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Design of 5G and cloud platform based intelligent battery management system

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Abstract

In view of this problem that electric vehicle traditional battery management system (BMS) is inefficient for its slow updating speed and single function. An intelligent battery management system based on 5G technology and cloud platform is designed in the paper. The hardware of the battery management system includes the micro controller unit (MCU), battery balancing module, voltage measurement module, current measurement module, temperature measurement module, charge and discharge protection module, Balong 5000 communication module and GPS orientation module. The system can accurately measure voltage, current, temperature, and GPS information. Meanwhile, battery data are upload with high speed. The cloud platform can realize real-time monitoring function and the whole life cycle management of battery.

Keywords

Battery management system, 5G technology, cloud platform, sensor.

1. Introduction

Under the background of sustainable development, research shows that electric vehicle [1,2] will take the major market share in the future. But opportunity always be side with challenge. The main problem hindering the development of electric vehicle is the battery safety. Battery Management System connects power batteries to electric vehicles or energy storage systems. Not only can it improve the performance of the battery effectively, but it can also extend the battery life and ensure it working safely. So it is an essential part of battery system. The traditional BMS processes the data by the micro controller unit (MCU). It manages different batteries with the same algorithm, parameters and strategies with the change of time. Therefore, the management efficiency is low. A lot of manufacturers had launched battery management system based on 4G communication. But 4G transmission efficiency is low. Therefore, the traditional BMS [3] is difficult to meet the demand of electric vehicle now. 5G technology is the latest generation of mobile communication technology. 5G technology has advantages of high rate data transmission and large device connection. Cloud platform is a service platform which provides hardware resources and software resources to compute and storage. 5G based intelligent battery management system based on 5G technology and cloud platform is designed in the work. A cloud collaborative management based on big data is proposed in this system. The cloud server powerful storage capacity is used to build data analysis model. Then, battery can match the latest battery management system. 5G intelligent battery management system realizes synchronous management and the whole life cycle management in the cloud. Not only can it reduce the risk of battery safety greatly, but also extend the battery life effectively.

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2. Design of the system architecture

The system is composed of the MCU, battery balancing module, voltage measurement module, current measurement module, temperature measurement module, charge and discharge protection module, Balong5000 communication module, GPS orientation module.

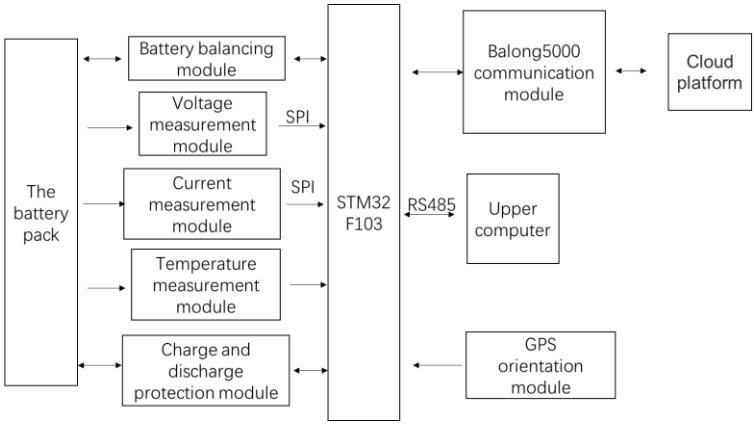

Fig.1 General framework

In Fig.1,the battery voltage, current and temperature are measured by various sensors and detection chips in the system. The STM32F103 chip is used for preliminary data processing. The data are uploaded to the cloud through 5G technology and the battery data are analyzed and processed in the cloud.

3. System hardware design

3.1. MCU

MCU is the core of the whole battery management system(BMS). The STM32F1[4] series processor which produced by STMicroelectronics (ST) is selected in the work. STM32F103VET6 processor is a 32-bit processor which adopts ARM cortex-M. It has 512K bytes flash memory, 64K bytes SRAM.

3.2. Voltage measurement module

The voltage measurement chip LTC6803[5] has fast collection efficiency and high accuracy . In Fig.2, the LTC6803 chip includes a 12-bit ADC, an accurate voltage reference, a high-voltage input multiplexer, and a serial interface. The voltage is input through the BAT terminal and the detection data are output at the I OUT and T OUT terminals. It can be finished in 13 ms to measure each battery voltage. The LTC6803 has the self-test circuit inside in order to ensure the security.

3.3. Current measurement module

In Fig.3, current measurement module is mainly composed by a hall sensor circuit (ACS712), a subtraction operation circuit (SMG358U8B), a voltage follower(SMG358U8A) and an AD conversion circuit (ADS1110). The hall sensor adopts ACS712[6] chip. The chip is designed by using a linear hall sensor circuit and a copper foil. When current flows the copper foil, the ACS712 chip produces a magnetic field. According to the magnetic induction, the hall element generates corresponding voltage signal. Then, when feeble voltage signal flows internal subtraction operation circuit(SMG358U8B), voltage follower (SMG358U8A) and AD conversion circuit(ADS1110), the chip outputs a voltage signal.

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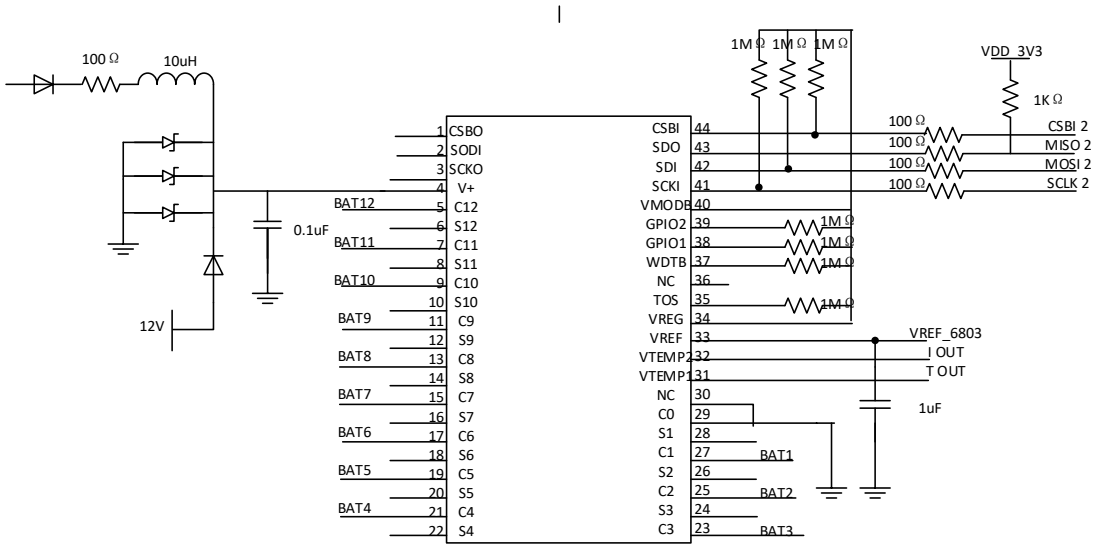

Fig. 2 Schematic diagram of voltage measurement module

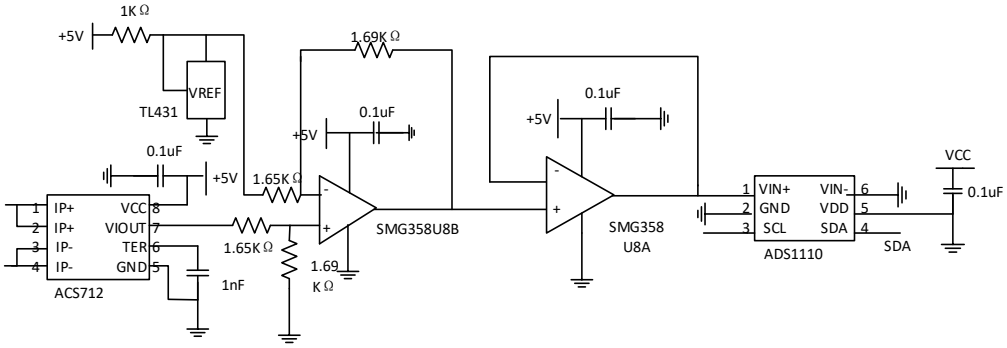

Fig. 3 Current measurement module

3.4. Temperature measurement module

The thermistor's resistance changes with the external temperature. In Fig.4, 10 K NTC thermistor[7] is selected in this work. The two-channel thermistor and RC filter circuit ensure the stability of the voltage of thermistor. Finally, the voltage outputs to the ADC pin of the MCU.

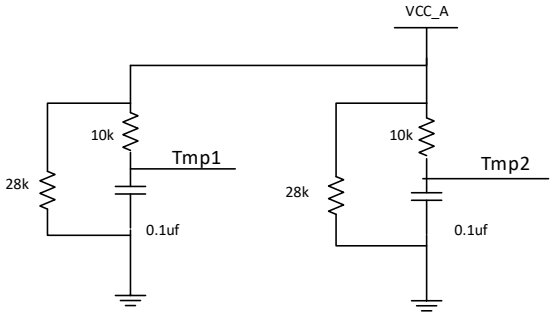

Fig. 4 Schematic diagram of temperature measurement module

3.5. GPS positioning module

NE0-6M GPS module has high sensitivity, low power consumption, miniaturization and other characteristics. In Fig.5, NE0-6M GPS module is supplied by 3.3 V. Ceramic antennas are connected with the SMA interface. It can also be connected to MCU for communication. This module increases the amplifier circuit, which is good for the ceramic antenna (MAX2659) fast searching information. Location information can be saved in EEPROM.

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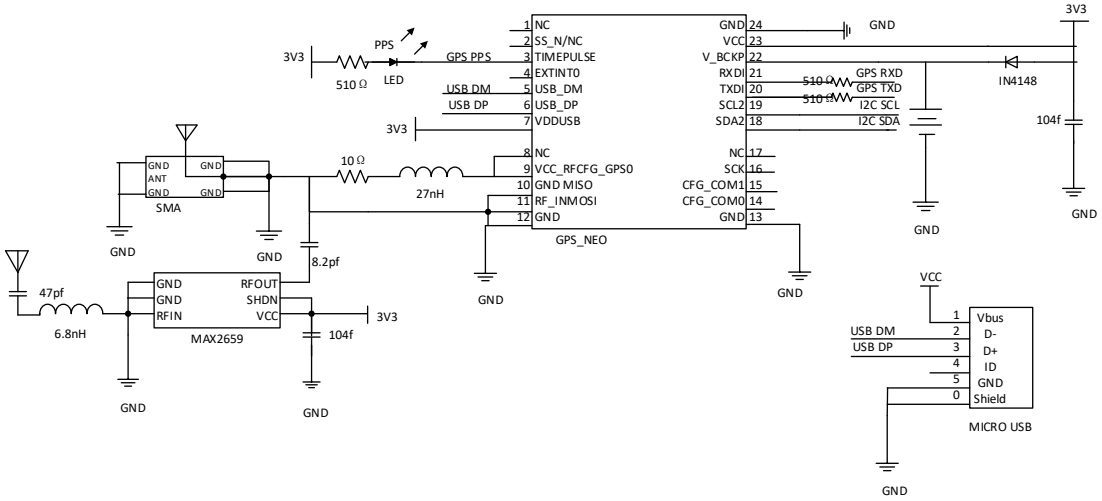

Fig.5 GPS schematic

3.6. Charge-discharge protection module

When the BMS is working, it needs to be safely controlled of each battery packthrough relay [8]. When the electric vehicles are running normally, the relay switches on to make the discharge circuit working. When charging, the charge circuit of the battery should be closed. When the battery pack is not being used properly, over current may occur. The discharge circuit or charge circuit should be disconnected to ensure the battery pack intact. In Fig.6, the measurement circuit generates current through an optocoupler (TLP521). The current is amplified by an audion to control the relay.

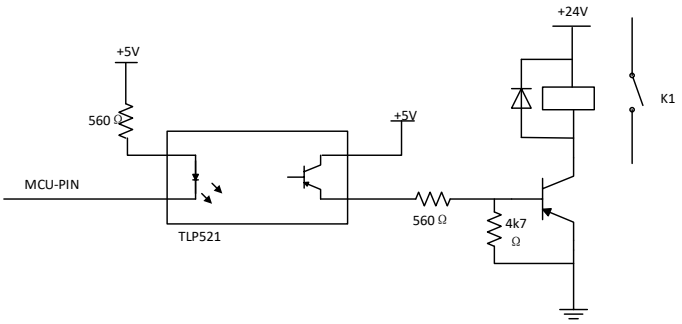

Fig. 6 Schematic diagram of charge and discharge protection module

3.7. Communication module

The communication module adopts MH5000-31MiniPcie industrial module. 5G [9, 10] industrial module is the core component of communication module which connects 5G baseband chip, radio frequency, storage, power management and other hardware. The core of MH5000-31minIPCIE5G industrial module adopts Huawei balong5000 chip. The module supports NSA/SA dual mode. It can connect to 5G+SA network. MH5000-31MiniPcie industrial module has ability of switching on 2G/3G/4G/5G. The downloading rate and uploading rate are respectively 2Gbps and 230Mbps. In order to meet the needs of industrial interface, multiple industry standard hardware interfaces are adopted. In Fig. 7, the 5G industrial module is powered by 4V and has a USIM card interface. It exchanges data through Pulse Code Modulation (PCM) and Universal Serial Bus (USB). MH5000-31MiniPcie industrial module not only ensures the accuracy of the collected data, but also improves the data transmission rate in the remote monitoring system.

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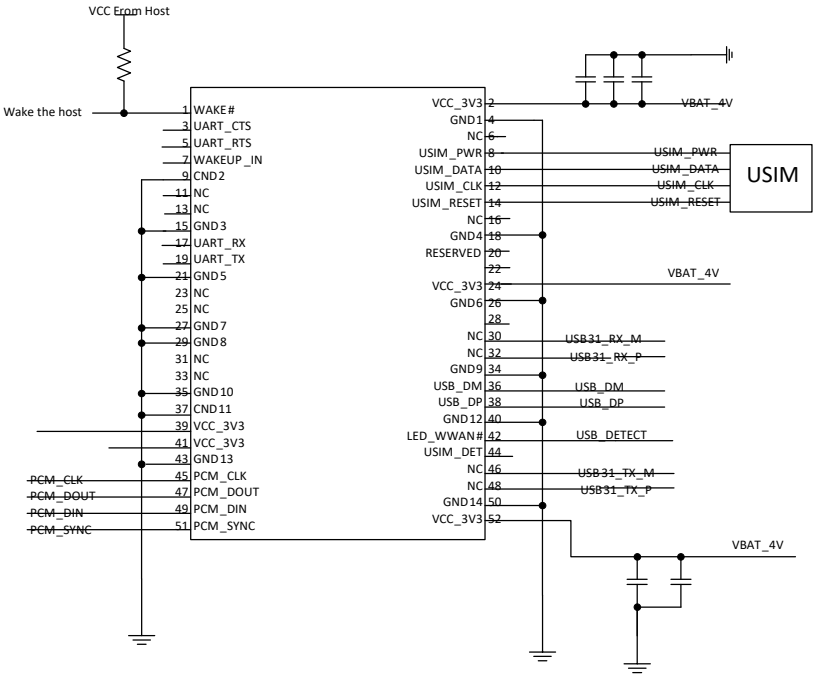

Fig. 7 Schematic diagram of MH5000-31miniPCIE industrial module

4. The software design

4.1. The software

The software is mainly divided into BMS, edge computing, cloud computing [11] and display layer. In Fig. 8, battery pack data are collected by BMS. The edge computing refers to the computing and storage platform nearing the terminal. Data are processed in real time by edge computing and faults are monitored. Cloud computing analyzes data according to specific algorithms. Battery characteristic data are obtained through cloud computing. The calculation results are optimized and stored. Finally, the data can be displayed at display layer.

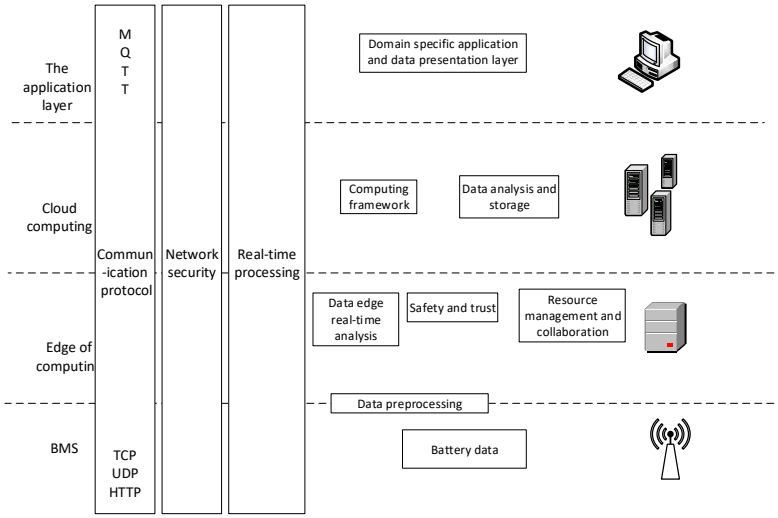

Fig.8 Software layer diagram

The system program operation diagrama is shown in Fig.9. At first, the procedure starts and the state of the receiving is checked. If correct, timing sampling is waiting. Then, the battery voltage, current, temperature are processed by STM32 and judged whether working properly. If wrong, the BMS trips the alarm. Charge and discharge protection circuit also begins to work after the information is stored and transmitted to the cloud. After that, the steps are repeated.

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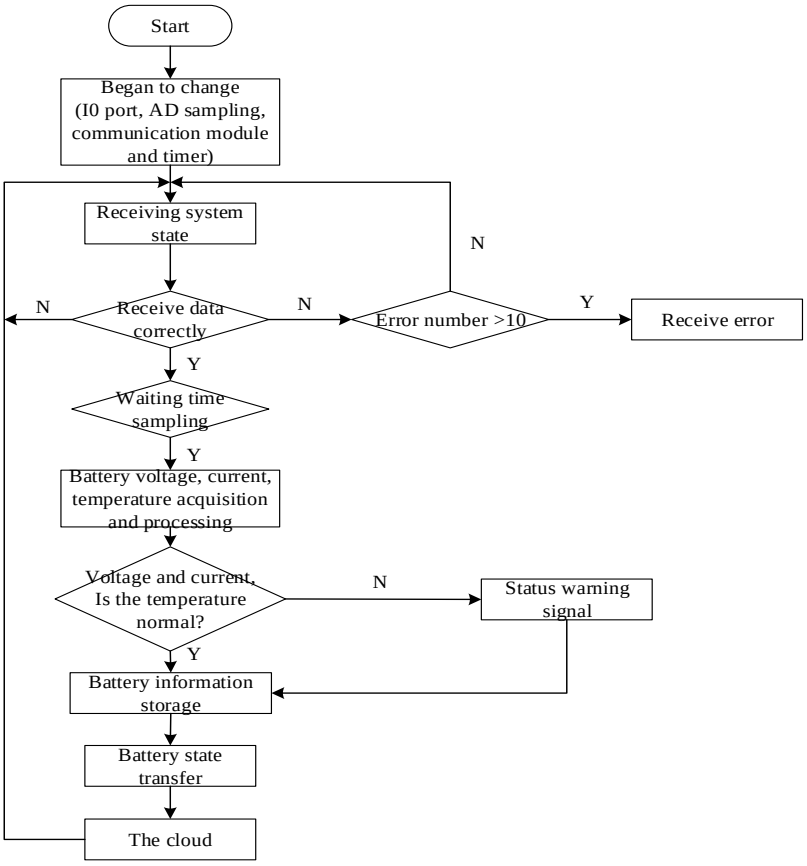

Fig. 9 Program flow chart

This system is programed by C language. Due to the 5G communication module, it also supports online updating system.

4.2. Cloud platform

The comprehensive cloud platform combining computing with data storage is adopted in this system. Not only can the cloud platform store the battery running data, but it can also analyze the uploaded battery data. Meanwhile, the battery running state is comprehensively diagnosed in the cloud. In Fig 10, in order to achieve the effect of real-time monitoring, the remaining battery power and location information of the vehicle is uploaded at cycle 0.5s when the BMS is working. When the data are uploaded to the cloud platform, they are filtered and processed by SQL language through the AI engine. After the data are analyzed and calculated by the algorithm, the cloud platform obtains the battery characteristic data and parameter optimization results. Finally, the date is showed on the client side.

The SQL database [12] is used to manage data to ensure the security of data, and it effectively prevents the reveal of personal information. It meets the requirements of rapid response such as data query, data analysis, abnormal alarm of battery pack.

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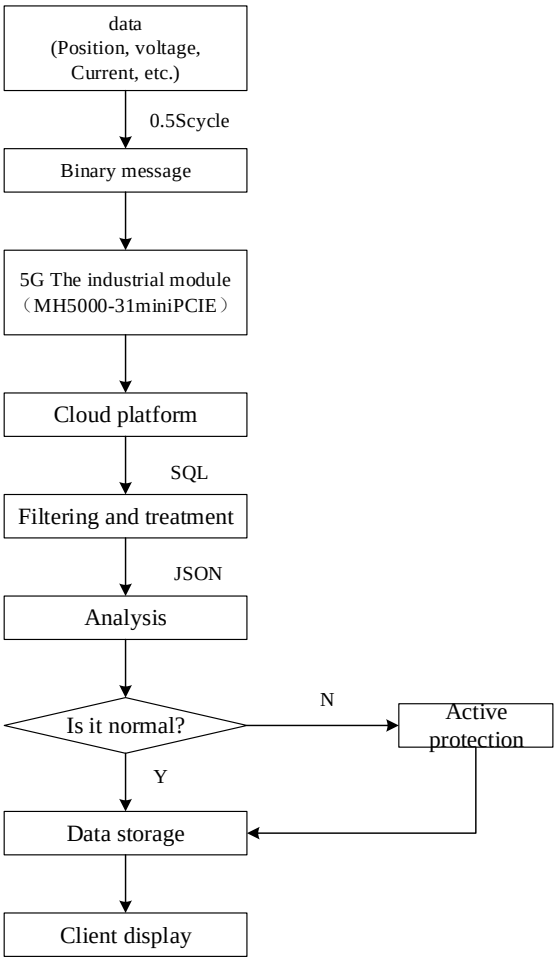

Fig.10 Flow chart of cloud platform

5. Conclusion

An intelligent BMS based on 5G communication and cloud platform has been designed in the work. The system can monitor the real-time operation data of the battery pack. Data such as voltage, current and temperature are preprocessed by the BMS. The data can be uploaded to the cloud through the MH5000-31miniPCIE industrial module. The cloud platform analyzes and optimizes the data in order to obtain the battery characteristic data, so as to realize the remote monitoring of the voltage, current and temperature of the battery. Accordingly, the stability and safety of electric vehicle batteries are greatly improved.

Acknowledgments

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