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IoT based Battery Monitoring System

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Abstract - *This paper describes the application of Internet-of-things (IoT) in monitoring the performance of electric vehicle battery. It is clear that an electric vehicle totally depends on the source of energy from a battery. However, the amount of energy supplied to the vehicle is decreasing gradually that leads to the performance degradation. This is a major concern for battery manufacture. In this work, the idea of monitoring the performance of the vehicle using IoT techniques is proposed, so that the monitoring can be done directly. The proposed IoT-based battery monitoring system is consists of two major parts i) monitoring device and ii) user interface. Based on experimental results, the system is capable to detect degraded battery performance and sends notification messages to the user for further action.*

Key Words: **PCB, Optocoupler, Arduino Mega 2560.**

1. INTRODUCTION

Electric vehicles are becoming more commonplace as the technology matures and gas prices remain higher than in previous decades. While the internal combustion engine still dominates much of the world's roads, electric vehicles and hybrids (vehicles with both an internal combustion engine and some form of electric motor) are more prevalent in urban areas than previous decades. Hybrids operate much like regular cars, requiring periodic refueling to supply the internal combustion engine, but typically with better fuel economy than their pure gasoline powered counterparts. On the other hand, electric vehicles do not have any on board power generation and rely solely on stored energy in batteries to power the electric motors during operation.

This paper outlines a scalable method of determining the voltage across each battery in an electric vehicle charging and an eventual path for the development of a real-time battery "fuel gauge" for use in the Department Electric Vehicle.

2. SYSTEM DEVLOPMENT

With the overall system in mind, a single circuit needed to be designed to measure the Voltage of a single battery in the motive power pack. This circuit could then be replicated and integrated into the system to measure the voltages of all batteries in question. because the alternator can keep the battery charged as long as the engine is running and the vehicle can be refueled quickly. However, on the EV, every joule used to power the battery Monitoring using IOT system is a joule that cannot be used to propel the car. Since electric vehicles already have a shorter range than their gas-powered counterparts and take much longer to "refuel" (on the order of a few hours compared to a few minutes) reducing power consumption is an obvious goal.

The Monitoring using IOT system will be made up of several different components installed in different locations throughout the vehicle. The Arduino Uno will act as the "brain" of the Monitoring using IOT system, recording data and allowing for future expansions of the scope of the Monitoring using IOT. Even though the Arduino Uno is capable of taking direct voltage measurements, it can only do so in the ±5 V range. The high DC voltage of the main power pack (144VDC) leads to the necessity of an intermediate circuit with an output voltage proportional, but much lower than the voltage across the main power pack.

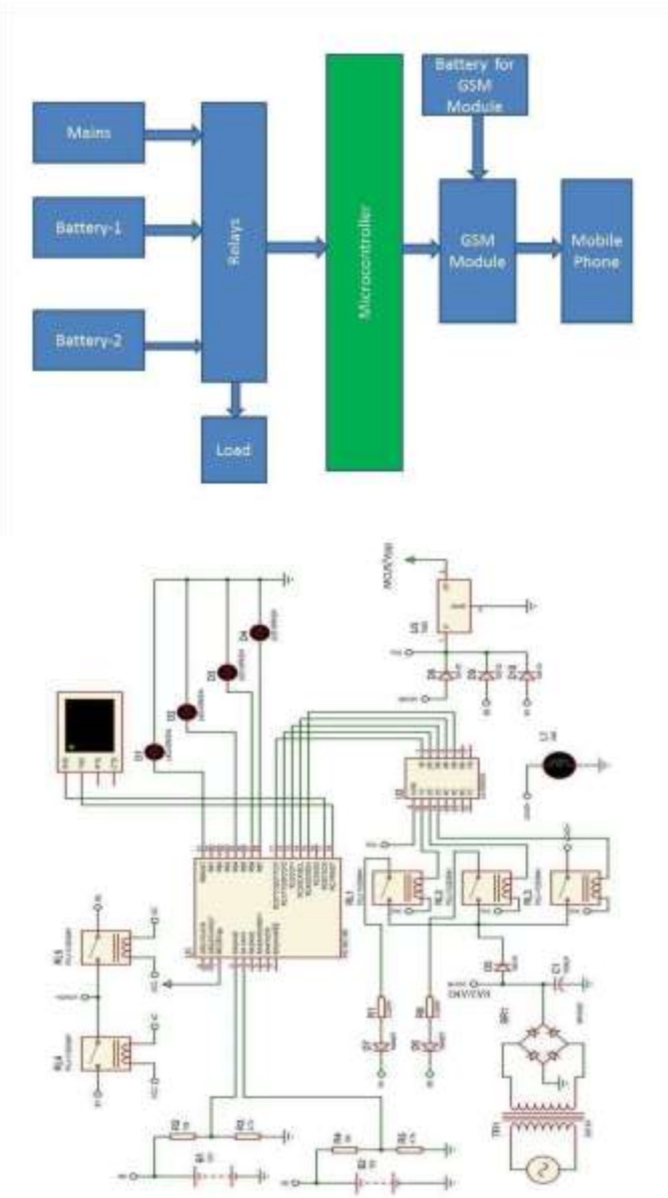


Fig -1: Block Diagram of Battery Monitoring System & circuit dig.

2.1 CHOOSING PARAMETERS

After the basic design of the circuit was decided, the operating conditions and consequent device parameters needed to be determined. The Vishay VO618A series of optoisolators was chosen because of its phototransistor output and lack of complicating features. Specifically, the VO618A-3 was selected because of a guaranteed current transfer ratio (CTR or the ratio of the collector current to the diode forward current) of 100200%, its low cost, and ability to operate well with forward diode currents on the order of a few milliamps. As with any transistor amplifier design, a DC operating point must be established. Figure 2 shows the phototransistor collector current (IC) vs. the collector emitter voltage (VCE) for several different forward diode currents (IF). Initial designs looked at setting IF to be 1 mA, but this was changed to 5 mA in the final design to allow for more stable operation and a larger collector current swing while remaining in the active region of the phototransistor.

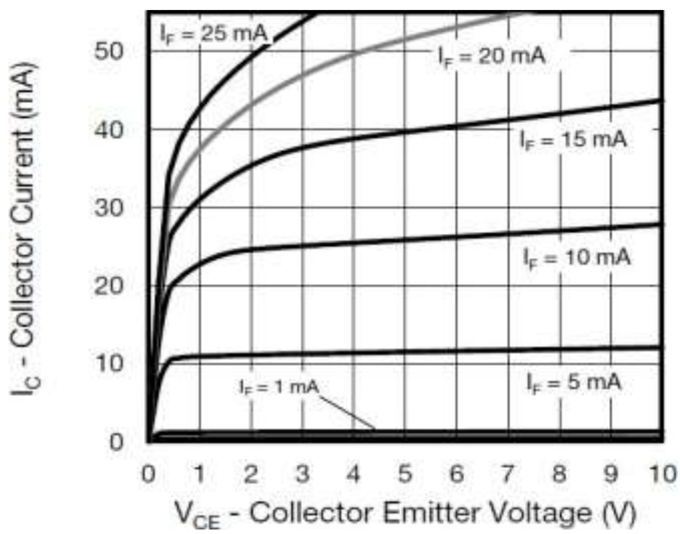
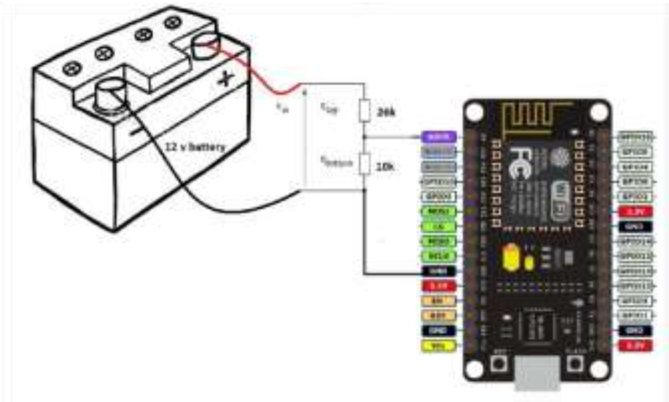


Fig -2

The load line method of determining collector resistance involves using the graph of collector current (I_C) vs collector-emitter voltage (V_{CE}). Because transistors are non- linear over their entire range of operation, the load line method is more intuitive and typically easier than solving a system of equations that may not be accurate at all of the solutions. To use the load line method, two points must be established: the collector- emitter voltage when the collector current is zero and the minimum possible collector- emitter voltage while the transistor is both in the active region of operation and subjected to the highest possible collector current. In the simple common-emitter amplifier of Figure 1, the relationship between the collector current and collector-emitter voltage is given by Equation (1), where $V_{out} = V_{CE}$. When the collector current is zero, the collector-emitter voltage goes to the rail, i.e. VCE = VCC = 5V. Using Equation (4) and known values of R1, R2, VF, CTRmax, and VB, max we can solve for the maximum possible collector current at the saturation voltage (the collector-emitter voltage below which the transistor exits the active region):

Or This corresponds to…..Normally, this would indicate a value of390 Ω per the standard 5% resistor tables, but a resistance of 330 Ω was chosen to increase the slope of the line and thus reach the maximum collector current before the transistor enters saturation. We could continue to solve the unique equation representing the load line, but the y-intercept does not relate to a physical occurrence in the transistor and is unnecessary for this application. The graphical representation of the load line method is shown in Figure 2

2.2 DESIGN AND DEVELOPMENT OF IOT BASE BATTERY MANAGEMENT



Measurement of Voltage and Current: As the battery is charging, the voltage of the battery by any means, will not provide the charging status or charging voltage of the battery. The charging voltage and the voltage measured across the terminals of the battery need not be the same. A dead battery which is not connected to any load can show an approximate voltage of 12.5 Volts (in case of Lead Acid Batteries). We need some complex circuitry to measure the charging voltage, or we can use any voltage detection module to measure the voltage across the terminals of the battery. A simple voltage division network, by putting correct values of resistance, regulating it and then using signal conditioning mechanism that is nothing but using an analog to digital converter, we could easily measure the voltage with the help of the Microcontroller and measure the output. By connecting the battery to a known value of load resistance, we can measure the current produced from the battery. The following figure shows the circuit setup for the measurement of voltage and current of the battery

2.3 BATTERY MONITORING SYSTEM BASED ON INTERNET OF THINGS (IOT)

The IoT based Battery Monitoring System which is developed in this work consists of a communication channel from and to the IED, data acquisition, cloud system and Human Machine Interface (HMI). An embedded system has been developed as an IoT to provide communication from and to the IED, as a data acquisition and as an internet gateway for all battery system system. The IoT based battery monitoring system utilizes digital communication TCP/IP with JSON format as a data acquisition to retrieve battery measurement parameter from the IED (See Fig. 2). Data is sent to the database and web server on the cloud system via the Internet gateway. The data in the cloud system is processed and analyzed to produce information which can be understood easily by users as it is displayed in Human Machine Interface (HMI) using ExtJS / HTML5 framework which can be accessed using desktop or mobile devices as per Fig.3

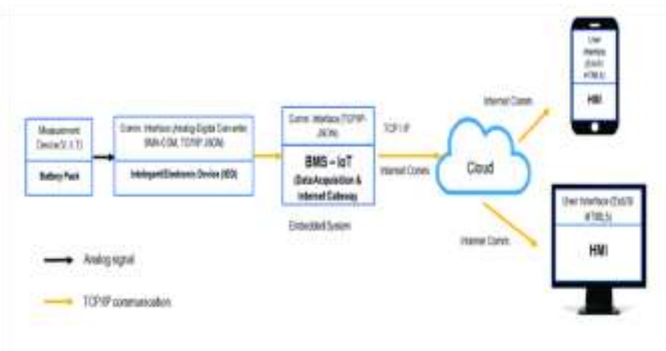
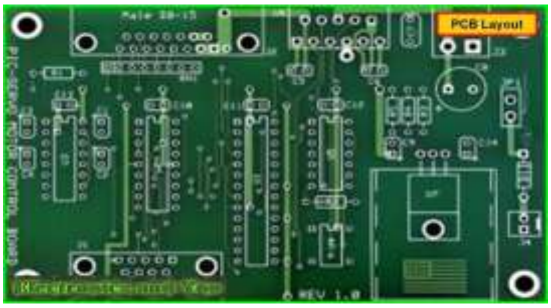


Fig 3

2.4 PCB DESIGN

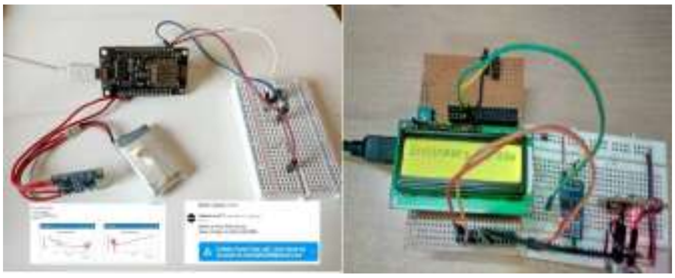
With growing circuit complexity and an eventual permanent installation, the decision was made to mount on a printed circuit board (PCB) all of the circuitry needed for Monitoring using IOT battery voltages and converting the analog signals to digital values that can be sent over an SPI bus to the Arduino. Since the batteries in the EV are split between the forward and rear compartments of the vehicle, the PCB will include 8 battery Monitoring using IOT circuits (6 for motive batteries, 1 for accessory, and 1 spare), a LT3082 power supply, a LT1461 voltage reference, and a LTC1863 ADC. Each battery will be wired directly to the PCB, with power being supplied from the accessory batteries, and additional wiring connecting the PCB and the Arduino. The PCB will be enclosed in a plastic enclosure to protect the board from the environment and prevent objects from shorting leads on the circuit board. The PCB itself will be a two-layer design, with all of the components and signal routing on the top surface. The bottom is reserved for a ground plane and some power routing. Instead of including discrete headers on the board itself, copper pads are laid around the board with the intention of directly soldering wires to the pads. Because of some routing complexities and surface mount components, the PCB will be manufactured by Sunstone Circuits (www.sunstone.com) before being assembled by Screaming Circuits (www.screamingcircuits.com). The PCB design was done using PCB123, Sunstone's free proprietary PCB layout software. And controller used Arduino Mega 2560 Microcontroller Board



2.6 POWER

The Arduino Uno can be powered via the USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the Gnd and Vin pin headers of the POWER connector. The board can operate on an external supply of 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may be unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts Note**:** The Arduino reference design can use an Atmega8, 168, or 328, Current models use an ATmega328, but an Atmega8 is shown in the schematic for reference. The pin configuration is identical on all three processors.

3. EXPERIMENTAL SETUP



4. CONCLUSIONS

With the system outlined above, the Department will be able to accurately measure and record the voltage on each individual battery used in the EV. This data will allow future students to study the usage patterns of the batteries in the EV and improve maintenance efforts by improving the detection of underperforming batteries in the motive power pack. In addition, the system can be adapted and expanded for future work in the Engineering Department related to the EV, specifically Monitoring using IOT other performance metrics, both electrical (motor current, charging efficiency) and otherwise (vehicle acceleration, battery temperature, inertial measurements) with minimal interfacing requirements. In effect, additional features could be added in parallel with the voltage measuring system already in place, using the SPI bus to communicate with other sensors and circuits around the vehicle. Using the Arduino family allows for easy upgrades to more powerful microcontrollers without relegating previous work to a state of obsolescence. Improvements could even include real-time display of information to the vehicle operator. The battery Monitoring using IOT system outlined herein improves the EV by collecting battery usage data and improving maintenance procedures.

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