Scientific Journal of Impact Factor (SJIF): 4.14
e-ISSN (O): 2348-4470
p-ISSN (P): 2348-6406

International Journal of Advance Engineering and Research Development

Volume 3, Issue 3, March -2016

DC Battery Monitoring

with full metering capabilities and continuous measurement of battery voltage, current, & temperature

Pratiksha Supal[1], Sayali Vavhal[2], Daminee Waghchaure[3]

[1]Electronics & Telecommunication, PES Modern College Of Engineering, Pune
[2] Electronics & Telecommunication, PES Modern College Of Engineering, Pune
[3] Electronics & Telecommunication,PES Modern College Of Engineering, Pune

Abstract —
The popularity of Hybrid-electric vehicles in today's automotive industry is because of its higher fuel-efficiency and reduced emissions of polluting gases. In a HEV, during the acceleration process, the power to run the vehicle is provided by the DC motor (powered by the battery) and during coasting (constant speed) period, the power is provided by the engine (powered by the fuel). This ensures optimum use of fuel and also the energy of the fuel is utilized to its best. However, the battery is constantly subjected to charging (during deceleration) and discharging (acceleration) process which causes depreciation in its performance with time. Since the battery forms an integral part in the operation of the vehicle it becomes essential to know the available charge left in the battery, how long will it be able to provide required energy and also about the life of the battery. This calls for an efficient model of the battery which can accurately monitor the performance of the battery and other critical battery parameters like State of Charge, State of Health, Time to Run, etc.
Based on the input (current demand) output (voltage profile) data that can be measured from the experimental results, the apt battery model is selected using model identification. The parameters of the model are computed on-line using parameter estimation techniques with the help of input output data while the vehicle is in operation. This monitoring algorithm provides the customer with the flexibility to use a wide range of batteries in their automobile so that the monitoring algorithm adapts itself to the battery based on the input-output data.

Keywords*-Battery charger, Lead acid battery, Voltage sensor, Temperature sensor, Current sensor, Controller, Wireless Zigbee module*

I. INTRODUCTION

The technological advancement in the world is rapidly progressing and one of the key factors for this rapid progress is because of the efficient vehicular transportation that facilitates people to travel to longer place within a short period of time. However, in all these years this has been possible because of the availability of fossil fuels which were being used as fuel. However, this availability of the fossil fuels is being reduced at a rapid rate and they are becoming more expensive these days due to the large demand.
Thus in vehicle transformation, a new technology is being introduced In vehicles, the vehicle is powered by battery when it is being accelerated, i.e. for the initial movement of the vehicle and once it reaches a constant speed then the fuel system is switched to the engine which is powered by the fossil fuels in the coasting operation. Thus we find that the importance of battery in vehicle is increasing. Thus it becomes critical to monitor the status of the battery and its parameters which indicates its available capacity, run-time and health of the battery, the State-of-Charge (SOC) and the State-of-Health (SOH) are quite important.
SOC defines the capacity and the useful energy present in the battery at a given moment that can be used. SOH is a parameter that indicates the age of the battery and how good the battery is.Battery monitoring systems are also important in UPS systems, in Distributed generation systems where batteries are used as storage devices for storing the excess DC power generated and in many other applications. The main purpose of the SOH of the battery is to provide an indication of the performance of the battery based on the current condition or how much of the useful life of the battery has already been consumed and how much more (or how long) we can expect from the battery before they are replaced.

A lot of research is been carried in modeling of the batteries, so that we can have accurate monitoring of batteries dynamically. Researchers around the world developed a wide range of battery models with varying degrees of complexity. Electrochemical models, mainly used to optimize physical design aspects of the batteries, characterize the fundamental mechanisms of power generation and relate battery design parameters with macroscopic (battery voltage and current) and microscopic (charge concentration) information. However, they are complex and time consuming, requires days of simulation time, complex numerical algorithms, and battery-specific information that is difficult to obtain.

Mathematical models adopt mathematical methods to predict system-level behavior such as battery run-time, efficiency and capacity. Also mathematical models cannot offer any information on I-V characteristics of the battery which are critical for designers for use in optimization algorithms.

Electrical models , the accuracy of which lies between electrochemical and mathematical models, are electrical equivalent model of a battery comprising of voltage sources, resistors and capacitors for co-design and co-simulation with other electrical circuits. They are more intuitive, useful and easy to handle for electrical engineers.

These days with the use of lead-acid batteries becoming more critical in vehicles, on-line modeling (adaptive) is becoming significantly important in order to compute the battery parameters, even when the vehicle is in operation, and to keep updating the model to give a more accurate value of the parameters. Adaptive models, however, require few cycles to update the model and give a more accurate model of the battery.

II. THEORY AND IMPLEMENTATION

In design and implementation of an advanced battery management system (BMS), the basic concept is to divide each series battery array into sub-arrays where each battery is individually monitored and managed. The proposed BMS continuously monitors the voltage, current, and energy of each battery. Based on these measurements, the BMS can calculate individual state of charge (SoC) levels and C-rates. Furthermore, the system has the capability to isolate each individual battery to apply different charging profiles and advanced diagnostics to detect the correct problems. Pulsed charging is deployed using different duty cycles for SoC balancing. The isolated battery is bypassed to maintain uninterrupted supply to the load despite reduced series array voltage.

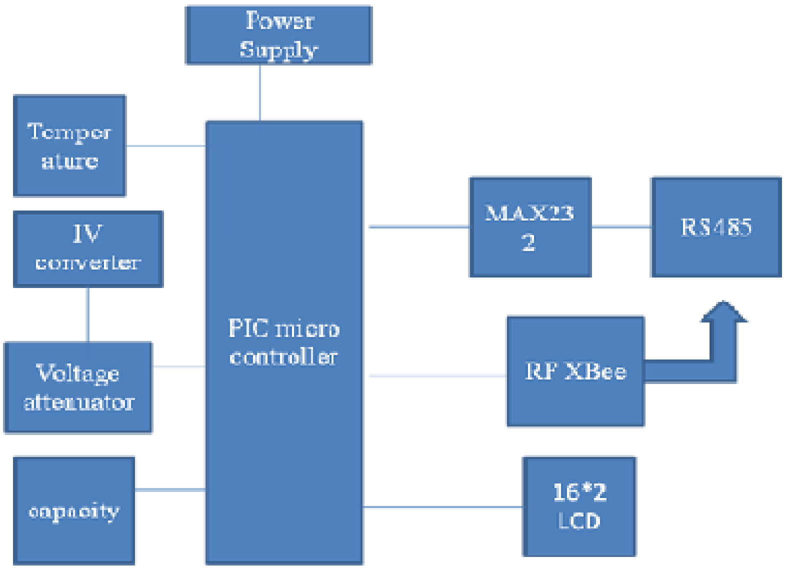


Figure 1. Block Diagram of Transmitter System

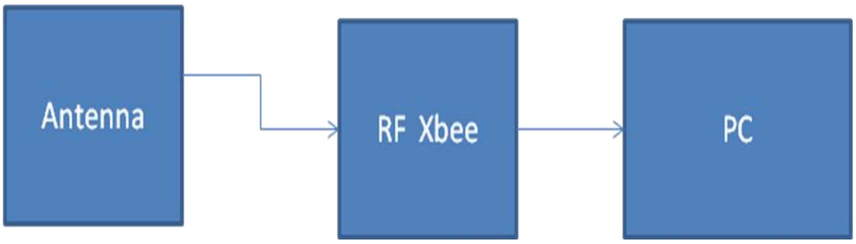


Figure 2. Block Diagram of Receiver System

The hardware involved in this project is a PIC Controller, Power Supply, a LCD to display the concerned information, RF Zigbee Module, MAX 232.
Power Supply:
This section is meant for supplying Power to all the sections mentioned above. Itbasically consists of a Transformer to step down the 230V ac to 12V ac followed bydiodes. Here diodes are used to rectify the ac to dc. After rectification the obtained rippled dc is filtered using a capacitor Filter. A positive voltage regulator is used to regulate the obtained dc voltage.

2.1. State of Charge

The primary purpose of a battery is to transform the energy produced from the chemical reaction into electrical energy so that it can used to drive the load. Since the lead acid batteries have a definite charge in them, they cannot be used to supply the load for an infinite time. Thus, it becomes critical to find out how much charge the battery has and also how long will it be able to supply the load at a specific discharge rate. The parameter that indicates the amount of charge present in a battery is the State of Charge (SOC). State of charge of a battery is its available capacity expressed as a percentage of its rated capacity. SOC defines the capacity and the useful energy present in the battery at a given moment that can be used.
Factors influencing the SOC:
The main factors that influence the capacity (SOC) of a battery are:

1. Internal Resistance :
   The internal resistance comprises of
   • Over-charge and over-discharge resistance:
   When the battery is overcharged or over discharged the internal resistance of the battery is significantly increased.
   • Self-discharge resistance :
   Self discharge resistance varies with temperature.
   • Resistance for charge and discharge :
   This resistance accounts for electrolyte resistance, the plate-resistance and the fluid resistance.

2. Discharge type :
   There are basically two types of discharges
   • Continuous Discharge:
   When the battery is continuously supplying energy to the load without rest and the battery capacity continuously drops.
   • Intermittent Discharge:
   In this type of discharge, the battery supplies energy to the load for some time, then the load is disconnected so that battery voltage is recovered (increases) and after sometime discharge starts again. In intermittent discharge, the battery will run for a longer discharge time.

3. Discharge Mode:
   There are basically three different modes of discharge which affects the capacity of the battery.
   • Constant Load:
   When the battery is supplying a load of constant resistance. Thus
   the load current decreases as the battery voltage drops in the course of discharge.
   • Constant Current:
   In this mode the load current remains constant. i.e. the load
   continuously decreases its resistance in order to maintain the load current constant.
   The battery voltage drops at a faster rate in this because of higher average load current.

• Constant Power:
A constant electrical power is drawn by a load from a battery when the load current increases in order to compensate for a decrease in the battery voltage. This mode of discharge has the shortest discharge time.

4. Rate of discharge/charge:
To extend service life of a battery, the rate of charge and discharge of a battery cannot be too high. Excessive overcharging and over discharging can reduce battery life significantly.

Method to determine the SOC of a battery :
There are basically four different ways of calculating the SOC of a battery.

(1) Direct Measurement:
This method is more accurate only if the battery is discharged at a constant rate. In this method, the total charge consumed in a battery is evaluated by integrating the battery current over time.

(2) SOC from specific gravity measurements :
In this method, the variations in the weight of the active chemicals present in the battery are measured in order to correlate to the amount of charge present in the battery. Usually in a lead-acid battery, the concentration of sulfuric acid in water (which acts as electrolyte) decreases in the course of discharge. Thus by measuring the concentration of the sulfuric acid (through specific gravity measurements) it gives direct indication of the charge present in the battery.

(3) Voltage based SOC estimation:
This uses voltage of the battery to calculate the SOC or remaining charge present in the battery. Results can vary depending on the actual voltage level, discharge rate and the age of the cell and compensation for these factors must be provided to achieve reasonable accuracy.

(4) Current based SOC estimation technique :
In this method, the current entering and leaving the battery is measured as a means to calculate the remaining capacity of the battery. This method is accurate than other methods because it depends on the value of current (which is dictated by the load and hence is more accurate than battery terminal voltage).

2.2 .State of Health

In today's world, the use of battery is increasingly becoming important. It is important to know whether the battery is performing as good as it is supposed to perform when it was new. However, when the batteries are being repeatedly used their performance decays with the cycle number. Thus it becomes necessary to have estimate of the health of the battery so that it may be replaced at appropriate time. The parameter which gives an indication on the health of the battery is State of Health (SOH) of the battery. Thus we define SOH as the "measurement" that reflects the general condition of a battery and its ability to deliver the specified performance compared with a fresh battery. It is generally expressed as percentage. Unlike SOC, which is a quantitative measure of the battery, SOH is a more qualitative measure. It is a more of estimation than a measurement. The main purpose of the SOH of the battery is to provide an indication of the performance of the battery based on the current condition or how much of the useful life of the battery has already been consumed and how much more (or how long) we can expect from the battery before they are replaced.

Factors affecting SOH of battery :

(1) Depth of Discharge(DOD) :
It is defined as the measure of how much energy has been withdrawn from a battery. It is expressed as percentage of the full-capacity of the battery. If DOD is very high, then large amount of energy has been utilized from the battery. This reduces the life of battery (i.e. SOH decreases drastically). Thus, the battery should not be discharged very close to its end-point voltage.

(2) Intensity of charge or discharge:
The rate (current) at which the battery is charged or discharged affects the health of the battery. If the battery is discharged (or charged) at a higher current it will tend to deteriorate the health of the battery at a faster rate. Thus it is always best to charge or discharge them at a nominal value of current.

(3) Self-discharge :

If the battery is left unused for a long time, its SOC slowly decrease due to self-discharge and also its SOH diminishes. This is because the chemical reactions inside a battery are always active and that tend to decrease the value of these parameters. This effect can be taken care of by keeping the battery in float charge which helps in recycling (to a certain extent) the lost charge of the battery.

(4) Effect of pulsating loads :
In vehicles, the battery is generally subjected to pulsating loads (as the car is getting accelerated or decelerated). In that case, the chemical reactions in a battery should be capable of reversing their process at a faster rate. However they have a definite response time and they cannot reverse their process at the frequency of the pulsating loads. This phenomenon causes a significant loss in the health of the battery.

Method to determine the SOH of a battery:

- Any parameter which changes significantly with age, such as cell impedance, can be used as the basis for calculating the SOH of the battery. To calculate the SOH of the battery,then the system must have the data of the cell impedance of the battery when it was new. This ensures that there is a comparison of the parameter with its standard value in order to indicate the SOH.

- Voltage-based SOH calculations :
  In this method, the deterioration of voltage profile with the ageing of the battery is employed to calculate the SOH. The present terminal voltage of the battery is compared with the actual voltage of the battery (when the battery was new) to give the health of the battery.

III. HARDWARE SYSTEM DESIGN

3.1. Microcontroller (PIC16F877A)

This section forms the control unit of the whole project. This section basically consists of a Microcontroller with its associated circuitry like Crystal with capacitors, Reset circuitry, and so on. The Microcontroller forms the heart of the project because it controls the devices being interfaced and communicates with the devices according to the program being written.

3.2. MAX 232

Since the RS232 is not compatible with today's microprocessors and microcontrollers we need a line driver (voltage converter) to convert the RS 232 signal to TTL voltage level that will be accepted by 89C55 transmitter and receiver pin. The MAX232 converts from RS232 voltage level to TTL voltage levels and vice-versa. One advantage of the MAX232 chip is that it uses a +5V power source which is the same as the source voltage of 89C55. In other words with a single +5V power supply we can power both the 89C55 and MAX232 with no need for dual power supplies that are common in older systems. MAX232 requires four capacitor between 1uF to 22uF. The most widely used value for this capacitor is 22uF.The voltage levels of RS 232 are not suitable for microcontroller and hence the buffer IC is used which is MAX 232. The voltage levels of MAX 232 are 0 to +5 volts. The MAX 232 is TTL to CMOS converter and also CMOS to TTL converter and thus making the system compatible with PC. The voltage level of MAX 232 is used to assure error free transmission over greater distances than would be possible with TTLMax 232 is driver ic used for serial communication, the pin no 11 & 12 of Max 232 is connected to the TXD0 & RXD0 of controller which is connected to the P0.0 and P0.1 pin respectively.
The features of IC MAX232 are as given below

- TTL to RS 232 Converter.
- VCC = 5V.
- Two sets of line drivers.
- Max 232 requires four external capacitors of value 22 µF.

3.3 Temperature Sensor

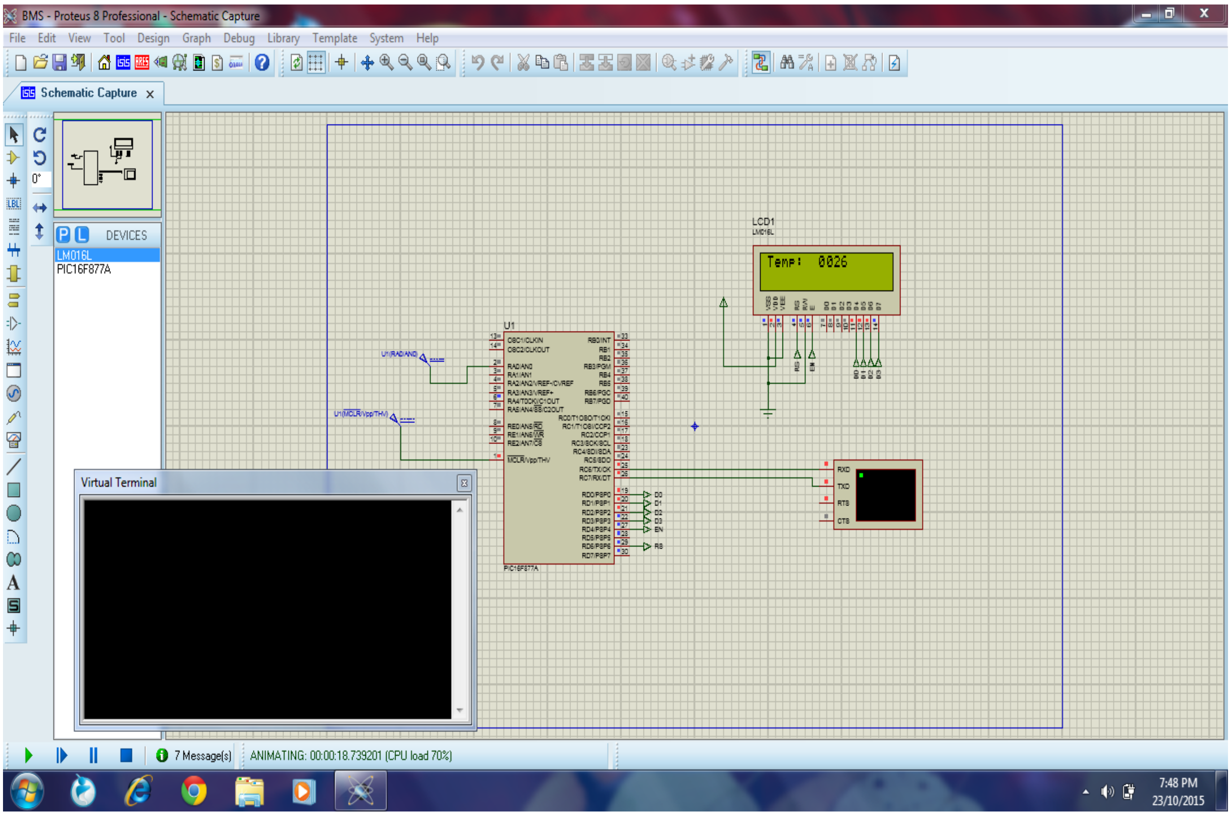
The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature

Features:

- Calibrated directly in ° Celsius (Centigrade)

- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guaranteeable (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±1⁄4°C typical
- Low impedance output, 0.1 ohm for 1 mA load

IV. CIRCUIT DIAGRAM



V. APPLICATIONS

- Hybrid Electric Vehicles which are powered by battery
- Battery monitoring systems are also important in UPS systems, in Distributed generation systems where batteries are used as storage devices for storing the excess DC power generated.
- Electronics gadgets
- Solar charge storage

➢ The most important battery operated devices are:

- DC power supplies
- Uninterruptible power systems

- High-voltage power supplies
- Power supplies for industrial applications
- Power active filters
- Traction battery chargers
- Static transfer switches
- Motor driving systems: AC and DC motors
- Measurement devices: battery earth fault meters, battery operation monitors
- Wind power converters

VI. CONCLUSION

With the rising importance for battery, both in the automotive industry and the energy sector, it is of critical importance to develop more accurate models of the battery. The inherent battery parameters are estimated using only the input-output relations of the battery

So, here we are preparing a model to monitor the battery and its parameters continuously. Battery-based systems require more user involvement for optimal performance. If ignored, batteries can easily become the weak link in the system and an expensive component to replace.

VII. ACKNOWLEDGEMENT

Words are inadequate to express our sincere deep sense of gratitude to Prof. Mr. Ramgopal Sahu our guide, for his consistent guidance throughout this project for his valuable guidance inspiration, motivating us to accomplish this project.We express our sincere thanks towards Prof. Mrs. R. S. Kamathe, Head Of Electronics and Telecommunication Department, for providing us with all facilities & infrastructure while doing this project as all the success is the result of their encouragement. We express our sincere thanks towards all the staff members of the department and our friends who have helped us directly or indirectly in completing the project.

REFERENCES

[1] Ahmed T. Elsayed, Christopher R. Lashway, and Osama A. Mohammed, " Advanced Battery Management and Diagnostic System for Smart Grid Infrastructure" IEEE Trans. Smart Grid, vol. 3, no. 2, pp. 950–958, Jun. 2012.

[2] Bharatkumar Suthar, Venkat asailanathan Ramadesigan, Paul W. C. Northrop, Bhushan Gopaluni, Shriram Santhanagopalan, Richard D. Braatz, and Venkat R. Subramanian " Optimal Control and State Estimation of Lithium-ion Batteries Using Reformulated Models " , in Proc. of the American Control Conference (ACC) Washington, DC, USA, June 17-19, 2013

[3] Shantanu A. Bhalerao, Abhishek V. Chaudhary, Raghavendra B. Deshmukh, Rajendra M. Patrikar , " Powering Wireless Sensor Nodes using Ambient RF Energy " , in the International Conference onSystems, Man, and Cybernetics IEEE October 8-11, 2006, Taipei, Taiwan.

[4] Nosh K. Medora, Alexander Kusko, " An Enhanced Dynamic Battery Model of Lead-Acid Batteries Using Manufacturers' Data " , Inc. 23445 North 19th Avenue Phoenix, AZ 85027 IEEE 2006. USA

