Battery Charging Management System Design with Voltage, Current and Temperature Monitoring Features in Electric Vehicles

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Abstract. Electric vehicles are a fresh trend in the Indonesian automotive world. The role of electric vehicles is supportive of maintaining the earth from air pollution. Electric vehicles use batteries to store the energy required. To preserve the condition of the battery, a good battery management system is needed that can protect the battery from overcharging, overuse, and even excessive surges due to backflow from an electric motor. The battery management system is designed using Arduino-Uno as a controller and processor using the ACS71230A current sensor module which is capable of measuring currents up to 30A. Using the waterproof sensor DS18B20 module to measure temperature. Apply a voltage divider circuit to measure the voltage on a battery because of an analog input voltage. Testing is done by examining the entire module and looking for the accuracy of the calculation of each module. To evaluate the level of accuracy is done by comparing the data that is read using Arduino and data measured using a multimeter. In designing this system, the final results of a battery charging management system can evaluate with an accuracy rate of current calculation far better than the accuracy rate of voltage calculation and an accuracy rate of 97% temperature calculation. The measurement of battery capacity is calculated based on the final power that can be achieved by the battery by calculating the multiplication between current and voltage. This battery charging management system can also display information using a serial monitor on the Arduino IDE when connected to a computer.

Keywords: Electric vehicles, battery management systems, Arduino

1. Introduction

The safety and reliability of electric vehicles are very dependent on the battery management system. The battery management system is enabled to monitor and determine the condition of the battery in conditions when in use or when the vehicle is being recharged by its battery. This is really important in improving battery performance and maximizing the performance of electric vehicles [1]. Over time, battery performance can diminish. This reduced performance can be experienced from the reduced voltage when the condition is fully loaded and empty. Lost power capacity due to repeated use and age of the battery itself. In a good battery management system can evaluate the value of battery capacity, the level of battery health from the speed of charging to the measurement of battery life which is measured by the rate of speed of loss of power used [1]. The battery that is conceived to be the main key in electric vehicles in the future is a lithium ion battery type. However, the heat that is accumulated during the discharge or charge process on this battery can cause a reduction in battery capacity, and reduce battery life quickly. This state of affairs can cause thermal runaway on one battery cell and can propagate to other battery cells. As for other batteries that are still often applied in electric vehicles and in general applications are lead acid batteries, and nickel metal hydride (NiMH) batteries [2]. Comparison of power and vigor from this battery can be seen in Figure 1.
As shown in Figure 1, lead acid batteries have less ability and energy per kilogram than NiMH batteries and Li-ion batteries. This means that with the same power and energy, the use of lead acid batteries in electric vehicles will be far heavier than using NiMH batteries or Li-ion batteries. If you want a great amount of energy and power you should avoid lead acid batteries because this will cause the batteries used to be too heavy later. The advantage of lead acid batteries is that they are inexpensive compared to other batteries. As considerably as the technology that has been much longer and developed compared to Li-ion batteries and NiMH batteries. The ideal temperature for maintaining batteries during the care and discharge process is 25 °C to 50 °C. Every increase or decrease of 1 °C will reduce the force output of the battery by 0.4-0.5%. Inserting the battery in an environment that experiences a very low temperature (below 0 °C) is not a solution to maintain the battery because it can affect the chemical reactions in the battery [3]. In Figure 2, it can be determined that the age curve of a battery is proportional to the temperature of the battery [3].

![Figure 1. Comparison of battery power and energy. [4]](image)

![Figure 2. the Age Curve of a Battery is Proportional to the Temperature of the Battery. [3]](image)
battery is proportional to the temperature used when a repeated charge and discharge is performed. The purpose of designing this tool is to design a model of battery management system that is able to protect batteries from overcharging excessive electricity, using excessive electric charges and surges in reverse currents and being capable to display voltage, current and temperature data on a computer screen for calculation analysis.

2. Concept & Modeling

In designing the priority system is the protection module, where if a short circuit occurs the system will be interrupted temporarily. In determining these conditions can be read by scanning the parameters of the current passing and the battery temperature that is too hot. It can be seen that the system is drawn according to Figure 3.

The protection module is applied as a relay component because the system will be completely disconnected and the system will be reconnected if the microcontroller system commands the protection system to be connected. After passing through the protection module, it enters the voltage measurement module which converts analog voltages into digital data into the microcontroller. In this case the voltage divider module is as well connected to the analog to digital converter system.

The temperature sensor is used as a temperature reader module with component type DS18B20 which is a digital sensor that is able to measure temperatures with an accuracy of ±0.5 °C and uses the one wire protocol to transmit. The current reading sensor uses the ACS712-

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**Figure 3.** Battery Management System Block Diagram for Electric Vehicle (Bicycles)

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**Figure 4.** (Left) DS18B20 Temperature Sensor and (Middle) ACS712-30A Current Sensor (Right) Relay Module
30A component type which can record up to a maximum of 30A. The element of the protection module uses the relay module component. Component images can be visualized in figure 4.

Use an Arduino microcontroller as a processor and decision maker and periodic checks for voltage reading modules connected using an analogue to digital converter. In the processing system in the microcontroller, if the voltage reads on the voltage checking module approaches full capacity, the system will itself try to disconnect the electrical connection to the electric charging system into the shelling. Which becomes a benchmark in measuring the capability of the battery that is battery power so that checks are made in the measurement of current and voltage which are then computed into the process of calculating the current multiplied by the voltage to produce a unit of power. If the battery has filled around 98% of the total maximum capacity, then the microcontroller were in a program to trim the power charging station to the battery system. When the battery runs out, the microcontroller can provide notification in the pattern of a sound signal notification so that the battery can be connected for charging mode immediately.

3. Results and Test

Module testing and analysis is packed out to determine the modules used in this design can work in accordance with the expected function. On that point are four modules tested, namely the voltage divider module, the protection module, the microcontroller module and the Computer Display. The microcontroller module testing and computer display are put together

![Figure 5](image5.png)

**Figure 5.** Arduino Uno as Microcontroller

![Figure 6](image6.png)

**Figure 6.** Voltage Battery Measurement Diagram
because Computer Display displays the results of the data obtained by the microcontroller module. Testing the voltage divider module is performed to test the success of the module to divide the battery voltage so that it can be read by the microcontroller. Testing is performed by measuring the voltage on the battery directly using a multimeter, and measuring the voltage after passing through the voltage divider module with the multimeter. From the examination results show the largest error rate of 2%, which actually can still be included in a pretty good tolerance.

Testing the Computer Display microcontroller Module is put together because of the interrelationship between the modules. Computer Display displays data received from the microcontroller module. Testing of these two modules is to perform a comparison of calculations on the microcontroller with those measured with a multimeter. Tests carried out on current sensors and temperature sensing elements. Testing will be done by estimating the current using a sensor and using a Multimeter which will be in series with the current and load sensors. For temperature sensor testing, testing is done by assessing the temperature of the battery with the sensor and with a multimeter.

Based on the results in the diagram of the voltage and current measurement diagram in Figure 6 and Figure 7, it is found that the voltage measurement system with a voltage divider module is no better than using measurements using a current reading module. On the
temperature sensor reading using the temperature sensor module, the reading is very sensitive so that between the measured temperatures there is a large difference. In this temperature measurement, measurement is required by using the average measurement between changes in temperature values that occur with the previously measured temperature. Temperature measurements can be viewed in Figure 8. In Figure 9, it is a circuit breaker or protection circuit where 2 relays are placed where relay 1 connects to the charging module while relay 2 is connected to the load module / motor module [4]. In the use of a battery management system, this is a scheme that can be referred to as a system that can balance the charging process and the use of electric power. Shown in Figure 10. [4]

**Figure 9.** Protection Module Circuit

**Figure 10.** Cell Balancing [4]
4. Conclusion
In planning this model it was found that the use of electronic circuit modules such as current-reading modules which are ready-to-use modules has far better read accuracy than using voltage-dividing modules which are self-assembled and connected to analog to digital converter systems. The accuracy of the temperature measurement when seen from Figure 8 is above 97.5% with the assessor still very beneficial. Figure 10 can be concluded that the battery management system is able to protect the batteries from overcharge, overdischarge and overcurrent because the protection module works very good. When linked to a computer, the results of data collection can be seen by opening the serial monitor and serial plotter in the Arduino IDE application on the computer.

5. References
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