Battery Management System

Muhammad Rafiuddin Bin Mar Sidek
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
Johor Bahru, Malaysia.
Mrafiuddin8@live.utm.my

Kumeresan A. Danapalasingam
Department of Control & Mechatronics Engineering
Faculty of Electrical Engineering
Universiti Teknologi Malaysia
Johor Bahru, Malaysia.
kumeresan@fke.utm.my

***Abstract*— A battery management system for management and control rechargeable batteries that connected in series. A microcontroller unit communicates with battery modules and a battery charger. Each of the battery modules consists of a rechargeable battery, a sensor hub including a battery sensors and a microcontroller that produces signals created by the battery sensors, and an auxiliary battery charger. During a charging cycle the charger provides a variable charging current to the rechargeable batteries and each of the rechargeable batteries receive a charging current from same current chargers but at a different charging time. During the charging or discharging cycle, the voltage and temperature of the rechargeable or auxiliary batteries are monitored by the microcontroller unit by means of the sensor nodes and the charging current reduced by one half when any battery voltage reaches a specified clamping voltage. Once the charging current is decreased to around 1 to 2 percent of the 3-hour release limit with respect to the rechargeable batteries, the charger is stopped.**

I. INTRODUCTION

Battery Management System or also known as BMS, is a system that monitors the charge in a battery or monitor the states of the battery [1]. BMS also provides a protection system to the batteries, this protection system can lengthen the lifespan of the batteries, also can prevent the batteries from exploding when overheating or even worse case. In other words, BMS is a system that balance the charge in a battery, and then report and record the data into a database for monitoring purpose. From the data collected, we can analyze or plot a graph and monitor the activity and performance of the batteries [2].

The battery management system is a general topic that can be also split up into a few sub-system. “Management system" itself named as the system can manage batteries automatically. This system can be implemented onto any type of battery as long as it follows they voltage range required. For this case the voltage range for battery is from 12V until 24V due to the limitation of the battery charger. In this project I am using Arduino Uno as the microcontroller, these will be explained more in next chapter.

This project can provide an automatic battery charging system to provide an automatic battery charging system for automatically maintaining a charge on auxiliary batteries and to couple the auxiliary batteries to a load when the main battery is not being charged [3]. The system will automatically switch the battery out of the charging circuit for immediate use as a power source when in blackout situation or else. Two or more auxiliary batteries can be provided and the coupling and decoupling of the auxiliary batteries to the charging system and to the load can be arranged such that the batteries are charged in parallel and loaded in series, thus providing optimum voltages for charging and loading, respectively. In addition to the automatic switching functions discussed, the system can also enable the user to select loading in parallel, for longer term operation at lower power [4].

II. PROJECT METHODOLOGY

A. *Overview*

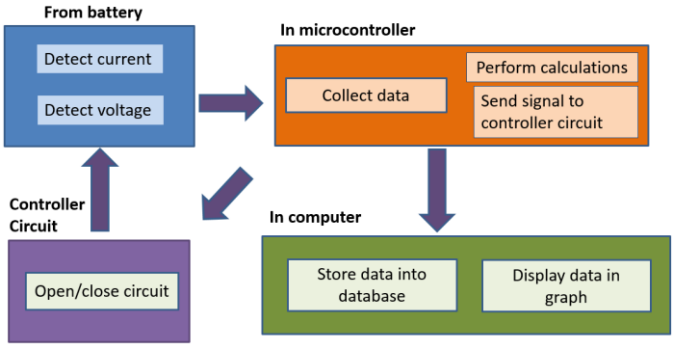


Figure 1: Process of the whole system.

Figure 1 explains the overall process of the system. From the battery part, we have current sensor, voltage sensor and temperature sensor to sense current, voltage and temperature respectively of the battery, and it will send the signal to the microcontroller which is Arduino Uno. So the Arduino Uno will collect the data and send it to the computer. The microcontroller also will perform some calculations and also send signal to controller circuit or electrical circuit. Meanwhile in the computer, it will store the data that has been sent from microcontroller in a database, and also can plot the received the data into a graph. It can be used for the user to analyze the battery performance based on the current and previous data. In

controller circuit, or also known as electrical circuit, it will receive signals from microcontroller and open or close the charging/discharge circuit. The circuit then is connected in discharging process.

B. Project Implementation

This project uses some relays and some other sensors and output. For the output, 5V buzzer will be used as an indicator to show the translation process between charging and discharging, while the buzzer is connected in series to a variable resistor to control loudness of the buzzer. 5V of DC relays will be used to control the open and close of the charging circuit, as in previous mentioned that the relays will receive signals from microcontroller, Arduino Uno. ACS756-50A of current sensor will be used to read the value of current in or out of the battery in order to reconfirm the minimum and maximum value of battery voltage.

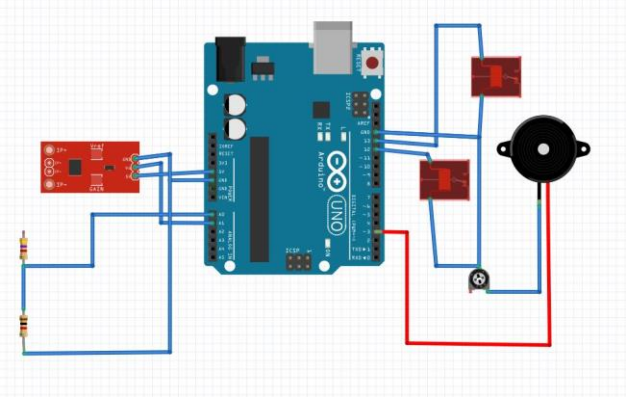


Figure 2: A part of data collecting circuit.

Once the data collecting process has completed, the data collected such as voltage value will be used on the full complete system. Schematic circuit is designed in order to fabricate the system circuit. The software used is Proteus 8, in this software the user can design the schematic and from the schematic circuit, it can come out to a PCB circuit with actual dimension of the components. Below is the schematic circuit done in Proteus 8.

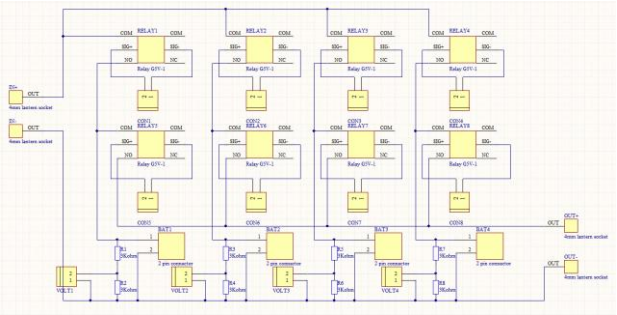


Figure 3: Schematic circuit of PCB board.

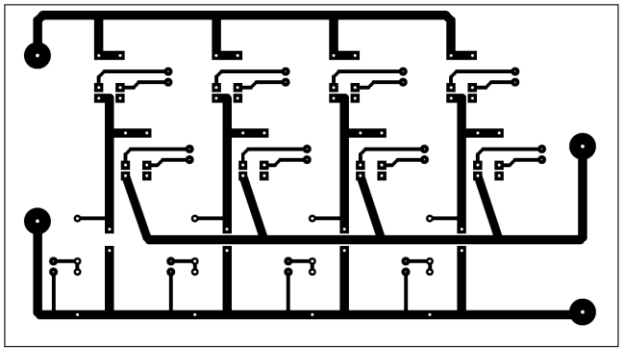


Figure 4: Printed copper line for PCB board.

Once the circuit has completed as in figure 4, fabrication process takes place and solder all the components on the fabricated PCB board.

III. RESULTS AND ANALYSIS

One of the purpose of the data collection process is to find the minimum and maximum voltage values during both charging and discharging process. These minimum and maximum voltage values will be the limitation of the BMS while the charging and discharging process. This data collection process also to estimate the total time needed for a battery to fully deplete for a given number of load.

A. Discharging of Battery

As mentioned earlier, for the current reading this project is using the ACS756-50A. However, before the project started with the ACS756 current module, ACS712 current sensor was used in the first place. Hence, some data collection has did using ACS712.

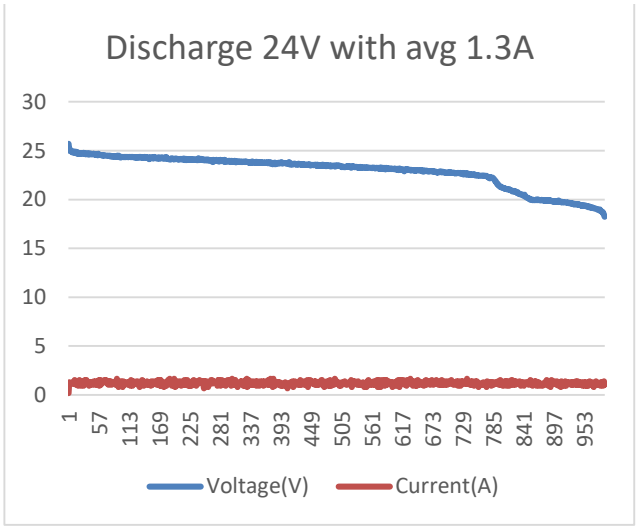


Figure 5: Discharging of a lead acid battery.

By referring to graph in figure 5, during the discharging processes, the current reading was around 2.3A until the end of the process which is 0.0A. Given we know the average current that being drained from the battery, and assume the current is consistent, we can estimate the total time for the battery to fully depleted by using equation below:

$$P = VI \quad (3.1)$$

$$P = 14.4AH \times 24V = 345.6\ Watt\ Hour \quad (3.2)$$

$$p = 24V \times 2.3A = 55.2\ Watt \quad (3.3)$$

$$t = \frac{345.6}{55.2} = 6.26\ Hours \quad (3.4)$$

where,

P = Power of battery
p = Power drained
t = Time for battery to fully deplete
V = Voltage of the battery
I = Current hour of the battery

From the equation we can conclude in theoretically that each battery has 345.6 Watt hour and it needs 6.26 hours to fully deplete if the power drain from the battery is 55.2 Watt, which also assume the power is constant and not fluctuate.

B. Charging of Battery

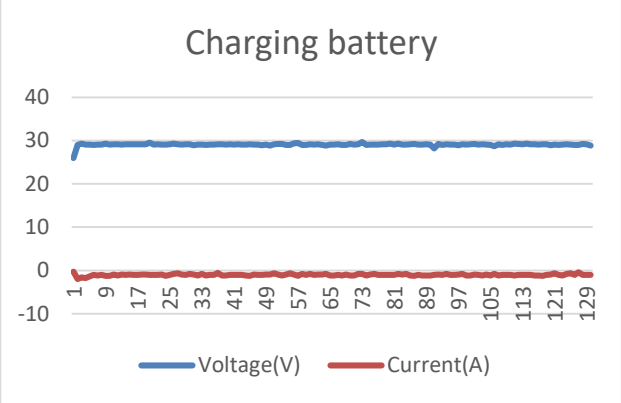


Figure 6: Charging of a lead acid battery.

The purpose if this charging process is almost similar to the discharging process, which is to get the estimation time for the battery to fully deplete and also to know the limitation of charging voltage. From graph in figure 6, the values of current on the orange line are negative due to the direction of the current was opposite to the direction of current during discharging process.

$$P = VI \quad (3.5)$$

$$P = 14.4AH \times 24V = 345.6\ Watt\ Hour \quad (3.6)$$

$$p = 24V \times 3.3A = 79.2\ Watt \quad (3.7)$$

$$t = \frac{345.6}{79.2} = 4.36\ Hours \quad (3.8)$$

where,

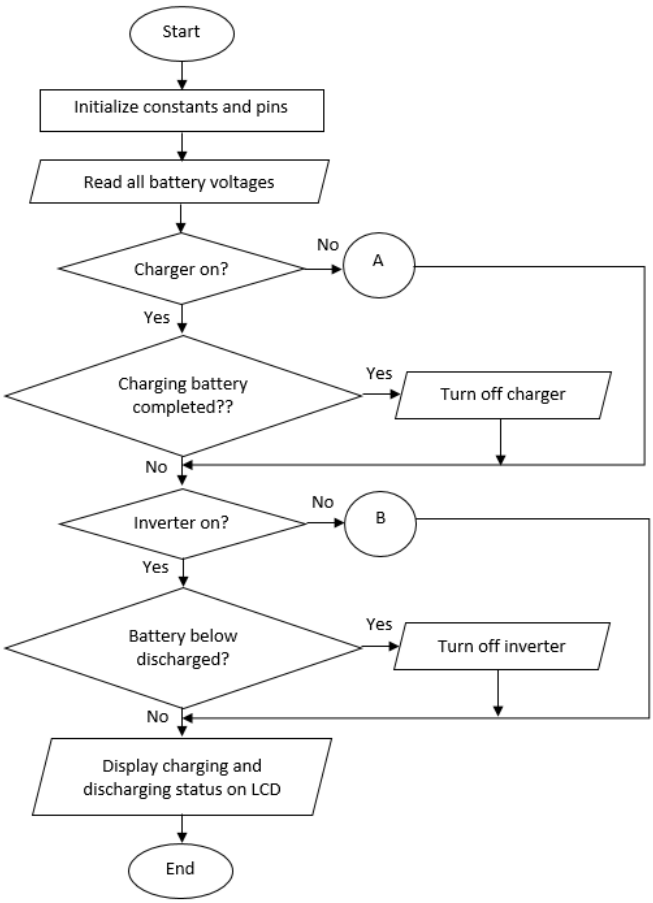
P = Power of battery
p = Power gained from charger
t = Time for battery to fully charge
V = Voltage of the battery
I = Current hour of the battery

C. Algorithm of the system

For the completed system, it does not use current sensor and instead just using voltage sensor to detect drop of voltage for each battery. Since in previous process we have estimated the maximum and minimum voltage of the batteries, we can proceed to discharge and charge of a battery upon the changing value of voltage of batteries.

From the data analyzing that has been done in previous part. We can come out to a full complete system where the voltage value for the discharging and charging process will be used in this system. The current sensor, which is used for data collecting, is eliminated since the full system only using voltage reading to turn on or off the system.

Then coding for the system need to be constructed, but flowchart needs to be constructed beforehand. Below is the flowchart, the flowchart of the full system is divided into 3 parts of flowchart, where all the 3 flowcharts are connected by connector symbol.



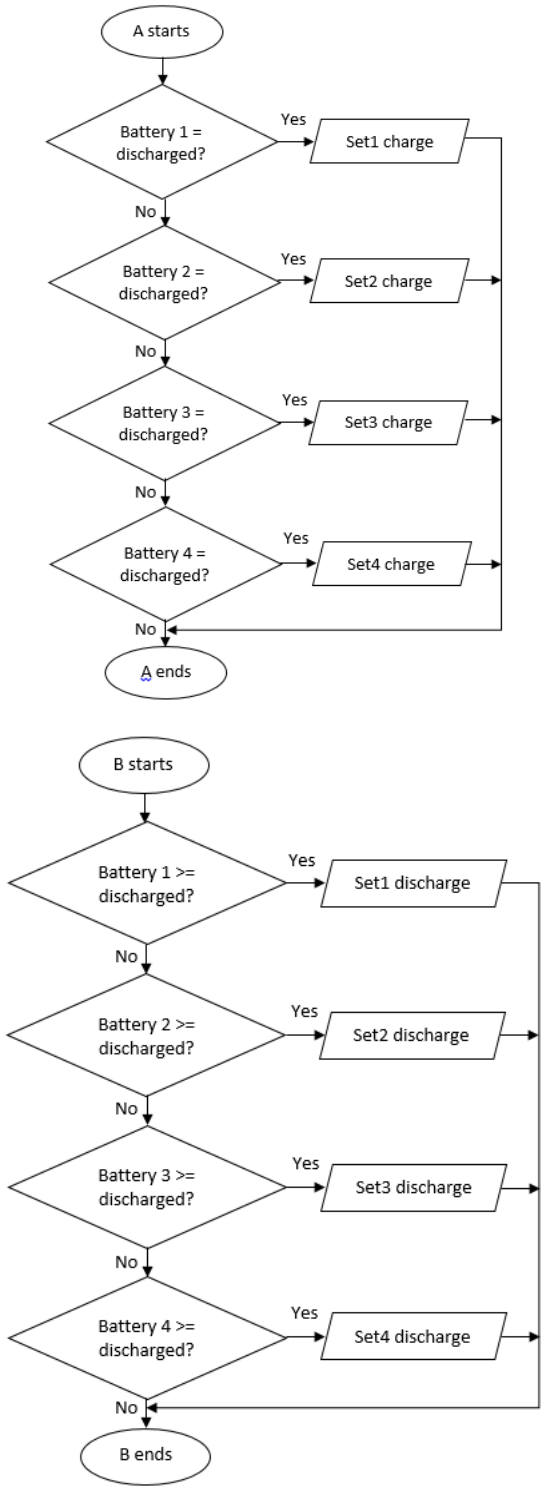


Figure 7: Three sets of flowchart of the full complete system.

The flowchart that has been structured will ease the construction of coding. There are a few conditions that need to satisfy before charging or discharging take place. The inverter will always be on, however the inverter only connected to one battery at a time. The value of the voltage of battery when need to charge is 19.2V while 28.5V for stop the charging.

On the other side the value of the voltage of battery when need to discharge is at least 23.85V, which comes from:

$$Voltage = \frac{charged\ value + discharged\ value}{2}$$

where,

Charged value = 28.5V

Discharged value = 19.2V

The discharging process will stop when the voltage drop to 19.2V and below. This process will be repeated and it will be continuous with the first battery takes the priority followed by second, third and fourth. In other word, if the first and second battery are at below of the discharged voltage level, the first battery will charge and then followed by second battery once the first battery has completed the charging. The same condition applied on the discharging process.

IV. CONCLUSION

Lead acid batteries has many advantages compared to other types of batteries. Lead acid batteries are more resistant to corrosion, overcharging, gassing, water usage, and self-discharge, all of which shorten battery life and higher Cold Cranking Amp ratings. All of these advantages make lead acid battery the best type of battery into this system [5].

On the other hand this system can manage to lengthen the lifespan of the batteries since this system will monitor the voltage of the batteries all the time and also supply power to load continuously [6].

REFERENCES

[1] G Sandeep Dhameja, Electric Vehicle Battery Systems, 2002, ISBN 0-7506-9916-7.

[2] Charles D. Albright, Hobe Sound, Fla, July 1993. Battery Management System.

[3] Philips Semiconductors, “Two-cell Lithium-ion battery protection IC with over-current, over- and under voltage protection”, datasheet number: NE57607, October 03, 2001.

[4] C.Deepthi, P.M.Sarma and M.Chakravarthy, “Intelligent Battery Management System Analyzing & Optimizing of Multicell Battery Voltage”, ISSN: 2319-2135, VOL.2, NO.6, December 2013.

[5] D. Bell, “A battery management system,” Master’s thesis, School Eng., Univ. Queensland, St. Lucia, Australia, 2000.

[6] D. Fisher, A. Lohner, and P. Mauracher, “Battery management: Increase in the reliability of UPS,” ETZ, vol. 117, pp. 18–22, 1996.