LOC based battery management system

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Abstract. Electric vehicles generate a large amount of real vehicle data every day, which poses great difficulties for researchers to conduct subsequent data analysis. This article proposes an overall plan for the data analysis system, and the software design implements its main functions, including reading different battery data types, analysing and displaying vehicle, individual, and fault information, greatly reducing the workload of researchers.

Keywords: LOC; data analysis system; fault information; LiFePO4 battery.

1. Overall system planning

For the specific operation of electric vehicles during the experimental phase, it is necessary to conduct a comprehensive and intelligent analysis of the actual vehicle data. The purpose of the data analysis system is to analyze the changes in battery characteristics based on the read actual vehicle data, diagnose faults such as BMS itself, battery pack, CAN bus communication, and compare the errors of SOC, LOC, SOH, and other parameters estimated by the algorithm in BMS through advanced algorithms added to the system, Finally, advanced algorithms that have been validated by the system can be downloaded to BMS.

The data analysis system planning includes four major parts: battery pack setting, data reading, display, and data analysis. The data analysis module also includes the diagnosis of faults such as the BMS itself, battery pack, voltage and temperature information collection, CAN bus communication, and the addition of advanced SOC and LOC, SOH, balance algorithms to determine the accuracy of the algorithms used in the BMS, as well as remote data transmission functions.

2. Software functions

The monitoring software functions of this system are as follows:

(1) Battery pack information settings. Including information such as the number of battery packs, corresponding batteries, and temperature numbers for different vehicles;

(2) Data reading. Read data of different storage types based on the battery pack settings information;

(3) Vehicle information display. Including battery pack SOC and LOC, total voltage, total current, and other curves, as well as parameters such as total data amount, highest standard deviation, and corresponding coordinates;

(4) Battery pack inconsistency. Display the voltage bar chart, voltage upper and lower limits, and mean curves of all batteries at any time, and observe whether there are any batteries that exceed the voltage protection limit, as well as the corresponding parameters such as SOC and LOC, total voltage, total current, maximum and minimum voltage, and corresponding battery number at the corresponding time;

(5) Open circuit voltage judgment. Determine whether the read data has open circuit voltage and provide open circuit voltage information, otherwise provide a prompt;

(6) Individual information Select. the battery pack, battery number, and temperature number at will, and display the corresponding change curve and parameter information;

(7) SOC and LOC and LOC estimation. Integrate the pure ampere hour method, improved ampere hour method, and the SOC and LOC estimation method based on online parameter identification proposed in this paper into the system for estimating the SOC and LOC of battery packs;

(8) Fault information statistics. Including fault level judgment of overall data and battery statistics with excessive voltage changes, providing the frequency of battery failures. Voltage and temperature thresholds can be set, and batteries with excessive voltage changes are defined as batteries that experience significant voltage jumps during the stationary process of an electric vehicle after starting;

(9) System operation mode. Including automatic analysis and manual analysis, both can be switched at any time. Automatic analysis automatically analyzes data after running the program, and the display speed of the analysis can be adjusted. Manual analysis allows researchers to independently choose the coordinate position for analysis;

(10) Cursor control. Move any cursor on the two waveform maps of the entire vehicle information to display the battery information at the cursor's location in real-time, and the two cursors move synchronously;

(11) Segmented display. For data of different dates, display in different colors and provide segment positions to help analysts distinguish the curve characteristics of different dates.

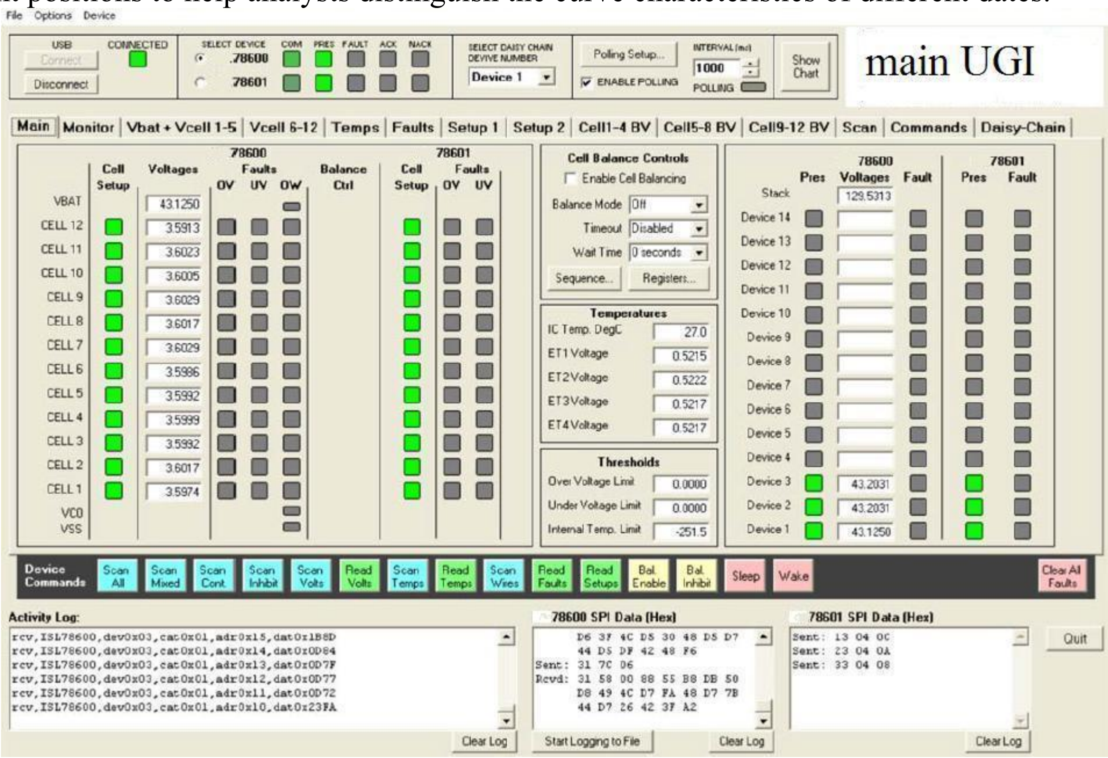

Fig 1 Management System

3. Design of battery pack information module

For pure electric buses in the research and trial phase, the battery pack settings of each vehicle may be different, and the data format stored after collection may also be different, which poses great difficulties in distinguishing various battery parameters after data reading. In order to solve the problem caused by this uncertain factor, this article has written a model for setting battery pack information block, generate an ini file for the battery pack information of each bus. Each time analyzing the actual vehicle data, call this set data information file to distinguish the type of data read and successfully read the data.

3.1 Storing Battery Pack Information

The generated ini file includes information such as battery pack number, number of batteries contained in each battery pack, and temperature. Users only need to input the file name and battery pack settings information that need to be saved, run the program, and automatically generate a file named "Input File Name - Battery Pack Count. ini". The file is saved in the "IniData" folder under the current directory, BTNum and tpNum store battery count and temperature count information respectively.

3.2 Call up battery pack information

When running the data analysis system software, select the existing battery pack information ini file corresponding to the data, and the program will call the information in it to classify and identify the data. Select the file save path, and the program will separate the required information from the file name - the number of batteries, and read the number of batteries and temperature corresponding to each battery pack number from the file based on the number of battery packs. The shift register function is used to achieve the collection of all data.

4. Design of data reading module

After selecting the data file and battery pack configuration file to be read, the user presses the "Read Data" button on the front panel, and the program will enter the event structure program for reading data. Firstly, initialize and clear the data displayed on the front panel, then read the battery pack information and data information in sequence. The memory space occupied by different data types also varies, with strings taking up the most memory space. In view of the large amount of real vehicle data, the data is read by category. The time is string type, the total voltage, total current and insulation resistance are double precision floating point numbers, and SOC and LOC, temperature and voltage are integer data. The raw data read is unprocessed and requires preliminary numerical processing, including time difference, maximum temperature and voltage, standard deviation, and corresponding battery number. These data information are combined into a cluster array for output for subsequent data processing and display. After the data reading is completed, there will be a prompt box that prompts the user to "successfully read the data". If the data reading fails due to factors such as large data volume or insufficient memory, there will also be corresponding prompts, providing suggestions for solving the problem, and stopping the system operation.

5. Design of vehicle information module

The displayed battery pack SOC and LOC, total voltage, total current, and standard deviation of battery pack voltage, as well as the total data and maximum standard deviation of the entire vehicle parameters. On the standard deviation curve, data from different dates are represented in different colors and segmented coordinate positions are provided for viewing. Drag the blue cursor on the waveform of SOC and LOC or standard deviation, and the lower part of the waveform will display the corresponding individual voltage at the corresponding time point in a bar chart, and calculate its voltage distribution. The individual inconsistency parameters will also change accordingly. The cursor can be manually dragged or automatically moved, and the speed of automatic analysis can be set according to the time of a single line of data and the running time of all data. The waveform can display all battery voltages and also the open circuit voltage of the data. If there is no open circuit voltage, there will be a message prompt, and the automatic analysis mode will automatically switch to manual analysis mode. After selecting the data analysis mode, the program determines whether the coordinates have changed. Automatic analysis mode. Every time the program runs, the coordinates automatically increase by 1. After the coordinates change, the data analysis type is determined to be overall data voltage display or open circuit voltage analysis, and the cursor position or open circuit voltage position is output. After obtaining the cursor, the data is processed, and the parameter information that needs to be displayed is indexed from the data cluster. Basic fault diagnosis is performed on the data, including the judgment of total voltage, individual voltage, and temperature, Taking the individual voltage judgment as an example, based on the input voltage protection limit value and the maximum voltage of the current time data, it is determined whether there is a problem with all battery voltages at this moment. It is divided into four voltage levels, namely high voltage (2) level, high voltage (1) level, low voltage (1) level, and low voltage (2) level. The total voltage and temperature judgments are similar to voltage, and each conclusion is ultimately merged and displayed in the current fault information on the front panel.

6. Design of individual information module

The program automatically displays the corresponding temperature and voltage curves based on the set module number, battery number, and temperature number, as well as the maximum and minimum temperature curves of the data, as well as parameters such as battery and total temperature. Changing the module number, battery number, and temperature number settings can display curve information for other batteries. They are the ampere hour open circuit voltage method, pure ampere hour method, and the SOC and LOC estimation methods based on online parameter identification used in this paper. Based on the ampere hour method combined with the open circuit voltage method, provide the estimation error curves for the other two methods.

7. Design of Fault Information Module

The fault level analysis of data is determined by setting boundaries between voltage and temperature. Provide specific battery fault information based on the set voltage and temperature protection thresholds. The upper left corner allows for setting of voltage and temperature thresholds as well as voltage jump parameters. Fault information is displayed in two aspects: one is the overall voltage and temperature level of the data determined by the voltage and temperature thresholds, and the other is the battery number information with the highest number of voltage jumps. The bottom left is the statistical chart of voltage jump faults. When there is a small current change lasting for dt (unit: s), batteries with voltage jumps exceeding the set value du are judged as having a large voltage change, unit: mV, and the number of battery jumps is given. The bar chart represents the battery number or temperature module number and the number of occurrences of overvoltage, undervoltage, high temperature, and low temperature phenomena in the read data. Use a bar chart to indicate the frequency of occurrence, with the battery or temperature module number and frequency with the highest number of failures at the top of each chart. A frequency of 0 indicates that there is no battery or temperature module with this fault. For example, if there is no undervoltage battery in the figure, the battery number defaults to the first battery with voltage issues and there is no temperature module with overheating. The module number here also defaults to the first module number with temperature issues. By visually displaying the lines and parameters, researchers can determine which batteries and temperature modules are malfunctioning and take targeted measures.

8. Design of cursor control module

The vehicle information SOC, LOC, and voltage standard deviation waveforms each have a cursor. Above the waveform, there is a cursor legend displaying the x and y coordinates of the cursor. Moving any of the cursors, the other cursor will also move synchronously. This module implements manual and automatic control of cursor movement based on the analysis mode selected by the user, and real-time display of battery information at the cursor's location, Update the overall analysis waveform and battery inconsistency parameters below the vehicle information. Firstly, initialize the two cursor positions to 0 and analyze the data from scratch. Users can choose their own analysis mode, and the two modes can be switched at any time. If it is manual analysis, the program will monitor in real-time whether any cursor changes. Once a change occurs, the new coordinate will be assigned to another cursor to synchronize the two; If it is automatic analysis, both coordinates will increase by 1, set the analysis time mode, adjust the analysis time, and control the analysis speed. Finally, process and display the data at the current coordinate position, and determine whether all data analysis has been completed. If not, continue to repeat the analysis process. Otherwise, the analysis process will end.

9. Design of segmented display module

Display data of different dates in different colors on the standard deviation curve, and provide segmentation positions for researchers to analyze the characteristics of the curve of different dates. In graphical display controls, NaN can achieve data hiding. However, due to the unpredictability of data dates, different color segments of the curve are uncontrollable, making programming difficult. Extracting data time and date as the primary basis for judgment, each time point is compared with the previous time to determine whether the date has changed, and the critical time point with date changes is obtained. Then, the data is segmented, and the index position of each segment does not change. However, each segment of data needs to be inserted into several Na N curves on different dates to merge and display a curve of different colors. Color control uses a set of colors. Due to the limited amount of data, there will not be too many consecutive data dates for the actual vehicle, so segmented display of data can be achieved.

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