iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 4 **Issue:** V **Month of publication:** May 2016

DOI:

www.ijraset.com Volume 4 Issue V, May 2016
IC Value: 13.98 ISSN: 2321-9653
International Journal for Research in Applied Science & Engineering Technology (IJRASET)

Battery Health Monitoring System with State Of Charge Estimation Using Artificial Neural Network

Ms. Pawar Ashwini Dilip[1], Mrs.Thorat Rupali.A.[2]
[1]M. E. (Electronics), KBPCE, Shivaji University,
[2]M.E.(Electronics),GUIDE, Prof at KBPCE, Shivaji University

Abstract: Today Battery is an essential component of all critical electrical systems. Battery stores chemical, not electricity. Two different lead in an acid mixture react to produce an electrical pressure. This electrochemical reaction changes chemical energy to electrical energy. Some batteries are sensitive to overcharge and deep discharge, which may lead to permanent damages. Hence all these stationary batteries require routine maintenance to identify and correct problems. A visual inspection can identify physical problems, electrical testing identifies overcharging and undercharging problem. And state of charge test checks the electrolyte strength. This paper presenting a design of a cost effective battery monitoring system which can be easily installed on various type of batteries, captures data regarding the status of battery and sends data to authorized person. Also to estimate state of charge (SOC) accurately a very accurate, robust, stable method such as Artificial Neural Networks (ANN) is used. It will help us to prevent overcharging and over discharging the battery which ultimately results in longer battery service time.

Keywords: Lead-acid battery, SOC, ANN, online monitoring

I. INTRODUCTION

An electrical battery is a combination of one or more electrochemical cells, used to convert stored chemical energy into electrical energy. If any operation carried on system relies on protection of battery bank, then it is necessary to have a healthy and being constantly monitored battery. Consider an application of battery back-up in hospitals; there are patients on life support systems that require absolute 100% electric power. In such condition power failure is not an option. This example show how important batteries have become in our everyday lives. The batteries used in various applications such as Telecom cell sites, Industrial, IT infrastructure, Automotive & Hybrid vehicles, Wind, solar, fuel-cell, etc., are expensive and need regular checking and maintenance to achieve their rated life. Battery should be in good condition to provide sufficient amount of power to the device without interruption. Battery monitoring system is relatively simple in low-power applications and, thus, a great number of integrated solutions are available. Today, there are number of solution for battery monitoring system have been proposed such as microcomputer based UPS battery management system [1], Generalized battery management system [2], Battery Health Monitoring System Based on PLC, Battery monitoring system for the operation of lead-acid battery group in telecommunication base stations. In some method starting, lighting, ignition of battery for an internal combustion engine was used for monitoring. In another way general state of charge of a battery can be determined by taking battery offline and connected to calibrated resistor. For State of charge (SOC) estimation we require voltage, current, temperature, electrolyte level and other related parameter of battery. All these historical data is nonlinear function of SOC and it depends on charge and discharge operation. There are various methods available for SOC estimation. Direct method that is used to estimate the SOC is the open-circuit voltage [3]. In this method, the voltage is measured continuously and the corresponding SOC is obtained from a lookup table. This method requires a very low discharge current for accurate results, which can be a good choice for applications that draw very small currents from the battery. Another method Coulomb counting (CC), also known as current-integration, is a common method that is used widely to estimate the SOC in real-time [4]. Other methods such as the "discharge test" is not practical because it wastes the energy stored in the battery and cannot be used in real-time. In addition, the "impedance spectroscopy" method requires an AC current injection into the cell to measure its impedance and is hard (if not impossible) to achieve in real-time [5]. On the other hand, there are several indirect methods that are used to estimate the SOC. These methods can be very accurate and reliable in general. Among these methods are extended Kalman filters (EKF) [6]-[8]. These indirect methods can be implemented in real-time and give very accurate results but their computational requirements and implementation cost are relatively high. Regardless of what SOC estimation method is used, the BMS must estimate the battery total capacity until the battery reaches its service-life. SOC estimation method based on ANN algorithms are highly robust, accurate, and can be implemented in real-time [9].

International Journal for Research in Applied Science & Engineering Technology (IJRASET)

II. DESIGN OF MONITORING SYSTEM

In Battery health monitoring system we have to develop a device which can let you know the battery status, electrolyte level, battery current, voltage and temperature. All these acquired data will be sent using wireless module to the authorized Person to calculate State Of Charge estimation of the battery. Using battery parameters estimation of the value of state of charge (SOC) of battery can be carried out using back propagation neural network algorithm to find out the problem and take the corrective action. Figure 2.1 shows Intelligent battery Monitoring System with SOC estimator in which different sensors are used to measure the battery parameter such as current, voltage, electrolyte level, and temperature. Microcontroller collects the data from different sensor node provides the central logic for each and connects to wireless module.

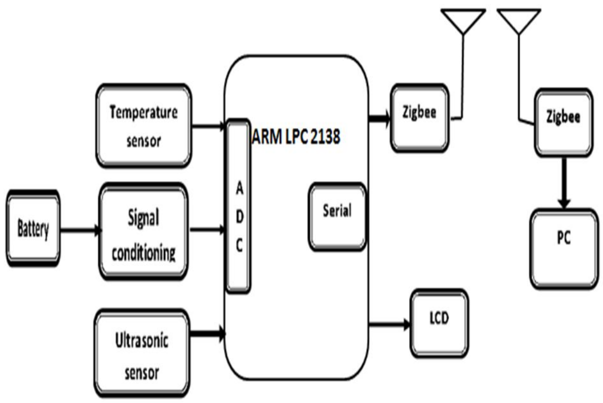


Figure 2.1 Block Diagram Battery Health Monitoring System

We have used Microcontroller ARM LPC2138 along with other peripherals like LCD, power supply, ultrasonic sensor, temperature sensor, battery, signal conditioning circuit, etc. LCD JHD16X2A is interfaced with ARM microcontroller through port 1 and port 0. We have used LM35 temperature sensor which is interfaced with microcontroller through ADC channel. Ultrasonic sensor, HCSR04 is used to check level of battery. Also, voltage and current of battery is monitored through readings obtained at other ADC channels. Variation of sensor's values is displayed on LCD during execution of complete project. Zigbee module is interfaced with microcontroller through MAX232 driver IC to serial port. Sensor values are sent to PC through Zigbee module.

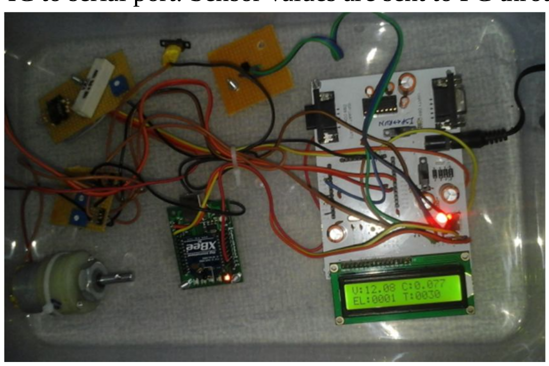


Figure2.2: Hardware used for Designing battery monitoring system

The battery monitor system further includes the analysis of sensed battery parameter using SOC estimator. At the receiver battery parameter data will be received using wireless module and used for SOC estimation. The SOC of batteries has a nonlinear relationship with its terminal voltage, current and temperature. As ANNs are universal approximators and can approximate any nonlinear function with desired accuracies, SOC estimation can be carried out using artificial neural network algorithm using MATLAB software.

III. ARTIFICIAL NEURAL NETWORKS

Artificial Neural Networks (ANNs) are nonlinear mapping structures based on the function of the brain. Training ANNs is the most critical phase that determines how accurate they are. ANNs can have open-loop (feed-forward) or closed-loop (feed-back) structure, and they have the capability to adapt to changes (this kind of neural networks is called adaptive ANN). The weights in adaptive

ANNs continuously adapt, in real-time, to changes that occurs after training, while non-adaptive ANNs have fixed weights that are determined in the training phase. The weights of an ANN are calculated in the training phase by minimizing the loss function (usually a quadratic function of the output error). One common technique that is widely used in training ANNs is the back-propagation, or back-propagation of errors, which is a supervised learning method that is commonly used in the training phase to calculate the weights of a neural network. Back-propagation uses a steepest-descent technique based on the computation of the gradient of the loss function with respect to the network parameters.

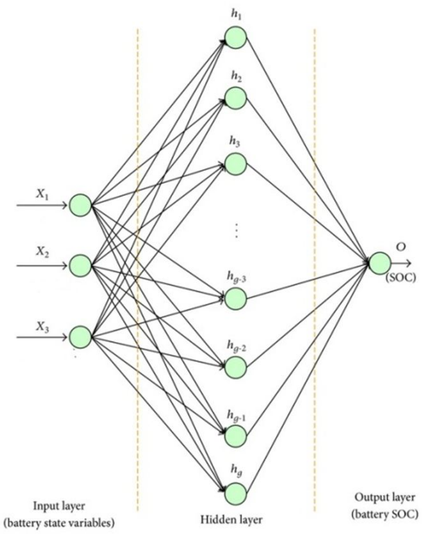


Fig.3.1: A two layer feed forward ANN with hidden neurons, n input neurons and 1 output neuron.

The architecture of the SOC estimating BP neural network is shown in Figure 3.1. The architecture of BP neural network contains an input layer, an output layer, and a hidden layer. Input layer has 3 neurons for terminal voltage, discharge current, and electrolyte level, hidden layer has *g* neurons, and output layer has only one neuron for SOC.
The total input of a neuron in hidden layer is calculated by the following form:

$$net\ i_j=\sum x_i\, v_{ij} + b_j,$$

Where net i_j is total input of the hidden layer neuron j; x_i input to the hidden layer neuron j from input layer neuron i; v_{ij} is weight between the input layer neuron i and hidden layer neuron j; b_j is bias of the hidden layer neuron j.

The activation function applied to neuron in hidden layer is the hyperbolic tangent function which is calculated by the following equation:

$$h_j = f(net\ i_j) = \frac{(1-e^{-2net}ij)}{(1+e^{-2net}ij)}$$

The total input of the neuron *o* in output layer is calculated by

$$net\ o = \sum h_i w_i + k,$$

Where net *o* is total input of the output layer neuron o; h_i is input to the output layer neuron from hidden layer neuron i; w_i is weight between the hidden layer neuron *i* and output layer neuron; k is bias of the output layer neuron *o;*

The activation function applied to neuron *o* in output layer is the sigmoid function as the following equation:

$O = f(net\ o) = 1/(1+e^{net\ o})$

A. The Neural Network Modeling Of Power Battery

The establishment of neural network, considering how to choose the input and output parameters properly is very important, basic principles of neural network input parameters:

1) Choose parameters which have a big influence on the output of the network, and easily measured or extracted as the inputs of network;
2) The correlation between selected input should be uncorrelated or little relevance;

As the voltage, current and temperature have a big impact on the battery SOC. at the same time can be easily obtained directly through the sensor, and that the battery voltage and current have a little relevance with temperature, the input of the neural network is voltage, current and electrolyte level of the power battery. The output of the neural network is the value of SOC. Learning samples expressed as vectors [U, I, L,]. U means the total voltage. I means the total current. L means the electrolyte level.

IV. EXPERIMENTAL ANALYSIS AND RESULTS

After BP neural network model is established, the sample data for training the neural network are getting through discharge test. First of all ,a part of discharge test data used as learning samples to train the network. Then part of discharge test data regarded as test data for SOC estimation. MATLAB software is used to calculate SOC using ANN algorithm

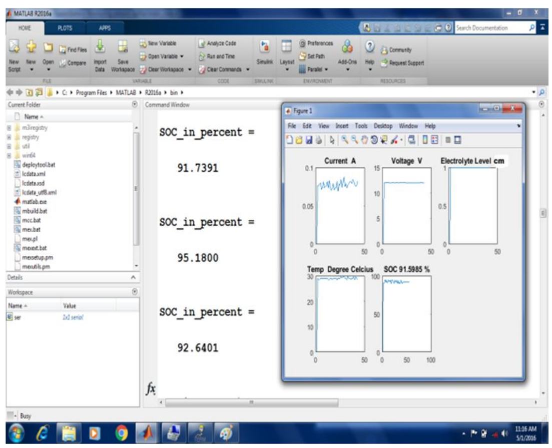


Figure4.1: The interface of monitoring PC software used in discharge test

The curve of SOC estimation based on neural network and the curve of discharge test is shown in Fig.4.2. This verifies the validity of the model and algorithm, and makes sure that the system achieves high efficiency to get accurate value of SOC

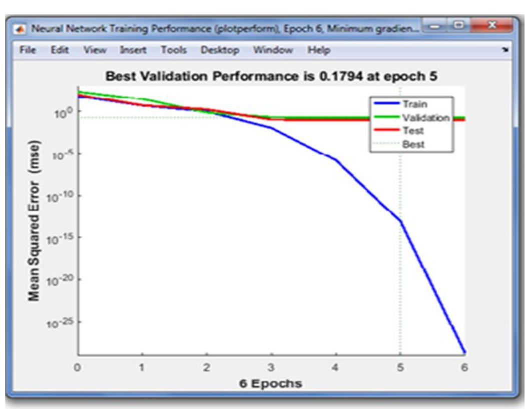


Figure 4.2: The curve of SOC estimation based on neural network and the curve of discharge test

Volume 4 Issue V, May 2016
ISSN: 2321-9653

V. CONCLUSION

Battery health monitoring system with state of charge estimation using artificial neural networks can be easily installed on batteries. It will collects related battery parameter such as current, voltage, electrolyte level, etc. and estimate state of charge of battery. By estimating the value of SOC and using SOC correction function we can know health of battery. The proposed system will help us to avoid regular site visits, prevent battery failure, extend battery life, reduce maintenance cost and increase safety.

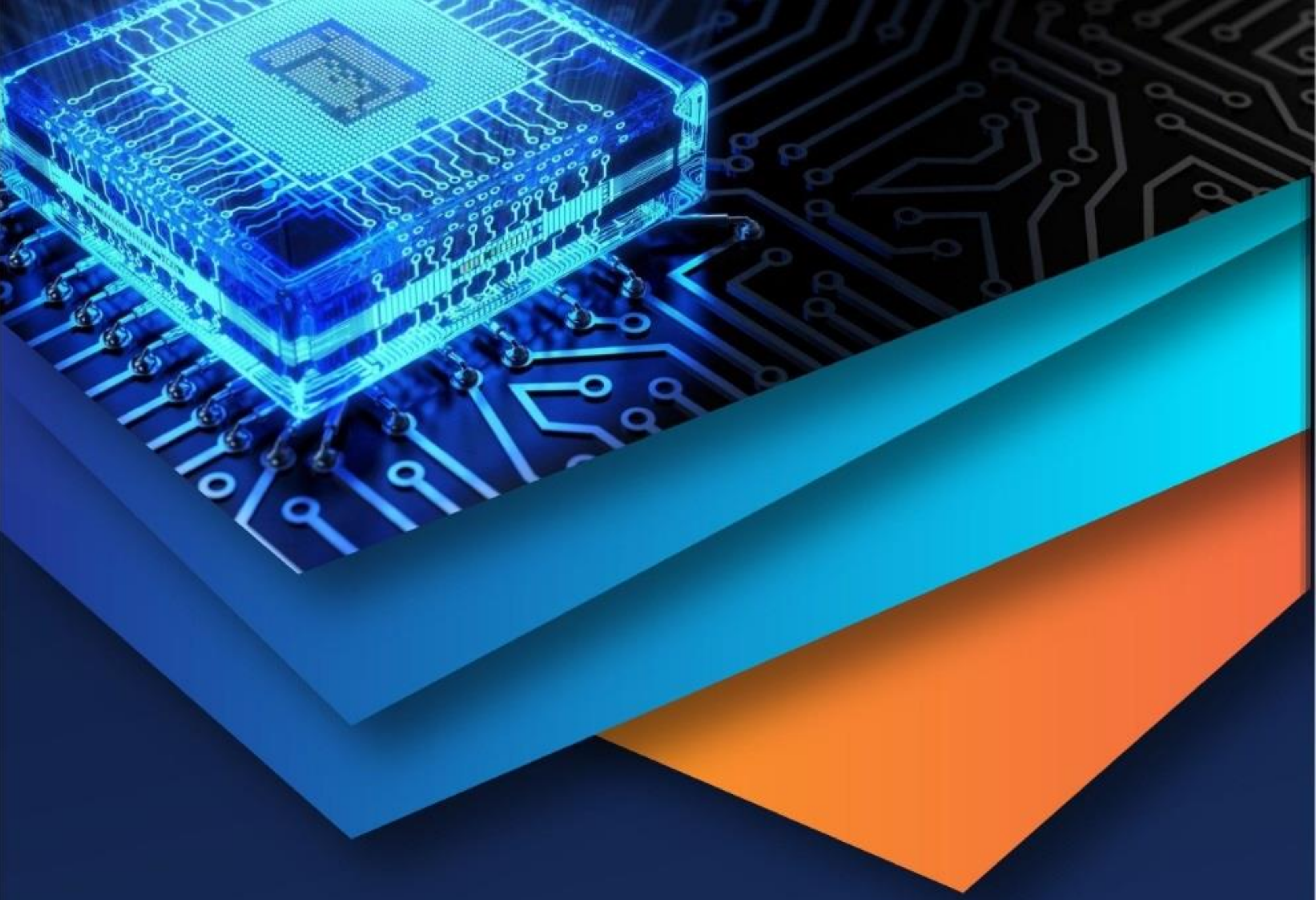
REFERENCES

[1] Z. Noworolski and J. M. Noworolski, "A microcomputer-based UPS battery management system," in Proc. IEEE APEC'91, 1991, pp. 475–479.
[2] John Chatzakis, Kostas Kalaitzakis, Nicholas C. Voulgaris, and Stefanos N. Manias, Senior Member, 'Designing a New Generalized Battery Management System' IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 50, NO. 5, OCTOBER 2003
[3] J. Kim, S. Lee, B. H. Cho, "Complementary cooperation algorithm based on DEKF combined with pattern recognition for SOC/capacity estimation and SOH prediction", IEEE Transactions on Power Electronics, vol. 27, no. 1, pp. 436-451, 2012.
[4] X. Hu, S. Li, H. Peng, F. Sun, "Robustness analysis of State-of-Charge estimation methods for two types of Li-ion batteries", Journal of power sources, vol. 217, pp. 209-219, 2012.
[5] A. A. Hussein, N. Kutkut, J. Shen and I. Batarseh "Distributed Battery Micro-Storage Systems Design and Operation in a Deregulated Electricity Market", IEEE Transactions on Sustainable Energy, vol. 3, no. 3, pp. 545-556, 2012.
[6] H. He, R. Xiong, X. Zhang and F. Sun "State-of-charge estimation of the lithium-ion battery using an adaptive extended Kalman filter based on an improved thevenin model", IEEE Transactions on Vehicular Technology, vol. 60, no. 4, pp. 1461-1469, 2011.
[7] S. Qiu, Z. Chen, M.A. Masrur and Y. L. Murphey "Battery hysteresis modeling for state of charge estimation based on Extended Kalman Filter" 6th IEEE Conference on Industrial Electronics and Applications (ICIEA), 2011.
[8] N. A. Windarko, J. Choi, and G. B. Chung "SOC estimation of LiPB batteries using Extended Kalman Filter based on high accuracy electrical model" IEEE 8th International Conference on Power Electronics and ECCE Asia (ICPE & ECCE), 2011.
[9] Ala A. Hussein, Member, IEEE ' Capacity Fade Estimation in Electric Vehicles Li-ion Batteries using Artificial Neural Networks' DOI 10.1109/TIA.2014.2365152, IEEE Transactions on Industry Applications

AUTHOR'S PROFILE

Miss. Pawar Ashwini Dilip
B.E. (Electronics), M.E. (Electronics)., K.B.P.College of Enginering 2012, 14 respectively Satara Area of Interest: VLSI Design, Embedded system. Software Known: Xilinx10.1, MATLAB11, Keil, Turbo C, Microwind. Work Experience: 5Ys as Assistant Professor in Jaywant College of Engg and Management, K.M.Gad (2010-2015).

Prof. Thorat Rupali Ashok
M.E.(Electronics)Guide, Area of interest: Power electronics Work experience: 33 years as professor in K.B.P. College Of Engineering Satara. Software Known: Xilinx10.1, MATLAB11, Keil, Turbo C, Microwind. Languages: Hindi, Marathi, English.



10.22214/IJRASET

INDEX COPERNICUS 45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY