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BMS Tool Monitoring Vertiv UPS and Vision Lithium-Ion Battery System

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Abstract—In my previous work published in an acknowledged publication, titled "Factory test of a TP-100 Lithium Ion Vision Battery System for possible Implementation in Soweto, Johannesburg, South Africa," According to the findings from the study report, the TP-100 Vision Lithium-Ion battery system was found to be suitable for implementing a wind turbine system in Soweto. Furthermore, the study's findings indicated that Lithium-Ion batteries were the optimal choice for storing energy in wind turbines. These batteries provided significant total cost of ownership (TCO) reductions over a 10-year period, without the inconvenience and expenses associated with replacing lead-acid batteries. This research paper aims to validate the precision of parameters obtained from the integration of a 160 kVA Vetiv Three Phase UPS to a TP-100 Vision Lithium Ion Battery system in contrast to those obtained from the Battery Monitoring System (BMS) while using Tool BMS Version 1.3 Software. The results validation was evident as the parameters acquired from the UPS and Battery system were found to be accurate when compared to those observed through the BMS tool. Finally, utilizing the Smart Cloud Management System (SCMS), validity was shown by the ability to remotely monitor the operation of both the UPS and the Li-ion Battery system.

Keywords: BMS Tool, Soweto Small Wind Turbine Implementation, TP Lithium Ion Battery, Vertiv UPS

INTRODUCTION

The BMS Tool Version 1.3 software primary interface appears after entry using a laptop/PC. The battery string, voltage, current, temperature, SOC, SOH, etc. may be seen in real time as required. The system interface has three primary parts: function button, list selection, and data display. Figure 1 [1] Battery Monitoring System (BMS) consist of the BMU, CBMS and GBMS panel's. Moreover, the LAN interface and the computer's network interface will be used for communication purpose. Red box indicates LAN interface location as shown in Figure 2 and 3 for CBMS and GBMS respectively [2]. Consequently, the research study will analyze evaluations from previous researchers on similar related work to address any gaps and improve the overall quality of the research.

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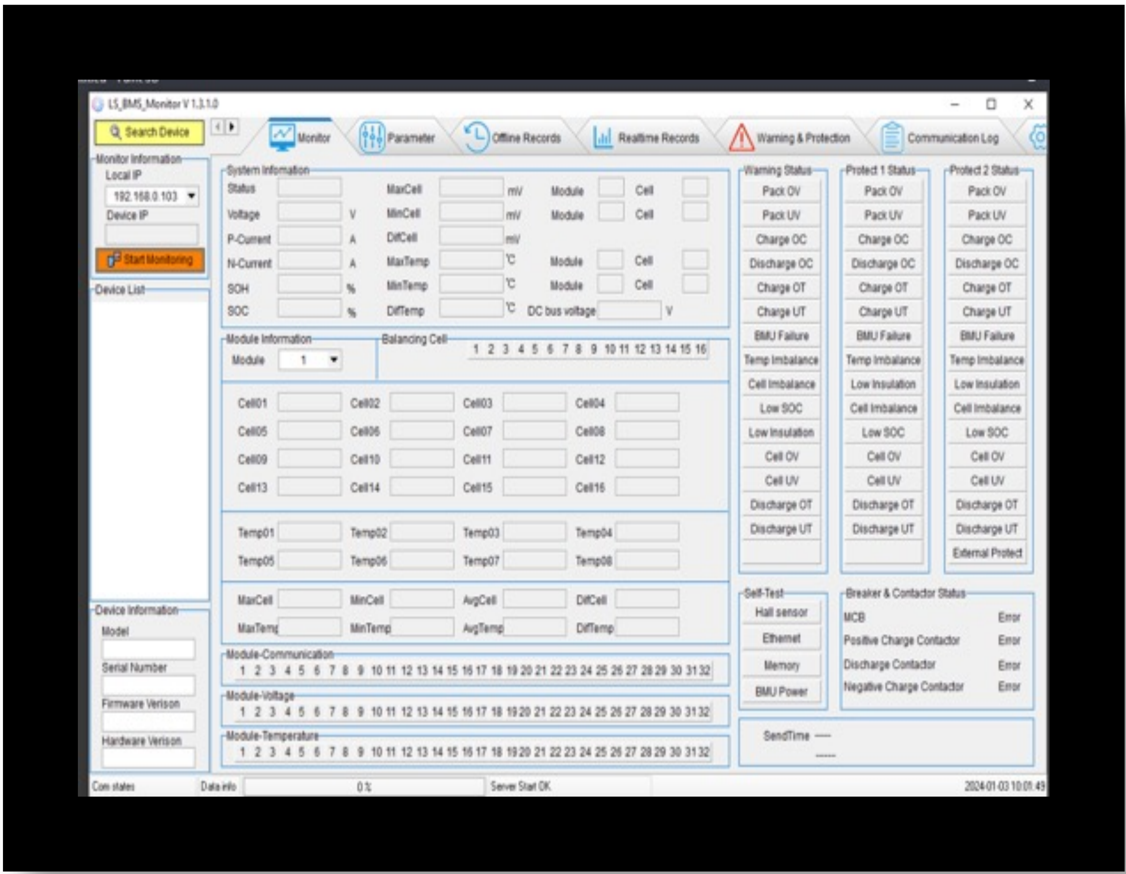

Figure 1. BMS Tool Version 1.3

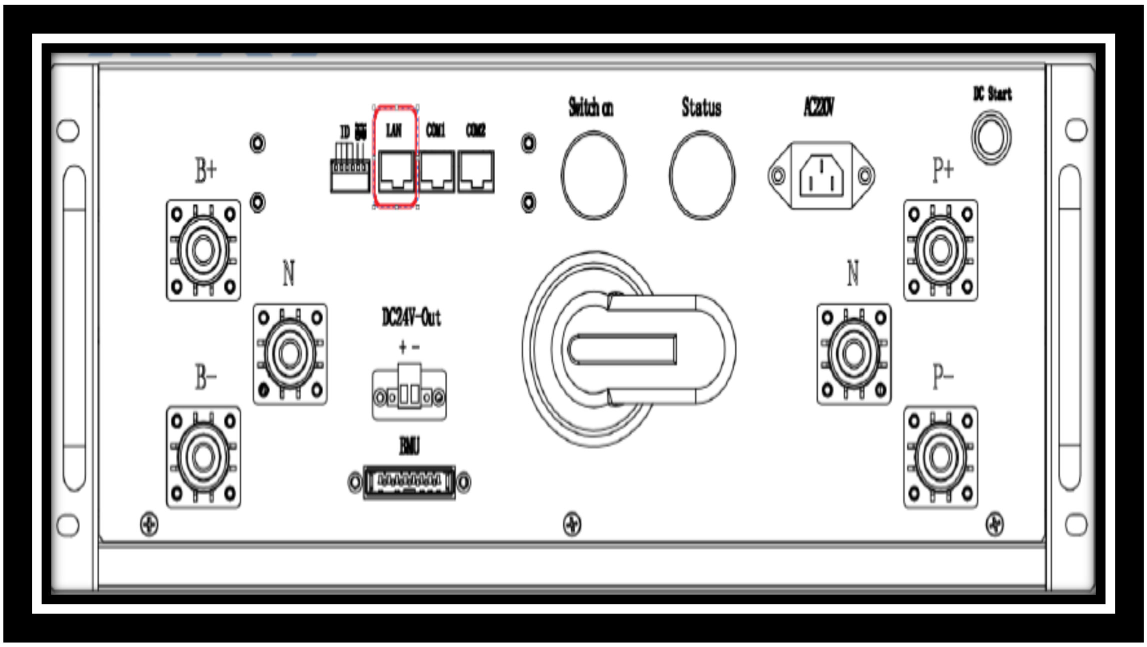

Figure 2. CBMS - LAN communication point [2]

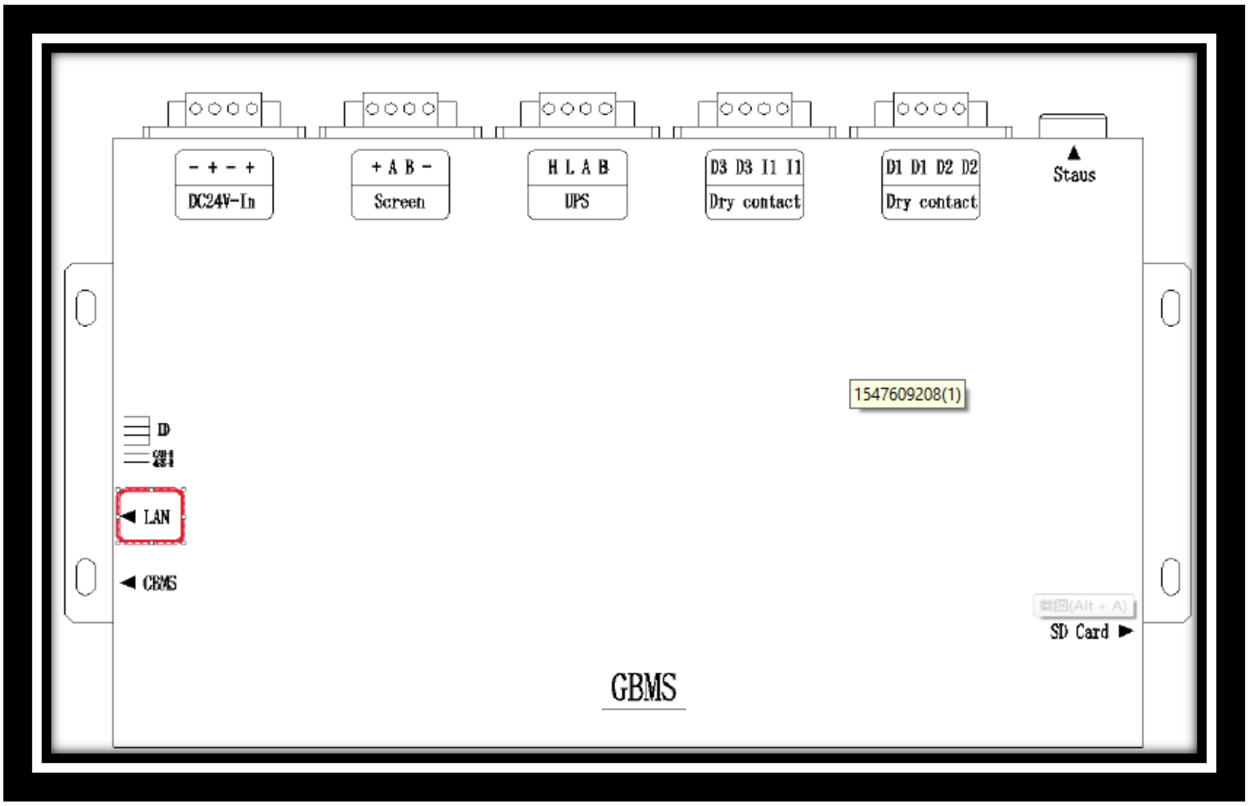

Figure 3. GBMS LAN communication point [2]

This chapter will also summarize some of the related reviewed work that were undertaken. [3] in their study introduced a versatile and adaptable battery management system (BMS) designed specifically for lithium-ion battery packages. The primary objective of this system was to tackle the aforementioned challenges. Hence, the use of a flexible approach in software design was necessary. The embedded hardware platform's structure was introduced, and its modular configuration was provided. A user-friendly, but robust architecture for constructing software and its accompanying documentation was presented. In order to cater to a wide community of developers and users, both the hardware design and software was a open-source and accessible without any cost. Consequently, the BMS provided functions as a user-friendly platform for academic research and as a developmental platform for industry customers. [4] in their research paper examined the intricacies of Battery Management Systems (BMS) used in electric mobility and large-scale energy storage systems, with a specific focus on their use in hazardous environments. The study focused on the topic of functional safety pertaining to BMS and adheres to the applicable industrial requirements. The presentation also included a thorough assessment of the elements, structure, methods for minimizing risk, and analysis of potential failure modes relevant to BMS functioning. The paper also included suggestions on enhancing safety design and optimizing performance in respect to the overall integration of the BMS. [5] studied the creation of a technologically advanced and user-friendly device that functions as an educational resource for the BMS. The learning tool replicated the voltage of the battery terminals, specifically for a maximum of 12 cells linked in series. To replicate the overcharge, over-discharge, and cell balancing conditions during laboratory research, the cell voltage were manually adjusted in real-time. The laboratory unit functioned as a specialized learning tool for two undergraduate courses. The implemented BMS learning tool not only improved the training and instruction on advanced energy storage, but also stimulated students' enthusiasm for the environmentally friendly transportation and renewable energy sector.

[6] introduced a monitoring system designed to visually display the functioning of a Lithium-ion Battery (LiB). The system utilized Internet of Things (IoT) technologies, namely deploying Grafana software for data analytics and visualization. The software was housed on a microcomputer called Raspberry Pi. The user anticipated real-time graphical and numerical data on various LiB parameters such as current, voltage, temperature, and state of charge via an online platform. A LiB served as the central support system for a microgrid that combines solar, wind turbine and electricity with hydrogen production. The proposal was innovative in scientific literature as it addressed the limitations identified in previous works, including the lack of long-term operation, medium-scale power/capacity, alerts for safe range of critical magnitudes, real operating conditions, and compatibility/interoperability management. The study presented the design and executed the monitoring system, together with experimental data of the LiB, to demonstrate its feasibility and successful performance. [7] objectives in their research were to regulate and maintain a constant DC bus voltage of the micro-grid by effectively regulating the power output of the wind energy system (WES) and the battery. The PMSG was connected to the DC/DC Luo converter, while the battery was incorporated into the DC bus via the DC/DC bidirectional buck-boost converter. The PMSG was regulated utilizing enhanced Torque Observer Control (TOC) to enhance the output of the wind turbine. The BMS was introduced using the proportional-integral (PI) control methodology. The simulation was conducted with the Matlab/Simulink software.

The findings demonstrated that the suggested WES/battery system was to function with excellent power quality, maintaining a stable DC bus voltage and a consistent frequency of 50Hz. The BMS approach ensured optimal power quality by regulating the bus voltage, which benefited the battery's performance and lifespan. [8] aims in their research paper were to examine the functioning of a 1 MW/1.29 MWh lithium-ion battery energy storage system (BESS) connected in parallel with a 50.4 MW wind generation system. The primary focus of the analysis was on power smoothing and power factor correction. Experimental findings demonstrated that the BESS effectively smoothed the active power and corrected the power factor of the wind generation, thereby enhancing the overall quality of electrical energy at the point of common coupling (PCC). [9] highlighted that their internet-based Building Management System (BMS) would address the issues of computing capacity and data storage in existing BMSs. Additionally, it would result in enhanced precision and dependability of battery algorithms, facilitating the advancement of various intricate BMS operations. Their work examined the idea and structure of cloud-based intelligent battery management systems (BMSs) and offered insights into their functionality, usability, and advantages for future battery applications. The possible dichotomy between the local and cloud functionalities of smart BMSs was also addressed. Cloud-based intelligent battery management systems (BMSs) were anticipated to enhance the dependability and overall efficiency of lithium-ion battery (LIB) systems, hence facilitating the widespread acceptance of renewable energy. [10] in their work stated that the widespread use of lithium-ion batteries in UPSs, mobile phones, electric vehicles, and electronic devices was attributable to their high energy density, low self-discharge, and low maintenance requirements. When utilized continuously, they may, however, become warm. Their objectives were to propose a system of a battery management system type to monitor variables such as charging and discharging cycle, temperature, input and output voltages, and currents. These served in determining the battery health and life expectancy. In response to abnormal temperature increases, a cooling system was triggered in order to restore temperature and efficiency to normal levels. The liquid crystal display displayed measured values, which were subsequently transmitted to the cloud via an ESP module that was programmed with Arduino. Experimental verification of the research was conducted on a 2000mAh, 12 V battery under constant DC load conditions of 2A.

Our paper in [11] stated that, recently, lead-acid batteries were the go-to source for storing energy for UPS/Inverter applications. The most common types of batteries used in wind applications were Valve-Regulated Lead-Acid batteries (VLRAs). But, lead-acid batteries had drawbacks that made them risky and expensive to use in wind turbine applications. They further elaborated that, their project of Soweto Small Wind Turbine was incorporated with the Vertiv (Inverter) and VRLA battery type. However, the TP-100 Vision lithium iron phosphate (LiFePO4) battery offered a substantial advantage. This battery system was ideal for both UPS/Inverters and energy storage systems, offering excellent compatibility and a secure, durable lifespan. Factory testing was carried out on the installation and testing of a TP 100 Vision battery to a Vertiv-type UPS at a South African company. A variable resistive load bank was added to the UPS output in order to test and evaluate the outcome. Their objectives in their work were to obtain testing results and propose the possible implementation of the TP100 Vision battery to a 500W Small Wind Turbine (SWT) in Soweto, Johannesburg, South Africa. Based on the results obtained, the TP-100 Lithium-ion battery system, proved to be feasible for a wind turbine implementation in Soweto. Authors in [12] added that Li-ion batteries are the most prevalent kind of rechargeable batteries. It is crucial to ensure that the batteries are consistently in optimal condition in order to maximize their longevity. Therefore, the battery Management System (BMS) was used to accomplish this objective. Due to the fact that a single rechargeable battery might include several cells, the complexity of a Battery Management System (BMS) showed potential of increasing. A significant drawback of implementing a comprehensive Battery Management System (BMS) is the potential for increased power overhead usage. Hence, it is essential to create a Battery Management System (BMS) that can effectively and precisely monitor power systems without sacrificing efficiency and using minimal resources. Their objectives were to this study and improve the traditional Coulomb Counting based State of Health (SOH) method in order to provide a dependable, efficient, and real-time approach for measuring the SOH of cells. The research also compared the newly devised approach with its conventional equivalent, and the experimental findings demonstrated that the novel model outperformed in terms of computing efficiency, compression gain, and accuracy in estimating state of health (SOH).

Authors in [13] emphasized that the power grid is becoming increasingly important, and renewable and distributed energy resources are becoming more prevalent. Their paper explored the potential of integrating these resources into a Mobile On/Off Grid Battery Energy Storage System (MOGBESS). The system combined a hybrid inverter and battery energy storage system, integrated through an external primary controller, and was configured into a portable chassis with plug-and-play connectivity. The design considered both the stationary design and the mobile system, including system control, communication, operational power, and mobile protection. As per authors in [14], renewable energy sources like solar, wind, biomass, hydro, and tidal are rapidly developing due to their eco-friendliness and availability. However, these sources are often uncontrollable, making it crucial to select the right renewable energy source for a power plant. The solar system is the primary renewable energy source for energy generation. Their work presented a dynamic hardware model for intelligent control-based effective utilization of hybrid renewable energy sources and a Battery Management System. The system was simulated using a fuzzy logic controller (FLC) in MATLAB software, explaining the charging and discharging states of the battery. The proposed control strategy was experimentally implanted, and practical results were compared to the simulation results to demonstrate the effectiveness of the system. The study emphasized the importance of selecting the right renewable energy source for optimal power generation. [15] stated that lithium-ion batteries are frequently used for real-time applications, making and evaluating their State of Health (SoH) crucial for their effectiveness and safety. Model-based methods with SoH prediction are helpful, but issues with battery modeling have led to increased dependence on machine learning (ML). Their work proposed a new preprocessing method using relative State of Charge (SoC) and a hybrid learning model (HLM) that combined auto-regressive integrated moving average (ARIMA), gated recurrent unit (GRU), and convolutional neural network (CNN). The HLM used time-series and SoC domain data, with the ARIMA+GRU algorithm training time-series data and CNN training SoC domain data. The HLM was evaluated for Root Mean Square Error (RMSE), Mean Absolute Error (MAE), and Mean Absolute Percentage Error (MAPE) using NASA's randomized battery usage data set (RBUDS). The recommended HLM was more accurate and had smaller error margin than existing ML models.

METHOD

The methodology in this chapter will highlight step by step procedures on how to communicate and monitor the parameters during the integration of a 160 KVA Vertiv UPS to a TP-100 Lithium-Ion Vision Battery system using BMS Tool Version 1.3. Step 1: Set the computer's wired network card's IP address, see Figure 4. Step 2: Launch the BMS Tool V1.3 Software, see Figure 5.

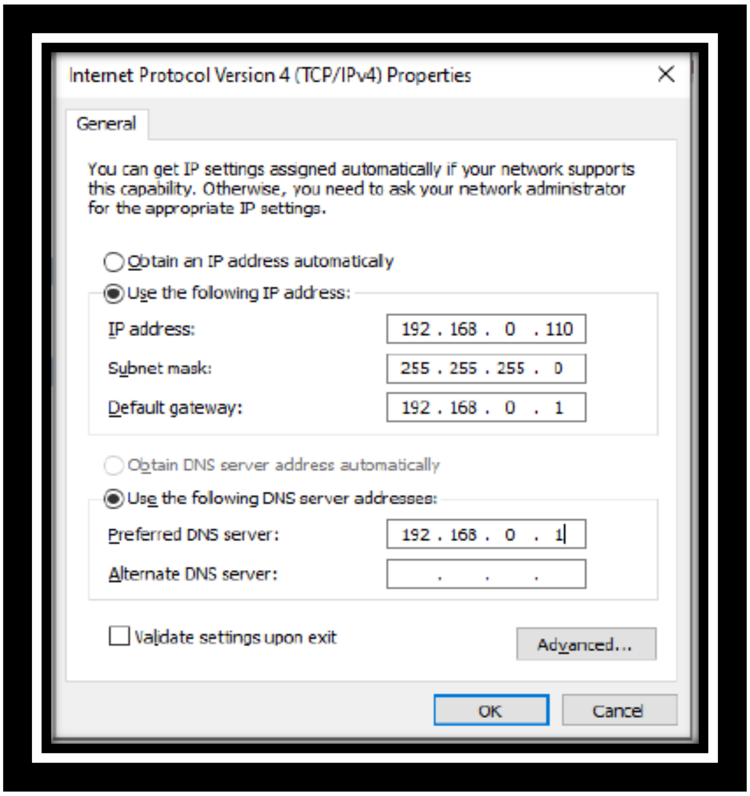

Figure 4. IP configuration from laptop to communicate with BMS tool.

Figure 5. BMS Launching tool Icon

Step 3: Connect the RJ45 network cable as shown in Figure 6, to either on the LAN points as shown in Figure 2 of CBMS or Figure 3 of GBMS. Step 4: In Figure 1, select the interface. Step 5: Confirm the wired net card IP is the same as the server IP by pressing the arrow button in Figure 8. Step 6: When the connection is synching in Step 5, then press start monitoring.

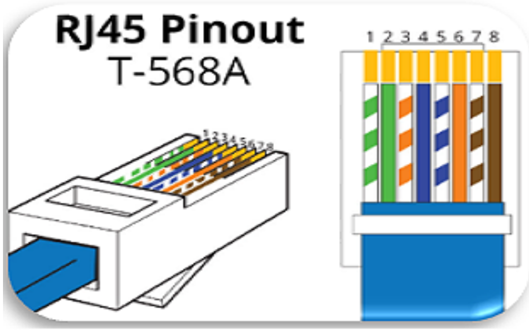

Figure 6. RJ45 Network cable.

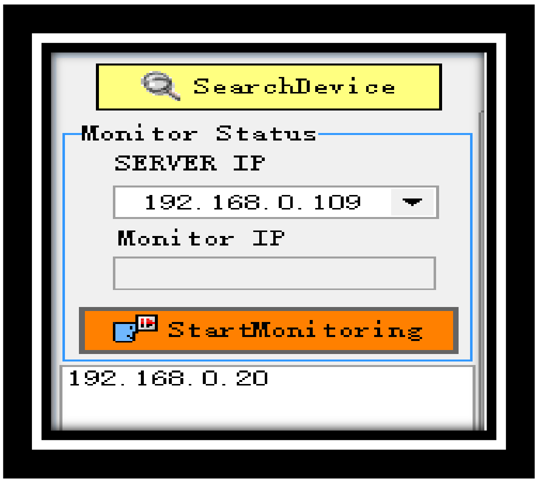

Figure 7. IP Search Interface

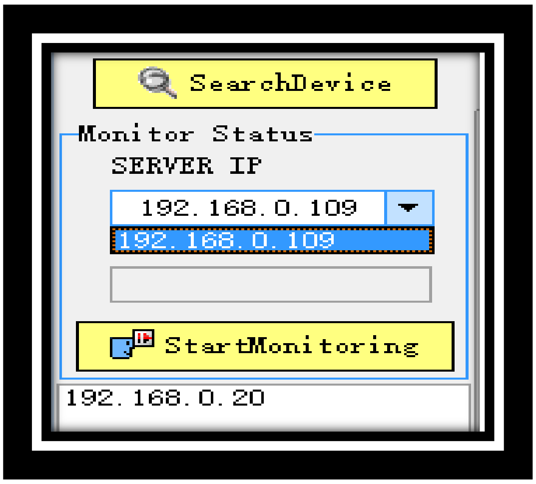

Figure 8. Validation of IP connection

Figure 9. Start monitoring functioning button

Step 7: Start monitoring using BMS Tool as shown in Figure 10: The BMS tool in this instance was able to remote monitoring the UPS and Vision Lithium battery system functionality. Parameters such as (Currents, SOH, SOC, DC bus voltage, temperature of the battery system, battery modular faultiness) were all validated using the BMS tool remotely.

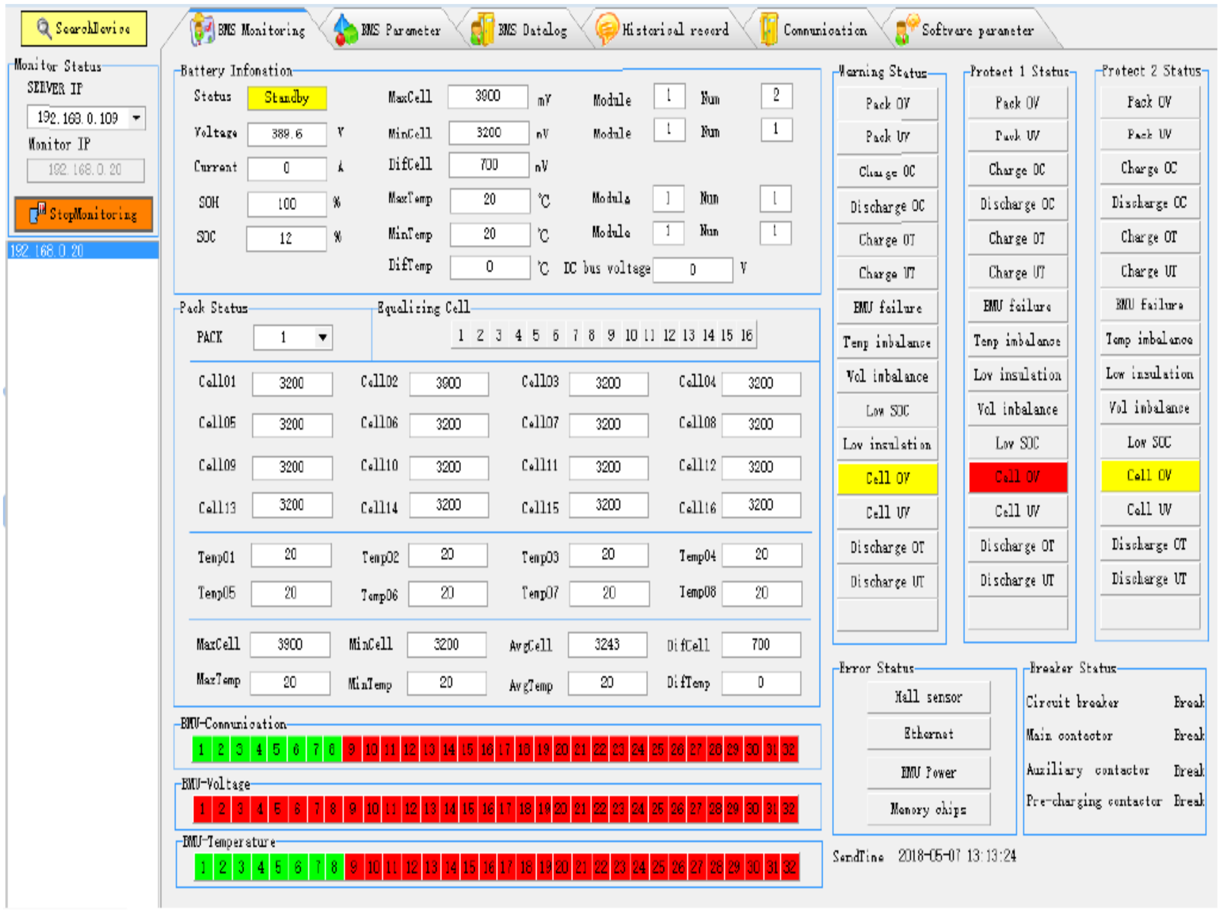

Figure 10. BMS Monitoring – Vertiv UPS and Vision Lithium battery modules during operation.

RESULT AND DISCUSSION

Figure 11 and 12, as shown below, display primarily the present state of the cabinet's charging and discharging, including the overall voltage, current, state of charge (SOC), state of health (SOH), maximum and lowest voltage, highest and lowest temperature, along with their respective locations. Additionally, it provides information on differential pressure, temperature variation, and DC bus voltage.

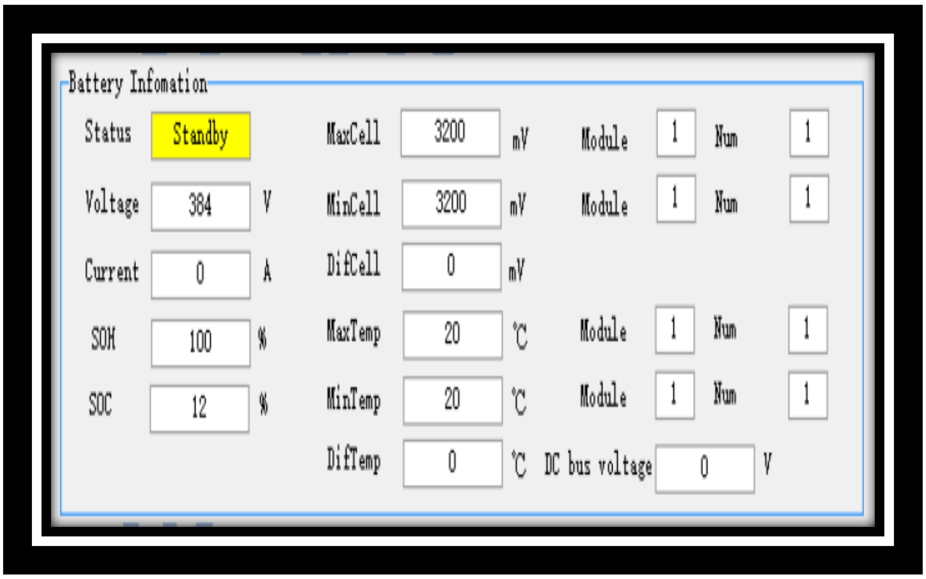

Figure 11. Battery Information using BMS Tool

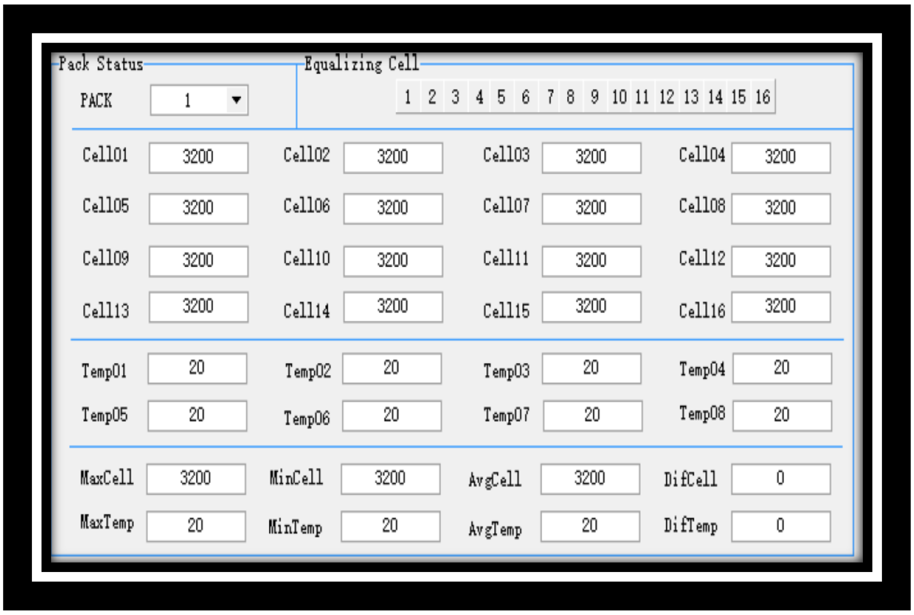

Figure 12. Pack status using BMS Tool.

Figure 13, shows that the self-test status is categorized into three components: communication, voltage, and temperature of the lithium ion battery modules. The color red signifies a failure, while green denotes a successful passage. The self-test from 1 to 8 is confirmed to have passed, while the self-test from 9 to 32 is reported to have failed.

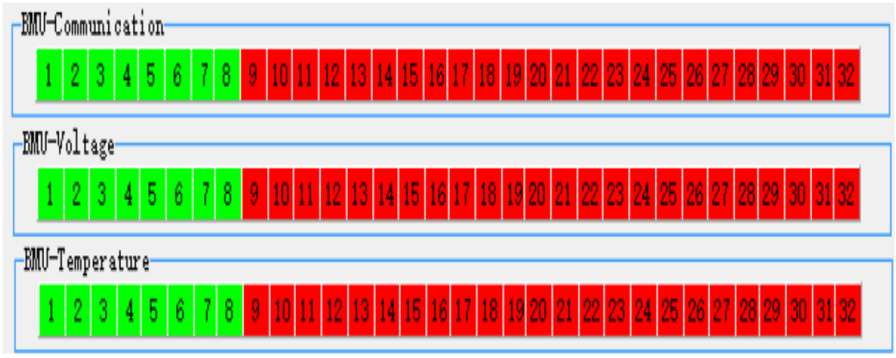

Figure 13: Status self-test display using BMS tool.

The objective of this research was to use existing project that was undertaken in [11], and test and validate some functionalities of the system using BMS Tool Version 1.3 Software. The acronym BMS stands for battery management system. The management is categorized into three distinct levels: namely, BMU, CBMS, and GBMS. By implementing this cellular management system in [11], point-to-point protection, the overall safety and dependability of the whole system was be guaranteed. The system was equipped with regular protective mechanisms, including over-protection, over-discharge, over-temperature, and balancing, among others. Additionally, the comprehensive management of the whole system and individual cells involved the incorporation of predictive management metrics such as State of Charge (SOC) and State of Health (SOH) was achieved. Lastly, with the existing system in [11], had the capacity to remotely monitor the funcionalities of the UPS and Lithium batteries using SCMS.

CONCLUSION

The aim of this study was to implement and validate the functionalities of the BMS Version 1.3 Tool software in an already established project of TP-100 Lithium Ion battery system, which was integrated into a 160 kVA Vertiv Three phase UPS system in one of the companies in South Africa. Derivation can be reached that, utilizing data obtained from BMS Tool, verified that the Vision Lithium Ion Battery and UPS system parameters corresponded precisely with the data retrieved from the BMS; thus, the software's dependability can be confirmed. Finally, it can be inferred that, based on the study conducted, incorporating the TP-100 Lithium Ion Vision battery system with Soweto Wind Turbine technology might be a feasible avenue to explore in the future.

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