Enhancing electric vehicle safety using iot-based real-time monitoring for analysis of wire cutting, short circuit detection and bms

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Abstract - In the present time, the wide use and successful working performance of electric vehicles (EVs) in terms of operation, range efficiency and saving the environment from pollution provides a number of opportunities for the researchers, engineers and industries manufacturing the electric vehicles. But due to several reasons, electric vehicles cause serious damages to the rider, and to the vehicle itself, simultaneously endangering the lives of others who are on the road. So considering this, the area of safety becomes the utmost area to be improved. The integration of Internet of Things (IoT) technology in EVs presents an opportunity to enhance safety through real-time monitoring and analysis of critical components such as wire cutting, short circuit detection, environmental conditions, battery condition etc. This paper enlightens the significance of IoT-based safety evaluation devices for EVs, focusing on their potential to prevent accidents, human injuries, reduce maintenance costs, and contribute to the overall growth of the EV market. The paper explores the technical aspects of wire cutting and short circuit detection, highlights key benefits, and presents a comprehensive overview of existing research and technologies in this domain.

Keywords: Electrical vehicles, Internet of things, short circuit detection

I. INTRODUCTION

In recent years the Automobile industry has shifted largely from the traditional combustion engines to electric vehicles due to several benefits of Electric vehicles like more environmentally friendly technology, better mileage, and many more. But electric vehicles have their own type of risks also related to their complex electrical systems. Either it is small E-bikes or the large electric trucks, all require more and more battery support. Most of them operate at a higher voltage and current to achieve the speed, range, load capacity etc. Battery management systems also play an important role in enhancing safety of EVs. Along with the proper working of the battery management system (BMS), detection and protection from conditions like wire cutting, short-circuits are crucial issues in the development of these vehicles to ensure overall safety[Yang, S.; Wang, W.; Lin, C.; Shen, W.; Li,].

IoT technology has revolutionized various industries, and its integration in EVs presents novel solutions for enhancing safety through real-time monitoring.[Emodi, N.V.; Akuru, U.B.; Dioha, M.O.; Adoba, P.; Kuhudzai, R.J.; Bamisile] Many researchers have worked on safety evaluation of EVs individually focusing either on the battery health of the EVs or on the type of battery to be used for EVs. One more important safety aspect to be considered in case of safety evaluation of EVs is analysis of wire cutting and short circuit detection in EVs. It is more crucial to take care of situations that may arise due to wire cutting or fire occurring due to short circuits in EV which not only can damage the vehicle but also endanger the life of the rider and others. There should be a system which keeps watch on such critical conditions so that an alert may be generated and corrective measures can be taken. If such conditions are taken care of with the help of technologies like IoT, fast measures can be taken. Also when a short circuit in EV or wire cut has been detected then the data related to that fault which might be responsible for this or may help to analyze why that situation has occurred can be sent and saved remotely using IOT to be analyzed later on.

IoT and EV Safety Enhancement

The hybrid combination of IoT devices & Electrical Vehicles provides a facility to gather real-time data, and to transmit that data to be saved remotely and analyzed, offering insight into the vehicle's health and condition. [Manjunathan Alagarsamy, Prabakaran

Kasinathan,] IoT-enabled safety evaluation devices can monitor critical electrical components, detect anomalies, and trigger alerts in case of potential wire cutting or short circuits. This proactive approach can prevent hazardous situations and reduce the risk of accidents caused by electrical faults. Based on data collected, this analysis may also help in predicting any incident that can occur.

Wire Cutting & Short Circuit Detection

Wire cutting can be caused by many factors like daily wear and tear of the vehicle, small damages to the vehicle like falling of the vehicle, minor collisions of vehicle etc. These minor reasons causing the wire cutting in EVs are more dangerous if they remain unnoticed and may lead to power loss, malfunctioning systems, and even fire hazards. IoT-based sensors can continuously monitor the integrity of wiring systems, employing technologies such as resistance measurement to detect any unauthorized wire tampering. Rapid detection and alert mechanisms can prevent further damage and ensure passenger safety. [Qinghui Lu, Xianggen Yin, Jian Qiao, Yikai Wang, Liming Tan, Lingjin Zhu]

Short circuits pose a significant risk in EVs, potentially leading to overheating, fires, or complete system failure. IoT-based systems can incorporate current, voltage and temperature sensors to monitor electrical pathways for abnormal fluctuations. Coupled with advanced algorithms, these systems can promptly identify and isolate short circuits, preventing potential safety hazards.

BMS (Battery Management system)

The Battery Management System (BMS) plays a crucial role in overall safety measures of an electric vehicle. [M. D. Kharisma, M. Ridwan, A. F. Ilmiawan, F. ArioNurman and S. Rizal] By analyzing data and parameters, the BMS can detect deviations and anomalies that might occur. [Manenti, A., Abba, A., Merati, A., Savaresi, S. M., & Geraci,] Integrating BMS with IoT, battery data can be communicated to external monitoring systems in real-time, ensuring quick intervention and minimizing risks. [S.Prabakaran, N.Ashok (2023]

In summary, the BMS serves as a critical component in the safety ecosystem of electric vehicles, collaborating with IoT technologies it ultimately contributes to the overall safety and reliability of EVs.

Benefits and Implications

Implementing IoT-based safety evaluation devices for wire cutting, short circuit detection and BMS offers several benefits by preventing life threatening situations caused by electrical fire, overheating etc. [S. Thombare, S. Baral, A. Gangrade and R. Jaiswal,2022] These include enhanced passenger safety, reduced maintenance costs, and increased confidence in EV technology, thus fostering broader EV adoption.[H. Chen, X. Liu, L. Li, Y. Liu, Y. Zhang, and Y. Huang,2019] Additionally, such systems can contribute to regulatory compliance and industry standardization efforts.

Current Technologies and Research

Several research studies and technological advancements have contributed to the development of IoT-based safety evaluation devices for EVs. [X. Kuang et al,2020] Prominent players in the automotive and IoT industries have collaborated to create integrated solutions that encompass hardware, software, and data analytics. [Mohd Helmy Abd Wahab*,1,5 , Nur Imanina Mohamad Anuar,(2018),] In this research detection of wire cutting and short circuit condition has been focused along with BMS (battery management system) in Electrical Vehicles using IOT which enhances electric vehicle safety. It detects the specific dangerous situation, generates an alert signal using IOT and gives preventive measures.

II. METHODOLOGY

The wire cut and short circuit detection system is developed using a combination of hardware and software components, including current sensors, voltage sensors, temperature sensor, a microcontroller, and advanced algorithms. Data collected during both controlled laboratory experiments and real-world driving scenarios. If the data collected crosses the threshold level it triggers the electromagnetic relay which cutts the supply from battery arrangement.[C. Huang, B. Zhang, Y. Ma, F. Zhou, and J. He] At the same time data is sent to the cloud and client via the internet by the microcontroller unit/wifi module. Several features like voltage, current and resistance are extracted from the sensor data to provide relevant information about short circuit and wire cut detection conditions. Data from BMS is also sent via IOT which helps in further enhancement of vehicle safety.[Mohd Helmy Abd Wahab*,1,5 , Nur Imanina Mohamad Anuar,(2018),] Same is explained in Fig 1 and Fig 2.

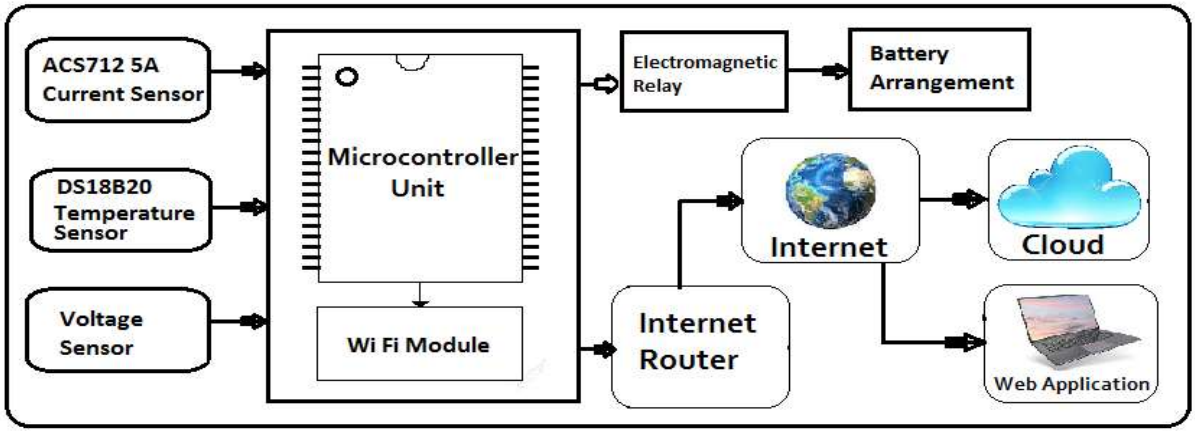


Fig 1: Block diagram showing IOT based short circuit & wire cutting detection system.

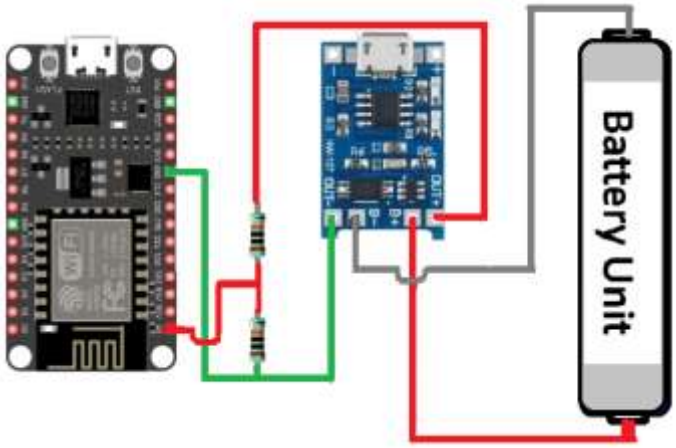


Fig 2: Circuit diagram showing IOT based BMS (Battery management system)

III. DATA ANALYSIS AND RESULTS

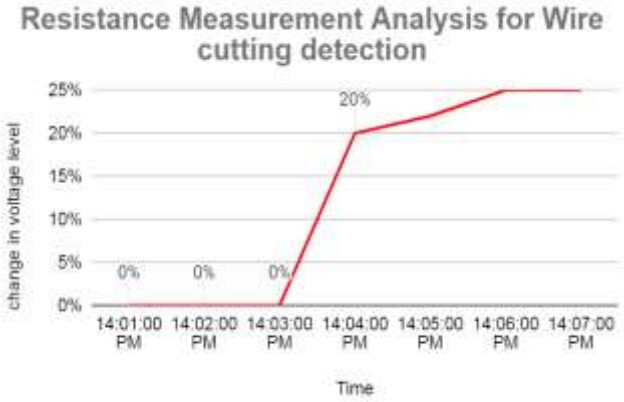
In this study, the following parameters have been observed during detection of wire cutting and short circuit condition:

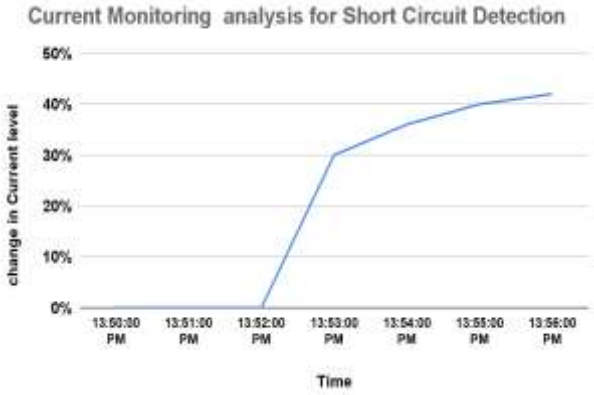
Table1: Parameters that have been observed during detection of wire cutting and short circuit condition.

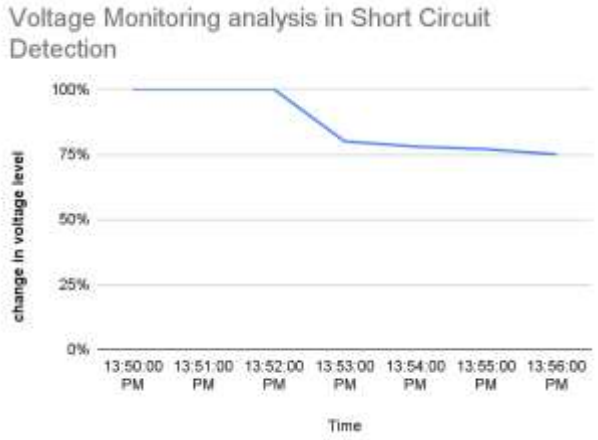
Sr. N	Parameter	Effect and Significance
1	Resistance Measurement	Effect: Measures the electrical resistance along wiring pathways. Significance: Sud increases in resistance indicate wire tampering or cutting, triggering alarms and alerts.
2	Vibration Analys	Effect: Monitors vibrations in wiring systems. Significance: Any abrupt or unusual vibrations could indicate physical tampering, prompt immediate attention and alerting the vehicle's owner.
3	Temperature Sensing	Effect: Measures temperature variations along wiring pathways. Significance: Anomalies in temperature could suggest localized heating due to con resistance changes from wire cutting.
4	Current Fluctuati	Effect: Monitors changes in current flow through wiring. Significance: Drastic fluctuations may imply a break or cut in the circuit, helping to de unauthorized wire interference.
5	Real-Time Alerts	Effect: Provides instant alerts to vehicle owners and manufacturers. Significance: Real-time alerts enable swift action, reducing the risk of further damage ensuring passenger safety.

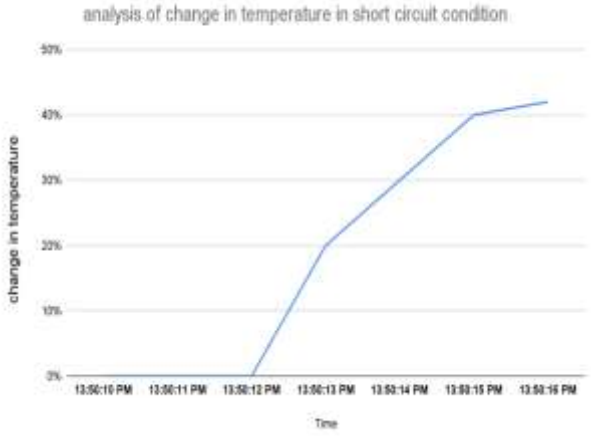
Table 2: Data analysis and Results for the Wire Cutting and Short Circuit Detection:

Scenario	Parameter	Data Collected	Findings and Facts
Wire Cutting Detection	Resistance Measurement	Voltage changes due wire tampering	- A voltage increase of more than 20% observed tampered wires.
Short Circuit Detection	Current Monitoring	Current spikes due to s circuit condition.	- Current spikes exceeding 30% indicate potential s circuits. - Detected and isolated short circuits in under milliseconds.
	Voltage Monitoring	Voltage drop found du short circuit condition	- Voltage drops of 20% volts or more signal short circu
	Temperature Monitoring	Rise in temperature.	- Rise in Temperature more than 20%









The collected data from various scenarios demonstrates the efficacy of IoT-based real-time monitoring and analysis for wire cutting and short circuit detection in electric vehicles. The combination of these parameters, coupled with IoT integration, results in a comprehensive safety evaluation system that significantly enhances electric vehicle safety by preventing accidents and mitigating potential hazards caused by wire cutting and short circuits.

IV. CONCLUSION AND FUTURE SCOPE

IoT-based safety evaluation devices are poised to revolutionize the safety landscape of electric vehicles. By providing real-time monitoring and analysis of wire cutting and short circuit detection, along with data from BMS these systems can significantly enhance passenger safety, reduce maintenance costs, and contribute to the widespread adoption of electric vehicles. Continued research, technological advancements, and industry collaboration are essential to realizing the full potential of IoT in EV safety. While IoT-based safety evaluation devices hold immense promise, challenges such as data security, integration complexity, and false positives must be addressed. Additionally, ongoing research is needed to optimize algorithms for accurate detection and to adapt to evolving EV architectures.

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