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A Technical Review of BMS Performance Standard for Electric Vehicle Applications in Indonesia

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Abstract

The development of Battery Management System (BMS) standards in Indonesia has been carried out causing the FACTS approach. That's approach makes it possible to accommodate all stakeholder requirements. However, the approach has not yet considered a technical review of the regulated standards. Based on this, this study undertook a comprehensive review of BMS performance parameters setout in the standard. In order that the regulated standards not only accommodate the needs of stakeholders but also consider BMS technical studies in order not to impede the future development of BMS.

Keywords: *BMS, Performance, Standar, FACTS, Analysis*

1. Introduction

The development of environmentally friendly vehicle demand, causing the phenomenon of a shift in the paradigm of the automotive industry in the world which makes fossil fuel-based vehicle manufacturers start developing electric-powered vehicles [1]. With zero tailpipe emissions in terms of fully electric drive vehicles, the electric vehicle also offers a cleaner alternative to vehicles by helping to reduce air pollution exposure due to fuel combustion and noise-reducing [2]. To enlarge the market share of the electric vehicle, security and reliability are the main concern of users. However, they not only rely on battery technology but also the battery management system (BMS) [3].

A battery management system (BMS) is an electronic control unit that is specifically designed to ensure that a battery is run within its safe operating area normally bound by the applied current, state-of-charge (SOC), and temperature [4]. Besides that, similar to the engine management system in a gasoline car, a gauge meter should be provided by the BMS in the electric vehicle. BMS indicators should show the state of the safety, usage, performance, and longevity of the battery. Due to safety reasons, cell balancing and aging issues, supervision of each cell are indispensable. For this purpose, the battery management system (BMS) is used. Moreover, over-discharge causes reduced cell capacity due to irreversible chemical reactions. Therefore, a BMS needs to monitor and control the battery based on the safety circuitry incorporated within the battery packs. Whenever any abnormal conditions, such as over-voltage or overheating, are detected, the BMS should notify the user and execute the preset correction procedure. In addition to these functions, the BMS also monitors the system temperature to provide a better power consumption scheme and communicates with individual components and operators.

The importance of BMS in optimizing battery performance have made Indonesia develop the BMS standard. Regulations such as these play important roles in industry. These roles include of (1) ensuring safety for consumers and producers, (2) increase of product competitiveness, (3) the reduction trade of barriers etc [5]. Development of BMS standards in Indonesia using FACTS (Framework for Analysis, Comparison, and Testing of the Standard) method. FACTS approach was developed by NIST (National Institute of Standards and

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Technology) which is used to develop and evaluate standards. FACT provides a framework for analyzing, comparing and testing standards by means compiling and formalizing information using the Zachman framework [6]. Zachman framework is used to obtain information using 5W + 1H (What, How, When, Who, Where, and Why) question. Moreover, this approach also accommodates all stakeholders' requirement so that in line with the principle of consensus in the standard although already using the FACTS approach, BMS standards should also consider the technical and technological developments of BMS. Therefore, a comprehensive study of BMS from the academic aspect is needed so that the BMS will not only meet the needs of stakeholders but also be scientifically responsible.

The purpose of this study is to provide a review of the content BMS standard in Indonesia. The rest of this paper is organized as follows. The rest of this paper is organized as follows. Section 2 provides a description of the function and development of BMS. Section 3 provides methodology, Section 4 performance of BMS in standard BMS are evaluated in this paper and the paper is concluded in Section 5.

2. BMS

BMS is an electronic device that manages a rechargeable battery pack [3]. BMS has 2 functions, i.e. monitor and protect [7]. The monitor function is concerned with current measurements, cell voltages, and temperatures while protecting with respect to on/ off switching systems depends on existing conditions. Monitoring also deals with the physical parameters such as current, the voltage of the battery cells, or estimate the state of charge, and fault detection and diagnosis, while protection includes safe and optimal utilization of the battery, energy optimization, cell balancing and thermal management [8]. Illustration of a battery management system is shown in Figure 1.

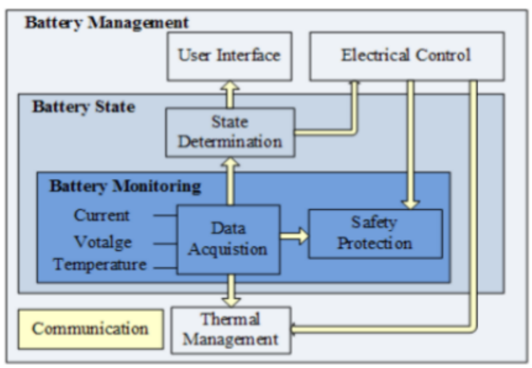

Figure 1. Illustrations of a Battery Management System [3]

BMS in vehicles is comprised of kinds of sensors, actuators, controllers which have various algorithms and signal wires. Three main tasks of the BMS in vehicles are protect the cells and battery packs from being damaged, make the batteries operate within the proper voltage and temperature interval, guarantee the safety and prolong their service life as long as possible and maintain the batteries to operate in a state that the batteries could fulfill the vehicles' requirements.

3. Methodology

Standard development in Indonesia has been done using FACTS approach [9]. There are four main steps in FACTS method: stakeholder analysis, technical analysis, standard comparison and testing of standards [4]. The first stage is stakeholder analysis. At this stage identify all stakeholders involved, and collect all relevant stakeholders' needs.

The second stage is technical analysis. At this stage, all stakeholders need is converted into the standard technical requirements of the battery management system. The purpose of this stage is to obtain the standard BMS requirements specification. Comparison stage is used to identify gaps and overlap between technical analyzes results with other standards (international standards). So, standard formulated harmonious with existing standards. Testing of the standard is used to determine the content of the standard meets all stakeholder needs. The standard testing process is done with Focus Group Discussion (FGD). In this study, more emphasis on the standard testing. This is important because the standards set not only accommodate the needs of stakeholders but also supported by scientific reasons. Briefly, the research methodology is presented in the Figure 2.

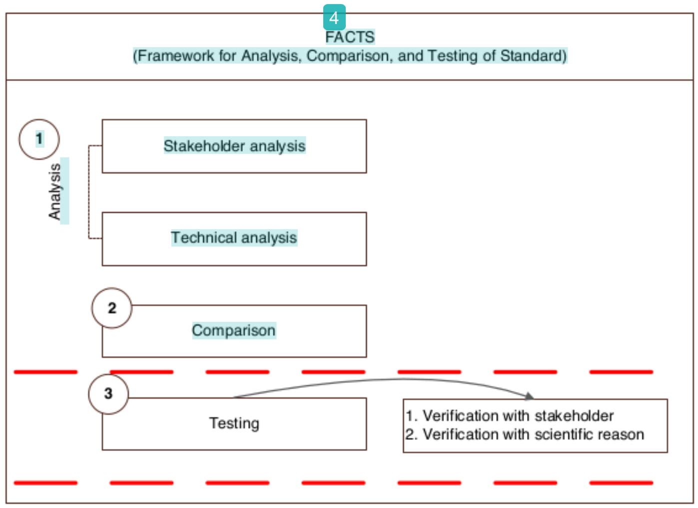

Figure 2. Research Stage in Technical Review of BMS

4. Result and Discussion

This research is a development of [9]. The stakeholder analysis was intended to define stakeholder requirements. In this research, the stakeholders involved were the government, battery testing laboratory representatives, battery manufacturers, relevant experts, electric vehicle manufacturers, and consumers.

The requirements of the collected stakeholders include the quality and testing parameters required for the development of BMS standards. Data conducted using a purposive sampling where an expert uses his judgment in selecting respondents with a specific purpose [10]. In the survey, a respondent check mark in the column containing the 1-5 interval scores. The value of "1" indicates the respondent "strongly disagree" while "5" indicates the statement "strongly agree". There are several BMS functions that can be used to construct BMS quality parameters such as (1) performance; (2) safety; (3) fault diagnosis; and (4) testing system. The results of questionnaires are processed by descriptive analysis to determine which priorities are required and used as an input technical analysis to identify technical aspects requirements to be regulated in the standard.

Research [9] gain a framework standard that can be used for BMS. but in the study, it has not been explicitly discussed why the parameters have used The result of a BMS standard framework is shown in Figure 2. Explanations for each parameter are shown as follow.

4.1. Voltage Measurement

The ability to monitor battery voltage is divided into two namely the ability to monitor the voltage of the cell and the total voltage (battery pack). On the battery cell voltage monitoring capabilities related to cell balancing. The total voltage monitoring capability is related to SOC prediction and battery charge-discharge monitor. Other capabilities related to the must-have that is controlling capability that set upper limit and lower limit of battery module voltage. According to [11] to protect the battery from overdischarged, monitoring of battery terminal voltage is required so that the terminal voltage of the battery can not get out of the boundary between the charging voltage limit and the discharge voltage limit where the battery can be used. The stress monitoring mechanism is performed by comparing the measured cell voltage values individually with the voltage measurement route and by the voltage measurement monitoring route, and then diagnosing whether the measured value is correct.

4.2. Current Charge / Discharge

The BMS standard regulates the ability of BMS to measure and monitor the total and real-time charging and discharging of batteries periodically and realtime and is capable of adjusting the upper and lower limits of the incoming and outgoing currents of the battery module. The current monitored and controlled in the BMS is the current during the charging and discharging process. This is because at the time of operation, the battery current will fluctuate depending on operating activities carried out, and it is reasonable during the operation of electric vehicles. While at the time of charging and discharging, the current is one of the parameters that can be used for the battery charging indicator. The amount of charging and discharging current is determined by the inrush. According to the plots in Figures 3 and 5.3, BMS will limit the charging current according to functions that depend on temperature, SOC, and cell voltage. For example, the charging current should be lowered if the temperature is in the range of 30 ◦C- 40 ◦C. Based on the battery specification, it is not advisable to remove the battery at a prescribed minimum temperature, ie less than -20 ◦C. The magnitude of the charging and discharging current rate is determined by the inventors [11].

4.3. Temperature Measurement

The ability of BMS to control the temperature to stay within the upper and lower limits of battery temperature. Battery characteristics that are affected by temperature cause serious attention to battery temperatures. In addition to the imbalance of temperature between cells can result in a reduced lifetime [12]. At the time of operation of the vehicle, a certain amount of heat will be generated especially when the vehicle starts to be operated and accelerated. If the temperature handler is not quickly handled then it can cause the temperature of the pack battery to increase rapidly which could further cause the battery to explode [13]. It is, therefore, necessary that temperature control and management be required to keep the battery temperature fixed in the battery operating area so as to ensure the safety and battery life.

4.4. State of Charge Estimation

The SOC Estimation Test aims to examine the functionality in the accuracy of SOC estimates by BMS. Lithium-ion batteries have a prohibited area in use because the use of the area may pose a fire hazard and other risks. Therefore, it is necessary to adjust the lithium-ion battery margin to prevent the margin from being used. Margin size depends on accuracy in estimating battery charge (SOC). Therefore, accurate estimates for SOCs make smaller margins and make usable cell capacity larger, resulting in better vehicle fuel efficiency and longer roaming range. Therefore, accurate SOC estimates are essential for maximizing cell performance.

SOC measurements cannot be performed directly, but involve measurements of voltages, currents, temperatures and other related parameters [14]. Accurate estimates of battery status (SOC / DOD) not only provide information on battery current and residual capacity (SOC) but also ensure safe operation of electric vehicles [15]. Many approaches are used to estimate the magnitude of SOCs in which each approach provides different error limit.

In the study of [15], it is known that the magnitude of error for SOC estimation varies between 1-6.5%. While in RSNI BMS for error received for SOC estimation is 10%. The value is chosen because the value is greater than laboratory-based research, where laboratory research in Laboratory-scale studies has much-simplified use complexity.

4.5 Accuracy Measurement

Tolerance of measurement of battery parameters such as voltage, current and temperature, and SOC estimation should be provided to ensure that the measurements are accurate and are in the safe zone of measurement. In RSNI BMS the tolerance of allowable measurements for stresses of ± 0.5%, for currents of ± 1%; temperature of 1 K and SOC by 10%.

Based on research [16] the accuracy of the recommended battery pack measurements is 0.5 - 1.0% for electric vehicles up to 450A, 1-2mV for battery cells, and 0.1% for total voltage (pack) for electric vehicles up to 600V. The accuracy value set in RSNI BMS is 1% indicating that the value is still within the recommended safe limits. The value of 1% in the accuracy of current measurement due to the consideration of the current sensor price and its availability in the country because of the more accurate a measuring tool than the more expensive price. In addition to the iru, the accuracy value set to measure the voltage is still safe is 0.5% [17]. The magnitude of the value of accuracy can depend on battery characteristics, for example, lithium batteries require higher accuracy for cell voltages due to very flat cell-voltage curve characteristics [18]. In addition, the measuring circuit must be resistant to electromagnetic interference (EMI), because devices that create high interference such as electronic power components of the electric drive trains are relatively close to the BMS. While the accuracy of temperature measurement is 1 K, it is taken from the accuracy suggested in international standard.

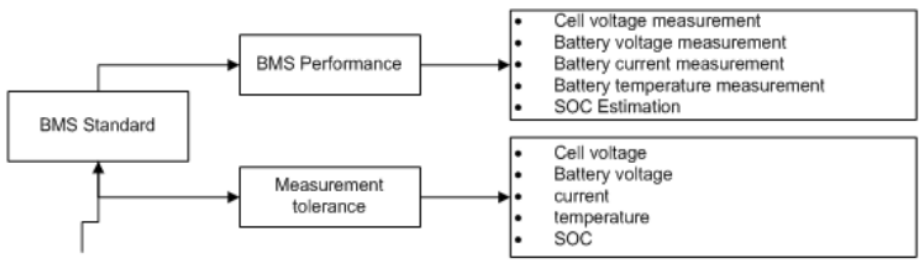

Figure 3. BMS Standar Performance Framework

5. Conclusion

This study provides a review of the parameters used in the BMS standards. Based on the study conducted, it is known that the parameters are set minimum requirements. In addition, a number of value constraints set in the standard have a more relaxed tolerance. So those BMS developers in Indonesia are expected to meet these requirements and can compete in the domestic market.

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