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Black Box based Battery Management System for E-Vehicle using IoT

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Abstract

The battery is a fundamental component of electric vehicles, which represent a step forward towards sustainable mobility. Though the electric vehicles are introduced domestically, majority of the global transportation still depends on the IC engine. The transition from the conventional IC engine to E-vehicle is very minimum. The main cause for this minimum transition is the issues created by the batteries in the E-vehicles. Recently most of the e-vehicle batteries were experiencing the explosion and general failure issue. The general causes for the explosion and failure of battery is classified into three main categories, Over-heating of the battery, Over-loading of the battery, during accidents. In this paper, we are providing a IoT connected system which continuous monitoring the battery using a microcontroller and preventing all these causes. At the present, the vehicle operation research on slope sections in mountainous areas mainly use statistical analysis to describe the correlations between operating speed and road alignment, which could not explain the vehicle's driving risks with different dynamic characteristics on slope sections. Based on vehicle dynamic analysis, a basic operating speed of a passenger car is achieved by the dynamic model, then the model amended by road factors is acquired to predict the operating speed. The operating speed of passenger cars on some of the slope sections were carried out by LABVIEW programming and GUI visualization. Mostly Battery efficiency will reduce in lower temperature. So travelling to hill stations through E-Vehicles becomes a serious issue. Hence a battery management system is needed and it is achieved through a BMS. This project

utilizes a Battery Management System (BMS) to manage battery cells in Electric Vehicles (EVs). Battery Management System is an automated control system which is employed to prevent batteries in the e-vehicle from explosion and failure. The battery management system can be integrated with the monitoring structure which is capable of both managing, monitoring and logging the data to an online database. This system monitors the battery parameters like voltage, temperature and status of charging and discharging. These parameters are then sent and stored in a database via internet which is then shown to the user by means of an android app.

Keywords: E-Vehicle Charging, IoT connected Battery Management System, Battery Switching Mechanism using IoT, AFS, Automatic braking, LabVIEW, Hill safety, Driving Assist, cruising control, tracking control, hybrid dynamical system, GPS,GSM.

1.INTRODUCTION

The technologies for global transportation are dominated by IC Engine powered vehicle that leads to major threat to Green gas emission. Even though the global transportation technology partially moved to Hybrid fuels and battery electric vehicle. These technology improvement are not attracted the global customer because of its cost and its compatibility. Recently batteries in EV were exploiting due to many reasons. In most of the cases battery overloading is the main cause for the exploitation. Through the continuous monitoring of the battery temperature, the controller will try to maintain a ideal condition (by Cooling mechanism). Battery-shift mechanism is an automated process which is used to improve the battery life and also prevent any trouble takes place due to battery. Mostly the battery can exploit and releases hazardous gases when an accident takes place. The BS-mechanism includes a vibration sensor in the vehicle which when detects the accident makes the battery detached from the supply. This prevents the battery from accident. In addition, the technical level of mountainous highways is relatively low. Due to the terrain limit, there are plenty of gradient sections and long slope, road safety issues become more and more prominent. The reason is that the vehicle's operating speed and design is inconsistent. The most important reason is that the area of irradiation of the front light is not at the proper position which causes low visibility and leads to accidents. Because of this, a new technology of enhancing vehicle driving safety appears which is called Adaptive Front light System (AFS). AFS is a driving safety enhancing system which can adjust front light dynamically based on the angle of the vehicle’s steering wheel, the velocity of the vehicle, the pitching and lateral roll angle of the vehicle, to make sure the best illumination to the front road the research on AFS is gradually being carried out around the world. The vehicle black box system VBBS, The VBBS can contribute to constructing safer vehicles, improving the treatment of crash victims, helping insurance companies with their vehicle crash investigations, and enhancing road status in order to decrease the death rate.

In this charging strategy was discussed deeply through a Photovoltaic (PV)-based Battery Switch Station, which is one of typical integration systems to implement solar-to-vehicle. . From this paper, we have studied a novel charging strategy for the PV-based BSS considering the service availability and self-consumption of the PV energy [1].

Here inferred about (SPEV), it is supported with a charging cable that plugs in to the vehicle and into a 230v wall socket. The electric vehicle have a built in features like security system, drive guidance system, route detection, android app support, Wi-Fi, Battery Update [2].

From this paper, we inferred about how to avoid overloading a EV battery transformer (DT) in a insular area through the means of a new smart electric vehicle (EV) charging scheduler [3].

The contribution of this paper is mainly on a novel charging strategy for the PV-based Battery Switch Station (BSS) considering the service availability and self-consumption of the PV energy. And also the general switching technology [4].

From we observed how to optimize the structure designing in safe charging mode. . It analyses the structure of charging equipment, and introduces the measures of safe charging in two aspects: power grid side charging safety and equipment side charging safety [5].

Here the basic experimental setup required for the internet of things has been studied. The general connection between the controller and the Wi-Fi-module also been analysed and also studied a system which monitors the battery parameters like voltage, current, temperature, power and state of charge. How to send these parameters and to store in a database via internet which is then shown to the user by means of an android app. [6]

From this paper was focused on control model and simulation for Adaptive Front light System (AFS) of vehicles on curve roads. Because vehicles' movement was related to complex dynamics, firstly linear two-degrees-freedom turning model and lateral role model of vehicles were studied. On the basis of these models, this paper put forward control algorithm of adaptive front light on curve roads [7].

Prototype of the Vehicle Black Box System VBBS there can be installed into any vehicle all over the world. This prototype can be designed with minimum number of circuits. The VBBS can contribute to constructing safer vehicles, improving the treatment of crash victims, helping insurance companies with their vehicle crash investigations, and enhancing road status in order to decrease the death rate [8].

Accident detection and collision is optimized using traffic signals and effective traffic management using vehicle class information. From this paper, we infer systematic approach to the above problem statement, outline the drawback of existing models and explain the need of effective traffic management in hairpin curves [9].

In this paper, we are going to prevent the battery with the help of a battery management system, which completely monitors the battery and takes the necessary control actions. Also, every parameters which causes the battery explosion and issues has been analysed and corresponding preventive control action has been programmed in a microcontroller. A battery switching mechanism is incorporated for charging strategy. Charging could be done using both the conventional plug-in method and also using solar panel. In addition the Battery can also be monitored via android app through internet (IoT).

2.BLOCK DIAGRAM

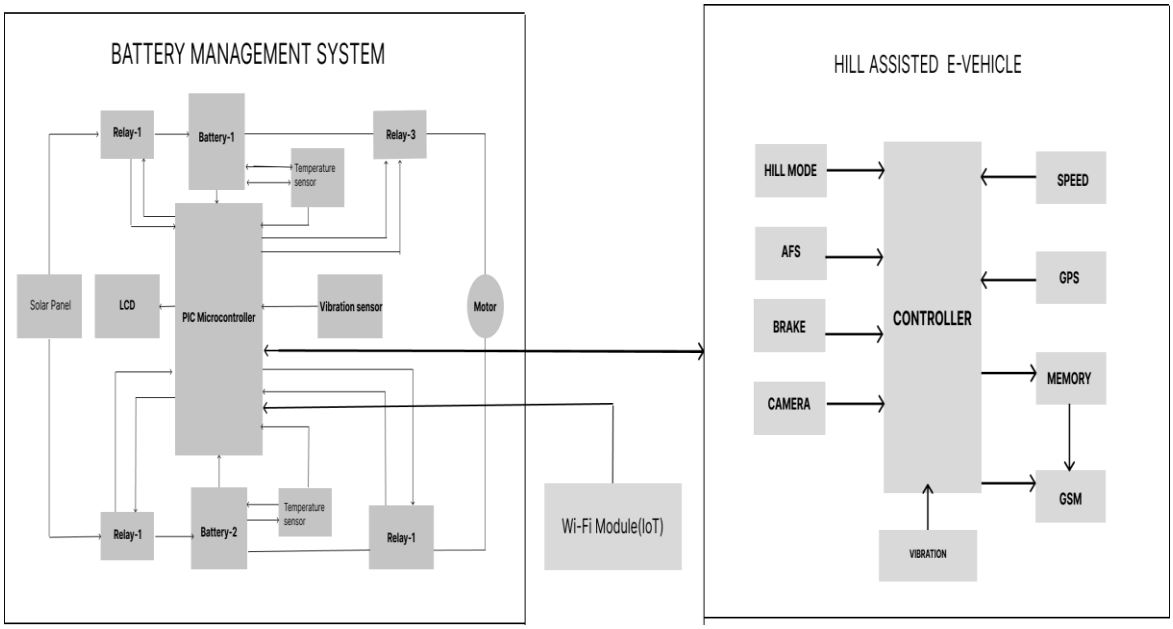

Figure 1 Block diagram of the system

3. HARDWARE DESCRIPTION

3.1 PIC Microcontroller:

The Controller section consist of a Micro-controller which could be any micro-controller such as PIC, Arduino, MyRIO, etc.., Here we are using a PIC micro-controller which are consistent and faulty of PIC percentage is very less. The performance of the PIC microcontroller is very fast because of using RISC architecture. When comparing to other microcontrollers, power consumption is very less and programming is also very easy. More specifically we are using PIC 16F877A The PIC microcontroller PIC16f877a is one of the most renowned microcontrollers in the industry. This microcontroller is very convenient to use, the coding or programming of this controller is also easier. One of the main advantages is that it can be write-erase as many times as possible because it uses FLASH memory technology. It has a total number of 40 pins and there are 33 pins for input and output.

PIC16F877A is used in many devices. PIC16F877A also have much application in digital electronic circuits.

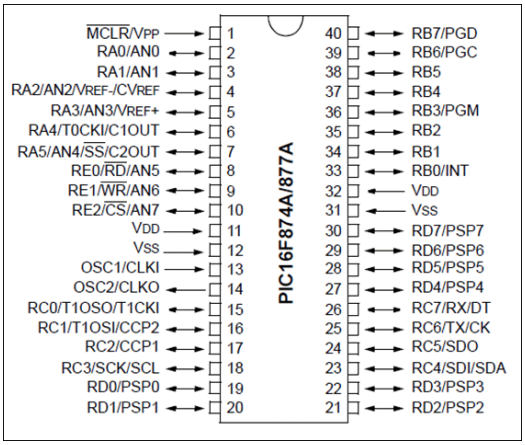

Figure 3.1.1 Pin Configuration of PIC16F877A

3.2 NodeMCU:

In IoT section a Wi-Fi module called NodeMCU is used. NodeMCU is an open source development board and firmware based in the widely used ESP8266 -12E Wi-Fi module. It allows you to program the ESP8266 Wi-Fi module with the simple and powerful LUA programming language or Arduino IDE. With just a few lines of code you can establish a Wi-Fi connection and define input/output pins according to your needs exactly like arduino, turning your ESP8266 into a web server and a lot more. It is the Wi-Fi equivalent of Ethernet module. Now you have internet of things real tool. With its USB-TTL , the nodeMCU Dev board supports directly flashing from USB port. It combines features of WIFI access point and station + microcontroller. These features make the NodeMCU extremely powerful tool for Wi-Fi networking. It can be used as access point and/or station, host a webserver or connect to internet to fetch or upload data.

Features:

- Finally, programmable Wi-Fi module.
- Arduino-like (software defined) hardware IO.
- Can be programmed with the simple and powerful Lua programming language or Arduino IDE.
- USB-TTL included, plug & play.
- 10 GPIOs D0-D10, PWM functionality, IIC and SPI communication, 1-Wire and ADC A0 etc
- Wi-Fi Networking
- Event-driven API for network applications.
- PCB antenna.

Figure 3.2.1 Wi-Fi Module Node MCU

3.3 LM-35 :

LM35 is a temperature sensor that outputs an analog signal which is proportional to the instantaneous temperature. The output voltage can easily be interpreted to obtain a temperature reading in Celsius. The advantage of lm35 over thermistor is it does not require any external calibration. The coating also protects it from self-heating. Low cost (approximately $0.95) and greater accuracy make it popular among hobbyists, DIY circuit makers, and students. Many low-end products take advantage of low cost, greater accuracy and used LM35 in their products. It's approximately 15+ years to its first release but the sensor is still surviving and is used in any products.

LM35 Temperature sensor Features:

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Suitable for Remote Applications
- Operates from 4 V to 30 V
- Less than 60-µA Current Drain
- Low Self-Heating, 0.08°C in Still Air

Figure 3.3.1Temperature Sensor LM35

3.4 SW-420:

Vibration sensor module SW-420 based on the vibration sensor SW-420 and Comparator LM393 to detect if there is any vibration that beyond the threshold. The threshold can adjust using an onboard potentiometer. When this no vibration, this module output logic LOW the signal indicates LED light, and vice versa.

If the module does not vibrate, the vibration switch was on the close state, the output of low output, the green indicator light. The product vibrates, vibration switches momentary disconnect, the output is driven high, the green light does not shine.

The output can connect to the microcontroller, which to detect high and low level; so as to detect whether the environment exists vibration, play a role in the alarm.

Figure 3.4.1 Vibration Sensor SW-420

3.5 Lead-acid battery:

Lead acid batteries are the most commonly used type of battery in photovoltaic systems. Although lead acid batteries have a low energy density, only moderate efficiency and high maintenance requirements, they also have a long lifetime and low costs compared to other battery types. One of the singular advantages of lead acid batteries is that they are the most commonly used form of battery for most rechargeable battery applications (for example, in starting car engines), and therefore have a well-established established, mature technology base**.**

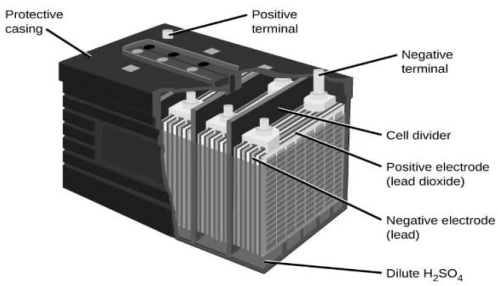

Figure 3.5.1 Lead-acid Battery

3.6 Solar Panel:

For this paper we are using a 10W 12Volts 36-cell Solar Panel (41 x 30 cm) for DIY Projects is ready to use without requiring a frame or special modifications. We have chosen to sell these Polycrystalline solar cells because they are Laser cut to the proper size and encapsulated in the special sun and weather-resistant materials which give them unique characteristics. You will not regret using such high performance, compact solar cells.

The 12v 10W mini Solar Panel has Polycrystalline solar cells which are encased and protected by a durable outer poly frame. This 3v 150mA mini Solar Panel for DIY Projects is light weighted, very strong and weather-resistant substrates or injection moulded trays custom-designed for the target product. These Small Epoxy Solar Panels are simple to install or add to your existing product and their construction requires no frame or special modifications. Polycrystalline solar cells have 2 to 3 times the power of amorphous thin-film solar panels. Very small space is required for installation and to connect 12v Solar Panel, just solder or crimp to the copper tape.

Figure 3.6.1 Solar Panel 12V 10W

3.7 myRIO:

myRIO is a portable device and students can easily use it for the design and control of robots and may other systems quite efficiently. It operates on the frequency 667 MHz myRIO has dual core ARM cortex A9 programmable processor. It has a Xilinx Field Programmable Gate Array (FPGA). FPGA support in myRIO helps the students to design real life developing systems and to solve real problems quite faster as compared to the other micro controllers. Using FPGA support we can avoid the complicated syntax used in C language and in many others. We just have to create logic instead of writing the complicated code with the proper syntax. So, it has reduced the student’s difficulties while designing complicated systems. It is student friendly device and is very easy to use. The processing speed of myRIO is quite higher than the standard micro controllers. So, it can be used t solve real life problems and it can be easily used in efficient systems which need a quick output response. It supports different languages e.g. C, C++ and graphical language (FPGA). The further detail about NI myRIO will be provided later in this article.

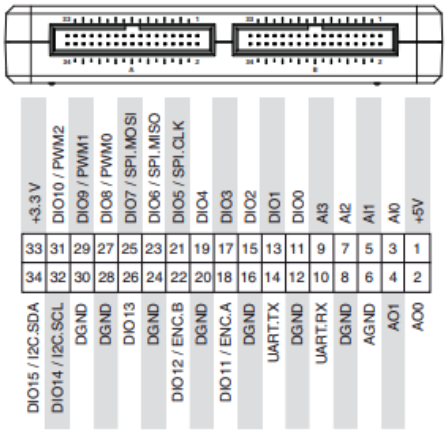

Figure 3.7.1 myRIO pin out Diagram

3.8 Black Box:

In science, computing, and engineering, a black box is a device, system, or object which produces useful information without revealing any information about its internal workings. The explanations for its conclusions remain opaque or “black. “Financial analysts, hedge fund managers, and investors may use software that is based on a black-box model in order to transform data into a useful investment strategy. Advances in computing power, artificial Intelligence and machine learning capabilities are causing a proliferation of black box models in many professions, and are adding to the mystique surrounding them. Black box models are eyed warily by potential users in many professions. As one physician writes in a paper about their uses in cardiology: "Black box is shorthand for models that are sufficiently complex that they are not straight forwardly interpretable to humans.

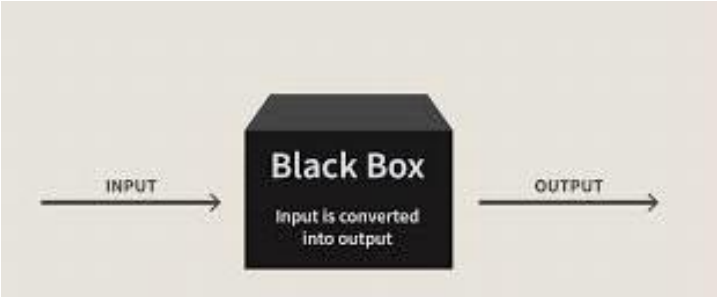

Figure 3.8.1 Black box block diagram

3.9 GPS:

Global positioning system (GPS) it provides users with positioning, navigation and timing (PNT) services. This system consists of three segments “SPACE SEGMENT, CONTROL SEGMENT, and USER SEGMENT”.

It provides geo location and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites. Using GPS, we can position the vehicle where accident took place with the co-ordinates, we can act accordingly.

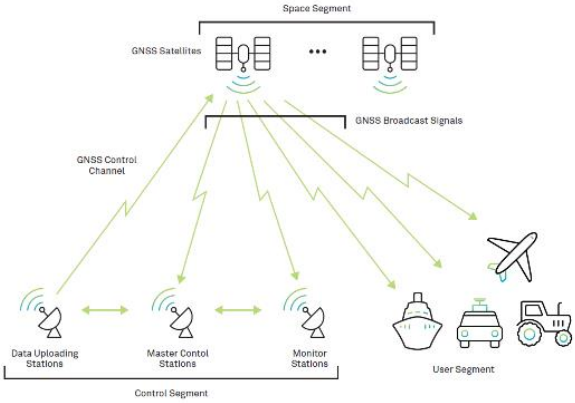

Figure 3.9.1 GPS working model

4. SOFTWARE DESCRIPTION

4.1 MPLAB IDE

MPLAB IDE is a free, integrated toolset for the development of embedded applications on Microchip's PIC and dsPIC microcontrollers. MPLAB IDE runs as a 32-bit application on MS Windows, is easy to use and includes a host of free software components for fast application development and super-charged debugging. MPLAB IDE also serves as a single, unified graphical user interface for additional Microchip and third party software and hardware development tools. Moving between tools is a snap, and upgrading from the free software simulator to hardware debug and programming tools is done in a flash because MPLAB IDE has the same user interface for all tools.

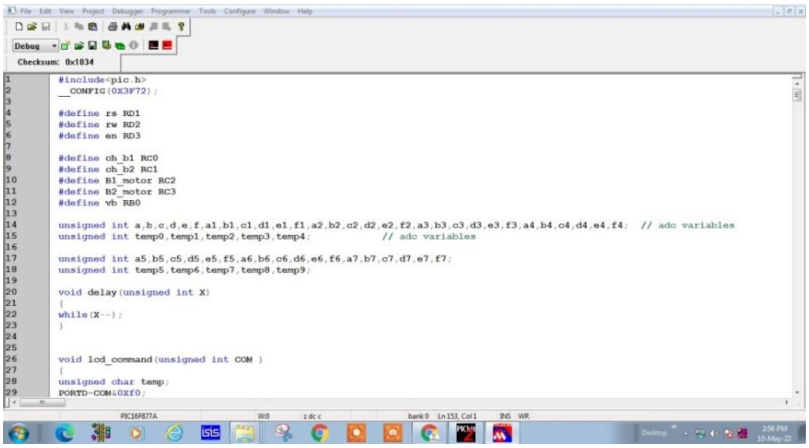

Figure 4.1.1 MP LAB IDE

4.2 Arduino Sketch IDE:

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus. It connects to the Arduino hardware to upload programs and communicate with them. Here the wifi-module (ESP8266-12E) has been programmed with the help of the Arduino Sketch IDE. This module which when connected to the desired network will start communicating with the free cloud storage called "Cayenne". The program has been coded in such a way that certain parameters will be shared to the cloud storage via this module.

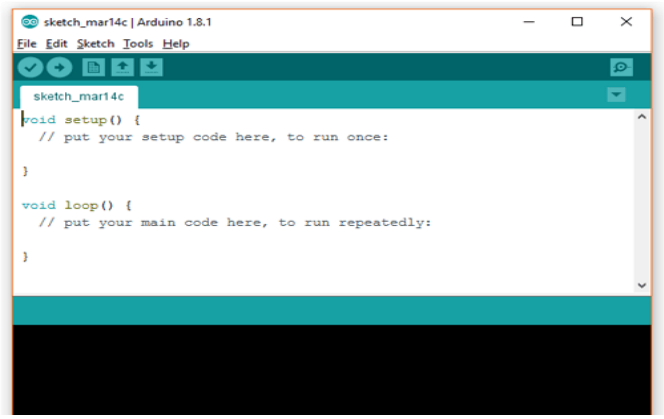

Figure 4.2.1 Arduino Sketch IDE

4.3 LABVIEW:

LabVIEW (**Lab**oratory **V**irtual **I**nstrument **E**ngineering **W**orkbench) is a graphical programming environment which has become prevalent throughout research labs, academia, and industry.

It is a powerful and versatile analysis and instrumentation software system for measurement and automation. Its graphical programming language called G programming is performed using a graphical block diagram that compiles into machine code and eliminates a lot of the syntactical details.

LabVIEW offers more flexibility than standard laboratory instruments because it is software-based. Using LabVIEW, the user can originate exactly the type of virtual instrument needed and programmers can easily view and modify data or control inputs. The popularity of the National Instruments LabVIEW graphical dataflow software for beginners and experienced programmers in so many different engineering applications and industries can be attributed to the software's intuitive graphical programming language used for automating measurement and control systems.

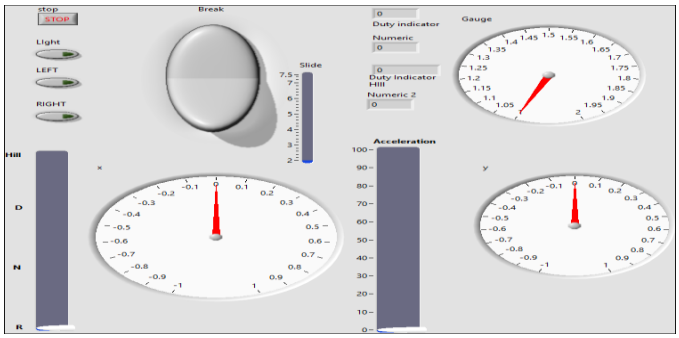

Figure 4.3.1 LABVIEW Front Panel of Hill Assist and Black Box in Four Wheelers

5. EXPERIMENTAL SETUP/HARDWARE PROTOTYPE

The below figure depicts the hardware prototype that has been developed to realize the proposed methodology. The tests were conducted using the below experimental setup.

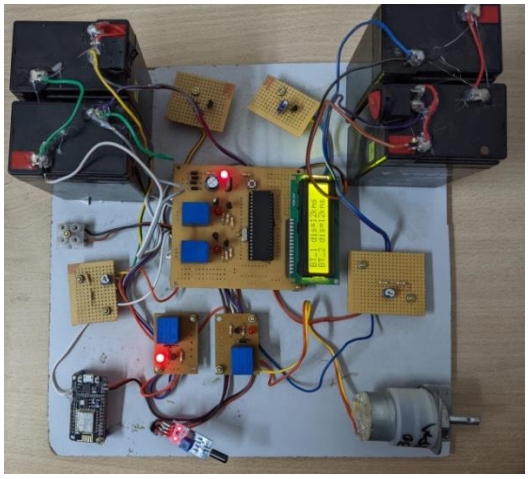

Figure 5.1.1Experimental setup

6. PROCESS DESCRIPTION

6.1 OVERALL OPERATION

Generally we can classify the operation of this Battery Management System into three categories. As we discussed earlier in this paper, the ultimate objective is to protect and prevent the batteries of the electric vehicles from explosion. This could be achieved by analyzing the parameters causing the battery explosion and failure. When we sort out the parameters by impact created, the temperature would be at the top, followed by the overloading of the battery and some explosion can also takes place during an accident. The operation is continuous monitoring all these parameters and taking necessary control actions through the controller.

6.2 TEMPERATURE MONITORING

As the temperature is the primary concern in the battery explosion, it should be monitored continuously. The temperature sensor (LM35) is three terminal linear temperature sensor from National semiconductors. It can measure temperature from-55 degree celsius to +150 degree celsius. The voltage output of the LM35 increases 10mV per degree Celsius rise in temperature. LM35 can be operated from a 5V supply and the stand by current is less than 60uA. This sensor is well-known for measuring the surrounding temperature with a wide range. The sensor will be mounted in a way which near enough to measure the temperature of the battery. It should be interfaced with the controller which will display the temperature in the LCD screen. For example, BT1 TEMP : 34, and the controller will also uploads the data to the cloud through the wifi-module. If the temperature exceeds the threshold, the controller will send the alert message to the LCD screen as “High Temp Detected Reduce the Speed-limit”, and will also boost up the default cooling system installed for the battery.

6.3 BATTERY SWITCHING MECHANISM

Battery Switching Mechanism (BSM) is a simple switching technique implemented in order to prevent the over-loading of the battery. Over-loading the battery beyond the limit will also be a factor for the explosion. When a battery is charging for a longer period of time, high current will flow through the battery which causes the affects the battery performance. This could be prevented through this BSM technique, initially the battery should be divided into two as battery1 and battery2, if battery1 is charging, then the vehicle will run through the battery2 and vice-versa. When the system gets on, the controller will start comparing the voltage level of the two battery, the below is the logic behind the BSM, using this technique will reduce the failures due to the overloading of the battery.

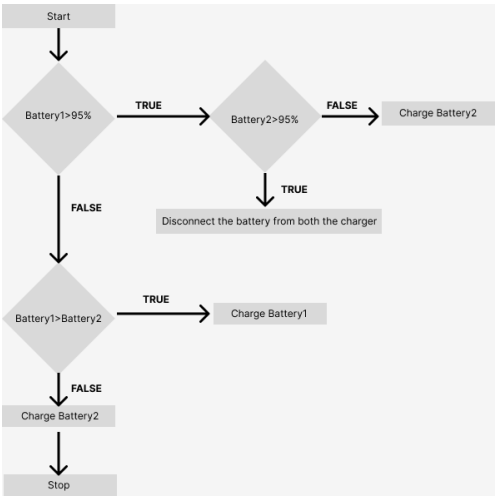

Figure 6.3.1 Flowchart of BSM

6.4 PREVENTION DURING ACCIDENT

As some of the report says that the accidents will also be cause to the battery explosion and failures. It is because of the high current (due to short circuit) which flow through the battery makes the cells gets damaged and causing release of hazardous gas or explosion. Although manufacturers and battery makers have made huge strides in improving vehicle safety, a violent crash in an electric vehicle can still result in the car catching fire. This can happen if the battery short circuits and heats up. In this Prototype, vibration sensor (SW-420) is used to detect accidents since there will be an enormous amount of vibration during accidents. When the vibration exceeds the threshold, the sensor will detect and communicate to the controller. The controller will detach the battery from the motor, makes the circuit open. Hence there will be no current flowing through the battery during accidents which protects the battery from getting exploded. In addition to this, to Support the Emergency Response Team The Accident Is Detected Using Vibration Sensor And The Damage Intensity Is Sensed, Also The Co-Ordinates (GPS) Of The Accident Location Is Shared Via GSM .Here The Accident Is Detected With The Help Of Vibration As Per Pre-Set Value. If The Vibration Detected Above The Pre-Set Value The Speed Of The Vehicle Is Slowed Down. As Soon As The Pre-Set Vibration Value Is Detected Parameters Like Speed, Indications, Gear And Door Status Will Be Recorded Like A Black Box.

6.5 HILL ASSIST MODE

The Process Starts With The Power Supply And Input Command. Engine On Checks For The Door Status If All Four Doors Are Closed The Processor Enables The Engine, Else an Indication Is Shown To Close All The Doors. Idle Works With Basic Working Of The Car Gets Starts Based On The Pre-Defined Conditions.
Gear Has Four Cases in This State
1. Neutral
2. Drive
3. Reverse
4. Hill Mode

Neutral -This Mode The Vehicle Is In Static Position (Zero Acceleration) And The Breaks Are Enabled.

Drive- In this Mode the Car Engine's Motor is Activated and Controlled by the User/Driver Based on the Acceleration in Forward Direction as per User's Acceleration.

Hill Mode (Up-Hill)-In this Mode Is Used To Assist While Driving In Inclined Surface By Controlling The Acceleration And Break Based On The Gyroscope's Input I.E. The Inclination Is Sensed With The Help Of Inbuilt Gyroscope Sensor In myRIO.To Increase The Acceleration During Uphill Drive An Additional Impulse Is Given To The Motor As Per Pre-Set Value.

Hill Mode (Down-Hill): This Mode To Increase The Safety Of The Vehicle During Down Hill Drive Break And Acceleration Is Controlled Using The Processor And Gyroscope.To Increase The Safety The Vehicle Speed Is Reduced As Per The Angle Of Inclination Also Maximum Speed Is Also Pre-Set.

AFS (Adaptive Front Light System): Adaptive Front Light System (AFS), Here Using Accelerometer's X-Axis the Servo Motor Turns the Head Light Accordingly. Adaptive Headlights Are Headlights That Actively Respond To Change In Direction Of Vehicle. Their Goal Is to Provide Drivers with Wide Range of Visibility and More Time to React to Conditions ahead .AFS Servo Motor Is Controlled with the Help of Gyroscope, Where the Processor Calculates the Better Visibility Angle.

7. RESULT

The result of the IoT connected Battery Management System is shown below.

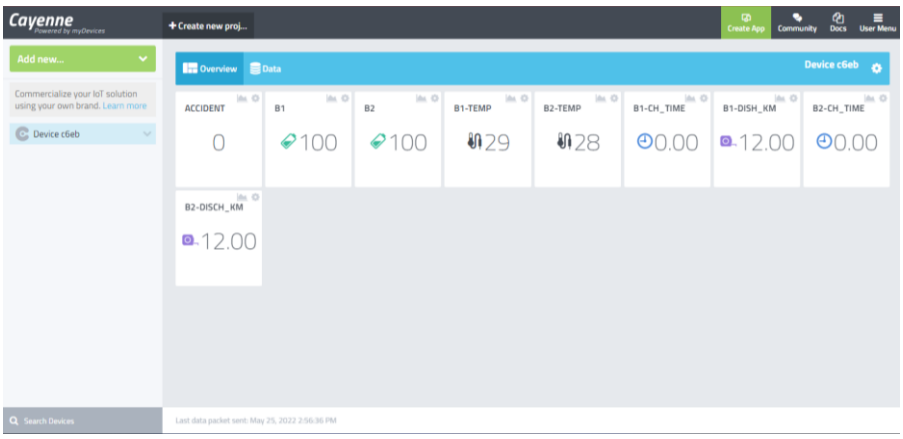

Figure 7.1 Front panel of the cayenne web application

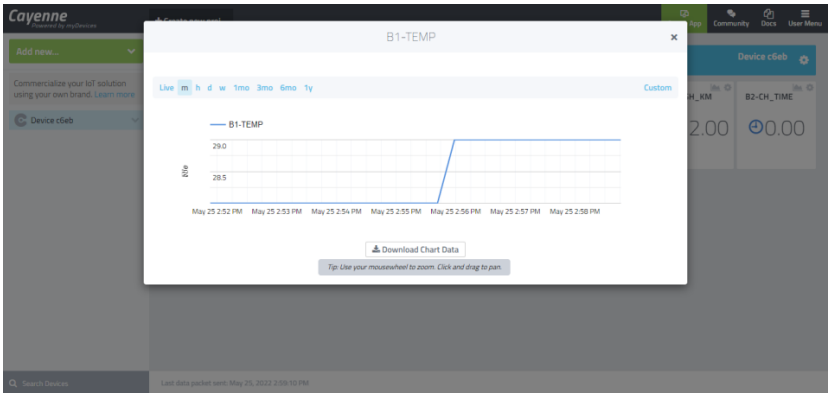

Figure 7.2 Graphical representation of temperature

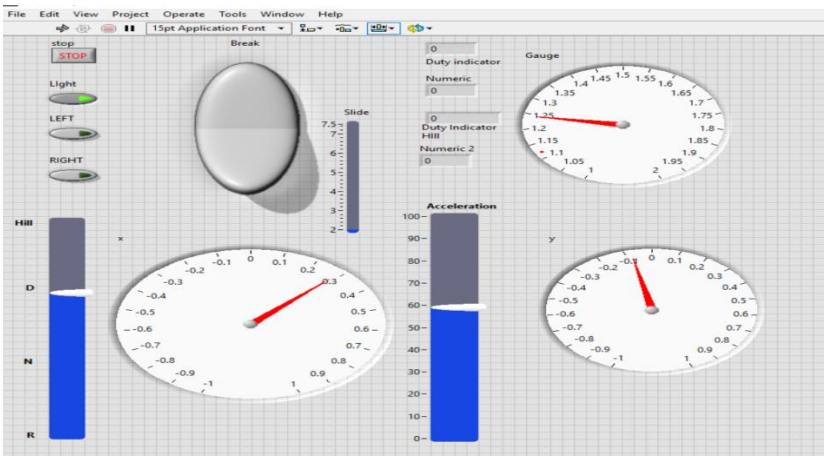

Figure 7.3 Front panel of the Hill assisted vehicle

8. CONCLUSION

As a conclusion, Various Causes of battery explosions of the electric vehicle such as overheating, over loading and accidents are detected using desired sensors, problems are rectified with the help of the temperature monitoring system, battery switching & management and accident detection system. The batteries are charged using PV cell (Solar panel) as well as conventional charging. This can be further extended to homes and industries which use large batteries for backup power and other commercial applications to predict the life of batteries and improve it. By knowing the life earlier, it would better be for timely replacement of the components without disrupting the day-to-day work of a person/industry.

REFERENCE

1. Manivannan S, ;Kaleeswaran E, (2016). [IEEE 2016 First International Conference on Sustainable Green Buildings and Communities (SGBC) - Chennai, India (2016.12.18-2016.12.20)] 2016 First International Conference on Sustainable Green Buildings and Communities (SGBC)
2. Godina, R.; Rodrigues, E. M. G.; Matias, J. C. O.; Catalao, J. P. S. (2016). [IEEE 2016 51st International Universities Power Engineering Conference (UPEC) - Coimbra (2016.9.6-2016.9.9)] 2016 51st International Universities Power Engineering Conference (UPEC)
3. Liu, Nian; Chen, Qifang; Lu, Xinyi; Liu, Jie; Zhang, Jianhua (2015). A Charging Strategy for PV-Based Battery Switch Stations Considering Service Availability and Self-Consumption of PV Energy. IEEE Transactions on Industrial Electronics.
4. J. linru, Z. yuanxing, L. taoyong, D. xiaohong and Z. jing, "Analysis on Charging Safety and Optimization of Electric Vehicles," 2020 IEEE 6th International Conference on Computer and Communications (ICCC), 2020.

5. Battery Management System Realisation for Electric Vehicles Philip Dost,ConstantinosSourkounis Power Systems Technology and Power Mechatronics, 22nd Mediterranean Conference on Control and Automation (MED), University of Palermo. June 16-19, 2014. Palermo, Italy.
6. Efficient Battery Monitoring System for E-Vehicles. M. Senthilkumar;K.P. Suresh;T.GunaSekar; C. Pazhanimuthu 2021 7th International Conference on Advanced Computing and Communication Systems (ICACCS)
7. Weifeng Wang, Qing Wu, Zhiyong Lu, XiuminChu , "Control Model and Simulation for Adaptive Front light System of Vehicle on Curve Roads"
8. SysCon 2018 – IEEE International Systems Conference Montreal, Canada, April 7–10, 2008 Vehicle Black Box System Abdallah Kassem, RabihJabr, GhadySalamouni, ZiadKhairallahMaalouf Department of Electrical and Computer Engineering, Notre Dame University, P.O.Box: 72 ZoukMikayel, ZoukMosbeh, Lebanon
9. V R Prajwal; (2020). Vehicle Detection and Collision Avoidance in Hairpin Curves. 2020 IEEE Pune Section International Conference