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EV BMS With Charge Monitor and Fire Protection Using STM32

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ABSTRACT:

Obviously, electric cars (EVs) will define the direction of society. Regarding efficiency and safety, EV technology has not yet completely realized 2023 though. Usually, the events involving electric vehicles fire originate from a battery explosion or fire. Combining charge monitoring and fire detection with a Battery Management System (BMS), this work provides a complete approach to control EV battery systems. Apart from instantly cutting off input or output should unusual activity be detected, the system is built to continuously track the voltage, current, and temperature of the battery.

KEYWORDS: Electric vehicle, Battery management, STM32,Sensors .

INTRODUCTION:

Motivated by several significant factors, the acceptance of electric vehicles (EVs) has been gradually increasing in recent years. Environmental problems are a major driver since the world strives to reduce greenhouse gas emissions and slow down the effects of climate change. Fuel economy is another strong case; electric vehicles offer a more reasonably priced and efficient replacement for conventional internal combustion engine vehicles. Government incentives including tax breaks, rebates, and subsidies also help manufacturers and consumers to embrace electric vehicles. Nevertheless, if we are to ensure the safety, performance, and efficiency of electric vehicles, the management of their battery systems becomes one of the most critical problems that has to be addressed.

The battery system of an electric vehicle is several linked battery cells with varied purposes. These cells must be closely watched and regulated since either condition can have major consequences to prevent overcharging or too great discharging. Overcharging or over-discharging the battery cells will cause reduced battery life, less performance, and—more importantly—safety risks including the possibility of fires or thermal runaway events. thus

solve these issues; electric cars have a sophisticated Battery Management System (BMS).

Comprising several crucial components—the Battery Management Unit (BMU) and several sensors—all of which cooperate to guarantee the best possible operation of the battery system—the Battery Management System is Important for this system are voltage sensors, which continuously monitor battery cell voltage levels. These sensors help to control the current passing to the battery during charging so preventing overcharging. While an LCD screen indicates the battery voltage to keep consumers informed of its condition, the charging circuitry controls this process guaranteeing safe and efficient energy transfer to the battery.

Much depends on current sensors when one watches the current drawn from the battery while it is connected to a load. The LCD displays the information from these sensors, which provide the user real-time comments on vehicle current consumption. In the same line, temperature sensors monitor battery temperature both during discharge and charging. Should the temperature deviate from the recommended safe range, the system displays a warning on the LCD and triggers an automatically buzzer alert. This alert system ensures that the battery system stays within reasonable running limits by helping to prevent overheating and possible safety hazards.

Furthermore made possible by intelligent battery management technology are quick and efficient battery charging and monitoring. Real-time data on state of health (SoH), state of charge (SoC), and battery system temperature is provided. The charge monitoring system records the power being delivered to the battery, the current charge level, and the speed with which the battery is charging. Constant comments on the charging process follow from This degree of observation ensures optimal lifetime and performance of batteries.

Moreover absolutely crucial for the battery management system is fire safety. Combining modern thermal management systems and fire suppression devices helps to identify any early on signs of overheating or possible fire hazards. By means of these proactive measures, the system will be able to prevent the start of fires, so enhancing the general dependability and safety of electric cars. so the intelligent

combined approach to battery management in electric vehicles not only protects the battery system but also helps the effective and efficient running of these ecologically friendly vehicles.

LITERATURE REVIEW :

Introduction to Electric Vehicle Battery Management Systems (BMS):

eneral picture of them The BMS determines both safety and performance of EV batteries. It extends battery life, guarantees best running performance, and prevents failure modes. Wang et al. 2021.

Safety management, thermal control, charge monitoring, and estimate of the state of charge (SoC) are among key uses.

2.Charge Monitoring in BMS:

Voltages and currents measured: Real-time tracking demands precise voltage and current sensing. Methods call for shunt resistors and Hall effect sensors (Li et al., 2020).

Approximate State of Charge (SoC) Among the several techniques applied for soC estimate are Kalman filtering and Coulomb counting. These methods mix correctness with computational efficiency (Wang & Zhang, 2022).

Maintaining equal charge across battery cells will help to raise efficiency and lifetime. Passive balancing is simpler even though active balancing provides better performance but at a more cost (Chen et al., 2023).

Fire Protection Mechanisms:

Staying from overheating absolutely depends on good thermal management. Widely used thermistors and thermocouples are Nguyen et al., 2022.

Early detection systems—algorithms for spotting anomalies including fast temperature increase or voltage spikes—are essential in preventing thermal runaway (Zhao et al., 2021).

Should dangerous conditions be discovered, emergency procedures call for disconnecting cells and starting cooling systems (Kim et al., 2020).

Microcontroller Selection: STM32

Benefits of STM32: STM32 microcontrollers offer high processing power, low power consumption, and flexibility in interfacing with various sensors and displays (Thompson et al., 2021).

Development Environment: STM32CubeIDE provides a robust platform for developing and debugging BMS software, facilitating integration with hardware components (Garcia et al., 2023).

key features of STM32 microcontrollers :

1. **Wide Range of Architectures**: Based on ARM Cortex cores (M0, M0+, M3, M4, M7) to accommodate various performance and power efficiency needs.
2. **Low Power Consumption**: Multiple low-power modes and power-saving features make STM32 ideal for energy- efficient and battery-powered applications.
3. **High Performance**: High clock speeds, optional floating-point units, and DSP instructions support demanding tasks like real-time data processing.
4. **Rich Peripheral Set**: Includes timers, ADCs, DACs, and communication interfaces (USART, SPI, I2C, CAN, USB, Ethernet) for versatile connectivity and control.
5. **Robust Development Ecosystem**: Tools like STM32CubeIDE and STM32CubeMX, along with comprehensive software libraries, simplify development and integration.

2. *Sensor Integration:*

Types of Sensors: Among other crucial sensors BMS makes use of are voltage sensors, current sensors, and temperature sensors. Monitoring batter conditions depends mostly on every sensor (Patel et al., 2021).

Calibration: Reliability of performance relies on proper calibration of the sensors. Calibration techniques ensure that sensors produce accurate readings under various environments (Lee & Kim, 2022).

3. *User Interface and Display:*

Display Technologies: User interfaces can utilize LCD or OLED displays to present real-time data such as SoC, voltage levels, And temperature (Smith etal.,2023).

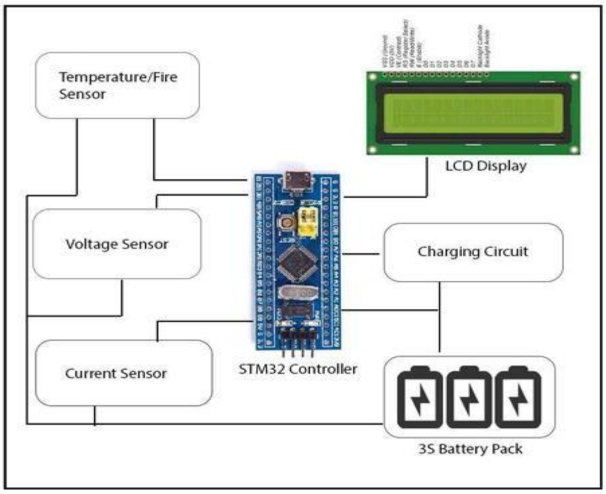
User Interaction: Interfaces may include buttons or touch screens, allowing users to interact with the system and adjust settings as needed (Jones et al., 2020).
Data Logging: Implementing data logging features can aid in performance analysis and troubleshooting (Liang et al., 2021).

4. *Communication Protocols :*

Interfacing Components: Communication protocols like CAN bus or I2C are commonly used to facilitate communication between BMS components (Zhang & Wang, 2021).
Remote Monitoring: Integration of Bluetooth or Wi-Fi allows for remote monitoring of battery status, enhancing user experience and accessibility (Kumar et al., 2022).

BLOCK DIAGRAM :

All of the active functions for a step down (buck) switching regulator are provided by the voltage regulator LM2576 family of monolithic integrated circuits. Fixed versions with
3.3V, 5V, or 12V fixed outputs are available. The output voltage range for adjustable versions is 1. 23 to 37 volts.



Both variants have excellent line and load regulation and can Fig.1 Battery Management System The STM32 is a popular type of microcontroller that used in many different kinds of gadgets. Additionally, it has the ability to connect to various other kinds of microcontrollers. STMicroelectronics developed the STM32 line of microcontroller units (MCUS), which is based on a 32-bit ARM Cortex-M processing core. Using a series and parallel communication method, a variety of external devices, including as sensors,cameras, motors, and other devices, can be connected to this microcontroller. The DHT11 is a common temperature sensor. Fig. 1 displays the circuit diagram. The sensor has an 8-bit microprocessor for serial data output of temperature and humidity information in addition to a dedicated NTC for measuring temperature. Furthermore, the sensor is factory-calibrated, which simplifies integration with other microcontrollers. The sensor can measure temperature from 0°C to 50°C and humidity from 20% to 90% with an accuracy of 1°C and 1%.

METHODOLOGY :

1. *System Design and Architecture:*

Define System Requirements

Identify key functionalities: charge monitoring, thermal management, communication, and user interface.Establish safety protocols and requirements for fire protection.

Select Components

Choose the STM32 microcontroller based on performance needs (e.g., STM32F4 series).Select appropriate sensors for voltage, current, and temperature monitoring (e.g., shunt resistors, thermocouples).

Design System Architecture

Create a block diagram showing the interactions between the STM32, sensors, communication modules, and display interfaces.

2. *Hardware Development :*

Circuit Design

Develop schematics for the BMS, including sensor connections and power management circuits.

Ensure proper grounding and noise mitigation techniques are employed.

PCB Design and Fabrication

Use software like Altium Designer or Eagle to design the PCB layout.

Fabricate the PCB and assemble components. Component Testing

Conduct tests to ensure each component functions correctly (voltage/current measurements, temperature readings).

3. *Software Development :*

Firmware Development

Use STM32CubeIDE for developing the firmware.Implement drivers for sensor interfacing, ADC configurations, and communication protocols (I2C, CAN).

Charge Monitoring Algorithms

Implement Coulomb counting for SoC estimation.Develop algorithms for cell balancing (active/passive methods).

Fire Protection Algorithms

Develop algorithms to monitor temperature thresholds and detect anomalies.Implement safety protocols to disconnect the battery or activate cooling systems upon detection of unsafe conditions.

User Interface Development

Design the user interface to display real-time data (SoC, voltage, temperature) on an LCD/OLED.Incorporate user inputs for settings adjustments and status checks.

4. *Integration and Testing :*

Integrate Hardware and Software

Load firmware onto the STM32 and connect to sensors and displays.Test all components together to ensure seamless operation.

Functional Testing

Verify each functionality: charge monitoring accuracy, response to thermal events, and display updates.Conduct stress tests to evaluate system performance under different operating conditions.

Safety Testing

Simulate over-temperature and over-voltage conditions to test the fire protection mechanisms.Ensure safety protocols trigger correctly during simulated faults.

5. *Data Logging and Analysis :*

Implement Data Logging
Enable data logging of battery parameters for analysis over time.Store logs in non-volatile memory for post-analysis.
Analyze Performance
Review data logs to evaluate the accuracy of SoC estimation and the effectiveness of thermal management.Identify any patterns in battery performance and safety incidents.

6. *Final Validation and Optimization :*

Conduct Field Testing
Deploy the BMS in a controlled EV environment for real- world testing.Gather data on performance, reliability, and user feedback.
Optimize Algorithms
Based on testing results, fine-tune algorithms for improved performance and response times. Update firmware as necessary to incorporate improvements.
Documentation
Prepare comprehensive documentation of the design, implementation, and testing processes for future reference.

CONCLUSION :

The system is intended to monitor battery voltage, current, and temperature continuously and to immediately stop taking input or output from the battery when any odd behaviour is noticed. The advantages that this system offers are as follows:
i. Battery Status Display and Monitoring ii. Battery charging according to the necessary input parameters iii. Temperature monitoring with an automatic cutoff The technology we created will not only keep an eye on the battery and charge it securely, but it will also guard against accidents. The system's charging and monitoring circuitry is activated when it is turned on, enabling the user to safely charge the 3S battery. The current sensor monitors battery current when it is connected to a load and displays the parameter on the LCD Display.

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