

IMPLEMENTATION OF MOVING ROBOT TO ACQUIRE DATA FROM HARMFUL RADIATION AREAS IN INDUSTRIAL APPLICATIONS

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Abstract

The proposed project presents the design and development of an intelligent robotic system capable of detecting harmful electromagnetic radiation in radiation-affected or leakage-prone areas. The robot employs receiving and transmitting coils to sense variations in electromagnetic field intensity and converts these variations into voltage levels readable by the ESP32 microcontroller. The sensed radiation values are processed in real time, and whenever harmful radiation levels are detected, an alert is generated through an onboard buzzer. Additionally, the robot is equipped with an HC-05 Bluetooth module that transmits radiation data wirelessly to a mobile application. The user can monitor live radiation levels and control the robot's movement remotely using Bluetooth commands sent from the smartphone. An onboard camera enhances the system by providing real-time visual feedback from hazardous zones, allowing safe inspection without human exposure. The ESP32 microcontroller plays a crucial role in integrating sensing, alerting, communication, and mobility functions. The system was tested under various controlled and real-world conditions, demonstrating stable performance, accurate detection, and reliable communication. This project offers a low-cost, portable, and efficient solution for identifying electromagnetic hazards and can be used in industries, laboratories, power stations, and electronic facilities where radiation safety is critical.

Keywords- Electromagnetic Radiation Detection, ESP32 Microcontroller, Robotic System, Electromagnetic Field Sensing, Bluetooth Communication, HC-05 Module, Mobile Application, Real-Time Monitoring, Hazard Detection, Wireless Control, Radiation Alert System, Onboard Camera, Remote Inspection, Radiation Safety, Portable Monitoring System.

1. Introduction

Electromagnetic radiation (EMR) is widely generated in modern industries through communication systems, electrical equipment, wireless devices, and high-frequency machinery. Although EM radiation is essential for many technological applications, uncontrolled or excessive radiation can become hazardous to both humans and electronic systems. Radiation leakage caused by damaged equipment, faulty circuits, or poor shielding may lead to health risks and unsafe working conditions in industries

such as power plants, laboratories, manufacturing units, and telecommunication centers. Traditional

monitoring methods often require workers to manually inspect hazardous areas using handheld devices, which is risky, time-consuming, and inefficient. To address these challenges, the project proposes an intelligent mobile robot capable of detecting harmful electromagnetic radiation in industrial environments. The system uses

transmitting and receiving RF coils to sense electromagnetic field intensity, while the ESP32 microcontroller processes the detected signals in real time. When radiation levels exceed safe limits, the system activates a buzzer alert to warn nearby users. The robot also includes an HC-05 Bluetooth module that wirelessly transmits radiation data to a mobile application, allowing users to monitor readings and control robot movement remotely from a safe distance.

Additionally, the robot integrates an ESP32-CAM module that provides real-time visual monitoring of hazardous areas. DC motors and an L293D motor driver enable smooth robot navigation in difficult or dangerous locations. By combining radiation sensing, wireless communication, robotic mobility, and live video streaming, the proposed system offers a low cost, portable, and efficient solution for industrial safety monitoring while reducing direct human exposure to harmful electromagnetic radiation.

2. Related Work

Recent research in electromagnetic radiation monitoring has focused on combining robotics, wireless communication, and embedded sensing technologies to improve safety in hazardous environments. R. Lyu et al. developed EddyBot, an autonomous robotic inspection system using multi-coil sensing and signal-processing techniques for detecting electromagnetic anomalies. Similarly, S. Li et al. proposed the RAMM robotic platform for generating magnetic-field maps and detecting anomalies in real time. Y. Liu et al. designed a high-sensitivity induction-coil magnetic sensor capable of detecting weak electromagnetic leakage, while Deprez et al. introduced a low-cost RF-EMF sensor for wireless exposure monitoring and calibration-based measurement systems.

These studies demonstrate the growing importance of robotic and wireless technologies in electromagnetic field detection and industrial monitoring.

Other researchers have focused on wireless communication, surveillance, and cooperative robotic systems for hazardous-area inspection. R. Jabeur et al. developed wireless RF-EMF monitoring nodes for remote radiation data transmission, while Fonseca et al. combined electromagnetic sensing with additional sensors to improve detection reliability and reduce false alarms. D. Yan et al. and Luo et al. proposed multi-robot radiation-source localization systems using intelligent search and particle-filter algorithms for efficient hazardous-area exploration.

Compared to existing systems, the proposed project provides a low-cost and portable solution by integrating ESP32, RF coils, Bluetooth communication, buzzer alerts, robotic mobility, and

live video streaming into a single smart radiation-

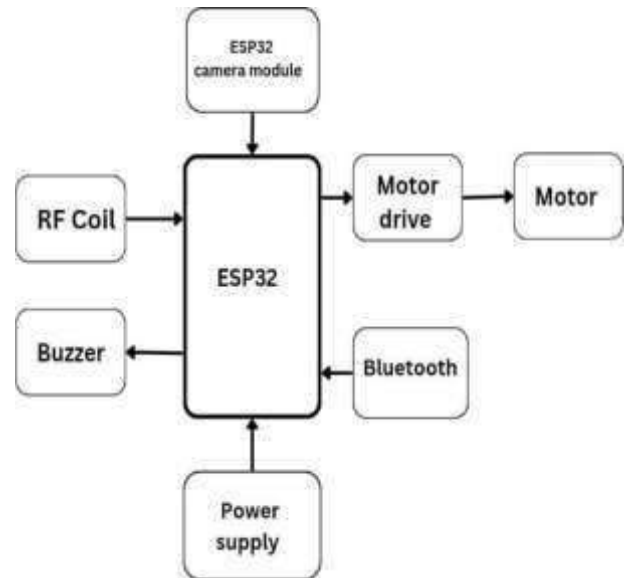


Fig-no:1 Block diagram

monitoring robot suitable for industrial safety applications.

3. Methodology

The proposed system is designed as a mobile robotic platform capable of detecting harmful electromagnetic radiation in industrial environments. The system integrates sensing, wireless communication, robotic movement, and visual monitoring into a single embedded platform.

The ESP32 microcontroller acts as the central processing unit, coordinating all hardware modules including the RF receiving coil, motor driver, Bluetooth module, buzzer, and ESP32-CAM. The robot operates by continuously monitoring electromagnetic field variations and transmitting the detected information to the user in real time.

The radiation detection mechanism is based on transmitting and receiving RF coils. The transmitting coil generates an electromagnetic field, while the receiving coil detects variations in field intensity through electromagnetic induction. The induced voltage produced by the receiving coil is proportional to the surrounding electromagnetic radiation level.

This analog signal is fed to the ESP32 analog-to-digital converter (ADC), where the signal is processed and compared with predefined threshold values. If the detected voltage exceeds the safety threshold, the ESP32 activates a buzzer alert to warn users about the presence of harmful radiation. For robotic movement and navigation, DC motors controlled through the L293D motor driver are used.

The robot can move forward, backward, left, and right based on commands received from a mobile application via the HC-05 Bluetooth module. Bluetooth communication enables wireless control and real-time transmission of radiation data to the user's smartphone. The mobile application displays live radiation readings, allowing operators to monitor hazardous environments remotely without direct human exposure.

An ESP32-CAM module is integrated into the robot to provide live visual monitoring of radiation-affected areas. The camera captures and transmits real-time images or video streams, helping the operator inspect the surroundings and navigate the robot more effectively. The complete system was tested under different environmental conditions to evaluate sensing accuracy, wireless communication performance, and robot mobility. Experimental results demonstrated stable operation, accurate radiation detection, reliable Bluetooth communication, and efficient remote monitoring, making the proposed system suitable for industrial safety applications.

4. Results and Discussion

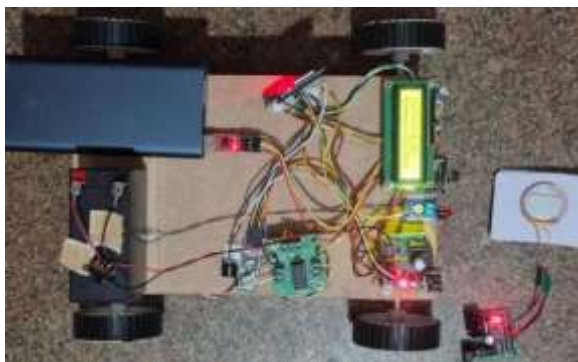


Fig-no:2

The developed robotic system was successfully tested under different environmental conditions to evaluate its radiation detection capability, wireless communication performance, and mobility functions. The RF receiving coil effectively detected variations in electromagnetic field intensity and generated corresponding voltage outputs, which were processed accurately by the ESP32 microcontroller. The system successfully differentiated between safe and harmful radiation levels based on predefined threshold values. Whenever the detected radiation exceeded the threshold limit, the ESP32 immediately activated the buzzer alert system, ensuring quick warning notifications. The robot also maintained stable

sensing performance while moving, demonstrating efficient multitasking capability of the ESP32 for simultaneous motor control and sensor data processing.

The HC-05 Bluetooth module provided reliable wireless communication between the robot and the mobile application, allowing real-time transmission of radiation readings and remote navigation control without noticeable delay. The ESP32-CAM module successfully delivered live visual monitoring of hazardous areas, improving situational awareness and remote inspection capability. The robot responded accurately to movement commands such as forward, backward, left, and right, while maintaining smooth operation during monitoring tasks. Overall, the experimental results confirmed that the proposed system offers a stable, low-cost, portable, and efficient solution for electromagnetic radiation detection and industrial safety monitoring applications.

5. Conclusion

The proposed project successfully designed and implemented an intelligent mobile robot capable of detecting harmful electromagnetic radiation in industrial environments. The system effectively integrates RF coil-based radiation sensing, ESP32-based real-time data processing, Bluetooth communication, robotic mobility, buzzer alert mechanisms, and live visual monitoring using the ESP32-CAM module. Experimental testing demonstrated that the robot could accurately detect variations in electromagnetic field intensity, generate immediate alerts when radiation levels exceeded the predefined threshold, and transmit radiation data wirelessly to a mobile application for remote monitoring. The integration of wireless control and onboard video surveillance improved the overall safety and usability of the system by allowing operators to inspect hazardous areas without direct human exposure. The robot exhibited stable movement, reliable communication, and efficient multitasking performance during continuous operation. Compared to traditional fixed or manual monitoring methods, the proposed system provides a low-cost, portable, and flexible solution for industrial radiation safety applications.

Overall, the project demonstrates the effective use of embedded systems, wireless communication, and

robotics in developing smart industrial safety solutions. The system can be further enhanced by integrating advanced sensors, IoT cloud connectivity, GPS tracking, autonomous navigation, and AI-based analysis for improved accuracy and wider industrial applications in the future.

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