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UPS AUTOMATIC FAULT DETECTION SYSTEM USING IoT

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Abstract - *Battery management system (BMS) forms a crucial system component in various applications like electric vehicles (EV), hybrid electric vehicles (HEV), Uninterrupted power supplies (UPS), telecommunications and so on. The accuracy of these systems has always been a point of discussion as they generally give an error of maximum 10% considering all the parameters together. Batteries are the heart of the automation system, and its applications are more in all the fields, where the electrical supply requires. The periodical monitoring/observations are required for battery source to provide continuous power to the load without any interruption. Our proposed system monitors and stores parameters that provide an indication of the lead acid battery's acid level, state of charge, voltage, current, and the remaining charge capacity in a real-time scenario. Wireless local area network is used as the backbone network. The information collect from all the associated battery clients in the system is analyzed. The malfunction of the battery status are continuously monitored based on sudden Charge & discharge voltage of battery bank and battery conditions are viewed in the cloud with help of IoT module.*

Key Words: **Battery cells, ATMEGA 2560 microcontroller, Arduino, Current sensor, Voltage sensor, Voltage divider, Temperature sensor, Internet of Things, Relay, Charging circuit, Regulator, Rectifier**

1 INTRODUCTION

The growing understanding of global warm around the world, the demand for clean fuel/energy is on the rise and as a result there is a continuous shift towards the electric vehicles and hybrid electric vehicles. Battery performance is influenced by factors such as depth of discharge (DOD), temperature and charging algorithm. This paper attempts to provide a measurement of voltage and current level of the battery using internet of things. Lead-acid batteries are very effective at powering many different applications. They are easy to obtain, relatively inexpensive, and provide a lot of power to whatever they are hooked up to. Regrettably, if there is nil monitoring the charge, the battery will eventually run out of power. In addition to determine the charge of the battery, the current voltage of the battery is needed. By depending on the output voltage of the battery, the approximate charge of the battery in the system can be estimated. A battery is a device that converts the chemical energy stored in its active materials to electrical energy through an electrochemical reaction (Jung et al., 2016).The active materials for the lead acid battery (LAB) are the lead oxide (PbO_2) and lead (Pb) terminal plates and a solution of sulfuric acid (H_2SO_4). A battery is a device that converts the chemical energy stored in its active materials to electrical energy through an electrochemical reaction (Jung et al., 2016).The active materials for the lead acid battery (LAB) are the lead oxide (PbO_2) and lead (Pb) terminal plates and a solutionofsulfuric acid (H_2SO_4).

2 HARDWARE DESCRIPTION

BLOCK DIAGRAM

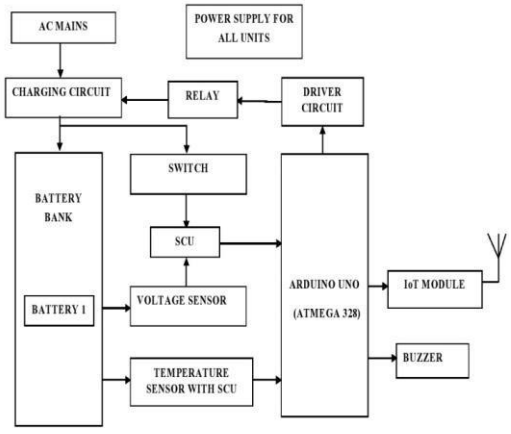


Figure : 1 block diagram

2.1 BATTERY CELL

Battery Cells are the most basic individual component of a battery. They consist of a container in which the electrolyte and the lead plates can interact. Each lead-acid cell fluctuates in voltage from about 2.12 Volts when full to about 1.75 volts when empty. Note the small voltage difference between a full and an empty cell (another advantage of lead-acid batteries over rival chemistries).

2.1.1 LEAD ACID BATTERY

A lead-acid battery is an electrical storage device that uses a reversible chemical reaction to store energy. It uses a combination of lead plates or grids and an electrolyte consisting of a diluted sulphuric acid to convert electrical energy into potential chemical energy and back again. The electrolyte of lead-acid batteries is hazardous to your health and may produce burns and other permanent damage if you come into contact with it.

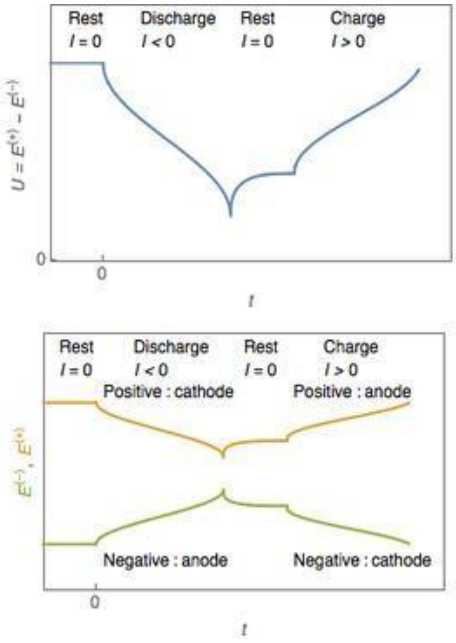


Figure: 2 graph – characteristics of lead acid battery

2.1.2 DISCHARGE

During discharge, the lead dioxide (positive plate) and lead (negative plate) react with the electrolyte of sulfuric acid to create lead sulfate, water and energy.

2.1.3 CHARGE

During charging, the cycle is reversed: the lead sulfate and water are electro-chemically converted to lead, lead oxide and sulfuric acid by an external electrical charging source. Many new competitive cell chemistries are being developed to meet the requirements of the auto industry for EV and HEV applications. Even after 150 years since its invention, improvements are still being made to the lead acid battery and despite its shortcomings and the competition from newer cell chemistries the lead acid battery still retains the lion's share of the high power battery market.

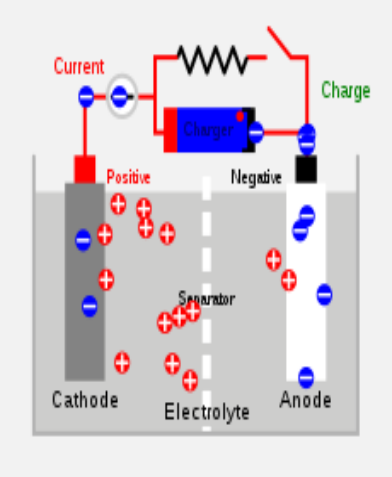


Figure : 3 charging and discharging

2.1.4 Lifespan and cycle stability

If batteries are used repeatedly even without mistreatment, they lose capacity as the number of charge cycles increases, until they are eventually considered to have reached the end of their useful life. Different battery systems have differing mechanisms for wearing out. For example, in lead- acid batteries, not all the active material is restored to the plates on each charge/discharge cycle; eventually enough material is lost that the battery capacity is reduced. In lithium-ion types, especially on deep discharge, some reactive lithium metal can be formed on charging, which is no longer available to participate in the next discharge cycle. Sealed batteries may lose moisture from their liquid electrolyte, especially if overcharged or operated at high temperature. This reduces the cycling life.

2.2 ATMEGA 2560 MICROCONTROLLER

Arduino is an open-source physical computing platform based on a simple i/o board and a development environment that implements the Processing/Wiring language. Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer (e.g. Flash, Processing, MaxMSP). The open-source IDE can be downloaded for free (currently support Mac OS X, Windows, and Linux).

The Arduino Mega is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 14 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega is compatible with most shields designed for the Arduino Duemilanove or Diecimila. This is the new Arduino Mega 2560 which replaces previous Arduino Mega. In addition to all the features of the previous board, the Mega 2560 now uses an ATmega8U2 instead of the FTDI chip. This allows for faster transfer rates, no drivers needed for Linux or Mac (inf file for Windows is needed), and the ability to have the board show up as a keyboard, mouse, joystick, etc. It also has twice as much flash memory. The Mega 2560 is a microcontroller board based on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started. The Mega 2560 board is compatible with most shields designed for the Uno and the former boards Duemilanove or Diecimila.

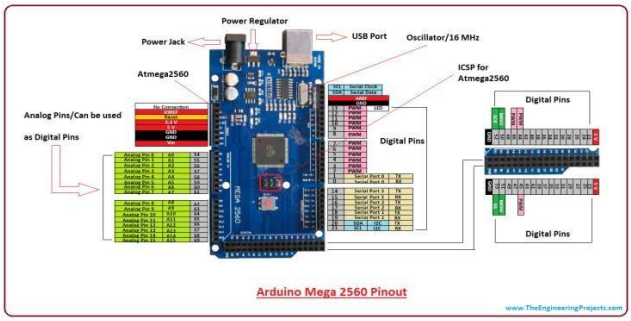


Figure : 4 atmega 2560

Arduino is an open-source physical computing platform based on a simple i/o board and a development environment that implements the Processing/Wiring language. Arduino can be used to develop stand-alone interactive objects or can be connected to software on your computer (e.g. Flash, Processing, MaxMSP). The open-source IDE can be downloaded for free (currently for Mac OS X, Windows, and Linux).

2.3 CURRENT SENSOR

ACS712 provides economical and precise solutions for AC or DC current sensing in industrial, commercial, and communications systems. The device package allows for easy implementation by the customer. Typical applications include motor control, load detection and management, switched-mode power supplies, and overcurrent fault protection. The device consists of a precise, low-offset, linear Hall sensor circuit with a copper conduction path located near the surface of the die. Applied current flowing through this copper conduction path generates a magnetic field which is sensed by the integrated Hall IC and converted into a proportional voltage. Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. A precise, proportional voltage is provided by the low-offset, chopper-stabilized BiCMOS Hall IC, which is programmed for accuracy afterpackaging.

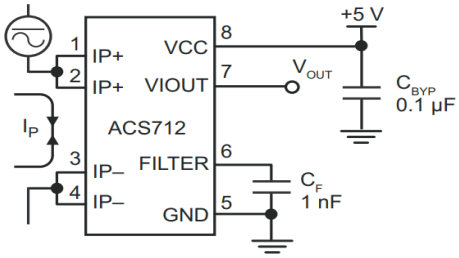


Figure : 5 current sensor

The output of the device has a positive slope (>VIOUT(Q)) when an increasing current flows through the primary copper conduction path (from pins 1 and 2, to pins 3 and 4), which is the path used for current sensing. The internal resistance of this conductive path is 1.2 mΩ typical, providing low power loss. The thickness of the copper conductor allows survival of the device at up to 5× overcurrent conditions. The terminals of the conductive path are electrically isolated from the sensor leads (pins 5 through 8). This allows the ACS712 current sensor to be used in applications requiring electrical

isolation without the use of opto-isolators or other costly isolation techniques.

2.4 VOLTAGE SENSOR

The voltage divider rule is used to solve circuits to simplify the solution. Applying this rule can also solve simple circuits thoroughly The main concept of this voltage divider rule is " The voltage is divided between two resistors which are connected in series in direct proportion to their resistance. Voltage divider involves of two important parts they are the circuit and the equation.2.4.1 Different Voltage Divider Schematics. A voltage divider includes a voltage source across a series of two resistors are called as Different Voltage Divider Schematics.

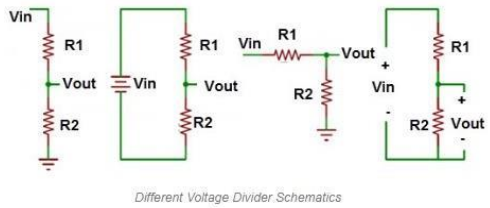


Figure : 6 different voltage divider schematics

2.5 TEMPERATURE SENSOR (LM35)

The LM35 is an integrated circuit sensor that can be used to measure temperature with an electrical output proportional to the temperature (in ºC). The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified. The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

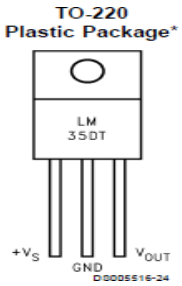


Figure : 7 temperature sensor

The LM35 does not require any external calibration or trimming to provide typical accuracies of ±¼°C at room temperature and ±¾°C over a full -55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 µA from its supply, it has very low self-heating, less than 0.1°C in still air.

The LM35 is rated to operate over a -55° to +150°C temperature range, while the LM35C is rated for a -40° to +110°C range (-10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

2.6 INTERNET OF THINGS (IoT)

The **Internet of things** (**IoT**) is the network of physical devices, vehicles, home appliances and other, items embedded with electronics, software, sensors, act uators, and connectivity which enables these objects to connectandexchangedata.Each thing is uniquely identifiable through its embedded computing system but is able to inter- operate within the existing Internet infrastructure. The IoT allows objects to be sensed or controlled remotely across existing network infrastructure, creating opportunities for more direct integration of the physical world into computer- based systems, and resulting in improvedefficiency,accuracy and economic benefit in addition to reduced human intervention. When IoT is augmented with sensors and actuators, the technology becomes an instance of the more general class of cyber-physical systems, which also encompasses technologies such as smart grids, virtual power plants, smart homes, intelligent transportation and smart cities.

2.7 ESP8266-12E Node MCU (IoT module)

Node MCU is an open source IoT platform. It includes firmware which runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "Node MCU" by default refers to the firmware rather than the dev kits. The firmware uses the Luascripting language. It is based on the eLua project, and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua-cjson, and spiffs.

2.7.1 ESP Arduino core

Arduino began developing new MCU boards based on non-AVR processors like the ARM/SAM MCU and used in the Arduino Due, they needed to modify the Arduino IDE so that it would be relatively easy to change the IDE to support alternate tool chains to allow Arduino C/C++ to be compiled down to these new processors. They did this with the introduction of the Board Manager and the SAM Core. A "core" is the collection of software components required by the Board Manager and the Arduino IDE to compile an Arduino C/C++ source file down to the target MCU's machine language. Some creative ESP8266 enthusiasts have developed an Arduino core for the ESP8266 WiFiSoC that is available at the GitHub ESP8266 Core webpage. This is what is popularly called the "ESP8266 Core for the Arduino IDE" and it has become one of the leading software development platforms for the various ESP8266 based modules and development boards, including Node MCUs. The Button is a Wi-Fi connected push button designed by Peter R Jennings. The Button is designed for single-purpose, internet-enabled functions. When the button is pressed, a connection is made to a web server which will perform the desired task. Applications include a doorbell or panic button. Node MCU is an open source IoT platform based on the ESP-12E module. The version1.0 is the 5th design of NodeMCU devkit. This uses CP2102 as UART bridge and can flash firmware automatically by using nodemcu-flasher. Also, it has a voltage regulator to convert from 5V to 3.3V which is the required by the esp21emodule.

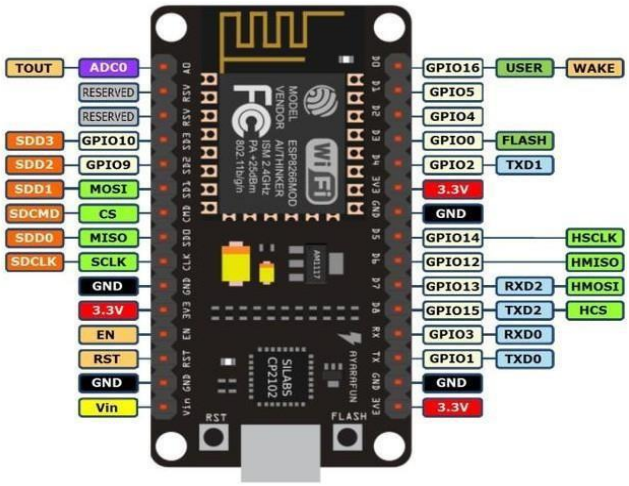


Figure : 8 ESP 8266

2.8 RELAY DRIVER

A relay is an electro-magnetic switch which is useful if you want to use a low voltage circuit to switch on and off a light bulb (or anything else) connected to the 220v mains supply. The diagram below shows a typical relay (with "normally-open" contacts). The current needed to operate the relay coil is more than can be supplied by most chips (op. amps etc), so a transistor is usually needed.

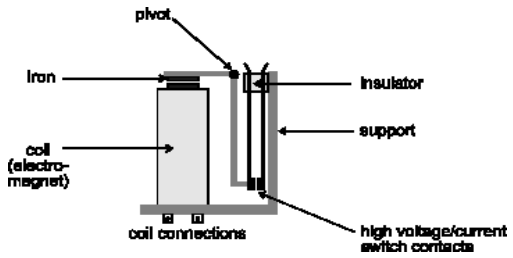


Figure : 9 relay driver

2.9 CHARING CIRCUIT

Power supply is a reference to a source of electrical power. A device or system that supplies electrical or other types of energy to an output load or group of loads is called a power supply unit or PSU. The term is most commonly applied to electrical energy supplies, less often to mechanical ones, and rarelytoothers.Powersuppliesforelectronicdevicescanbe

broadly divided into linear and switching power supplies. The linear supply is a relatively simple design that becomes increasingly bulky and heavy for high current devices; voltage regulation in a linear supply can result in low efficiency. A switched-mode supply of the same rating as a linear supply will be smaller, is usually more efficient, but will be more complex

2.11 RECTIFIER

There are several ways of connecting diodes to make a rectifier to convert AC to DC. The bridge rectifier is the most important and it produces full-wave varying DC. A full-wave rectifier can also be made from just two diodes if a centre-tap transformer is used, but this method is rarely used now that diodes are cheaper. A single diode can be used as a rectifier but it only uses the positive (+) parts of the AC wave to produce half-wave varying DC. The varying DC output is suitable for lamps, heaters and standard motors. It is not suitable for electronic circuits unless they include a smoothing capacitor.

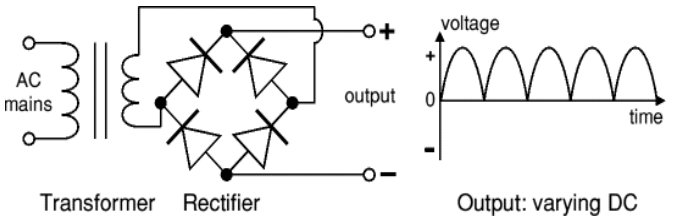


Figure : 12 bridge rectifier

2.12 REGULATOR

Voltage regulator ICs are available with fixed (typically 5, 12 and 15V) or variable output voltages. They are also rated by the maximum current they can pass. Negative voltage regulators are available, mainly for use in dual supplies. Most regulators include some automatic protection from excessive current ('overload protection') and overheating ('thermal protection'). The LM78XX series of three terminal regulators is available with several fixed output voltages making them useful in a wide range of applications. One of these is local on card regulation, eliminating the distribution problems associated with single point regulation. The voltages available allow these regulators to be used in logic systems, instrumentation, HiFi, and other solid state electronic equipment. Although designed primarily as fixed voltage regulators these devices can be used with external components to obtain adjustable voltages and current.

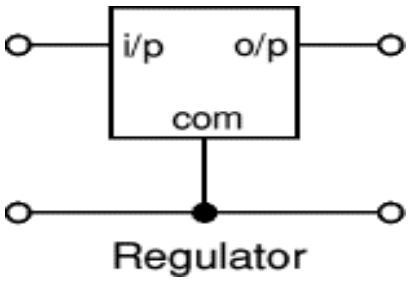


Figure : 13 regulator

3 CIRCUIT DIAGRAM

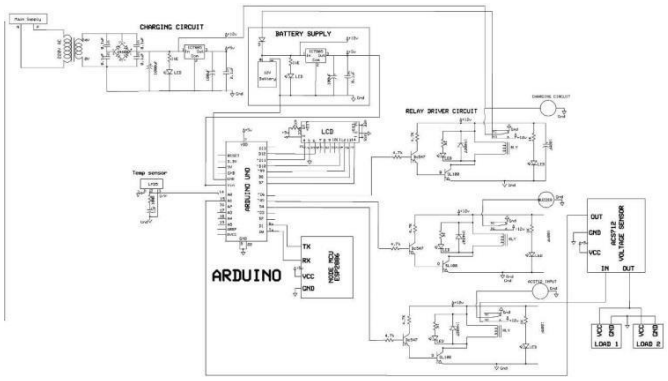


Figure : 14 circuit diagram

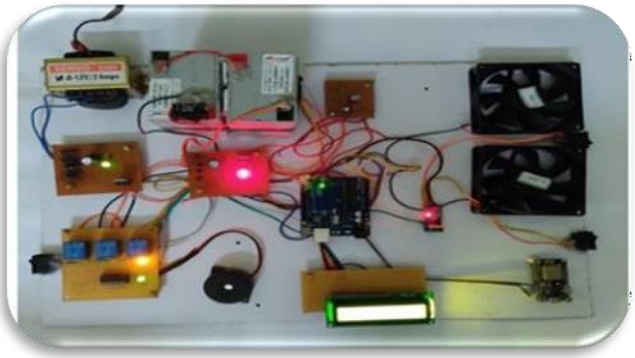
- An efficient energy-management system for Lead Acid Battery, using IoT and Arduino/ATMEGA 2560 is developed
- The system uses an ACS712 sensor to detect current and voltage in the circuit while LM35 Thermistor is used to detect the temperature.
- The LM35 is a temperature sensor which gives voltages which are proportional to the temperature in degree centigrade. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin.
- The LM35 draws only 60 μA current from the supply hence it has very low self-heating of less than 0.1°C. The LM35 device is rated to operate over a −55°C to

150°C temperature range, while the LM35C device is rated for a −40°C to 110°C range (−10° with improved accuracy).

- Current and voltage Sensor ACS712 device is for AC or DC current sensing in commercial, industrial and communications systems. This device basically works on the principle of Hall Effect.
- The current in the circuit flows through the copper coil which generates a magnetic field which is then sensed by the integrated Hall IC and converted into a proportional voltage.
- Device accuracy is optimized through the close proximity of the magnetic signal to the Hall transducer. It is also being used as a voltage sensor for measuring OCV.
- The data output from these sensors is stored and manipulated through Arduino (microcontroller). The State of charge (SOC) of the battery is the index which shows the amount of charge present in the battery.
- The SOC depends upon various parameters, such as current, voltage, temperature and pressure. In our system, the temperature, current and voltage are considered for determining the SOC.

This system utilizes the advance ATMEGA controller and IoT system to monitor and display the parameters of the individual battery in the battery bank in real time and informs the users about the battery present status by displaying on webpage/mobile phone and through IoT it sends the information to authorized person about battery condition and temperature. By monitoring each battery in battery bank one can improve the system reliability by detecting battery problems at early stage before they can cause an abrupt system failure to other power handled system. By using discharge time and number of discharge cycles, it's going to tell the status of individual battery in battery bank. In this project, we are going to monitor the battery level using current sensor, temperature sensor and voltage sensor and also measuring sudden charging and discharging of the battery bank. When the battery level is getting low and charging circuit will be triggered automatically as well as send information to the particular person using internet of things.

HARDWARE PICTURES



OUTPUT AND RESULTS

4 CONCLUSION

Battery is the most essential component of any vehicle. So perfect maintenance of any battery is very much essential for it to function properly. Lead Acid batteries which are more commonly used in the vehicular batteries, need to be efficiently monitored, for it to perform better under all circumstances. So, a more systematic battery management system needs to be implemented so that the performance of the battery can be monitored continuously. When it comes to battery, the two most important parameters are the State Of Charging (SoC) and State of Health (SoH) of the battery. There are several coherent methods to calculate these parameters.

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