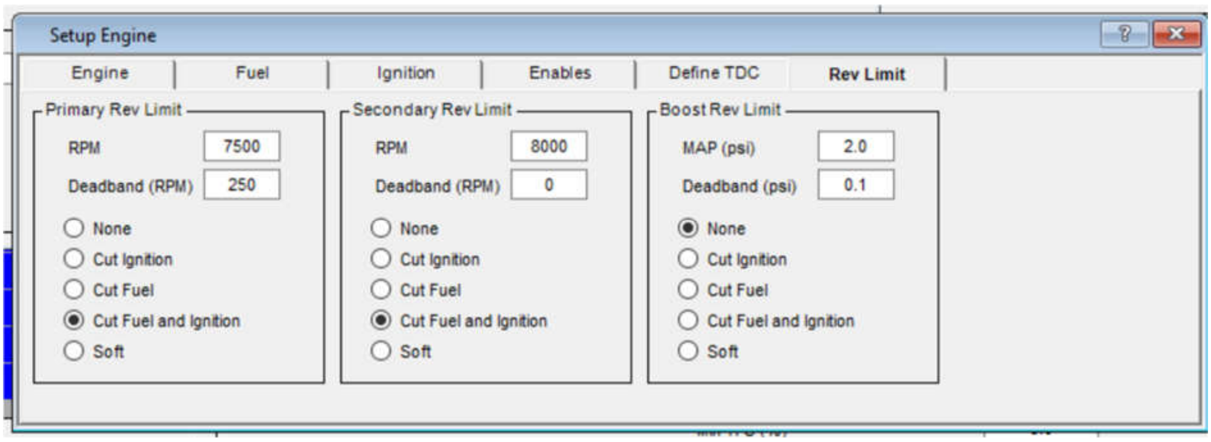
- The engine data such as RPM, temperature, etc. transmitted by the ECU
- Data retrieved from data logger
- Gear position, broadcasted onto CAN from gear control unit

The dashboard is also integrated with a **High Temperature Indicator, Display Control Module(embedded CAN)** and **Peripheral Ports**.(figure 2.7).



(fig 2.7)

- **Launch Control**
  - Launch Control is an electronic aid to assist drivers to accelerate rapidly from a standing start, by avoiding slipping of the drive wheels, engine failure due to over-revving and clutch and gearbox problems
  - It is available only at the start of any dynamic event, so it is used primarily for acceleration events



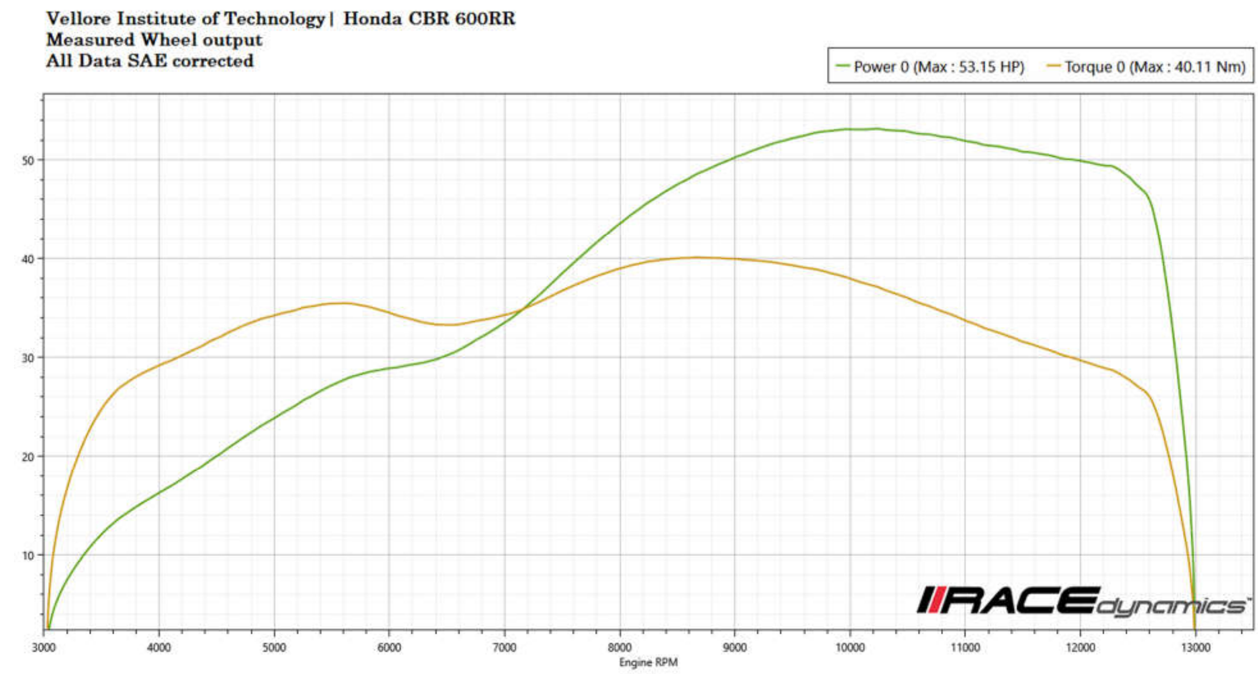
(fig 2.8 above shows the Rev Limit Tab in the ECU tuning software.)

- From the dyno graph given in fig 2.9, the RPM range for maximum torque output was between 8000-9000
- The optimum shifting points as observed at dyno runs were:

  1^{st} – 2^{nd} : 9500-10,000 RPM

  2^{nd} – 3^{rd} : 9000-9500 RPM

  3^{rd} – 4^{th} : 800-9000 RPM



(fig 2.9)

- Based upon the data and multiple test runs, the secondary Rev limit was set at 9000 RPM

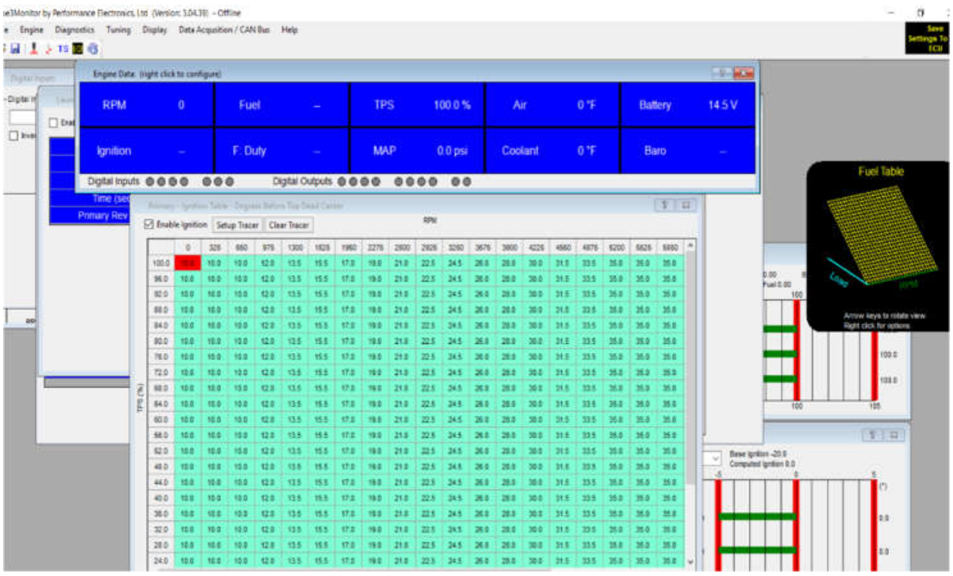
WIRING HARNESS:

1. The ECU.

- An engine control unit (ECU), also commonly called an engine control module (ECM), is a type of electronic control unit that controls a series of actuators on an internal combustion engine to ensure optimal engine performance

(fig 3.1)

- It includes 8 injector drivers and 4 internal ignition coil drivers (up to 8 possible with external igniters or smart coils) and comes in an aluminium enclosure. The ECU comes with peMonitor and peViewer software

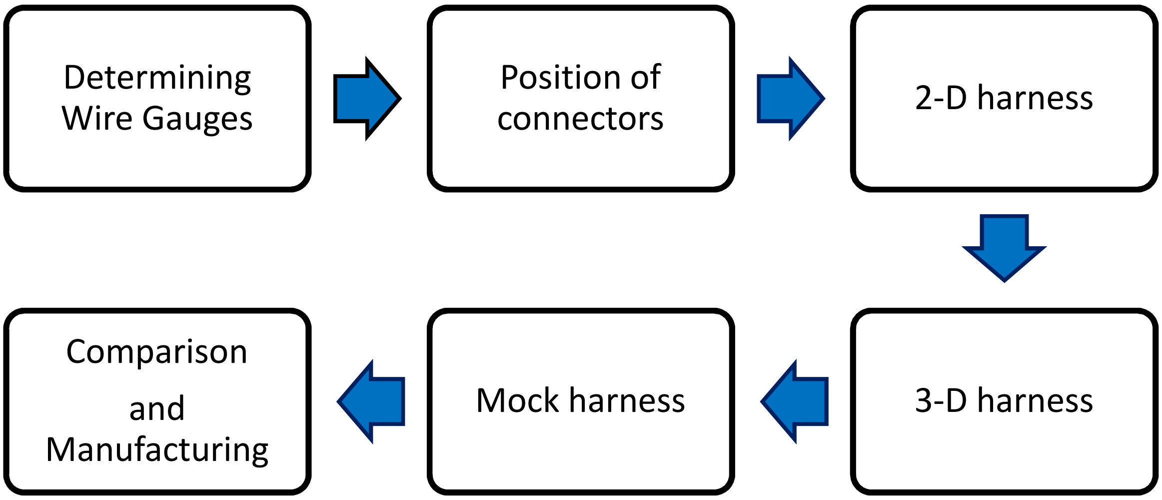


(fig 3.2 given above shows the peMonitor tuning software.)

2. Harness.

- A cable harness, also known as a wire harness, cable assembly, wiring assembly or wiring loom, is an assembly of electrical cables or wires which transmit signals or electrical power

Given Below is the Block diagram for harness design.

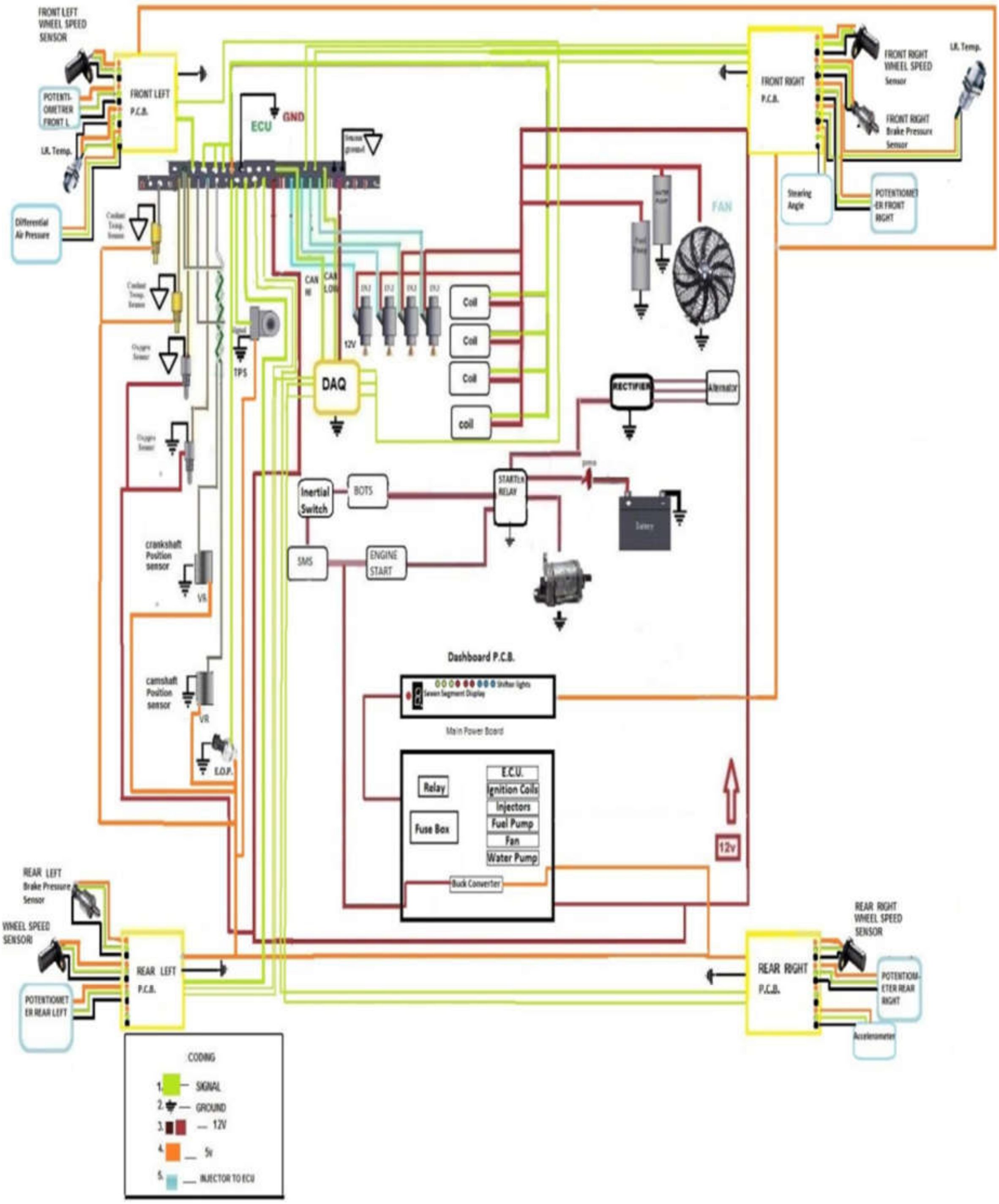


- Through data from current sensor for different loads and their respective lengths, the gauges determined are given in the table below:

LOAD	CURRENT DRAWN (in Amps)	Wire Gauge
FUELPUMP	<=7	18
WATERPUMP	<=7	18
FAN	<=7	18
INJECTORS/ IGNITION COILS	<=5	20
SIGNALS	Few mAmps	24
STARTER MOTOR/ ENGINE GROUND/ BATTERY SUPPLY	30 or more	12

(fig 3.3)

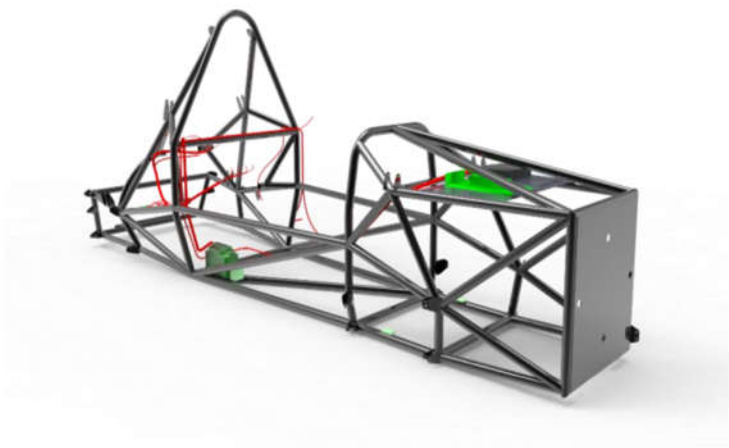
The 2-D layout of the wiring harness is given in figure 3.4.

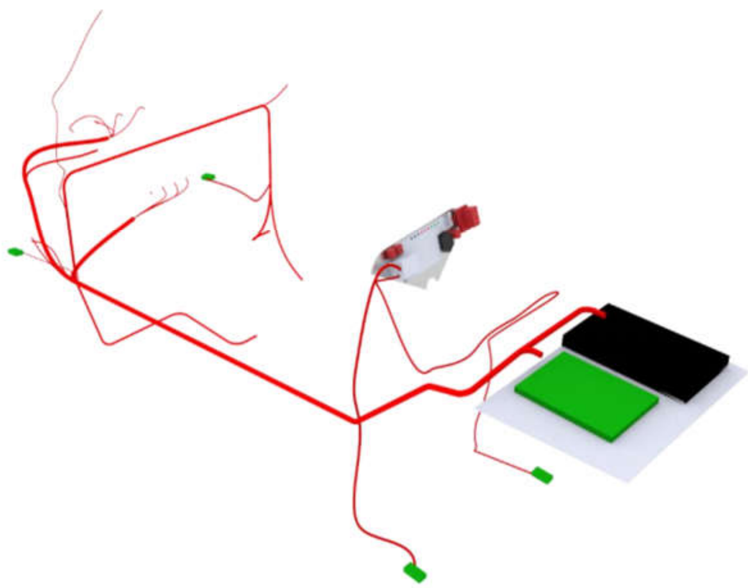


(fig 3.4)

- The 2-D harness gave the idea of the necessary connections required, and the number of wires distributed
- The 3-D harness was then designed keeping shortest and safest path for the wires in mind

The 3-D harness layout is given below (3.5).





(fig 3.5)

- Following the 3-D harness(designed in SolidWorks), Mock harness was laid out, measuring the links from actual chassis

Given below is the Mock harness layout.

(fig 3.6)

Future Scope

1. **Live Telemetry System.**
2. **Development on Traction Control.**
3. **Improving PCB design.**
4. **Using dedicated software for harness design and overall Electrical System thermal analysis.**
5. **Steering Wheel Information display and driver interface.**