DEVELOPMENT OF E-HELP MANUAL USING GRAPHICAL USER INTERFACE (GUI) FOR BATTERY MANAGEMENT SYSTEM (BMS) IN ELECTRIC VEHICLE

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ABSTRACT: GUI is commonly used in most applications. Each component in GUI activates itself to monitor, control and manage the system operation. This paper developed e-Help Manual module using Graphical User Interface (GUI) for Battery Management System (BMS) in Electric Vehicle (EV). Overcharge and over discharge often occur in the system without proper maintenance of the battery. Therefore, this study used GUI for BMS in EV to develop a user friendly electronic-Help (e-Help) manual with a few options; Let Me Do It ~ auto (LMDI), Do It Yourself ~ manual (DIY), and Others ~ call for Technical Assistant (OTHERS) to reduce faults in the system, tasks in the battery troubleshooting and cost of battery maintenance. This study used hybrid (PI, PD, and LQR) controller in the system to control current and voltage flow of the external charger for the battery. As a result, the output performance was improved based on battery charging or discharging states of the Li-Ion characteristics in EV and the energy use was optimized.

KEYWORDS: *e-Help Manual; GUI; BMS; EVs*

1.0 INTRODUCTION

Graphical User Interface (GUI) is commonly used in most applications such as Control System, Power Distribution and others that focus on monitoring and controlling system performance devices. This study used GUI for BMS in EV to develop a user friendly e-help manual.

Over the past years, users typed commands on computer keyboard to monitor and control the system applications. Today, users enable the monitoring and controlling of the system applications using GUI through graphical icons and visual indicators for fast action. Therefore, a few components need to be considered in designing GUI; a) period, b) system analysis tool, c) data size and d) hardware-wiring.

Battery management system (BMS) optimize the electrical energy and analyse the system processes as the main roles to manage the battery electrical energy distribution in EVs efficiently. Therefore, GUI is used as an interface in the battery process by requiring the test bench [1] to manage and operate the system for the fast action within a short period. The high-level powertrain analysis requires detailed data and expert knowledge to run correctly. Thus, tool such as the Future Automotive Systems Technology Simulator (FASTSim) which includes selecting a vehicle to run, choosing the drive cycles to simulate, and viewing the results is easy and efficient to use by applying a GUI [2].

The sensitivity and reliability of the range estimation algorithm changes under different environmental and operating conditions required GUI in EV. A GUI in Figure 1 is designed for the big-data-based range estimation concept as a prototype by coding a MATLAB/SIMULINK. This prototype enables searching for the range estimation-related data including route, weather, driving behavior, electric vehicle, and battery data from different resources [3].

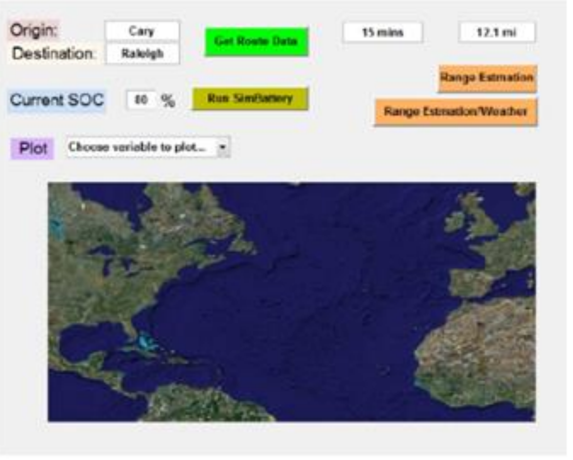

Figure 1: Big-data based range estimation GUI front-page [3]

A graphical user interface (GUI) tool is designed for an automotive battery application. This tool support cell design and development of manufacturing processes to ensure that the battery stack can work efficiently and securely. The GUI is able to load and analyze raw test data as its input, and is also able to simulate the performance of a full battery pack consisting of a specified number of single cells using standard driving cycles and a generic electric vehicle model as shown in Figure 2.

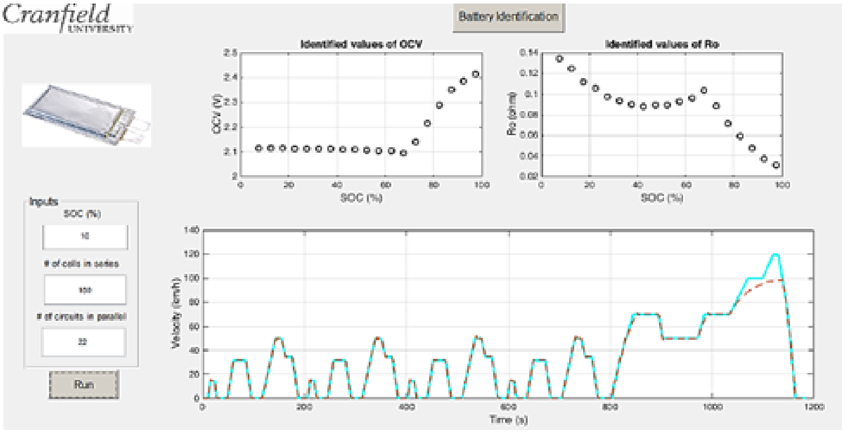

Figure 2: A practical use of GUI for lithium-sulphur cell model Identification [4]

In automotive mobile such as electric car, GUI data create its own driving cycle. The terrain profile of particular route of a driving cycle is determined for create data and actual data to increase the accuracy of the energy performance calculation of an electric car [5].

The over-charged fault, over-discharged fault, over-current fault and external short-circuit fault are critical faults to be diagnosed for different algorithm. These algorithms required a higher computational time and further resources to perform the fault diagnosis. Thus, GUI is used to monitor the faults occur in battery-charging or discharging voltage through the self-initialization scheme for state-of-charge (SOC) estimation and fault diagnosis scheme. The condition mentioned is recommended to design and implement an e-help manual in EVs [6].

An EV takes hours for recharging especially when the corresponding charging station is unavailable. Thus, an ICT-enabled vehicle sharing system based on GUI of Green e-Box (GEB) is developed to manage the coordinate. This Green Move project is a useful platform for EV sharing in urban areas [7]. Battery Management System (BMS) is a system of monitoring and controlling battery performance to improve an EV movement. Parameters from BMS and EV are matched to each other for an integration.

Battery comes in a cell or pack. The voltage changes is not considered for the individual cells that monitored by Battery Management System in the charge-discharge process. This inconsistency made the different charge-discharge characteristics of the batteries and in proper to use the traditional power BMS. Thus, a study [8] analyzed the BMS power to detect voltage and temperature of each battery for $LiFePO_4$ power battery pack at which CAN communication transmits the detection data to the touch screen microprocessor. Figures 3 and 4 show charging and discharging performance with 16 series 200Ah/3.2V $LiFePO_4$ cells.

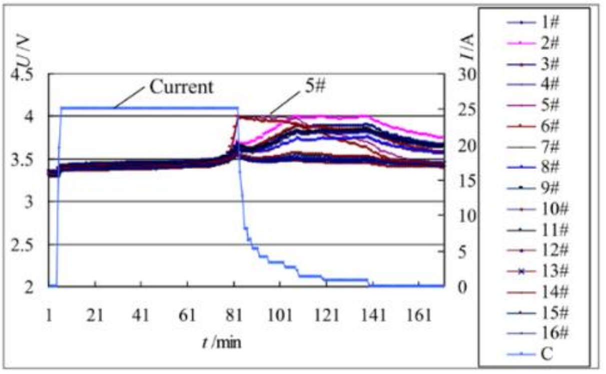

Figure 3: Charge experiments of power battery pack

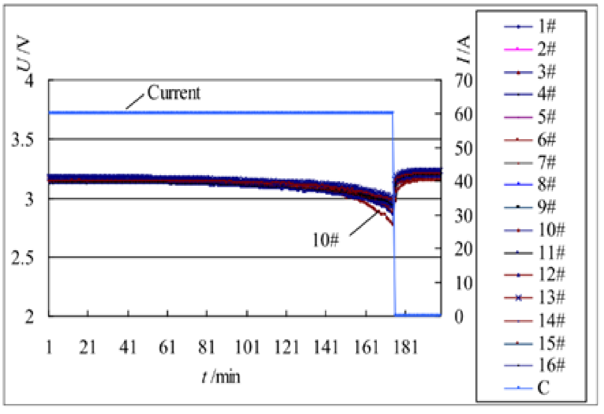

Figure 4: Discharge experiments of power battery pack

A 18650 Lithium-Ion battery for 144V 50Ah is used to develop BMS [9-10]. Seem lithium-ion batteries have high value of specific energy, high energy density, high open circuit voltage, and low self-discharge. Hence, this battery type is suitable for EVs among other cell chemistries. Battery Management System is found as an alternative energy. For example, Lithium based energy for EVs. The authors claimed that BMS is useful and safe to monitor and control vehicles for different states [11].

Electric Vehicle (EV) used electrical source to energize the system. There are many types of EVs such as Plug-In EV, Hybrid EV and any vehicle that include road and rail vehicles, surface and underwater vessels, electric aircraft and electric spacecraft. The mismatch values between EV and BMS parameters stop the operation of vehicle to well function. Thus, an e-help manual user is developed to fix the problem.

Electric Vehicles (EVs) are commonly used for commercial, business and tourism purposes. Natural disaster situations often take a long time to supply outages in different areas, encourage vehicle designers to design EVs based on Vehicle to Home (V2H) concept. This EVs product give users a chance to charge their EVs by micro-RES [12].

For low voltage EVs, resistance shunt method is adopted in BMS design to avoid over-charging the battery cells [13]. The system has been tested to maintain the battery stacks at a good state and improve the reliability and security of the EV. However, this BMS is limited for low voltage electric vehicle that can be improved to high voltage, high efficiency and long life battery systems.

The future for vehicle technology is still unpredictable without knowledge in movement mobile especially in EVs. Users have to be alert on the durability of electric car battery [14]. Bill Wallace (respondent 1) claimed that the Chevy Volt in Phoenix would last at least 10 years, 150,000 miles, and 6,000 cycles in extreme hot climates. The second respondent asserted that the financial savings of the Volt versus the non-EV vehicle depend on the time of an electric battery's charging period. Each interview most probably focused on the performance of EV based on the battery use, Li-Ion.

How far EVs users can really go in an electric vehicle [15] depends on few factors. A study found feedback from user the battery charge would last as well as which routes are taken by users. Other EVs' users claimed that flat road and hot or cold weather influence the life cycle of the battery.

A study in [16] found how far a few models of electric cars in UK can travel on one charge. Based on the UK route, Tesla Model S is in the range of 311 miles, BMW i3, 125 miles, Volkswagen E-Up, 93 miles, Nissan Leaf, 124 miles, Tesla X, 300 miles, Volkswagen Golf, 80 miles, Kia Soul, 131 miles, Renault Zoe, 100 miles, Ford Focus, 99 miles, and Nissan eNV200 is in the range of 110 miles from the first route of each EVs. It is not quite different in 2017 where an author [17] found the top 10 EVs ranked by the total driving range. Road users have problem to find charging stations or plug in for the car. Therefore, in a study [18], an on-line electric vehicle (OLEV) system is developed by the research team at Korea Advanced Institute of Science and Technology (KAIST) in Daejeon. The wireless scheme for this system might also be improved in the future.

2.0 METHODOLOGY

Green technology is very helpful in saving the world, human being and all types of life creatures. The growth of EVs has encouraged industries to develop technology from battery energy sources. Energy sources like batteries have to be controlled and monitored by BMS. This section shows the process development of BMS for Li-Ion battery in EVs. Process development focused on two conditions of EV battery performance in BMS to relate the battery characteristics with EVs. The two conditions are; i. charging and ii. discharging.

2.1 EV Battery Charging and Discharging

From literature, EV and BMS are relevant with each other. Faulty occurrences such as overcharge and over discharge of the Li-Ion battery in EV would damage the battery. Therefore, for research purposes, BMS was implemented in advance to monitor and control the battery state. Besides, the battery performance and state of charging (SOC) were displayed in GUI based on development of e-help manual module. This module would reduce tasks in troubleshooting the Li-Ion battery performance and cost for battery maintenance. The hybrid controllers (PI, PD and LQR) in the system controlled the current and the voltage flow through external charger. The overall system is shown in Figure 5.

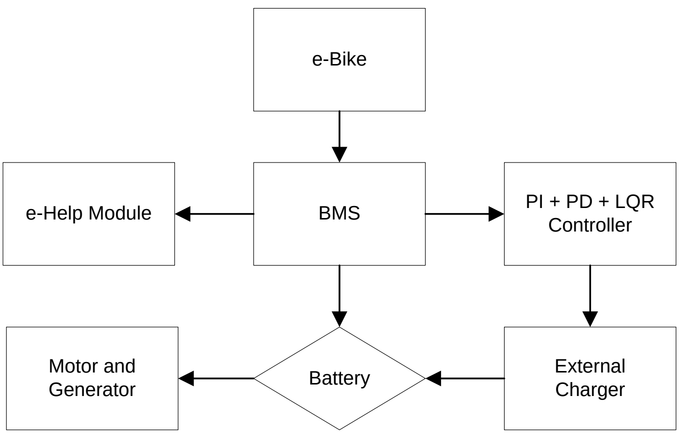

Figure 5: Flow chart of overall system

Moreover, the e-help manual module user was developed using GUI for solving faulty in battery with few help options. User had options either LMDI, DIY, or OTHERS for solving faulty in battery electronically.

3.0 RESULTS AND DISCUSSION

The results for the EV battery charging and discharging are discussed for further development in EV battery e-Help manual.

3.1 Results and Discussions for EV Battery Charging and Discharging

Battery performance Sub 1 Model is connected to DC Motor Machine for the output of the voltage, state of charge (SOC), speed and armature current as shown in Figure 6.

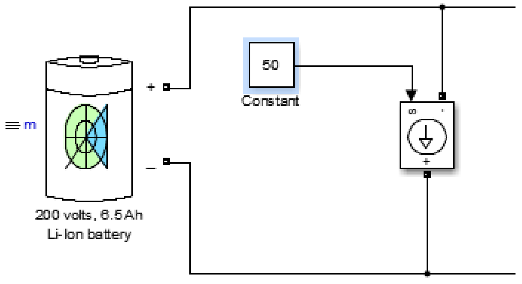

Figure 6: Simulink model in battery performance sub 1

Each output depended on the specific AC current initial value for nominal voltage, 200 volts. The single specific AC current with 100A initial value for 50 A load showed no change in the time period to charge and to discharge. These output performances are represented by GUI in Figure 7.

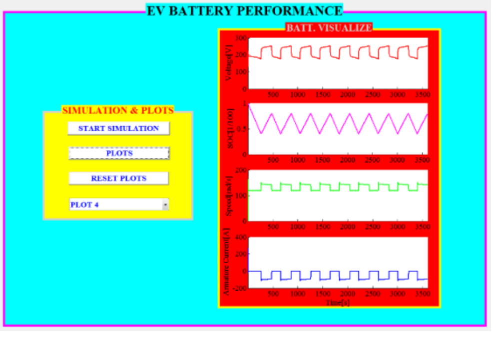

Figure 7: The GUI of battery performance with specific AC current initial value for nominal voltage 200volts

The single specific AC current with 100 A initial value for 100 A load showed the time period to charge was longer than the time period to discharge. This output performance is represented in GUI as shown in Figure 8. Vehicle charging was considered to be in a steady state when the RMS current magnitude was not changing and the voltage source was close to nominal. Vehicle charging was considered to be in a steady state when the RMS current magnitude was not changing and the voltage source was close to nominal.

The single specific AC current with 100 A initial value for 25 A load showed the time period charge was shorter than the time period to discharge. These output performances are represented in GUI as shown in Figure 9.

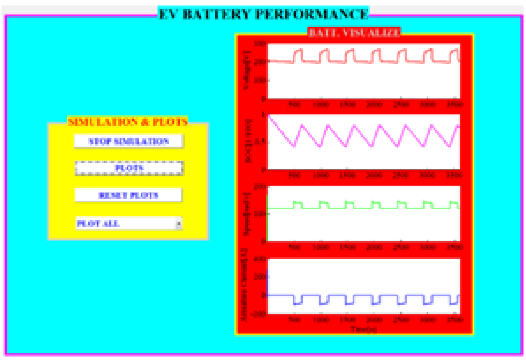

Figure 8: The GUI of battery performance with 2 specific AC current initial value for nominal voltage 200volts

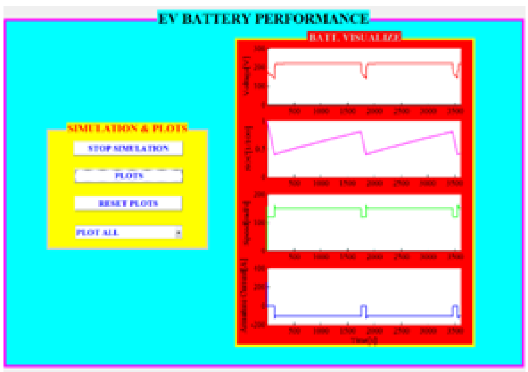

Figure 9: The GUI of battery performance with 0.5 specific AC current initial value for nominal voltage 200volts

3.1 EV Battery e-Help Manual

Usable devices do not function all the time. Problems might occur when the period cycle ends. EV battery is one of usable devices that also have period cycle. Thus, EV battery e-Help Manual module was designed to optimize time use and extend battery life. Users have few choices to solve EV battery problems such as LMDI (Auto), DIY (Manual) and OTHERS (Call Technical Assistant). These choices were advantageous to either the old or new users to save maintenance cost and learn how to fix EV battery as a revision and new knowledge.

Moreover, EV battery e-Help Module was designed to solve problems by analyzing the EV battery performance for each output. The performance is represented in Figure 10. Each output gave different explanation to relate to each other in determining and identifying problems. This EV Battery e-Help Manual module was user friendly. The module would connect the battery either directly or indirectly for troubleshoot guidance for any outputs with faulty occurrences such as overvoltage and overcharge. Direct troubleshooting guidance was conducted through devices such as smartphones and computers automatically. Indirect troubleshooting guidance was done manually by users to capture live video of two-way communication and to open video file. The troubleshooting guidance of EV Battery e-Help Manual module is shown in Figure 11 based on MATLAB and Visual Basic GUI applications.

Figure 10: Battery visualize performance of EV battery e-help manual

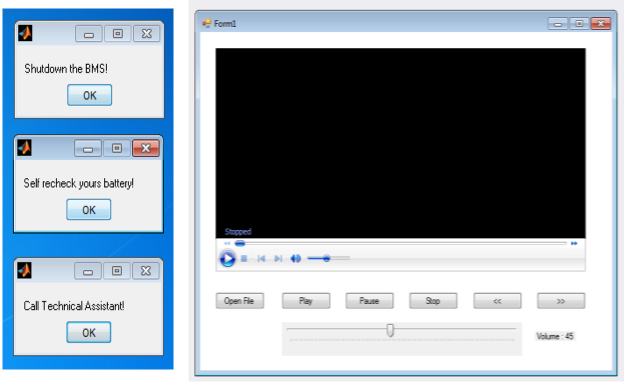

Figure 11: Direct and indirect troubleshoot guidance of EV battery e-help manual

4.0 CONCL U S ION

Graphical User Interface (GUI) is designed for EVs Battery e-Help Manual to simplify the complexity of the hardware connections to perform the fast action. EVs gain energy from Li-Ion battery to replace generator usage during electricity breakdown. The battery is monitored and controlled by the Battery Management System. This paper reviews various types of GUI to monitor, control and troubleshoot the battery in EVs, BMS operates to monitor battery characteristics performance, and EVs development. Each development in this paper is relevant to the implementation and development of the specific RTU for the charging and discharging of the battery life cycle in EV. EV Battery e-Help manual is helpful for users to guide them for battery troubleshooting either directly or indirectly during the process. Thus, the safety and performance in EVs is well-secured at any duration.

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