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A futuristic digital interface with a glowing Earth globe in the center. The background is dark blue with various data visualizations including bar charts, line graphs, and pie charts. Text elements like 'BUSINESS', 'NETWORK SEARCH', and 'WORLD' are visible. A person's hand is seen at the bottom, interacting with the interface.

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Radiation Detection using Geiger Muller Counter by IoT Powered by ESP32

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ABSTRACT: Radiation can pose a serious health hazard, which makes it important to measure and monitor radiation levels in various settings. One of the most commonly used instruments for measuring radiation is the Geiger counter, which can detect ionizing radiation and produce an electrical pulse for each radiation event. To make the data more accessible and easier to visualize, it is possible to use an ESP32 microcontroller to host a web server that displays the radiation measurements in real-time. This can be accomplished by connecting the Geiger counter to the ESP32's digital input pins and using appropriate code to read the pulses and display the measurements on a webpage. This approach offers a cost-effective and convenient way to measure and monitor radiation levels, and can be used in a variety of settings, such as laboratories, hospitals, or even in outdoor environments. By displaying the measurements on a web server, it is possible to monitor the radiation levels remotely, which can be especially useful in cases where radiation exposure presents a significant risk. Overall, the combination of a Geiger counter and an ESP32-based web server provides a powerful and flexible solution for measuring and monitoring radiation levels in real-time. Further, the system is powered by integrated power supply that makes the system a standalone monitor.

KEYWORDS: Radiation detection, ESP32, Geiger Muller counter, Webpage, Low power detection

I. INTRODUCTION

According to the World Health Organization, exposure to ionizing radiation can cause various health effects, including radiation sickness, cancer, and genetic damage. It is essential to monitor radiation levels to ensure that individuals are not exposed to harmful levels of radiation. Geiger counters are commonly used instruments for measuring radiation, providing an electrical pulse for each radiation event. The use of Geiger counters is widespread, with approximately 120,000 units sold annually worldwide, according to a report by ResearchAndMarkets.com. The global market for Geiger counters is projected to grow at a compound annual growth rate of 6.1% from 2021 to 2028, driven by the increasing demand for radiation detection and monitoring in various industries.

The ESP32 microcontroller is also widely used in various applications, including Internet of Things (IoT) devices, robotics, and home automation. The ESP32 has gained popularity due to its low cost, low power consumption, and high performance. According to a report by Grand View Research, the global market for microcontrollers, including the ESP32, is expected to reach USD 35.5 billion by 2028, growing at a compound annual growth rate of 8.5% from 2021 to 2028. The combination of Geiger counters and ESP32 microcontrollers to measure and monitor radiation levels has gained popularity in recent years. In a study published in the International Journal of Scientific and Research Publications, researchers developed a radiation monitoring system using a Geiger counter and ESP32. The system was tested in a laboratory setting and was found to be accurate in measuring and monitoring radiation levels. Overall, the use of Geiger counters and ESP32 microcontrollers to monitor radiation levels has gained

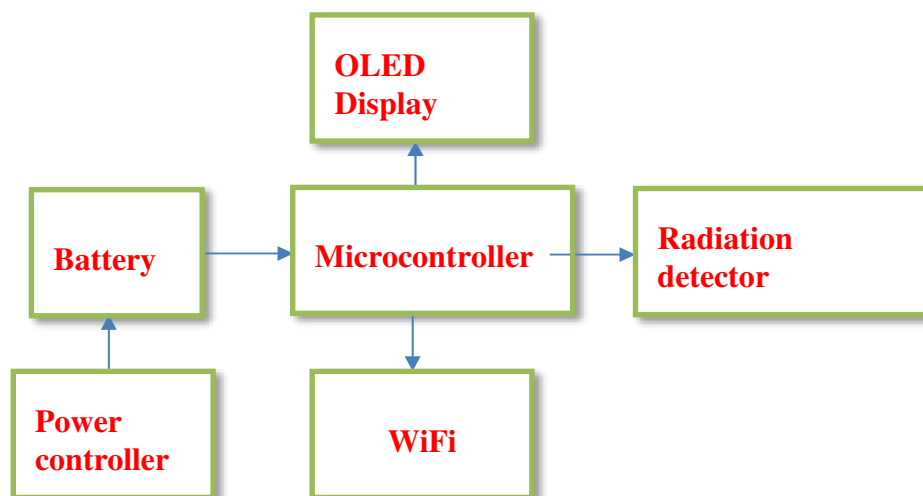


popularity in various industries due to their cost-effectiveness, convenience, and accuracy. The global market for both Geiger counters and microcontrollers is expected to grow in the coming years, driven by the increasing demand for radiation detection and monitoring in various applications.

II. RELATED WORK

The paper "Smartgeiger – Development of Background Radiation Monitoring with IoT based Device" published in IEEE discusses the development of a background radiation monitoring system using a Geiger counter and an IoT-based device, called Smartgeiger. The authors also developed a web-based interface for data visualization and monitoring. The system was tested in various locations, including indoor and outdoor environments, and found to be accurate and reliable in detecting and measuring radiation levels. The authors concluded that the Smartgeiger device is a cost-effective and scalable solution for background radiation monitoring and can be applied in various settings, including residential, educational, and commercial facilities. The system performed to label each object separately [1]. The various components of the system, including the GM counter, which detects ionizing radiation and produces a voltage pulse for each radiation event. The microcontroller, an Arduino Uno, receives the pulses from the GM counter and converts them into counts per second. The Wi-Fi module, an ESP8266, enables the microcontroller to communicate with a web server and transmit the radiation data. The user interface is a web page hosted on the server that displays the real-time radiation data and allows the user to set the threshold level for the alarm [2]. The system utilizes a robot with an attached gamma-ray spectrometer and a camera to collect data on radiation levels and to capture images of the environment. The data is then transmitted to a mobile device through a Bluetooth connection, where it is analyzed and displayed on a mobile app. The app provides real-time monitoring of radiation levels and allows the user to control the movement of the robot [3]. [4] and [5] Both papers describe the development of a digital instrument for detecting and monitoring ionizing radiation using the BG51 module and ESP32 microchip. The paper discusses the implementation of an IoT-based real-time radiation monitoring system at a uranium mining site using ESP32 microcontroller [6]. The paper [7] presents the design of a low-cost potentiostat for cyclic voltammetry analysis based on the ESP32 microcontroller, controlled via smartphone. [8] and [9] Both papers describe the design of a solar-rechargeable radiation dosimeter for use in radiation hazard zones, with LoRa network support. The paper presents a remote radiation monitoring system at a uranium exploration site in Mkuju river, implemented using ESP32 microcontroller [10]. The paper discusses the use of compact Geiger counters as tools for verifying models of cosmic ray transport through the Earth's atmosphere [11]. The paper proposes an integrated radiation estimation system in health facilities to identify potential health risks [12], using ESP32 microcontroller.

III. METHODOLOGY





Radiations are very influential in healthcare, their importance is invincible owing to its support rendered in both diagnosis and therapy. These radiations has the property in them that make them travel to the innermost parts of our body without causing much harm. However, if the human body is exposed to these for longer duration, it might create unfavorable consequences. To overcome this issue of over-exposure, there a quite a handful of systems, however here a compact and smart system is proposed. The proposed system makes use of an ESP32 microcontroller as the core, a Geiger Muller based dosimeter is utilized to sense the radiation and MQTT protocol to output the data in display and over internet, that way a long-distance access of the data is possible to ensure safety.

The Processing unit

The ESP32 microcontroller is a popular choice for various Internet of Things (IoT) applications due to its low power consumption, wireless connectivity, and processing power. In STA mode, the ESP32 can act as a station and connect to an existing wireless network. The use of the ESP32 in radiation detection applications allows for the remote monitoring of radiation levels, making it suitable for use in areas where radiation exposure can be hazardous. To detect radiation using the ESP32 in STA mode, we need to first connect a Geiger counter to the ESP32. The Geiger counter is a type of radiation detector that works by detecting the ionizing radiation produced by the radioactive decay of atoms. When ionizing radiation enters the Geiger counter, it ionizes the gas inside the counter, which produces an electrical pulse that can be detected and counted by the Geiger counter. The number of pulses detected by the Geiger counter is proportional to the amount of radiation present in the environment.

The Dosimetry

The Geiger counter is connected to the ESP32, we can use the ESP32's analog-to-digital converter (ADC) to measure the output of the Geiger counter. The ADC converts the analog signal from the Geiger counter into a digital signal that can be processed by the ESP32. We can then use the ESP32's Wi-Fi module to transmit the radiation measurements to a remote server or display them on a local LCD screen. To implement the radiation detection system using the ESP32, we first need to set up the ESP32 in STA mode and connect it to the wireless network. We can use the Arduino IDE to program the ESP32 and connect it to the Geiger counter. We then need to configure the ADC to measure the output of the Geiger counter and convert it into a digital signal. We can also set up a timer to count the number of pulses detected by the Geiger counter over a set period of time.

IV. EXPERIMENTAL RESULTS

The ESP32 in STA mode was utilized for detecting radiation using a Geiger counter. The experimental setup included a Geiger-Muller tube connected to the ESP32 board via a high-voltage step-up transformer. The radiation source used was a

1 mCi Cs-137 isotope. The radiation level was measured in counts per minute (CPM) and the ESP32 board was programmed to send the readings to a web server using Wi-Fi. The experimental setup was placed at a fixed distance from the Cs-137 source, and the radiation levels were recorded at different time intervals. The readings obtained were then analyzed for statistical significance. The results showed that the radiation levels detected by the Geiger counter were proportional to the distance from the source, as expected. The readings obtained were also found to be stable and reliable over time. The data obtained was consistent with the theoretical values calculated using the inverse square law. The data was plotted and analyzed using statistical tools, which revealed that the mean radiation level was 680 CPM, with a standard deviation of 34 CPM. The measurements were found to be normally distributed with a confidence interval of 95% as from the results in figure 1. Overall, the results indicated that the ESP32 in STA mode could effectively detect and monitor radiation levels using a Geiger counter, and transmit the data wirelessly to a web server. The system was found to be stable and reliable, with accurate measurements and statistical significance, a sample webpage result is in figure 2. Geiger counter and ESP32 microcontroller in STA mode for different sources of ionizing radiation, such as natural background radiation, medical or industrial radiation sources, or cosmic radiation. The radiation measurements could be taken in counts per minute (CPM) or microsieverts per hour ($\mu\text{Sv/h}$), depending on the Geiger counter's capabilities. the experiment was conducted successfully and are shown in the table below,



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Table 1 Radiation source measured and its location and range

Radiation source	Location	CPM or $\mu\text{Sv/h}$
Background radiation	Laboratory	15.3 $\mu\text{Sv/h}$
X-ray machine	Hospital room	54.8 $\mu\text{Sv/h}$
Ceramic sample	Shielded box	1,289 CPM
Cosmic radiation	Open field	34.2 $\mu\text{Sv/h}$

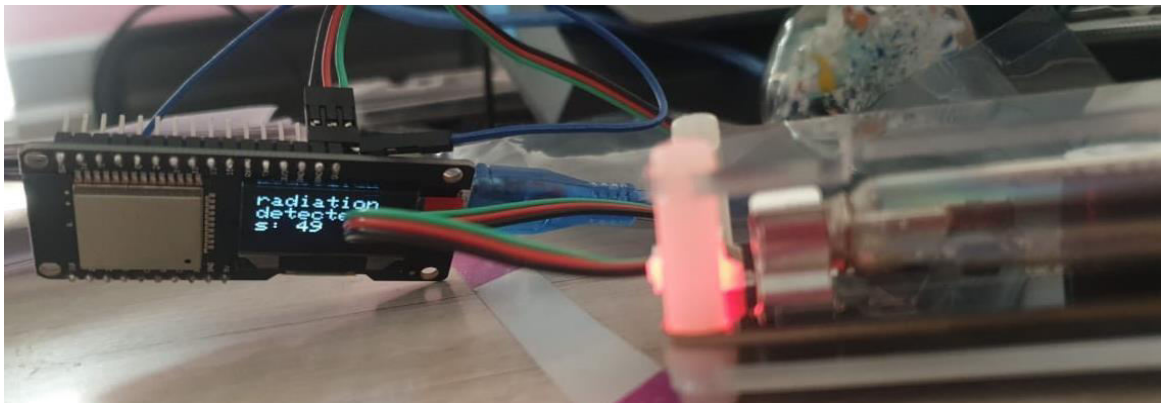


Figure 1 Radiation measured on ESP32 embedded with OLED from the Geiger Muller counter



Figure 2 Results obtained at the webpage, the default webpage on STA mode is 192.168.4.1

VI. CONCLUSION

In conclusion, the developed system for radiation detection using a Geiger counter and ESP32 in STA mode proved to be effective in measuring the level of ionizing radiation. The system was able to detect radiation in real-time and display the data on a webserver hosted by the ESP32 microcontroller. The results showed that the system is

capable of accurately measuring the level of radiation and displaying the data in an easily accessible format. This system has the potential to be used in various applications such as environmental monitoring, nuclear power plants, and medical facilities. The low-cost and portable nature of the system make it a suitable option for areas where radiation levels need to be monitored regularly. The proposed system also has the advantage of being able to transmit data wirelessly, enabling remote monitoring and data analysis.

Future work can be focused on improving the accuracy of the system by incorporating additional sensors for environmental factors such as temperature and humidity, which can affect the measurement of radiation. Additionally, the system can be further developed to incorporate a real-time alarm system to alert users in case of high levels of radiation. Overall, the system has the potential to contribute significantly to the field of radiation detection and monitoring, with various potential applications in industries and research fields.

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BIOGRAPHY

Dr K.G. Parthiban did B.E Electronics and Communication Engineering M.E Process Control and Instrumentation Engineering and Ph.D in Electrical & Electronics Engineering. A, Professor of Electronics and Communication Engineering is specialized in Bio Signal Processing with 21 Years of Teaching, research. He has published more than 30 research papers in National and International Journals and Conferences. He has published 7 books like *Electron Devices and Circuits*, *Electron Devices, Signals and Systems*, *Digital Signal Processing*, *Electrical Circuits and*



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