DEVELOPMENT OF A REAL-TIME MONITORING SYSTEM FOR LEAD–ACID BATTERIES BASED ON IOT.

Anusha R* Nireeksha K N* Niveditha K V* Pallavi G V*
Student*,Assistant Professor #
Department of Electrical and Electronics Engineering
GSSS Institute of Engineering and Technology for Women, Mysuru, India
Affiliated to Visvesvaraya Technological University, Belagavi, India

Abstract- In this paper, real-time monitoring of multiple lead-acid batteries based on Internet of things is proposed and evaluated. Our proposed system monitors and stores parameters that provide an indication of the lead acid battery's acid level, state of charge, voltage, in a real-time scenario. To monitor these lead–acid battery parameters, we have developed a data acquisition system by building an embedded system, i.e., dedicated hardware and software. The wireless local area network issued as the back-bone network. The information collected from all the connected battery clients in the system is analyzed in an asynchronous transmission control protocol/user datagram protocol-based C# server program running on a personal computer (server) to determine important parameters like the state of charge of the individual battery, and if required, appropriate action can be taken in advance to prevent excessive impairment to the battery. Further, data are also displayed on an Android mobile device and are stored in an SQL server database. We have developed a real prototype to devise an end product for our proposed system.

Index Terms battery; embedded system; Internet of things; monitoring; prototype; real-time; sensors; TCP/UDP

1. INTRODUCTION

The demand for electric power for industrial purposes is growing rapidly. Many transportation vehicles and uninterruptible power supply (UPS) systems that are used in heavy industries require electric power for their smooth operation. These vehicles and UPS systems are equipped with lead–acid batteries as an alternate source of electric power. In addition, fuel saving strategies that actively utilize the power from these batteries [1] are being considered. Therefore, a reliable battery system is indispensable for effective operation in industry. However, it is to be noted that these batteries are considerably costlier and excessive use could result in their malfunction. Also, the damaged lead–acid batteries can have a negative impact on the environment during the recycling process. It is therefore very important to continuously monitor the development and management of these batteries to preclude undue damage and prolong the lifetime of the battery.
In technical terms, the effect of the overuse of these batteries could reduce the lifetime operation and in the worst case can lead to system failure, a highly undesirable situation in heavy industries. There are several ongoing studies underway to find a solution by effective remote monitoring based on Internet of things (IoT). IoT is a multitude integration of several fields such as sensor networks, embedded systems, data processing and fusion, intelligent control, task scheduling and allocation, etc.

2. LITERATURE SURVEY

A literature survey is the section which shows various analysis and research made in the field of interest and the results already published, taking into account the various parameters of the project and extends of the project

[1] Development of integrated fuel cell hybrid power source for electric forklift. J. Power. This includes all the management and analysis of these measurements in battery management software. An online monitoring terminal for electric vehicles based on GPRS wireless communication.

[2] Online Battery Monitoring System Based on GPRS for Electric Vehicles: It consists of an online monitoring panel for battery parameter measurements with a GPRS data transmitter unit and a computer equipped with battery online monitoring software, to monitor the various operating parameters of the battery in real-time. The authors further showed that through their system it is possible to judge the status of the battery, execute the fault diagnosis, and establish a database to facilitate data storage.

[3] Smart Battery Power Management Unit: It includes a temperature and humidity sensor module, a liqmodule and a BQ34Z110 moduleuid level sensor.

[4] Closed-loop design evolution of engineering system using condition monitoring through internet of things and cloud computing: The authors employed condition monitoring in the design improvement process by evaluating the system performance, detecting system failure and estimating system heath status.

[5] A task-efficient sink node based on embedded multi-core soC for Internet of Things: The authors also proposed master–slave architecture and a weighted-least connection (WLC) task schedule strategy to allocate the tasks for slave cores in order to achieve lower congestion and better load balance for the parallel computing.

[6] Web Based Home Monitoring System :The temperature and humidity data is estimated around the battery with the use of a chipcap-D sensor.

3. TOOLS USED:

3.1Arduino UNO R3

The Arduino Uno R3 is a microcontroller board based on a removable, dual-inline-package (DIP) ATmega328 AVR microcontroller. It has 20 digital input/output pins (of which 6 can be used as PWM outputs and 6 can be used as analog inputs). Programs can be loaded on to it from the easy-to-use Arduino computer program. The Arduino has an extensive support community, which makes it a very easy way to get started working with embedded electronics. The R3 is the third, and latest, revision of the Arduino Uno. The Arduino Uno is a microcontroller board based on the ATmega328.It has a a 16 MHz resonator, a USB connection, a power jack, an in-circuit system programming (ICSP) header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer (or appropriate wall power adapter with a USB cable or power it with an AC to DC adapter or battery to get started.
The Uno differs from all preceding boards in that it does not use the FTDI USB-to-serial driver chip. Instead, it features an ATmega16U2 programmed as a USB-to-serial converter. This auxiliary microcontroller has its own USB bootloader, which allows advanced users to reprogram it.
This is the 3rd revision of the Uno (R3), which has a number of changes:

- The USB controller chip changed from ATmega8U2 (8K flash) to ATmega16U2 (16K flash). This does not increase the flash or RAM available to sketches.
- Three new pins were added, all of which are duplicates of previous pins. The I2C pins (A4, A5) have been also been brought out on the side of the board near AREF. There is an IOREF pin next to the reset pin, which is a duplicate of the 5V pin.
- The reset button is now next to the USB connector, making it more accessible when a shield is used.

Figure2:ArduinoUNO R3

Pin Description:

- LED: There is a built-in LED driven by digital pin 13. When the pin is HIGH value, the LED is on, when the pin is LOW, it's off.
- VIN: The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power source). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V: This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 20V), the USB connector (5V), or the VIN pin of the board (7-20V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage the board.
- 3V3: A 3.3-volt supply generated by the on-board regulator. Maximum current draw is 50 mA.
- GND: Ground pins.
- IOREF: This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.
- Reset: Typically used to add a reset button to shields which block the one on the board
- Serial / UART: pins 0 (RX) and 1 (TX). Used to receive (RX) and transmit (TX) TTL serial data. These pins are connected to the corresponding pins of the ATmega8U2 USB-to-TTL Serial chip.
- External Interrupts: pins 2 and 3. These pins can be configured to trigger an interrupt on a low value, a rising or falling edge, or a change in value.
- PWM (Pulse Width Modulation): 3, 5, 6, 9, 10, and 11 Can provide 8-bit PWM output with the analogWrite function.
- SPI (Serial Peripheral Interface): 10 (SS), 11 (MOSI), 12 (MISO), 13 (SCK). These pins support SPI communication using the SPI library.
- TWI (Two Wire Interface) / I²C: A4 or SDA pin and A5 or SCL pin. Support TWI communication using the Wire library.
- AREF (Analog Reference): Reference voltage for the analog inputs.

The Arduino/Genuino Uno has a number of facilities for communicating with a computer, another Arduino/Genuino board, or other microcontrollers. The ATmega328 provides UART TTL (5V) serial communication, which is available on digital pins 0 (RX) and 1 (TX). An ATmega16U2 on the board channels this serial communication over USB and appears as a virtual com port to software on the computer. The 16U2 firmware uses the standard USB COM drivers, and no external driver is needed. However, on Windows, a .inf file is required. The Arduino Software (IDE) includes a serial monitor which allows simple textual data to be sent to and from the board. The RX and TX LEDs on the board will flash when data is being transmitted via the USB-to-serial chip and USB connection to the computer (but not for serial communication on pins 0 and 1). A Software Serial library allows serial communication on any of the Uno's digital pins.

3.2 WI-FI Module ESP2866

ESP8266 is an UART-Wi-Fi transparent transmission module with ultralow power consumption and allows microcontrollers to connect to a Wi-Fi network and make simple TCP/IP connections. It offers a complete and self-contained Wi-Fi networking solution, allowing it to either host the application or to offload all Wi-Fi networking functions from another application processor.

ESP8266 has powerful on-board processing and storage capabilities that allow it to be integrated with the sensors and other applications Its high degree of on-chip integration allows for minimal external circuitry, and the entire solution, including front-end module, is designed to occupy minimal PCB area. ESP8266 Serial Wi-Fi Wireless Transceiver Module is suitable for Uno, Mega 2560 and Nano.

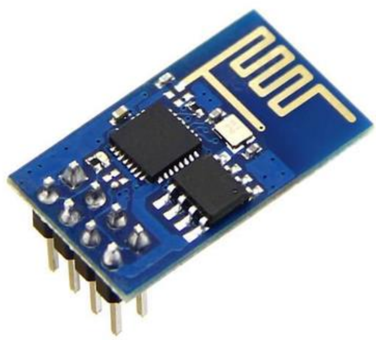

Figure3: WIFI Module ESP8266

3.3Temperature sensor DS18B20

The DS18B20 digital thermometer provides 9-bit to 12-bit Celsius temperature measurements and has a nonvolatile user-programmable upper and lower trigger points. The DS18B20 communicates over a 1-Wire bus that by definition requires only one data line (and ground) for communication with a central microprocessor. In addition, the DS18B20 can derive power directly from the data line ("parasite power"), eliminating the need for an external power supply. Each DS18B20 has a unique 64-bit serial code, which allows multiple DS18B20s to function on the same 1-Wire bus. Thus, it is simple to use one microprocessor to control many DS18B20s distributed over a large area. Applications that can benefit from this feature include HVAC environmental controls, temperature monitoring systems inside buildings, equipment, or machinery, and process monitoring and control systems.

3.4 BLOCK DIAGRAM

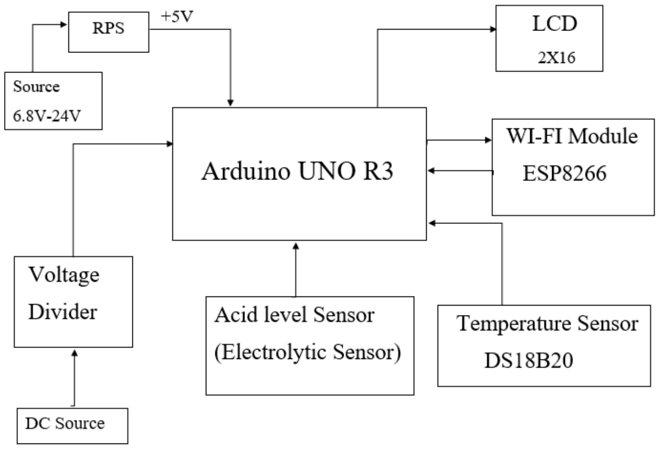

Figure 1: Block diagram of the proposed system.

The block diagram of our proposed system is presented in Figure 1; it includes a temperature sensor, voltage divider circuit, acid level sensor, Wi-fi module, Arduino UNO R3 and LCD display. The battery's acid level, one of the most important parameters to be determined, is evaluated through an electrolyte level sensor. The battery's important parameters, namely, the full charge capacity, the remaining charge capacity, the state of charge, voltage and temperature. The ADC is used for communication between the device and the microcontroller. The battery data from the sensors are received and the calculation and the analysis part are implemented in the microcontroller. Further, for our proposed system, the data is transferred to a Wi-Fi card (ESP8266). It should be observed that in our proposed system the communication between the various parts of the system is done using WLAN technology, considering the mobility of the vehicles and the batteries in an industrial environment.

The source of 6.8V – 24V is given to Regulated Power Supply (RPS), the regulated supply of +5V is supplied to all the components. The data such as Voltage, Temperature and Acid level concentration is collected, analyzed and implemented in Microcontroller (Arduino UNO R3).
The data collected is displayed in LCD (2X16) and also can be viewed in MQTT Dashboard in real time scenario

4. TESTBED IMPLEMENTATION

The testbed implementation, prototype, for our proposed method is shown in figure 2. The electrolyte level sensor is connected to the ICSP of Arduino UNO R3. The A2 pin of analog inputs is connected to the temperature sensor DS18B20. The voltage divider circuit is connected to the A3 pin of analog inputs to detect the voltage.
All the information collected from the sensors is sent through WLAN (Wireless Local Area Network) with the help of microcontroller and the ESP8266 wi-fi module to the server and the android application. The data can also be viewed in LCD display. The battery data from the sensors are received and the calculation and the analysis part are implemented in the microcontroller. Further, for our proposed system, the data is transferred to a Wi-Fi module (ESP8266) with the help of serial communication.

Integrating the battery management system with IoT enables us to view the data obtained from the batteries anywhere with the help of our Mobile phone or it can be saved in Cloud and retrieved anytime for analysis. This feature is enabled by using a wi-fi module, which will collect the data from the controller and display it in cloud via any of the available bearer services with appropriate time delays. Once the connection with the bearer is established, the data can be transferred to the website and then monitored online. We have to provide the URL of the website in which we need to post while configuring the wi-fi.

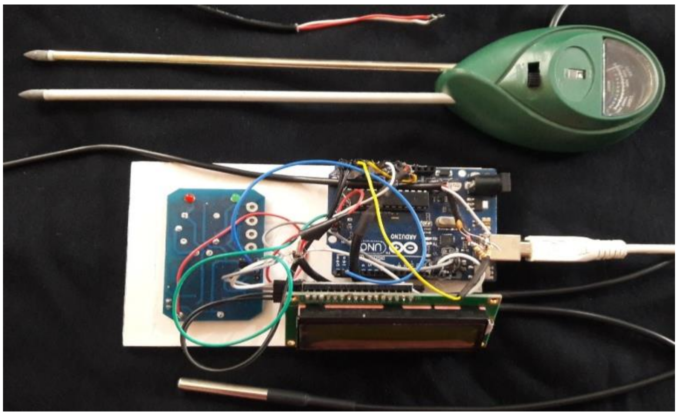

Figure 2: Proposed system

5. CONCLUSION

Understanding the importance of effective remote monitoring of the lead–acid batteries in industrial environments, in this paper, a monitoring system prototype for handling lead–acid battery is designed and developed in real time based on Internet of things. To achieve this, we have developed a data acquisition system by building an embedded system through dedicated software and hardware.

6. REFERENCE

1. Karden, E.; Ploumen, S.; Fricke, B.; Miller, T.; Snyder, K. Energy storage devices for future hybrid electric vehicles. J. Power Sources 2007, 168, 2–11.
2. Atzori, L.; Iera, A.; Morabito, G. Understanding the Internet of Things: Definition, potentials, and societal role of a fast-evolving paradigm. Ad Hoc Netw. 2017, 56, 122–140.
3. Back, J.A.; Tedesco, L.P.; Molz, R.F.; Nara, E.O.B. An embedded system approach for energy monitoring and analysis in industrial processes. Energy 2016, 115, 811–819.
4. Velandia, D.M.S.; Kaur, N.; Whittow, W.G.; Conway, P.P.; West, A.A. Towards industrial internet of things: Crankshaft monitoring, traceability and tracking using RFID. Robot. Comput. Integr. Manuf. 2016, 41, 66–77.
5. Xia, M.; Li, T.; Zhang, Y.; de Silva, C.W. Closed-loop design evolution of engineering system using condition monitoring through internet of things and cloud computing. Comput. Netw. 2016, 101, 5–18.
6. Qiu, T.; Zhao, A.; Ma, R.; Chang, V.; Liu, F.; Fu, Z. A task-efficient sink node based on embedded multi-core soC for Internet of Things. Future Gener. Comput. Syst. 2016. doi:10.1016/j.future.2016.12.024.
7. López-Benítez, M.; Drysdale, T.D.; Hadfield, S.; Maricar, M.I. Prototype for Multidisciplinary Research in the context of the Internet of Things. J. Netw. Comput. Appl. 2017, 78, 146–161.
8. Xia, Z.; Su, H.; Liu, T. Remote Monitoring System of Lead-Acid Battery Group Based on GPRS. In Proceedings of the 2010 International Conference on Electrical and Control Engineering (ICECE), Wuhan, China, 25–27 June 2010; pp. 4023–4026.
9. Rosolem, M.F.N.; Pessenti, G.R.; Beck, R.F.; dos Santos, G.R.; Arioli, V.T.; Lopes, P.H.O.Stationary lead-acid batteries remote monitoring system. InProceedingsofthe2011IEEE33rdInternationalTelecommunications Energy Conference (INTELEC), Amsterdam, The Netherlands, 9–13 October 2011.
10. Keränen, T.; Karimäki, H.; Viitakangas, J.; Vallet, J.; Ihonen, J.; Hyötylä, P.; Uusalo, H.; Tingelöf, T. Development of integrated fuel cell hybrid power source for electric forklift. J. Power Sources 2011, 196, 9058–9068.
11. Luo, M.; Xiao, Y.; Sun, W.M.; Wang, Z. Online Battery Monitoring System Based on GPRS for Electric Vehicles. In Proceedings of the 2013 5th International Conference on Intelligent Human-Machine Systems and Cybernetics (IHMSC), Hangzhou, China, 26–27 August 2013; pp. 122–125.
12. Ananda, A.L.; Tay, B.; Koh, E.K. A survey of asynchronous remote procedure calls. ACM SIGOPS Oper. Syst. Rev. 1992, 26, 92–109.
13. PSpice, O. Electronic Design Software; EMA Design Automation: New York, NY, USA, 2017.
14. Deda, S. Smart Battery Power Management Unit 2014. Available online: http://urn.fi/URN:NBN:fi: tty-201405131162 (accessed on 21 December 2015).