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Custom Wiring Harness of FS CAR

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***Abstract*—A Complete wire harness (circuitry) of F-1 vehicle, composed of many different sensors and many parameters of engine which requires certain evaluations and this model deals with the same which is a custom wiring harness of F-1 car at student level. MECHSONIC Racing SAE race car consists of an engine Honda CBR 600 RR and an ECU of PE3. Custom wiring harness is designed, keeping in mind the modelling of FS car. Custom wiring minimizes overall circuitry, provides feasibility and an ease to remove and connect various segments with the help of connectors. This document describes the modelling and designing of FS car wiring harness from the beginning to end.**

Keywords: FSAE, Honda CBR 600 RR engine, PE3 ECU, Relay box, Fuse box, Battery (SHORAI).

I. INTRODUCTION

This paper is a documentation of electrical methods, designing and tools involved for the modeling of wiring harness of FS car which is used on the MR015 MECHSONIC RACING SAE Car, 2015.

Formula SAE® [2] is a student design competition organized by SAE International. FSAE is a competition of student design team to develop a small Formula-style race car, competitions challenge teams of university undergraduate and graduate students to conceive, design, fabricate and compete with small, formula style, competition vehicle. FS car must have very high performance in terms of its acceleration, braking, sensor performance, electronics and electrical wiring. The car must be low in cost, easy to maintain, and reliable. The end result is a great experience for young engineers in a meaningful engineering project as well as the opportunity of working in a dedicated team effort.

Figure 1: MECHSONIC RACING Team's 2015 Vehicle.

II. LITERATURE REVIEW

SAE teams, employs stock wire harness or they design their own custom wire harness in the cars for the competition. We prefer to design the new custom wire harness for our car to avoid the bulkiness of the stock harness and tune it with the programmable ECU-PE3 [1]. This paper entails the

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description of methodologies adopted and fabrication process involved, while designing the new custom wire harness for the car.

Various theories and concepts of the electrical systems and electronics are considered, to design the final circuitry of the complete wire harness suitable methods are chosen. The finalized circuitry is fabricated on the factors of, availability of resources, cost, reliability, ease of designing and its functioning.

III. PROBLEM ANALYSIS

MECHSONIC Racing SAE race car, MR015 utilizes Honda CBR 600 RR [3] in its car and a programmable ECU, PE3. Earlier team uses a stock harness which was reliable but has connections for unused sensors, which are of no use in formula-type race car and some new connections has to be made as per latest rule of events like FS-ITALY and FS-INDIA which limits its usage.

The solution to such limitations is to design a custom wiring harness as per FS-race car design and relative positioning of various electrical components on MR015. The analysis and modeling of wiring harness helps in minimizing the wires, as unused wires and sensors are shorted from this custom harness. It is seen that the battery of the FS-car ideally powers the each electrical component. Custom wiring harness helps to reduce the weight of harness in grams which is among the most significant factor must be kept in mind while designing a formula student-race car.

IV. SYSTEM SETUP

The main objective of designing a custom harness is to minimize the wire, in order to reduce the inconvenience caused by unused wire. This is accomplished by modeling a wiring diagram of MR015 using PE3 wiring diagram and keeping in mind the wiring of stock harness, the wiring is divided in 2 parts. Firstly, wiring the Engine CBR 600 RR (figure: 2 shown is the PE3 wiring diagram) and secondly, wiring the dashboard of FS-car.

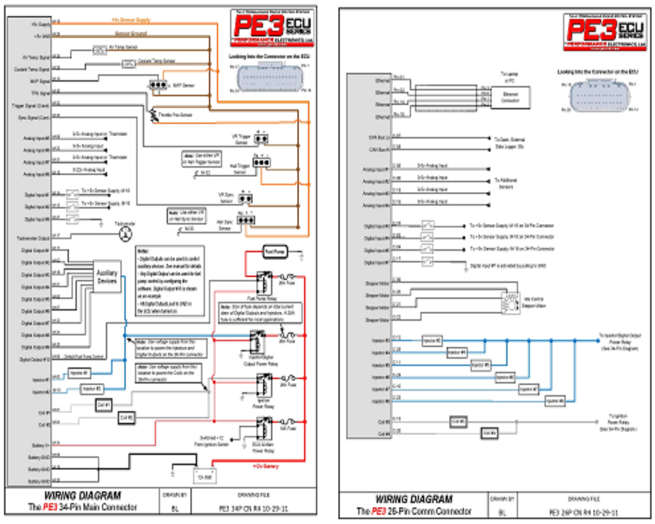

Figure 2: PE3 Wiring Diagram.

Figure 3: Engine Control Unit (Performance Electronics).

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A. *Wiring Engine:*

Engine wiring consists of ignition coils, injector coils, sensors, relay and fuse box which are powered using the Car battery. First we examined the role of each component in FS-Car, so unused components can be shorted from the harness. The following sections are intended to give some basic understanding of engine management.

Fuel Injector - Fuel injectors are high speed solenoid valves that are either open or closed. When the injector is open, fuel is allowed to flow to the engine. When the injector is closed, fuel flow stops to the engine.

High Pressure Fuel Pump - Fuel injected engines require a high pressure fuel pump to provide a constant flow of fuel to the injectors.

Trigger Sensor (Crank) - Many of the functions the PE3 must perform are solely or partially determined by the position of the crankshaft within the engine cycle.

Intake Air Temperature (IAT) Sensor - The IAT sensor measures the temperature of the incoming air charge to the engine.

Coolant Temperature (CLT) Sensor - The CLT sensor is used to measure the coolant temperature of the engine. Like the IAT sensor this information can be used to add or remove fuel or ignition timing to the engine.

Oxygen (Lambda) Sensor [8] - An oxygen, or lambda, sensor measures the oxygen (O2) content of the exhaust. The amount of remaining oxygen in the exhaust can be used to determine the air-fuel ratio (A/F) of the engine in real time.

Ignition Coils - The PE3 ECU can directly drive up to 4 inductive ignition coils using external ignites.

Manifold Absolute Pressure (MAP) Sensor - A MAP sensor measures the Manifold Absolute Pressure in the intake. MAP is commonly used as an indication of engine load.

Throttle Position (TPS) Sensor - Throttle position is one of the most basic measurements used on any engine. TPS can also be used to signal different operating conditions of the engine like idle or wide open throttle operation.

Knock Sensor- Based on vibrations and pressure, knock sensor has a piezoelectric element which creates a voltage signal. Helps to retard ignition timing and protects the engine from knocking. Rest all unused sensors of the engine are shorted.

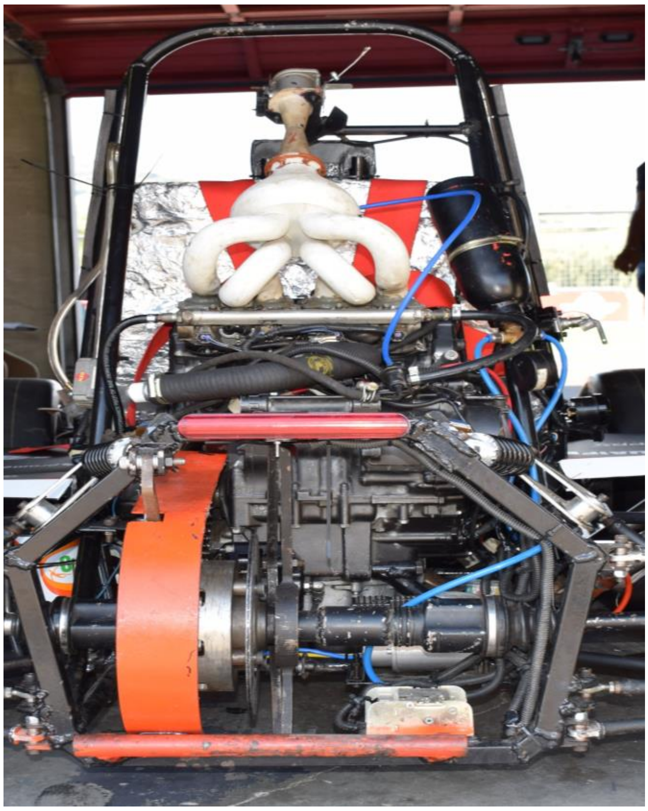

Figure 4: Honda CBR 600 RR engine installed in the MR015 MECHSONIC RACING SAE Car, 2015.

The PE3 begins to run anytime that power is applied. It is necessary to power the ECU off when the engine is not running to avoid depleting

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the vehicle battery. Thereby, Power to the PE3 should be provided through a relay activated with switched +12v power, relay box is positioned in between PE3 ECU and +12v battery supply. In accordance with the applications there are usage of only 5 relays i.e. ECU & Main power relay, fan relay, fuel pump relay, ignition power relay, compressor relay.

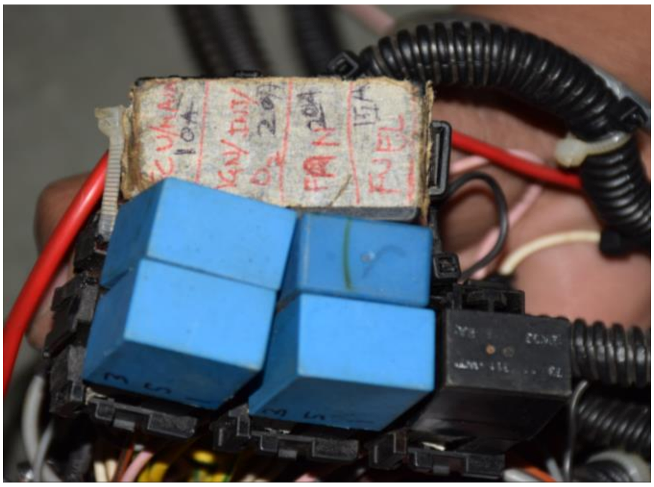

Figure 5: Relay Box.

The main circuitry or device is protected from excessive power draws through fuses, which secures the circuit from over-current and over-voltage. Thereby, fuse box must be designed and needs to be placed in between +12v battery and the main circuitry to be protected. Size of fuse depends upon the total current draw of digital outputs and injectors. There is a main fuse (30 amp) connected directly to the battery for the protection of whole circuitry. Otherwise, fuse of 20amp is sufficient for most applications but ampere ratings vary from application to application. Different fuse must be placed inside the fuse box for the protection of circuitry and ECU, thereby 6 fuses are used i.e. ECU & Main power fuse (10A), fan fuse (20A), ignition fuse (20A), fuel pump fuse (20A), O2 sensor gauge (5A) and compressor fuse (20A).

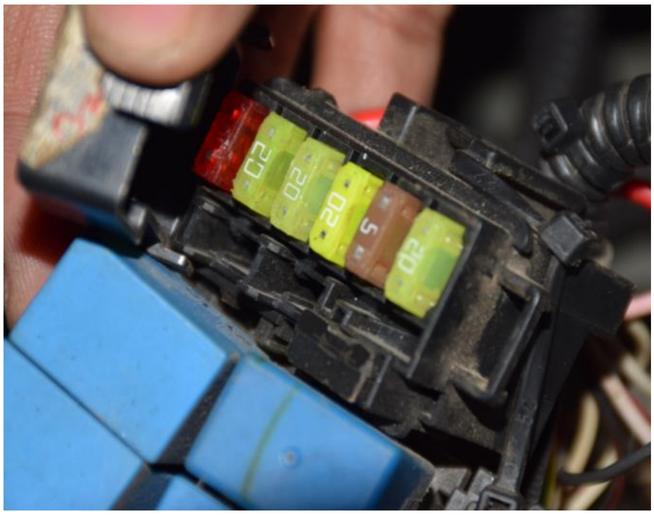

Figure 6: Fuse Box.

B. *Wiring Dashboard:*

The dashboard wiring has to be designed in such a way that it provides complete control and accessibility to the driver. The Switches are placed in the dashboard panel for each electrical applications, provides ease to the driver to switch ON/OFF electrical components. The following sections are intended to give some basic understanding of Dashboard panel.

The right panel of the dashboard consist of 4 switches with led and a starter switch. Switches are used to turn on Fuel system, Ignition of the car, Compressor, Radiator’s Fan. Wiring is designed in such a way that whenever a switch is in ON state corresponding led to the switch glows.

Starter Switch- Starter switch, is a switch in the control system of an internal combustion engine motor vehicle that activates the main electrical systems for the vehicle. The green color push button in figure: 6 is starter switch. *Primary*

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Master Kill switch- The Switch on the left panel of dashboard is a kill switch, purpose of kill Switch in ON state is to cut off the supply of Fuel pump and ignition.

7 Segment display-placed in the center panel of dashboard, display gear positioning (1-N-2-3-4-5-6, where each number represents the corresponding gear).

LCD- The center panel is for 16*4 characters LCD, which is used to display Speed and Rpm of MR015.

Center panel has 2 led, yellow led is the Neutral Indicator (Neutral gear) and the Red led is the Warning Led. Warning Led- Led will be in ON stage only when any of the PE3 ECU pin receives extra current from the circuitry, representing the warning signal that ECU may get damaged. Male and female 16 pin connectors are used to connect the dashboard wiring and harness of FS Car. Use of 16 pin connector is to provide an ease to detach and connect the dashboard wires.

Figure 6: Dashboard.

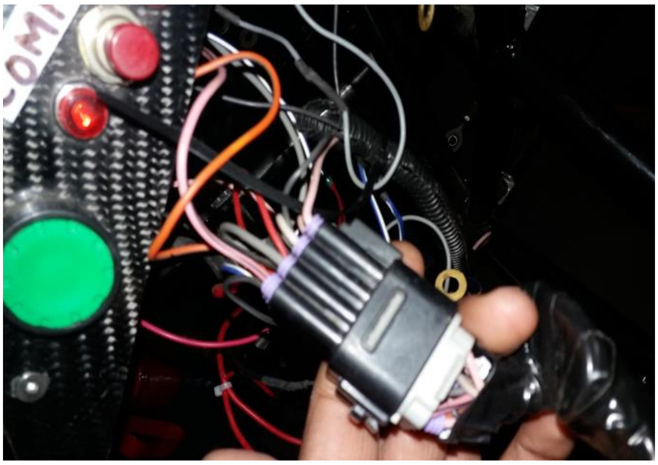

Figure 7: 16 pin dashboard connector.

V. DESIGN IMPLEMENTATION

We tried to implement the highest priority one's first, because usually the list of requirements will keep increasing. The sensors which the team thought would be useful are taken into the account while other sensors are found irrelevant (if we are going as per the rules of the FSAE). Out of 9 sensors, 7 are found to be relevant sensors (CMP sensor, CKP sensor, MAP sensor, O2 sensor, IAT sensor, ECT sensor, TPS sensor) and 2 are found to be irrelevant (Bank Angle sensor, Side stand sensor). Thereby, irrelevant sensors are shorted from the harness.

Equipment for designing custom harness is listed and bought i.e. 6-7 gauge of wires, 4pins, 6pins, 10pins, 16pins male and female connector, Rubber insulations for connectors, to prevent the connectors getting wet, Crimping tools, Crimps for all types of connectors, Cutting tools, Heat shrinks, Electrical tape, Battery terminal.

Selecting the correct cable (wire) gauge ensures the proper voltage and current supply to an electrical device and prevents the cable from overheating. Performance of wire gauge depends on certain factors which are listed. Cable Ampacity- Ampacity is the cable's ampere capacity. The

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resistance of a cable increases as the cross sectional area or gauge decreases. Conversely, cables with a larger cross section have less resistance and thus, a higher ampacity. When current increases to a level high enough to raise the internal conductor temperature to a point that exceeds the maximum temperature rating of the cable, the insulation begins to degrade. Cable (Wire) Gauge Selection- Determine the maximum current (load) the cable is expected to carry, length of cable needed to extend from the power source to the load, maximum ambient temperature to which this wire will be subjected, under all vehicle operating conditions. This helps in selection of wire gauge which differs from application to application.

Custom harness designed and is ready to be tested on our MR015, FS-race car. The connectivity for the complete harness is tested using multi-meter. Next step is to calculate the current and voltage value of each individual components using multi-meter and verify the ratings with value stated in CBR 600 RR service manual.

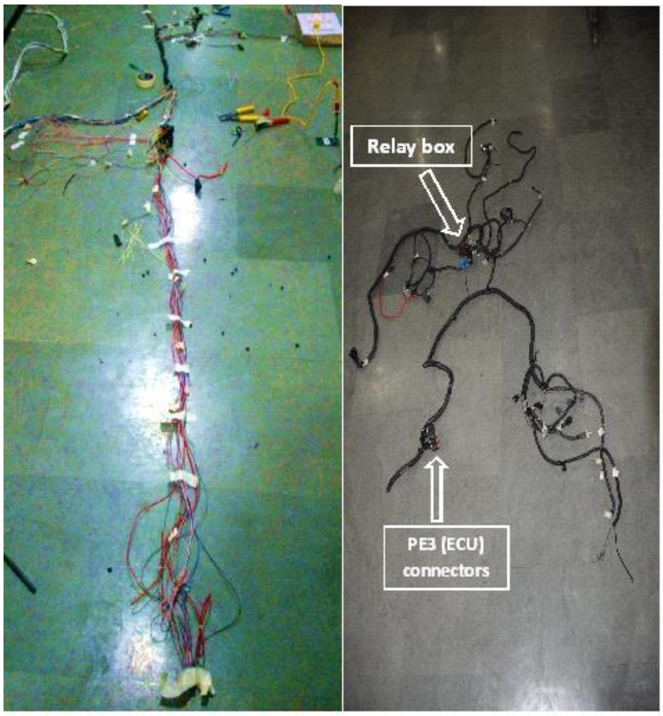

Figure 9: Complete Wire Harness.

Battery Selection: SHORAI battery (Li-ion) [5] powers MR015, FS-race, battery offers certain benefits over other batteries, light in weight (one fifth the weight of lead acid batteries), no use of- explosive gases, acid, lead i.e. battery is environmental friendly, smaller in dimension than other lead acid batteries.

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Figure 8: SHORAI Battery.

Engine and Sensors Tuning: Performance Electronics, PE3 Monitor and PE Viewer Software are used to program ECU (PE3). Software provides a user friendly environment and it is easy to calibrate and map sensors, to start their tuning with the CBR 600 RR Engine. The software provides illustrative form of sensor's data that we could also verify with our already calculated data. Also, with large resolution Air Fuel ratio table, we are able to get exact reading with the help of this software.

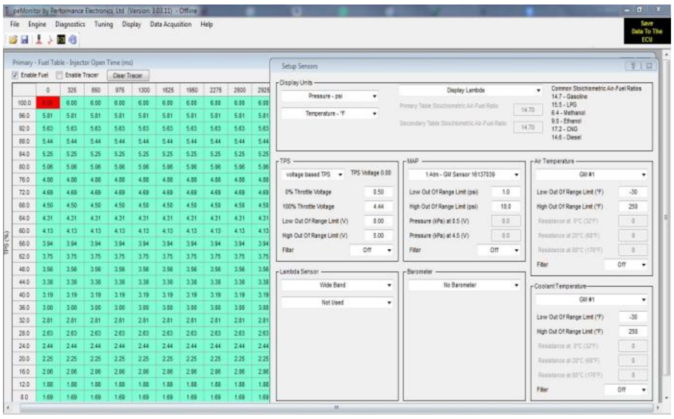

Figure 10: Fuel Air Ratio Table and Sensor data.

VI. CONCLUSION

The Custom harness developed is able to remove the complications of earlier unused wires in stock harness, provides Feasibility of easy to plug and remove from the engine. It also helps in maintaining proper power distribution in the circuitry i.e. powers each component ideally.

In future design, power distribution module can be designed for FS-race car which ensure maximum reliability of power distribution (i.e. absolutely no chances of failure) and further helps in simplification of harness. Power distribution module also helps in overcoming over current and under current failure.

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