Design of Safeguarding Device to Minimize Fatality Rate Due to Electrical Accidents.

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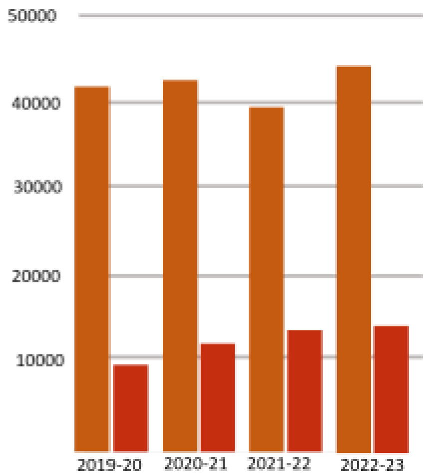
Abstract— *Electrical accidents are common due to ignorance and carelessness. By acknowledging them in initial stages and performing maintenance it is possible to minimize risk of severe accidents. Electrical accidents pose significant risks, leading to severe injuries and fatalities in various sectors, including residential, industrial, and commercial environments. This project aims to design an advanced safeguarding device to minimize the fatality rate due to electrical accidents. The device integrates real-time monitoring, fault detection, and automatic response mechanisms to prevent hazardous situations such as electric shocks, short circuits, and overcurrent faults. The proposed system utilizes microcontroller-based technology with sensors to detect leakage current, voltage fluctuations, and abnormal power conditions. It features an automatic shutdown mechanism that disconnects the power supply when unsafe conditions are detected, thereby preventing electrocution and fire hazards. Additionally, the device is equipped with an alert system that notifies users through alarms or mobile notifications for immediate action. By implementing this safeguarding device, electrical safety in households, workplaces, and industries can be significantly improved, reducing the number of accidents and fatalities. The design will be cost-effective, easy to install, and compatible with existing electrical systems, making it a practical solution for enhancing electrical safety.*

Index Terms— **Electrical accidents, Health monitoring, wrist band, current sensor, ESP 32.**

I. INTRODUCTION

Electrical accidents remain one of the leading causes of fatalities, injuries, and property damage worldwide. These incidents are often caused by factors such as electric shocks, short circuits, leakage currents, overloaded circuits, and faulty wiring. In industrial environments, the risks are further amplified due to high-voltage machinery, exposure to live conductors, and operational hazards. Similarly, in residential and commercial settings, poor wiring practices, lack of proper grounding, and outdated electrical systems contribute to an increased risk of accidents. While existing protective measures such as circuit breakers, fuses, and grounding systems provide some level of safety, they are often insufficient in preventing severe electrical hazards. These conventional safety .mechanisms typically operate reactively, responding only after an accident has already occurred. Therefore, there is a pressing need for an intelligent safeguarding device that can detect faults in real time and take immediate preventive action.



Electrical accidents occurred

Death due to Electrocution

Fig.1 Overview of electrical accidents in India from last 5 years

This project aims to develop an advanced safeguarding device to minimize the fatality rate due to electrical accidents by incorporating modern technologies such as microcontrollers, sensors, wireless communication, and automation. The proposed system will continuously monitor electrical parameters, detect faults such as leakage currents, short circuits, voltage fluctuations, and unauthorized access to live conductors, and trigger an automatic power shutdown to prevent hazardous situations. Additionally, the device will be equipped with an alert system that notifies users through visual indicators, audible alarms, or mobile notifications, allowing for quick intervention and corrective actions. The integration of smart sensing technology ensures that potential hazards are detected at an early stage, reducing the chances of fatal accidents and electrical fires.

One of the key features of the proposed safeguarding device is its real-time monitoring capability, which allows it to track electrical abnormalities as they occur and respond instantly. Unlike traditional protection devices that may have a delay in detecting faults, this system will utilize high-speed sensors and microcontrollers to analyze electrical data within milliseconds, ensuring rapid response to potential dangers. The device will also feature self-diagnostic capabilities, which enable it to continuously check for system integrity and alert users in case of any malfunctions. Furthermore, the incorporation of IoT (Internet of Things) technology can enhance functionality by allowing remote monitoring and control via smartphones or computers, making it highly suitable for industrial applications where constant supervision of electrical systems is required.

Another crucial aspect of this project is its adaptability and ease of integration into existing electrical infrastructures. The safeguarding device will be designed to be compact, cost-effective, and user-friendly, making it accessible for a wide range of applications, from residential households to large-scale industrial plants. Its modular design will allow for customization based on specific safety requirements, ensuring that it can be effectively implemented in different environments. Additionally, the device will comply with international electrical safety standards, ensuring reliability and effectiveness in preventing electrical hazards.

The primary objective of this project is to develop a highly efficient, automated, and proactive electrical safety solution that significantly reduces the risk of electrocution, fire hazards, and equipment damage. By integrating cutting-edge technology with practical safety mechanisms, this safeguarding device aims to revolutionize electrical safety standards and contribute to a safer living and working environment. As electrical systems continue to evolve with increasing energy demands and technological advancements, ensuring their safety remains a top priority. The successful implementation of this device can lead to a substantial reduction in electrical accidents, saving lives and preventing economic losses associated with electrical failures.

II. LITERATURE REVIEW

Between 2011 and 2023, the U.S. recorded 1,940 workplace fatalities involving electricity, averaging approximately 150 deaths annually. In India, electrical accidents have been a significant concern, with data from the National Crime Records Bureau (NCRB) indicating that approximately 12,500 fatalities occur annually due to electrocution. This translates to an average of about 34 deaths per day. According to NCRB, most of the severe electrical accidents can be prevented by acknowledging them in initial stages and taking suitable actions such as maintenance etc.

The absence of real-time monitoring and predictive analysis in traditional protection devices is a critical limitation in industrial safety. Industrial facilities require advanced safeguarding solutions that can detect faults early, analyze system health continuously, and provide proactive interventions to prevent catastrophic failures.

Table 1 Effect of current on human body for different magnitudes

MAGNITUDE OF CURRENT	**EFFECT ON HUMAN BODY**
1mA	Feeling of slight tingling sensation.
5mA-10mA	Painful shock. Muscle contractions may occur, but you can usually still release the conductor.
10mA-20mA	Muscle contractions are strong, making it difficult to release the conductor.
20mA-50mA	Respiratory paralysis. The chest muscle contract making it difficult or impossible to breath.
50mA-100mA	Ventricular fibrillation (irregular heartbeat). This is a potentially fatal condition
100mA-200mA	Ventricular fibrillation is highly likely. Severe burns are possible.
Above 200mA	Severe burns. Severe muscle contractions. Cardiac arrest. Death is highly probable.

Recent advancements in electrical safety technologies have introduced more sophisticated protection mechanisms that leverage real-time monitoring, automation, and predictive analytics. The integration of microcontrollers, sensors, and Internet of Things (IoT) technology in electrical safety systems has significantly improved fault detection accuracy and response times. Smart protection devices now incorporate leakage current sensors, thermal sensors, and voltage monitoring modules that continuously assess the health of an electrical system and trigger alarms or automatic shutdowns when necessary.

Additionally, the implementation of wireless communication modules such as Wi-Fi, GSM in safeguarding devices enables remote monitoring of industrial electrical networks. Industrial safety personnel can receive real-time alerts on mobile applications or cloud-based dashboards, allowing for immediate action in case of electrical anomalies. This remote monitoring capability significantly enhances industrial safety by ensuring that electrical faults do not go unnoticed.

Wearable health monitoring devices incorporate several technologies to collect, analyze, and communicate health-related data. These devices use a combination of sensors, communication technologies, microcontrollers, and software platforms to provide real-time tracking and monitoring.
By combining the advantages of antistatic wrist band and features of wearable health monitoring system it is possible to monitor health of working personnel in real time along with detection of current flow through antistatic wrist band.

III. METHODOLOGY

This project focuses on designing a safeguarding device that not only detects current through an antistatic wristband but also monitors the health of the personnel working with it, generating an event if any abnormal condition occurs. To monitor the flow of current through the antistatic wristband to ensure proper grounding. If the wristband is improperly grounded, the device should generate an alert. ACS712 (current sensor) will be used to measure the current flowing through the wristband. If current levels fall below a set threshold, an alarm will trigger. To monitor key health parameters of the personnel working with the device. HW827 is used for measuring the body temperature. DS18B50 is used for ambient temperature monitoring to detect environmental conditions. To enable the personnel to manually trigger an emergency alert in case of an abnormal condition. Panic Button integrated into the system for immediate intervention. The device will generate an event (alert or notification) if:

- The current flowing through the wristband is not detected or is outside of the predefined threshold.
- Health parameters such as body temperature, ambient temperature, or emergency panic button activation cross abnormal thresholds.

The ACS712 current sensor will be used to detect the current passing through the antistatic wristband. The sensor works by providing an output voltage that is proportional to the detected current. The ESP32 microcontroller will read the output voltage from the ACS712, which will then be converted to a corresponding current value. If the current value is below a predefined threshold, it indicates a problem with grounding, and an alert will be generated. The ESP32 will convert the raw analog signal from the ACS712 into a digital value using its ADC (Analog to Digital Converter). The system will process the data and compare it with a threshold value to identify whether the wristband is properly grounded.
The DS18B20 sensor is there to keep an eye on the person's body temperature. It provides accurate and real-time temperature readings. The ESP32 will read the temperature data and monitor if it crosses the critical threshold (e.g., body temperature > 37.5°C or < 35°C), triggering an alert if necessary. The DS18B50 will be used to monitor ambient temperature. This is important to track the environmental conditions around the personnel to ensure safety, as extreme temperatures can also be hazardous. The ESP32 will read the output from the DS18B50 sensor and trigger an alert if the temperature is above or below safe operating limits.
A panic button will be integrated into the device, allowing personnel to manually activate an alert if they feel unwell or are in an emergency situation. This ensures that the system can respond to situations that may not be automatically detected by the sensors. When the panic button is pressed, the ESP32 will register this event and trigger an alert (e.g., buzzer, LED, or communication to a remote system).
The ESP32 microcontroller will handle the data from all the sensors (ACS712,HW827, DS18B20) and manage the logic for detecting abnormal conditions. It will continuously monitor the sensors and check if any of the health parameters (temperature, current, etc.) are outside the normal range. If any condition triggers an alert (such as abnormal temperature, improper grounding, or panic button press), it will activate the appropriate warning systems. The buzzer will be used to give an audible alert when abnormal conditions are detected. The ESP32 can be connected to a wireless communication module (e.g., Wi-Fi) to notify remote personnel or administrators if the device detects an abnormal condition. A LED or display can also be used to show the current status of the device (e.g., "Normal", "Abnormal", or "Panic Mode").

Design the circuit to integrate the ACS712 current sensor, HW827and DS18B50 temperature sensors, panic button, buzzer, and ESP32 on a breadboard or custom PCB. Ensure proper voltage regulation for the ESP32 and sensors, considering their individual power requirements. Program the ESP32 using the Arduino IDE or PlatformIO to:
Read analog and digital inputs from the sensors (ACS712, HW827, DS18B50, panic button).
Apply appropriate logic for current measurement and health condition monitoring.
Trigger alerts via buzzer or display.
Implement communication with other devices (if needed, for example, using MQTT or HTTP over Wi-Fi).

Verify the operation of the ACS712 sensor by simulating different levels of current passing through the wristband (e.g., using resistors or a power supply) and ensuring the ESP32 correctly detects and responds to grounding failures.
Test the HW827 and DS18B50 sensors by measuring body and ambient temperatures under various conditions, ensuring accurate readings and timely alerts for abnormal temperature values. Ensure that the panic button works reliably to trigger the appropriate alert or notification when pressed. Calibrate the ACS712 current sensor to ensure accurate current readings. Calibrate the HW827 and DS18B50 temperature sensors by comparing their readings to known reference temperatures. Conduct field tests to simulate real-world conditions, where the system is worn by personnel performing tasks. Monitor for false alarms or missed events. Design a suitable enclosure to house all the components (ESP32, sensors, panic button, and buzzer) in a compact, ergonomic form, suitable for continuous wear.
Ensure the enclosure is durable, protective from environmental factors (e.g., dust, water), and comfortable for the user. Deploy the device in a real-world environment where personnel can wear it for extended periods, ensuring it operates reliably and generates alerts when necessary.

IV. FLOWCHART

So, the big picture shows how this safety gadget works, step by step. It kicks off by getting the sensors ready and then it just keeps going in a loop, grabbing data. The ACS712 (current), DS18B20 (temperature), and HW827 (pulse) sensors are constantly feeding info to the ESP32 chip for it to handle. The microcontroller compares the sensor readings with predefined thresholds to detect potential electrical hazards, such as overcurrent or overheating, and physiological distress, such as abnormal heart rate [8]. If any hazard is detected, the alarm system is activated, triggering visual and auditory alerts. The system then loops back to acquire new sensor data, ensuring continuous monitoring. The diamond shaped boxes represent decision points, where the system checks if sensor values are within safe operating parameters.

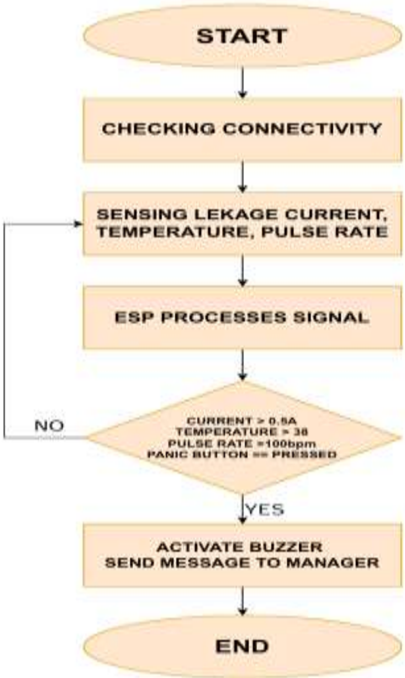


Fig. 1 Flowchart of project

To avoid confusion between severe accidents and indication of health fluctuation it is necessary to either provide different sounds or provide buzzer sound only for severe incidents only. Before starting device check connections once and then it is ready to monitor all the parameters and upon detecting any parameter above threshold value.

V. BLOCK DIAGRAM

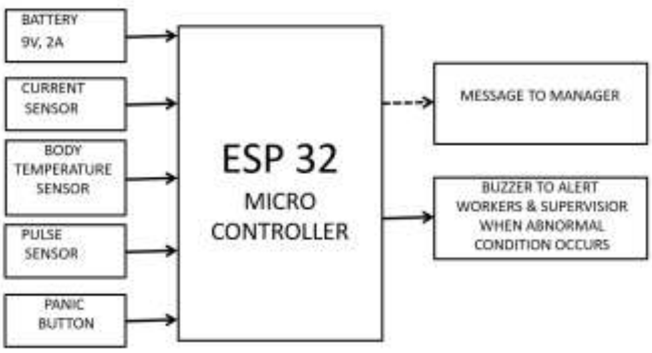


Fig. 2 Functional block diagram

Note: ----------→ Represents wireless connection

———→ Represents wired connection

- Antistatic wrist band: An antistatic wrist band must be wear in non- dominant hand to ground current safely. It is made up of carbon material to conduct electrical energy and it’s terminal which need to ground is metallic [7].
- Current Sensor (ACS712): This sensor measures the current flowing through a circuit. It sends data to the ESP32 about the electrical current being drawn, which can be used for monitoring and control [9].
- Temperature Sensor: This sensor detects the temperature in the environment or a specific object. It sends temperature readings to the ESP32 for further analysis [7].
- Pulse Sensor: The pulse sensor monitors heart rate or any other pulse-based activity. It sends pulse data to the ESP32 for monitoring the user's health or detecting abnormal activities [7].
- Panic Button: This is a manual input device used for emergency situations. When pressed, it sends a signal to the ESP32, indicating a panic situation.
- ESP32 Microcontroller: the ESP32 is the main brain, getting info from the current (ACS712), temperature, and pulse sensors, plus that panic button. It crunches all that data and decides what to do based on how it's been programmed. If any of those sensors go past certain limits – like too much current, too hot, a weird pulse, or someone hits the panic button – the ESP32 will set off whatever response it's supposed to.
- Buzzer: The buzzer serves as a local alert mechanism. If the ESP32 detects a critical condition (e.g., too high current, temperature, or an emergency triggered by the panic button), it activates the buzzer to alert users nearby.
- Message to Manager: If critical conditions are met, the ESP32 sends an online message (via Wi-Fi or Bluetooth) to the manager's device or a cloud-based system. This allows the manager to receive real-time notifications of any alarming situations [9].

VI. IMPLIMENTATION

The ACS712 sensor is integrated to monitor current through anti static wrist band in real-time. The HW827 is to monitor pulse continuously . The DS18B20 temperature sensor was used to monitor the temperature of the operator’s body. The antistatic wristband was used to ground person’s body in order to ensure safety. Upon detection of an overcurrent condition by the ACS712, the microcontroller activates and provide alarm and notification to manager. ESP 32 is programmed using assembly C language to achieve desired output.

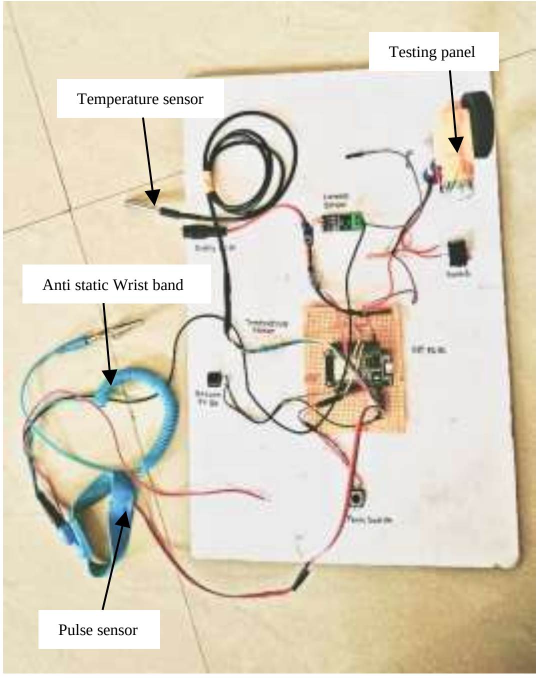


Fig. 3 Implementation of project

Fig. a

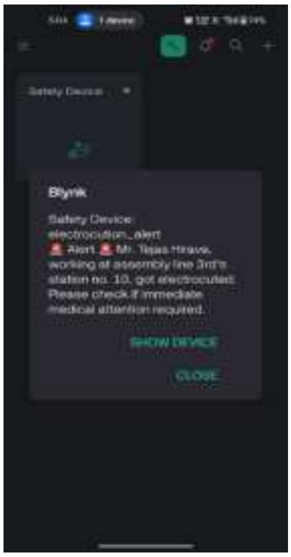


Fig. b

Fig. a) Interface of app which shows Temperature, current and heart rate.
Fig. b) Notification of electrocution to manager.

VII. RESULT

Through the use of an antistatic wristband, the device can monitor current and, if the value exceeds a threshold, will sound a buzzer. Furthermore, a buzzer is activated for panic commands. The ESP 32 microcontroller can be used to send a message to the manager in the event that the temperature and heart rate rise above the threshold value or in the circumstances described above.

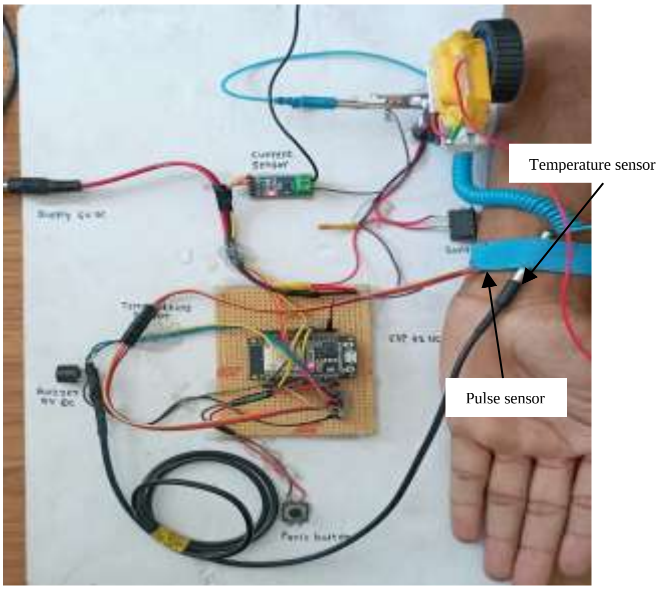


Fig. 3 Circuit in working condition.

Fig. c

Fig. d

Fig. c) Notification due to panicness of operator to manager.
Fig. d) Notification due to rise in temperature.

VIII. CONCLUSION AND FUTURE WORK

Device is able to detect current through Antistatic wrist band and generate buzzer sound upon detecting value beyond threshold value. In addition to this, buzzer activates for panic command. For rise in temperature and heart rate beyond threshold value as well as for above mentioned situations a message can be send to manager using ESP 32 microcontroller.

It is possible to assemble this circuitary in pouch and can be fitted on workers' arm to reduce complexity and ease of access of panic button. More accurate sensor can be interfaced with Esp 32 to get better results such as MAX 30102 instead of HW827 [1]. A LED or display can also be used to show the current status of the device (e.g., "Normal", "Abnormal", or "Panic Mode").

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