IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 4, April 2024

DOI: 10.17148/IJIREEICE.2024.12428

ADVANCED ELECTRIC BIKE WITH INTEGRATED SAFETY AND MONITORING SYSTEM

Usha H.N[1], Balaji S [2], Sumukha R [3]

Assistant Professor, Department of Electronics and Communication Engineering,

A.P.S College of Engineering, Bangalore, India[1]

8th SEM BE, Department of Electronics and Communication Engineering,

A.P.S College of Engineering, Bangalore, India[2-3]

Abstract: In the realm of electric vehicle (EV) technology, safety and user experience are paramount considerations. This paper presents a comprehensive overview of an electric vehicle system that emphasizes safety and battery protection through advanced sensor integration and proactive control mechanisms. The system features a groundbreaking helmet detection sensor, a 16-cell battery pack monitored by voltage and current sensors, and an over-temperature sensor to regulate battery thermal conditions. An Arduino Mega serves as the central control unit, orchestrating safety protocols and user interface interactions. Proactive measures, including a cooling system and motor speed control, prioritize safety and battery health. Real-time information display and user notifications enhance rider engagement and accident prevention. This electric vehicle system exemplifies the integration of technology and safety, paving the way for a safer and more sustainable future in personal mobility.

Keywords: Electric vehicle (EV), helmet detection sensor, battery pack, Arduino Mega, over-temperature sensor, safety protocols, proactive measures, real-time information display, user notifications, personal mobility, sustainability.

I. INTRODUCTION

In the dynamic landscape of electric vehicle (EV) technology, a standout innovation lies in a meticulously crafted electric vehicle system, exemplifying a fusion of advanced engineering and a resolute commitment to safety and user experience. At the forefront of its safety features is a ground-breaking helmet detection sensor, compelling the use of a helmet before bike ignition to install a crucial safety practice. However, the system's dedication to safety extends further, with a 16-cell battery pack at its core, closely monitored by voltage and current sensors to ensure continuous battery health. An over-temperature sensor acts as a vigilant guardian, regulating the battery's thermal conditions and preventing potential risks associated with overheating. Driving the system's operations is the Arduino Mega, not only orchestrating the vehicle's functions but also serving as the custodian of safety logic. Proactive measures are seamlessly integrated, including a cooling system that activates a fan and buzzer when the battery temperature surpasses predefined thresholds. Motor control dynamically adjusts the DC motor's speed based on battery temperature, with speed control mechanisms establishing limits to prioritize safety. The user interface is comprehensive, featuring a real-time vehicle display providing crucial information on battery status and temperature. This empowers riders with insights into the vehicle's operational conditions, fostering a sense of control and proactive engagement in maintenance. User notifications and an emergency shutdown relay further enhance safety, ensuring riders remain informed and capable of swift responses in unforeseen circumstances. In essence, this electric vehicle system epitomizes the harmonious integration of advanced sensor technology and safety mechanisms, redefining personal mobility with a focus on well-being and sustainability.

II. LITERARTURE SURVEY

1. “**Electric Vehicle Interactions with Power Distribution System**”

Authors: Andres Arias, Oscar Danilo, "Electric Vehicle Interactions with Power Distribution System," IEE, Issued on 11 June 2020

This paper extensively examines the interactions between electric vehicles (EVs) and power distribution systems, with a keen focus on enhancing safety measures. It delves into battery capabilities, emphasizing the suitability of different battery types based on energy requirements. Notably, it stresses the importance of selecting low-power output batteries for optimal

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 4, April 2024
DOI: 10.17148/IJIREEICE.2024.12428

mileage efficiency and discusses the advantages of high-power output batteries for enhancing vehicle performance. Moreover, the paper discusses strategies for customizing battery output to meet specific usage demands and highlights the pivotal role of DCDC converters in regulating battery energy to ensure optimal utilization and safety during operation. By providing a nuanced understanding of battery dynamics and their interactions within the power distribution system, this paper offers valuable insights for implementing robust safety protocols in EVs.

2. “**A Review of Battery Fires in EVs**”

Authors: Peiyi Sun, Roeland Bisschop, Xinyan Huang, "A Review of Battery Fires in EVs," IEE, Issued on January 2020

This study conducts a thorough analysis spanning five years from 2012 to 2017, focusing on battery fires in electric vehicles (EVs) and identifying key contributing factors. Emphasizing safety concerns associated with EV batteries, particularly in high-powered vehicles like Tesla, the paper underscores the importance of addressing these issues. It highlights seasonal variations in fire occurrences, notably during summer months, advocating for proactive measures to mitigate risks.

3. “**A Systematic Literature Review of State of Charge Estimation Methods for Batteries Used in EV Application**”

Authors: Radhika Swarnkar, Harikrishnan Ramachandran, "A Systematic Literature Review of State of Charge Estimation Methods for Batteries Used in EV Application," IEE, Issued on 5th September 2023

This literature review systematically examines state-of-charge estimation methods for batteries in electric vehicles (EVs), focusing on optimizing battery performance and ensuring longevity. Stressing the critical importance of maintaining battery health, it explores various estimation techniques and underscores the role of thermal management systems in preserving battery health and preventing degradation due to temperature fluctuations. Through meticulous analysis, the paper offers valuable insights into battery monitoring and management, empowering EV manufacturers and researchers to develop robust battery management systems for enhanced performance, safety, and sustainability.

III. ELECTRIC VEHICLE SYSTEM

A. System Architecture

The electric vehicle (EV) system comprises several interconnected components:

- Powertrain: The core of the system consists of a 16-cell battery pack monitored by voltage and current sensors.
- Safety Features: A helmet detection sensor ensures helmet usage before bike ignition, while an over-temperature sensor prevents battery overheating.
- Control Unit: An Arduino Mega serves as the central control unit, managing safety protocols and system functions.
- Cooling System: Proactive measures include a cooling system activated by a fan and buzzer to control battery temperature.
- Motor Control: DC motor speed adjusts based on battery temperature, with speed control mechanisms enhancing safety.
- User Interface: Real-time battery and temperature information is displayed on a vehicle dashboard for rider awareness .

This basic framework shows electric vehicle system integrates advanced safety features, including helmet detection sensors and battery health monitoring, to ensure rider well-being and operational reliability. Real-time user interfaces and emergency response mechanisms empower riders with control and proactive engagement, setting new standards for electric vehicle safety and sustainability.

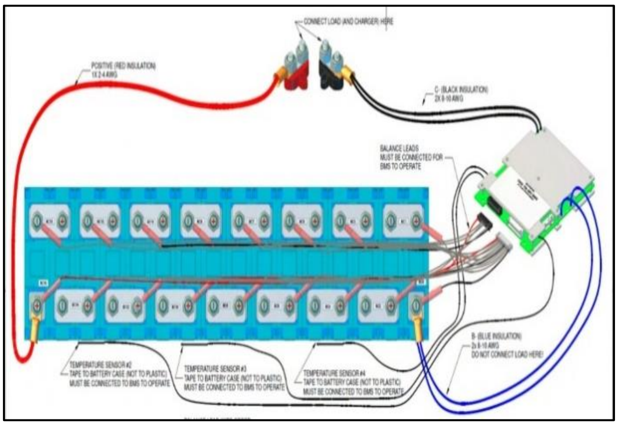

Fig 1: 16-cell battery pack

- Battery Pack: Fig 1 represents the 16-cell battery pack monitored by voltage and current sensors.
- Helmet Detection Sensor: Ensures helmet usage before bike ignition, enhancing rider safety.
- Arduino Mega: Serves as the central control unit, managing safety protocols and system functions.
- Cooling System: Activates a fan and buzzer for temperature control.
- User Interface: Displays real-time battery and temperature data for rider awareness.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 4, April 2024

DOI: 10.17148/IJIREEICE.2024.12428

B. Battery Health Monitoring

The battery's health is crucial for the EV system's performance and longevity. The system employs various monitoring mechanisms.

- **Voltage and Current Sensors**: Continuously monitor the battery pack for optimal performance
- **Cooling System**: Activates proactive measures to control battery temperature, ensuring optimal performance and safety.
- **Over-temperature Sensor**: Regulates battery temperature to prevent overheating and associated risks.

C. Safety Logic and Control

The Arduino Mega processes data and implements safety logic:

- **Helmet Detection:** Enforces helmet usage before bike ignition, promoting rider safety.
- **Temperature Thresholds:** Initiates proactive measures, including the activation of the cooling system, when battery temperature exceeds predefined limits.

D. User Interaction and Safety Measures

The user interface provides real-time information and safety features:

- **Real-time Display:** Presents battery status and temperature information for rider awareness.
- **User Notifications:** Alerts riders to critical information and emergency situations.
- **Emergency Shutdown Relay:** Ensures swift responses to unforeseen circumstances, enhancing overall safety.

IV. HARDWARE DESCRIPTION

I ARDUINO MEGA

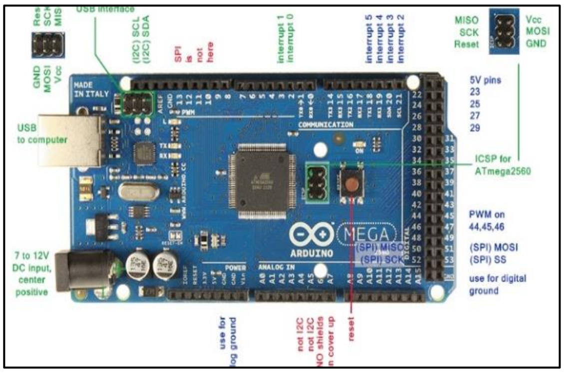

Fig 2: Arduino Mega Pin Configuration

The fig 2 (Arduino Mega) is the central processing unit for the electric vehicle system, offering extensive I/O capability with 54 digital I/O pins and 16 analog input pins. Powered by the ATmega2560 microcontroller running at 16 MHz, it ensures rapid data processing and real-time responsiveness. With 256 KB of flash memory, the Arduino Mega can accommodate large program codes and data storage needs. Multiple pins support Pulse Width Modulation (PWM) for precise motor control. It features four hardware UART (Serial) ports for seamless communication with external devices. Integrated SPI and I2C interfaces enable communication with a wide range of peripherals and sensors, facilitating efficient data exchange and system expansion.

II RF Transmitter and Receiver Module

The RF transmitter and receiver modules are integral components of the electric vehicle system, facilitating wireless communication with several key features. Operating at the 433 MHz frequency band, these modules ensure reliable long-range communication suitable for various vehicle telemetry and remote control applications. One notable advantage is their low power consumption during transmission, which helps conserve battery life and optimize overall energy efficiency within the system. Data transmission occurs serially from the transmitter to the receiver, enabling seamless communication between microcontrollers and peripheral devices. Additionally, the modules employ interference mitigation strategies to minimize disruptions caused by other RF devices operating in the same frequency band, ensuring reliable communication even in congested environments..

III Sensors

- **MQ-135 Sensor:** The MQ-135 gas sensor module detects various gases and air quality parameters, providing valuable environmental monitoring capabilities for the electric vehicle system.

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁂ Peer-reviewed & Refereed journal ⁂ Vol. 12, Issue 4, April 2024
DOI: 10.17148/IJIREEICE.2024.12428

- **DS18B20 Sensor:** The DS18B20 temperature sensor offers accurate temperature measurements using a one-wire bus protocol, eliminating the need for complex wiring and external power supplies.
- **Limit Switch:** Employed for object detection and motion control, the limit switch consists of an actuator, switch body mechanism, and electrical terminals, ensuring precise positioning and safety compliance.
- **Buzzer:** A buzzer serves as an audible alerting device, generating warning signals and notifications to the vehicle operator during critical system events and fault conditions.
- **Relay:** A power relay module controls high-current electrical circuits using an electromagnet, enabling safe and reliable switching of vehicle subsystems and accessories.

IV Motor Driver

The voltage regulator is essential for maintaining stable voltage levels within electric vehicles, ensuring optimal operation of electronic components. It acts as an intermediary between the power source, typically the battery, and the vehicle's electronics. Its primary function is to stabilize voltage supplied to components despite fluctuations in battery voltage due to load changes or charging conditions. Stability is crucial for sensitive systems like control units, sensors, and actuators. Voltage regulators incorporate protection features like overvoltage protection and thermal shutdown to prevent damage. Efficiency features include low dropout voltage to minimize power loss and enhance energy efficiency, vital in electric vehicles. Overall, voltage regulators are critical for reliable, efficient, and protected operation of electric vehicle electronics.

V Electric Motor and Motor Controller:

The electric motor and its controller represent the heart of the electric vehicle's propulsion system. Electric motors are available in various types, including brushed DC motors, brushless DC motors, and induction motors. Each type offers distinct advantages and limitations in terms of efficiency, torque delivery, and complexity. The motor controller regulates the electric motor's speed, torque, and direction of rotation by adjusting the flow of electrical current. It plays a pivotal role in converting electrical energy from the battery into mechanical motion, ensuring smooth acceleration, deceleration, and effective regenerative braking.

VI Battery Management System (BMS):

The Battery Management System (BMS) serves as the guardian of the electric vehicle's battery pack, ensuring its optimal performance, health, and safety. Key functions of the BMS include cell voltage monitoring, temperature monitoring, state-of-charge estimation, and cell balancing. By continuously monitoring these parameters, the BMS can prevent overcharging, over-discharging, short circuits, and thermal runaway events, thereby extending the battery pack's lifespan and maintaining its reliability. Moreover, advanced BMS systems incorporate sophisticated thermal management systems to regulate battery temperature and prevent overheating during charging and discharging cycles.

VII Charging Infrastructure and Onboard Charger:

The charging infrastructure and onboard charger are essential components of the electric vehicle ecosystem, enabling convenient and efficient battery replenishment. Charging infrastructure encompasses various charging standards, including Level 1 (120V AC), Level 2 (240V AC), and Level 3 (DC fast charging). Each standard offers different charging speeds and compatibility with existing infrastructure. Onboard chargers convert AC power from the grid into DC power suitable for charging the vehicle's battery pack. Furthermore, advancements in smart charging technologies, bidirectional charging capabilities, and vehicle-to-grid (V2G) integration empower electric vehicles to interact with the electrical grid intelligently, participating in demand response programs and optimizing energy usage for both consumers and utilities.

V. SOFTWARE REQUIREMENTS

I. ARDUINO IDE

Arduino is a prototype platform (open source) based on an easy-to-use hardware and software. It consists of a circuit board, which can be programmed and a ready-made software called Arduino IDE (Integrated Development Environment), which is used to write and upload the computer code to the physical board. Arduino IDE supports languages C and C++ using special rules of code structuring. It supplies a software library from the wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub main (). A minimal Arduino C/C++ sketch, as seen by Arduino IDE programmer, consists of only two functions:

- **setup ():** This function is called once when a sketch starts after power-up or reset. It is used to initialize variables, input and output pin modes, and other libraries needed in the sketch.
- **loop ():** After setup () has been called, the function loop () is executed repeatedly in the main program. It controls the board until the board is powered off or is reset.

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526

International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering

Impact Factor 8.021 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 12, Issue 4, April 2024

DOI: 10.17148/IJIREEICE.2024.12428

II.ALGORITHM

The initialization process for Arduino IDE involves several sequential steps to set up and upload a program to your Arduino board. Firstly, ensure that you have your Arduino board and USB cable ready for connection. Next, download the Arduino IDE software from the official website, making sure to select the version compatible with your operating system, whether it's Windows, macOS, or Linux. Once downloaded, connect your Arduino board to your computer using the USB cable to power it up. You should notice the onboard LED illuminate, indicating that power is properly supplied to the board. Launch the Arduino IDE application by locating the downloaded file and double-clicking the icon to open it. Within the IDE, you can either create a new project or open an existing project example from the File menu. Select the appropriate Arduino board model, such as Arduino Nano, and choose the corresponding serial port from the Tools menu. After your project is open, click on the right arrow icon, usually labeled "Upload," in the IDE toolbar to compile your code and upload it to the Arduino board. During this process, the TX and RX lights on the board may flicker, indicating data transfer. Once the upload is complete, you'll see a message in the status bar confirming "Done uploading." Finally, you can open the Serial Monitor by clicking on the magnifying glass icon in the upper-right corner of the Arduino IDE window to monitor the data being sent or received by your Arduino board. This allows you to view and interact with the data transmitted between your Arduino board and the computer effectively. By following these sequential steps, you can successfully initialize and set up your Arduino board for programming and experimentation.

VI. BLOCK DIAGRAM IMPLEMENTATION

The Fig 3 represents the block diagram implementation of the electric vehicle (EV) system serves as a visual representation of the interconnected components and their functionalities. It depicts the integration of advanced sensor technology, such as helmet detection sensors and temperature sensors, with the control unit, typically an Arduino Mega, to enforce safety measures and monitor battery health. The diagram showcases the flow of data and control signals between the various subsystems, including the battery pack, cooling system, and motor controller, illustrating how they work together to ensure the safety and optimal performance of the EV. This visual representation aids in understanding the system architecture and facilitates the implementation and optimization of safety protocols and battery management strategies.

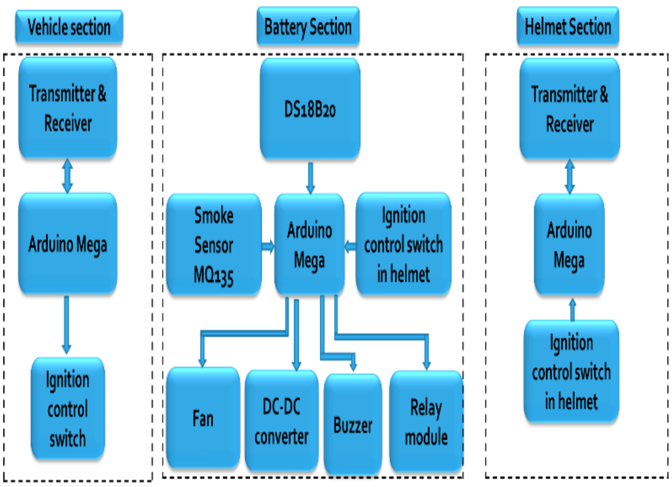

Fig 3: Block Diagram of Advanced Electric Bike

VII. RESULTS AND DISCUSSIONS

The final implementation of the electric vehicle (EV) system, as depicted in Fig 4 for the final hardware model and Fig 5 for the helmet detection system, represents a significant achievement in integrating advanced safety measures and battery management strategies. This integrated system architecture seamlessly combines helmet detection sensors, temperature sensors, and a centralized control unit, such as the Arduino Mega, to enforce safety protocols and monitor battery health in real-time. Through meticulous design and implementation, the EV system ensures the safety of riders by mandating helmet usage before ignition while also optimizing battery performance and longevity. The block diagram showcases the interconnected components and their functionalities, illustrating how they work in harmony to enhance EV

Fig 5: helmet detection system

IJIREEICE ISSN (O) 2321-2004, ISSN (P) 2321-5526
International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering
Impact Factor 8.021 ⁝⁝ Peer-reviewed & Refereed journal ⁝⁝ Vol. 12, Issue 4, April 2024
DOI: 10.17148/IJIREEICE.2024.12428

safety and efficiency. This achievement underscores our commitment to pioneering advancements in electric mobility, ushering in a new era of sustainable transportation characterized by safety, reliability, and user-centric design.

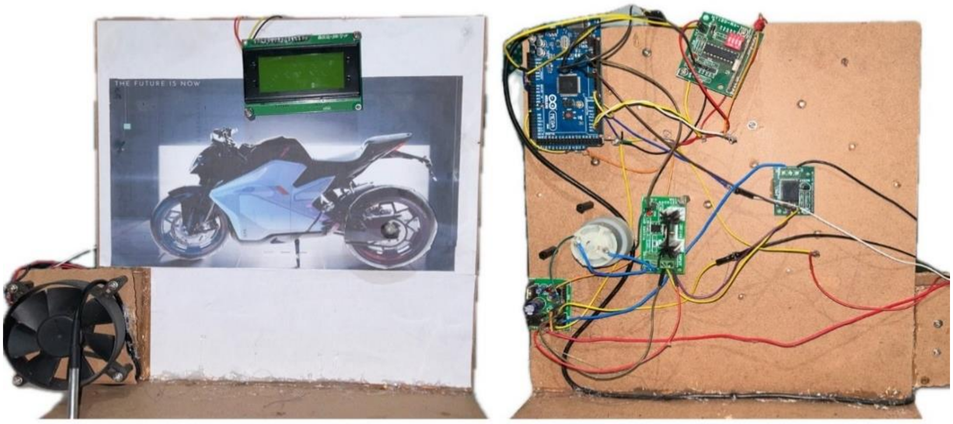

Fig 4: Final integrated hardware model

VIII. CONCLUSION

In conclusion, the meticulously designed electric vehicle system exemplifies a harmonious integration of advanced sensor technology and safety mechanisms, prioritizing rider safety and battery protection. From the groundbreaking helmet detection sensor to the 16-cell battery pack closely monitored by voltage and current sensors, every component is intricately woven into a comprehensive safety net. The system's central control unit, the Arduino Mega, orchestrates safety protocols with precision, ensuring proactive measures like temperature control and emergency shutdown relay activation. Real-time monitoring through the user interface empowers riders with crucial information, fostering a sense of control and proactive engagement in maintenance. With user notifications and an emergency shutdown relay, the system offers additional layers of safety, enhancing overall reliability and security in electric mobility.

IX. FUTURE SCOPE

Looking ahead, the future scope of electric vehicle systems holds promise for further advancements and innovations. Integration of autonomous safety protocols using advanced AI algorithms could revolutionize accident prevention mechanisms. Developing more intuitive user interfaces with touchscreen controls and voice commands could enhance user experience and accessibility. Research into technologies optimizing battery efficiency and lifespan could pave the way for more sustainable electric mobility solutions. Additionally, exploring GPS integration for location-based safety features and collaboration with smart infrastructure for enhanced communication could redefine standards in electric vehicle safety and efficiency. Continued research, innovation, and collaboration will be essential in shaping the future of electric mobility, driving towards a safer, more sustainable, and interconnected transportation ecosystem.

REFERENCES

[1]. Rajatha R . Ignition control of EV bike using helmet detection sensors ; Smart Safety Security Helmet ,Aps college of engineering ,Bengaluru,2023.
[2]. Lin J et al. Are view on recent progress, challenges, and perspective of battery thermal management system. International Journal of Heat and Mass Transfer 2021.
[3]. Tete PR et al. Developments in battery thermal management systems for electric vehicles: A technical review. Journal of Energy Storage 2021.
[4]. Choudhari VG et al. A review on the effect of heat generation and various thermal management systems for the lithium-ion battery used for the electric vehicle. Journal of Energy Storage 2020.
[5]. Zhao C et al. Hybrid battery thermal management system in electrical vehicles: A review. Energies 2020.
[6]. Bernhart W et al. E-Mobility Index 2019; Roland Berger-Automotive Competence Center & fka GmbH: Munich, Germany, 2019.
[7]. Pesaran Act al. Tools for designing thermal management of batteries in electric drive vehicles (presentation); technical report. National Renewable Energy Lab. (NREL), USA, 2013.