IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

# VEHICLE HEALTH MONITORING SYSTEM WITH IOT APPLICATIONS

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***Abstract:*** This paper aims to develop an automotive embedded system which serves as a network of communication between the various subsystems of an automobile, providing information to a local display system for the driver and an IoT platform for storage and visualization. This is achieved by gathering real time data (sensory and actuation) directly from the monitored subsystems while they are in operation, this data is then used as information for monitoring the different parameters of the subsystems with the help of software programs or algorithms to provide predictions, insights and critical recommendation providing a method for vehicle health monitoring. This model doubles as a mode of data acquisition which can be used in coordination with machine learning algorithms, cloud computing and other such data processing techniques to facilitate monitoring of elements like material aging and environmental effects, subsystem life cycles, fleet management, or simple warning systems for performance degradation etc...

***Keywords* - Automotive Embedded Systems, IoT, data acquisition, vehicle health monitoring.**

## I. INTRODUCTION

Vehicles are comprised of an enormous amount of parts which are put together to make a functional subsystem like engine, fuel system, transmission, etc… These hardware components are all complex in structure and costly to manufacture and assemble. The complex operation of these hardware components are optimized with the aid of increasingly complex network of software components. It can be understood that it is tough to keep track of all these components, especially when there is any form of damage or failure. In the current situation most maintenance is performed only when there is tangible / noticeable failure in the vehicle, this form of maintenance is called reactive maintenance, which is costly and time consuming not to mention dangerous, due to the concept of waiting for failure to occur to start with maintenance. For this method to change there is a need to introduce a health monitoring system which can auto diagnose the operating conditions of various subsystems and warn the driver / owner ensuring conversion to predictive form of maintenance improving component and subsystem lifetimes, reducing vehicle servicing and repair costs as well as providing a fault / failure prediction method in vehicles. To meet the requirements to develop a monitoring system some research has been done using the resources presented in the references from [1-10] with other websites and tools [11-13].

## II. LITERATURE SURVEY

References [1], [4], [5], [6], [7] and [9] where referred for the purpose of developing an embedded system to detect specific condition by using sensors to monitor the vehicle parameters, use of data processing techniques to collect and format the sensor data and use of servers or cloud storage to hold the collected data. While [9] and [10] being a review paper was also useful for summarizing the functionalities and threats of a vehicle health monitoring system providing an idea on the improvements it will ensure in the vehicle life cycle while also stating this method as a much needed solution for the need of information to further the research and development of vehicles. The references [2]. [4], [6] and [7] where especially useful to explore the concept of repurposing the sensory data in the ECU (Engine Control Unit) using its CAN (Controller Area Network) connections instead of attaching new sensors and provide a method to display these sensory values to the driver as well. The references [1], [2], [3], [5], [6], and [7] provided an idea for the processing techniques that can be employed to convert the acquired data into useful information. While [2], [3] and [8] were not specifically related to health monitoring it portrayed similarity in concept of data acquisition and processing. There were also multiple other research done related to potential objectives and future scopes of the project concept including material related to self driving vehicles and smart traffic management.

## III. DESIGNING AND SIMULATING THE MODEL

The purpose of this paper is to develop an embedded system which functions as a network of controllers, sensors, displays and IoT components as shown in Fig 1. which can also stream the data onto an IoT platform like "thingspeak" [13] or "blynk", etc.…

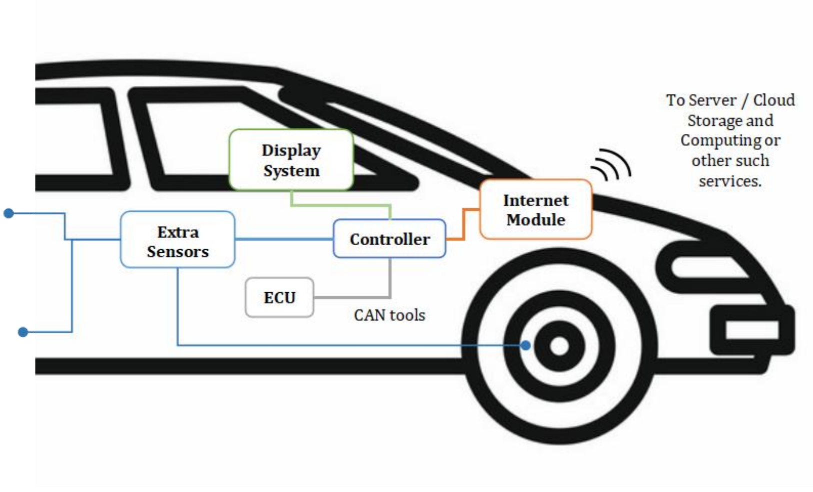



Fig 1: Block Diagram of Proposed Project

First requirement for the model to work is the micro-controller which will act as a base for the electronic network, to which the multitude of sensors will be connected, these sensors will be used to monitor the parameters of various components of the subsystems, then we will need displays for the purpose of illustrating the data acquired from the sensors to the driver / owner of the vehicle, in such a way that they can select what is viewing. This display will also serve as a purpose for warning the driver / owner of any hazards which will be detected using data processing in the micro-controller with the help of sensory data. For the second part we will need IoT related components, usually a module that can provide some form of internet access to the model to stream data from micro-controller onto an IoT platform. We will also need communication port in case we want to directly communicate with the computational device preset in the vehicle. Lastly we will need software starting from simulation software for model development and simulation, then coding software both to code the controller and for computer language programming, then we need IoT platform software to develop an IoT platform where the data is streamed for storage and illustration purposes. We will also require debugging and troubleshooting tools along with some select emulators.

Model simulation was achieved using the “proteus design suit” software where, The developed model as shown in Fig 2 is that of an embedded system which collects data from a temperature sensor and pressure sensor, and then displays this data onto an LCD, while also streaming it through a COM port, from where a computer programming language script coded using python picks the COM port information which gets sent through a Serial port Emulator as shown in Fig 3, decodes the COM port data and uploads it onto an IoT platform using TCP protocols.

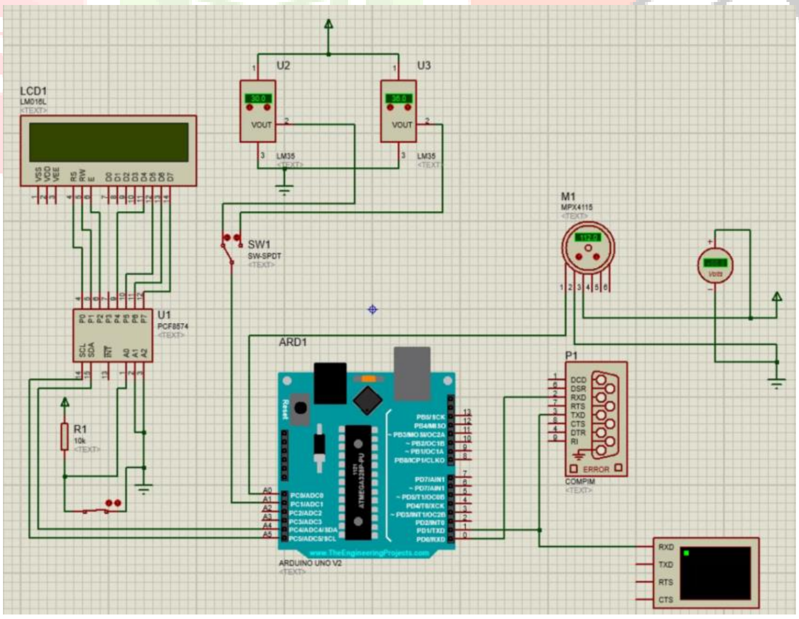



Fig 2: Simulated Model

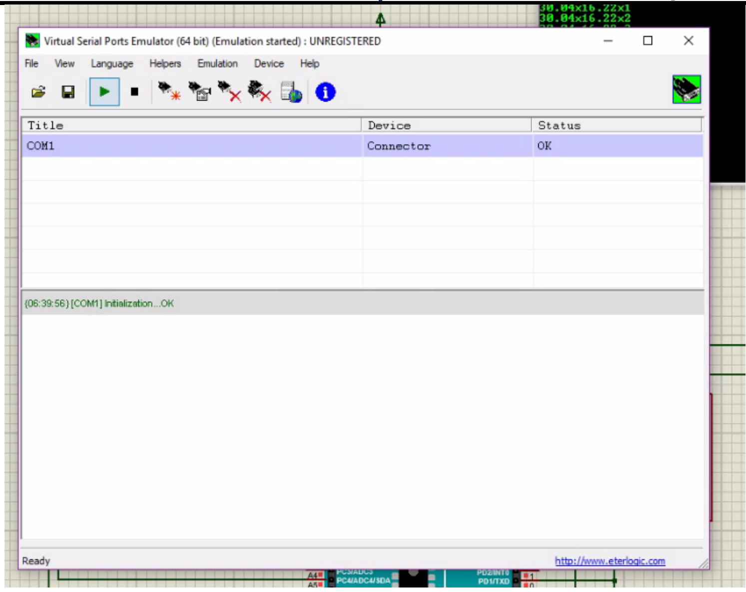



Fig 3: Virtual Serial Port Emulator

The results of running the simulation, is depicted using the fig 4 which shows the streaming of sensory data into the COM port. From fig 5 we can see the Python code decoding the streamed data and converting it into an URL hyperlink which uploads data onto the IoT platform as shown in fig 6.

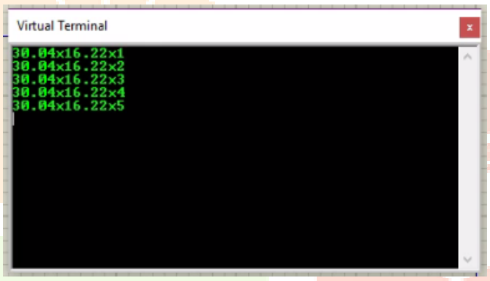



Fig 4: Virtual Terminal for viewing Serial port data in Simulation

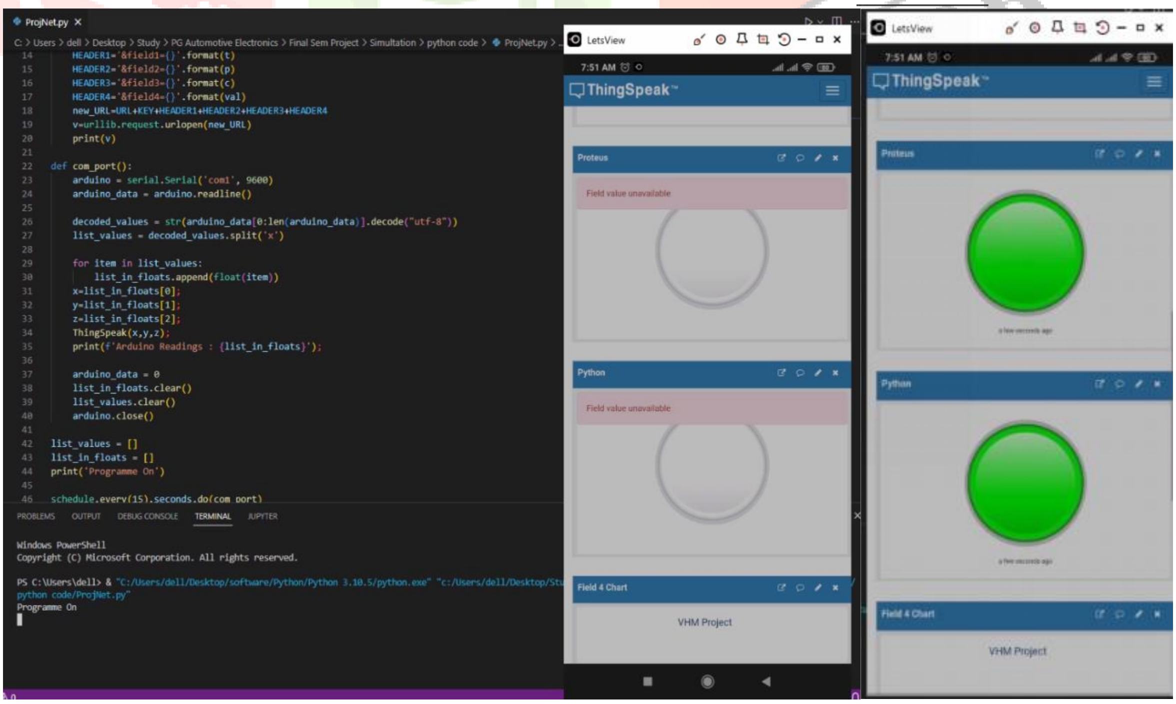



Fig 5: Working of Python script

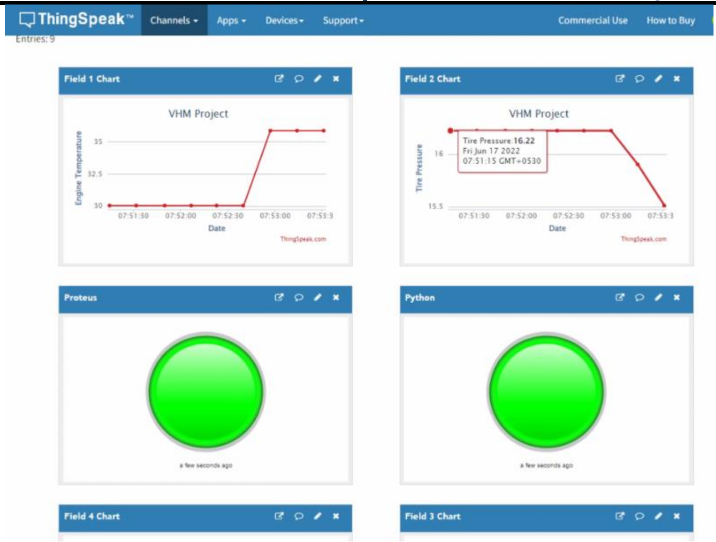



Fig 6: Data illustrated through the IoT platform

## IV. Developing and Interfacing the Prototype

The prototype as depicted in fig 7 is that of an embedded system made using Arduino Uno controller, which is connected to temperature sensors for ambient viz LM35 present on the bread board and Engine temperature sensing using MAX6675 with K type thermocouple module, as well as 16x2 LCD module with I2C backpack for displaying the sensory information and warning system. It also uses an ESP8266 WiFi Module to provide TCP/IP protocols which is used to stream data into an IoT platform.

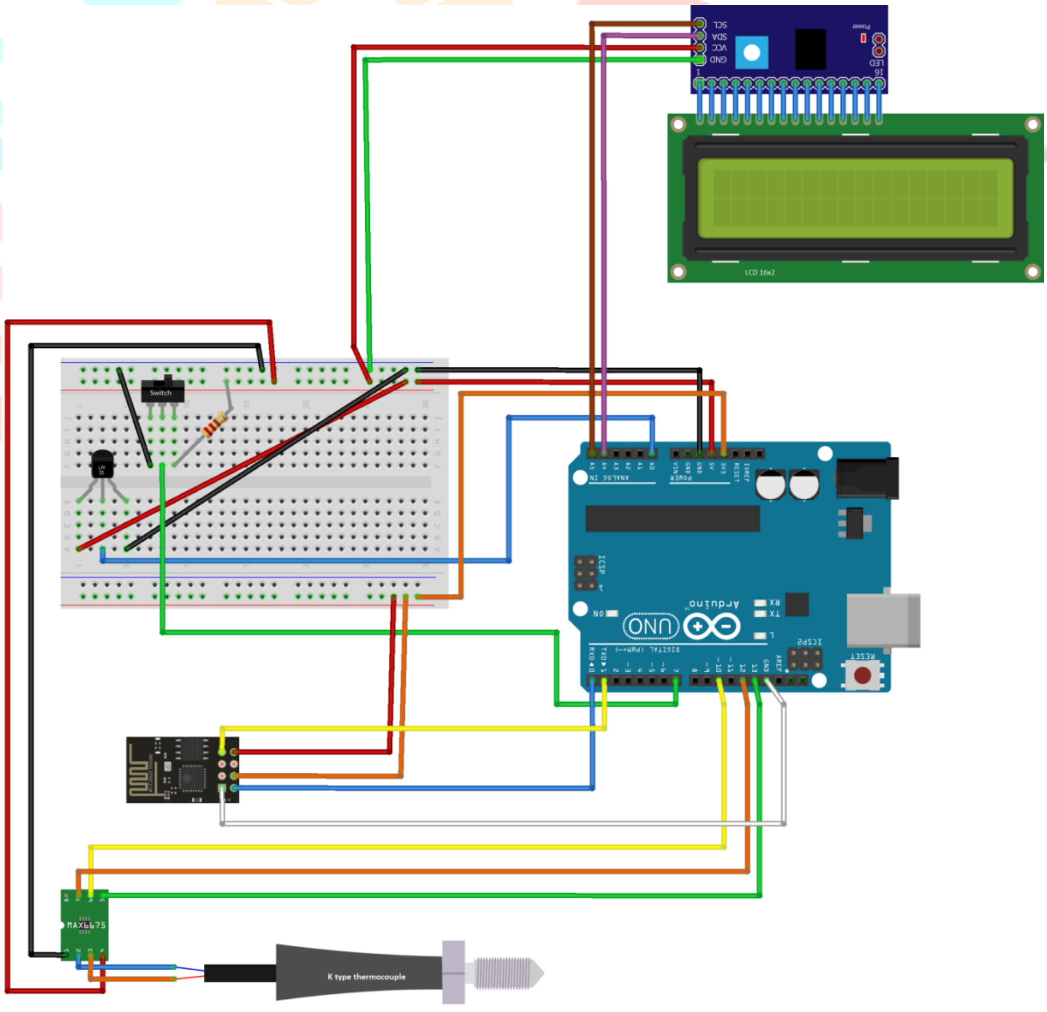



Fig 7: Data illustrated through the IoT platform

While in operation the K type thermocouple is fit onto the engine block while the module hangs off the side wall of the foot space as shown in fig 8, from where it records the engine temperature. The Arduino Controller and bread board with its attached LM35 sensor including the display selector switch will be attached to the Neck of the steering handle as shown in fig 9. While the main display component viz the 16x2 LCD will be attached near to the Speedometer of the steering handle as shown in fig 10.

Fig 8: Attachment of Thermocouple and MAX6675 module

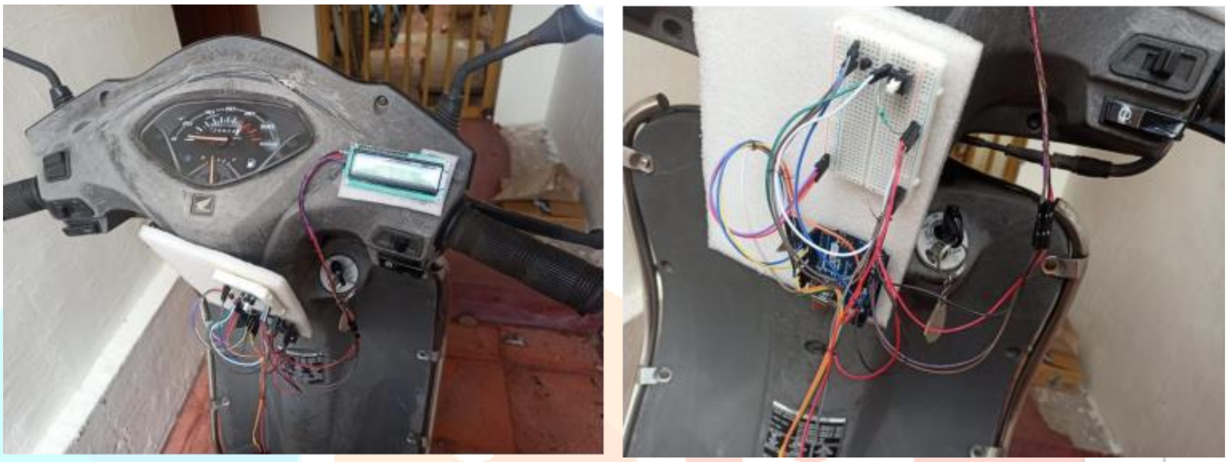


Fig 9: Attachment of Arduino controller and Bread board


Fig 10: Attachment of 16x2 LCD

## V. Experimentation of Prototype

The experimentation carried out after interfacing with moped / 2 wheeler, was by operating the vehicle in 2 cycles, the first one involved idling of vehicle with 50% throttle till the temperature reading reached around the 55 $^{o}$C mark. After which the vehicle was removed from idling and driven uphill at 30-40 km/h speed then downhill at 40-50 km/h speed. The LCD was used to keep track of the temperature during this experiment. The pictures of LCD as shown in fig 11 depicting the temperature value while idling started till the end of idling cycle.


Fig 11: Values of Engine temperature displayed in LCD during the idling cycle

The values of engine temperature during the driving cycle while it was displayed in the LCD could not be recorded using the camera, but the results where recorded and illustrated using the IoT platform which depicts a graph of the recorded engine temperature and ambient temperature vs time. These readings where uploaded in 5 sec intervals through the use of ESP8266 internet module and WiFi provided by mobile hotspot. The illustrations are shown in the fig 12 which was achieved by screen recording the computer screen logged onto the IoT platform while the vehicle was in the idling cycle of the experimentation, whereas the fig 13 depict the IoT illustrations while the vehicle was in driving cycle or normal operation.


Fig 12: Values of Engine temperature illustrated in IoT platform during the idling cycle


Fig 13: Values of Engine temperature Illustrated in IoT platform during the driving cycle

The following results of experiment showed the viability of the prototype as a functional monitoring system, as it could display the data accurately while also streaming it onto the IoT platform.

## VI. Results and Conclusions

This section will compile the results of the experimentation and simulation of the prototype and model -

From the simulation of the model we could observe that the model could successfully function as per design, allowing for display of emulated sensory data onto the LCD which could be controlled using the selector switch to switch between the temperature and pressure displays as shown in Fig 14. We can also confirm the functioning of warning system by observing the change in displayed condition as the parameters strayed from their expected operational range and the switching of its status if the parameter persisted outside the operational range as shown in fig 15. As evidence from fig 4, 5 and 6. we can also verify the functioning of the model if interfaced with a computational system as observed in modern trucks and trains using a COMs port while also proving its effectively streaming data onto the IoT platform where the data gets illustrated and recorded.

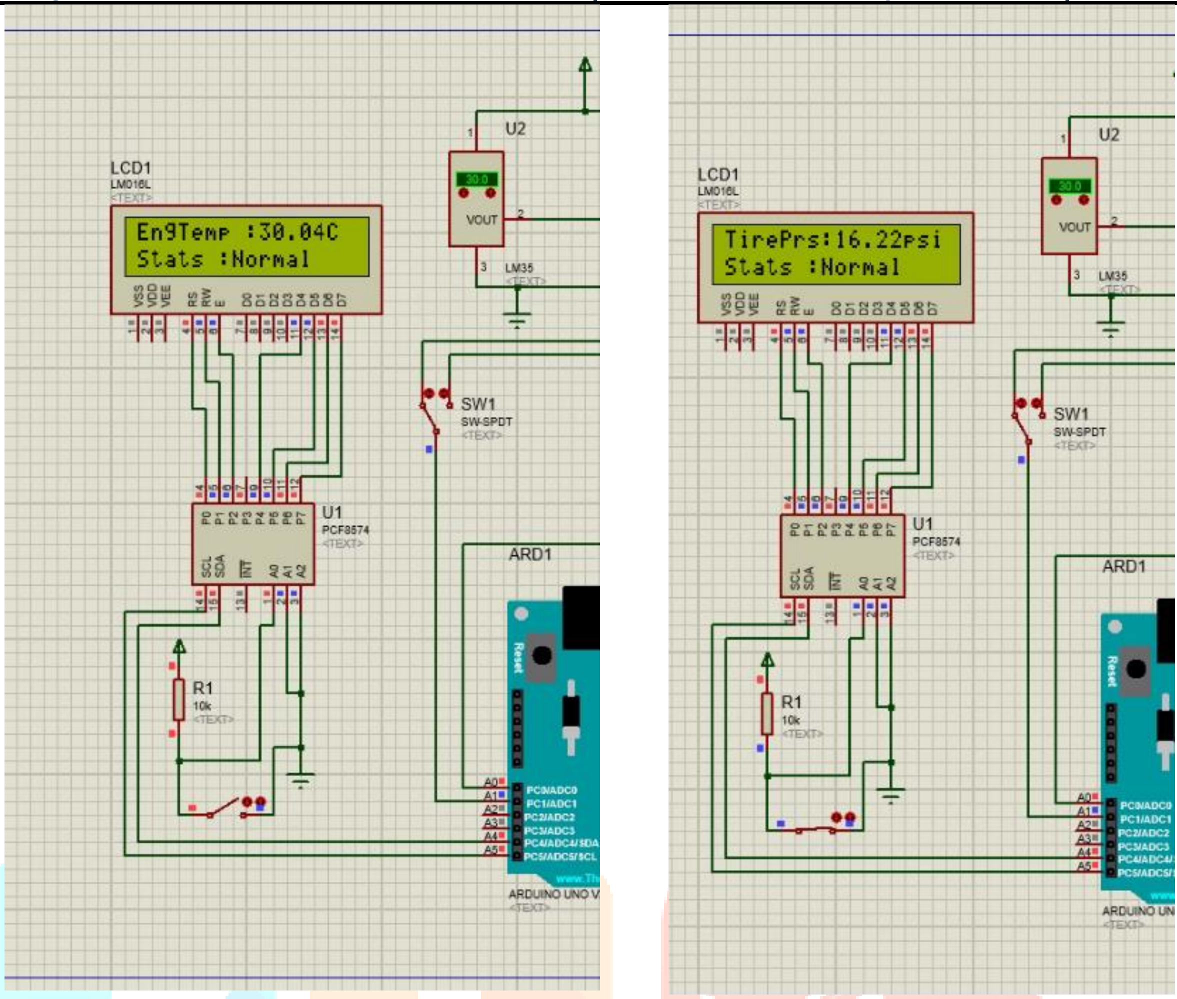



Fig 14: Switching between Engine temperature and Tire Pressure Displays

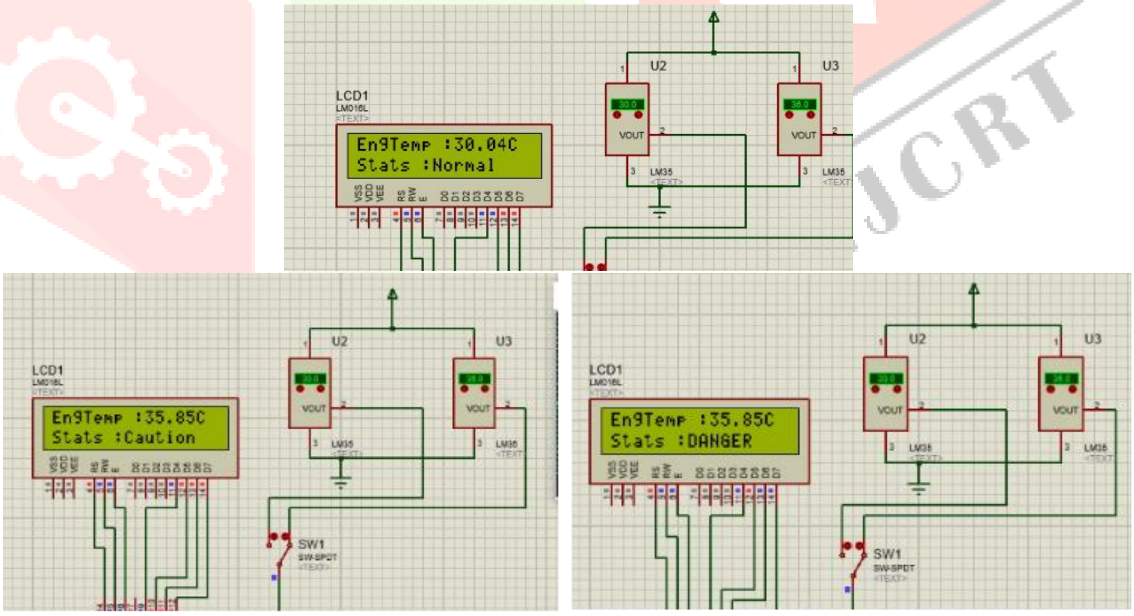
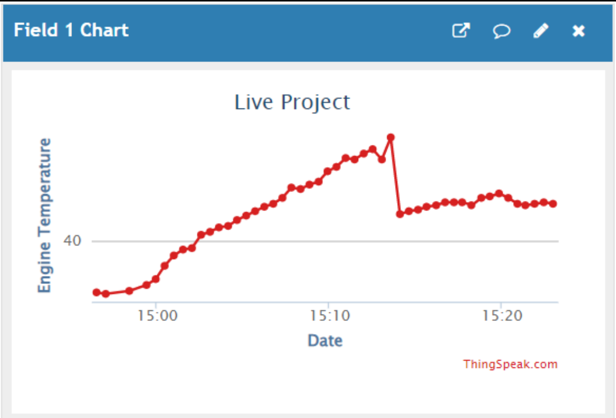



Fig 15: Warning displayed in status of engine temperature as measured parameter exceeds range

From the experimentation of the model we could prove the prototype could function as a real time data acquisition and monitoring system that collected information from the subsystems using the attached sensors as evidence from Fig 11. From the Fig 12 and 13 we could observe that the prototype could also stream the collected data / information onto the IoT platform. It could also be observed that the IoT platform could store and illustrate the collected data successfully. The final readings taken from the experimentation is as shown in fig 16 which represents the data collected by the IoT platform.



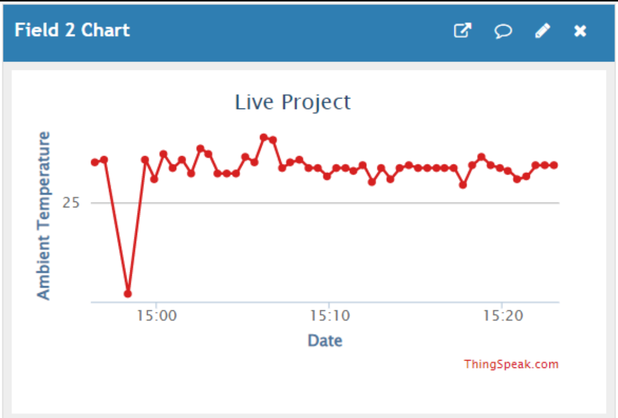




Fig 16: Readings of IoT platform obtained from prototype experimentation

From these results we can conclude the aim of developing cheap and effective vehicle health monitoring system was fulfilled, using which the monitoring of vehicle conditions is made easy for the owner. This also serves as a method for data acquisition to get information of variety of subsystems of the vehicle.

For future endeavors it could be noted that the collected information could be shared with the corresponding service providers will allow them to discern and warn the user and direct them to servicing of vehicle, which is a form of remote monitoring that can be done by original manufacturers and servicing personnel just by sharing the information logged on IoT platform with them. The collected information will also serve its purpose for use in developing improved versions of the vehicle improving the research and development field. This allows the vehicle manufacturers to keep track of their vehicle parameters even after its sold allowing them to provide improved services to their customers.

The use of data sharing can also be done to avail online computing / cloud computing services as well as machine learning to provide various results and estimations of vehicle components and predict its future performance vastly improving its efficiency, This also allows the usage of powerful computational devices remotely, that is data collected from subsystems can be processed in devices that are installed in our homes or service provider locations, through the use of data streaming from the Internet modules.

Inclusions of vehicle monitoring systems allows the vehicle to know its own operating conditions in real time which when integrated with an AI control system can essentially lead to automation of vehicles leading to self driving vehicles. The data of vehicle can be shared with other nearby vehicles for effective traffic management and further improve self driving capabilities. It is also an essential tool used in already existing systems like fleet management and safety systems that are implemented in commercial and military vehicles.

Further development will allow us to develop vehicles with improved subsystems that can provide a more comfortable driving experience and allow for improved efficiency and lifetimes of the vehicle.

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