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Development of Alert Radiation Monitoring System

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Abstract: At the moment, radiation workers still maintain use survey meters to read the level of radiation in a place or place where they work. Users of survey meters that are relatively heavy and not user-friendly require employees or users to be sensitive to radiation readings around them. this study has been done to help radiation workers be more sensitive to radiation readings more easily in the workplace to avoid self-harming incidents by providing a warning system. The method used to perform the study was by connecting the detector, Arduino radiation detector compatibility kit, battery, and ESP8266 NodeMCU with the Blynk web application. The study was conducted for 3 days at the Malaysian Nuclear Agency and proved that the system works well and was able to read the background level of radiation in the workplace. This study successfully met all the stated objectives.

Keywords: Geiger-Muller, Radiation Detector, ESP8266

1. Introduction

The annual dose of radiation for the general public is 2.5 Sv/Hr, while radiation workers receive 7.5 s/hr. Background radiation from televisions and mobile phones exposes humans both directly and indirectly. Radiation can be employed for a variety of purposes, and around 23 million workers are exposed to ionizing radiation on the job all around the world [1]. Hence to protect the safety of the workers and the general public, practical and conveniently accessible dose monitoring is essential. This technology will benefit radiation workers in a variety of fields, including medical, NDT, and research.

This research work embarks on the following objectives to integrate the hardware for the detection of radiation using radiation detectors with high sensitivity to radiation, to detect the level of background radiation in the workplaces and to develop a website application for the alert system. The average dose level from natural background radiation is 0.17-0.39 Sv/h. If the radiation level is exceeding the range stated, the website of the Blynk Apps will notify along with the radiation detector kit will make a noise to give a sign and consider the workplace are not safe. In general, this study was conducted to able to read and detect background radiation levels in the workplace to have a safe workplace and also to alert people whenever the place is exposed to harmful radiation levels. Other than that, this study wants to

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contribute to the industry especially industries that are involved with radiation to have another option for monitoring radiation levels other than using the conventional survey meter.

The scopes for conducting this study are the type of radiation detector being used which is the Geiger Muller tube detector and the testing is done at Blok 60, Agensi Nuklear Malaysia. Other than that, since this research aims for having an alert system, so the Blynk website application had been used along with Arduino IDE. Hence, the expected outcome of this research is to observe the background radiation level that occurred in Blok 60, Agensi Nuklear Malaysia in order to ensure a safe environment for the workers and have an alert system to notify workers of the risky condition of the workplace.

1.1 Source of radiation

Natural background radiation is produced by three sources. Cosmic radiation was caused by the interaction of a charged particle from the sun or a star with the earth's atmosphere and magnetic field. The next type of radiation is terrestrial radiation, which is radioactive material found in soil, plants, and rocks [2]. The next source of radiation is created by humans. Radiation can be found in products, medical procedures, and radioactive materials emitted from surrounding materials as a result of human activity.

An accelerator is a device that accelerates and boosts the energy of an electron or ion beam. Mobile phones emit radiation in the radiofrequency range, which is still classified as non-ionizing. Cell phones are widely used. Nuclear reactors have also been used for larger purposes, such as power generation. Last but not least, sources of radiation can be nuclear reactors. Research on radiation chemistry was undertaken in the early days of the field, and radiation applications were tested with neutron beams from nuclear reactors

1.2 Type of radiation detector and its advantages and limitations

There are many different types of detectors, but this article focuses on three that are commonly used in the industry: gas-filled detectors, Nal (TI) detectors, and semiconductor detectors.

The basic types of ionizing radiation are alpha radiation, beta radiation, x-radiation, gamma radiation, and neutron radiation. When the gas comes into contact with radiation, it can cause ionization and excitation, resulting in an electronic charge is the basic principle of a gas field detector [3]. Nal(TI) stands for sodium iodide detector and is a scintillation detector, which produces photons of visible light when radiation strikes the crystal (scintillator) [4]. The semiconductor detector has an unrivaled high light output and a perfect fit of the emission spectrum to photomultiplier tube sensitivity - resulting in detectors with extremely high energy resolution [5].

Geiger-Muller counter is the simplest in principle among all gas-filled detectors and is capable of detecting, as well as having a good detector design and calibration. Geiger-muller detectors have more advantages to be compared with ionization and proportional detector and more sensitive than Ion Chambers [6]-[8]. The scintillation counter uses the scintillation effect to detect tiny amounts of contamination in the lab. NaI scintillation counters and high-purity germanium detectors are the most prevalent gamma spectrometry detectors. NaI(Tl) scintillators have an advantage over the scillantors in terms of an interaction mechanism that allows for energy resolution in photo peaks due to the larger amount of information-carrying a quota [8].

2. Materials and Methods

The procedures for performing the research are outlined in further depth in this chapter. The analysis methodology is defined as a systematic approach of resolving a research topic by collecting data using various methodologies, interpreting the data, and drawing conclusions regarding the study data.

2.1 Tools

In the conceptual design of this work, the radiation detection sensor system, wireless communication system, and monitoring interfaces system can be divided into three major categories. The radiation detection sensor system employs the Geiger-Muller tube. As shown in Figure 1, the sensor will collect data, which will then be transmitted wirelessly to the base station. After receiving the data, the microcontroller will store it and send it to an Internet-connected web interface. The Serial Peripheral Interfaces are used to transfer data between the microcontroller and the sensor (SPI). Under the master-slave architecture of this SPI, the master devices can initiate and control all communication with the slave. Blynk, the study's public platform, and the ESP8266 NodeMCU will be used.

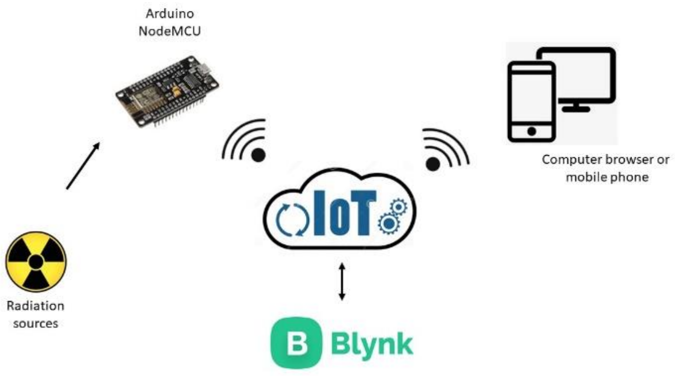


Figure 1: Overall system architecture.

2.2 System design

The main components for the development of a smart radiation monitoring system are a Radiation Detector Arduino Compatibility DIY Kit, SBM-20 Geiger Tube, ESP8266 NodeMCU, and batteries. The radiation sensor system's radiation data is uploaded to the internet via the ESP7266 Node MCU. It can be powered by connecting the VIN pin to the power supply and the GND pin to the ground pin. The radiation detector must be linked to the microcontroller ESP8266 NodeMCU. This is a full-duplex synchronous system in which data transmission between the two devices is synchronized by a common clock signal. Before sending data to the base station, all data must be displayed on the serial monitor. Blynk is an IoT application development platform. It allows for data collection in real-time and displays it in the form of charts. Blynk makes use of the Internet, so the microcontroller selected must have internet access since it provides a unique token for each gadget to communicate with one another. The complete hardware is shown in Figure 2.

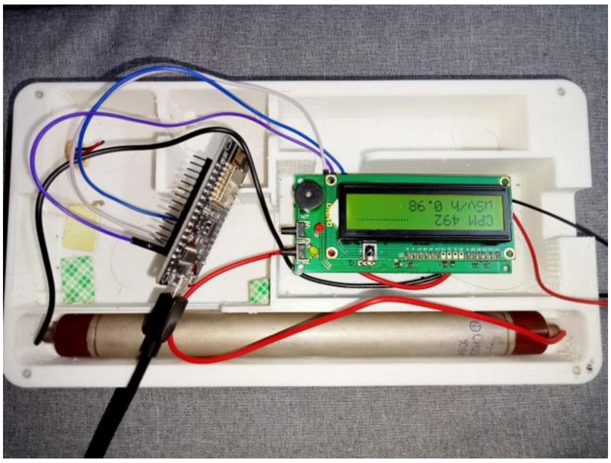


Figure 2: Complete hardware of the project

2.3 System testing and configuration

Due to the fact that the monitoring interfaces system needs input data to be shown on its platform, both systems were tested at the same time. The source code contains the mathematical methods, and the output of these algorithms must be viewable on a public platform. The OTA instruction in the source code is tested by uploading it to the ESP8266 during the development phase of the wireless network system to see if the wireless communication through the Wi-Fi module worked or not.

To determine if the data transferred to the cloud via the wireless network system can be accessed on this open platform, the Blynk channel that was established during the development phase is being watched. The API Keys for this channel are incorporated in the source code instruction, and it has been set to public view. The source code instruction to start the connection between Blynk and the cloud server also contains the Wi-Fi SSID and password.

The sub-systems are integrated into one device once each system has been tested for functionality. Making sure that every pin on the hardware component is connected correctly before adding the battery power source and switch is the first step in system integration. The source code is created in accordance with the command that the gadget needs to carry out. The radiation detection, wireless connection, and interface with the Blynk platform must all be enabled by a command in this source code. Figure 3 shows an integrated system used.

Figure 3: Schematic diagram of an integrated system

3. Results and Discussion

The results and discussion section presents data and analysis of the study. begins by analyzing the collections of data on background radiation levels. Next, the effectiveness of NodeMCU in transferring data from the detector to the serial monitor. Then, the effectiveness of the system for transmitting radiation signals and readings to the Blynk site.

3.1 Radiation detector.

The data collection process to test the effectiveness of the device was conducted over 3 days in block 60, Malaysian Nuclear Agency, Bangi. The device is placed in a laboratory located in block 60. The Geiger kit, built with the SBM-20 detector and coupled with the ESP8266 NodeMCU microprocessor, is put through a routine operational test. The sievert is the unit of absorbed radiation dose (Sv). Because one sievert is a large quantity, radiation doses are commonly expressed in millisievert (mSv) or microSievert (Sv), which are one-thousandth or one-millionth of a sievert, respectively. Figure 4 shows the result for graph day 1. These graphs are plotted based on time as the x-axis and dose rate as the y-axis is for three days and all the data are attached in the appendixes.

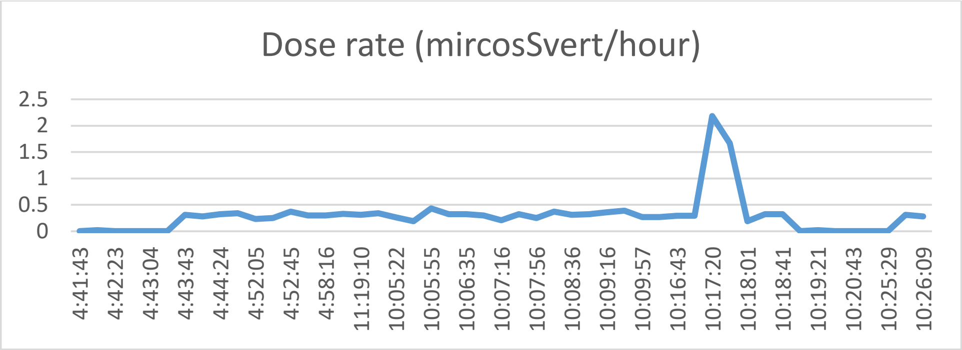


Figure 4: Graph of result for day 1

According to the graph in Figure 4, the average dose rate occurred is 0.5784 microSivert/hour which does not exceed the average dose levels from natural background radiation. The maximum dose rate occurred is 2.18 microSivert/hour at 10:17:12 hour while the minimum dose rate is 0 microSivert/hour from 4:41:43 until 4:43:23. Hence, the radiation level of the background environment is still under 2.8 microSivert/hour, in other words, does not exceed the dangerous level of radiation. This means that the level of background radiation in the laboratory on day 1 is safe.

For day 2 referring to the graph in Figure 5, the average dose rate occurred is 0.3207 microSivert/hour which does not exceed the average dose levels from natural background radiation which experts define as modest, and just below the 0.17–0.39 Sv/h worldwide average of naturally occurring background radiation. The maximum dose rate occurred is 0.44 microSivert/hour at 11:05:07 while the minimum dose rate is 0 microSivert/hour. The radiation level of the background environment is still under 2.8 microSivert/hour several times at 11:05:08-11:06:06 and 11:08:49-11:09:45 hour. The level of background radiation in the laboratory on day 2 is safe too.

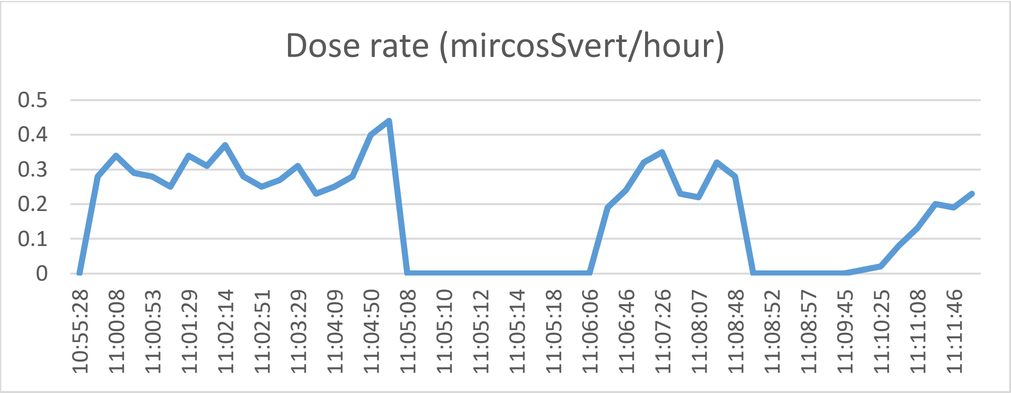


Figure 5: Graph of result for day 2

While graph in Figure 6, the average dose rate occurred is 0.1451 microSivert/hour which does not exceed the average dose levels from natural background radiation which experts define as modest, and just below the 0.17–0.39 Sv/h worldwide average of naturally occurring background radiation. The maximum dose rate occurred is 0.34 microSivert/hour at 11:12:46 while the minimum dose rate is 0.01 microSivert/hour. The radiation level of background environment is still under 2.8 microSivert/hour for several time which at 11:25:29, 11:19:48, 11:21:08, 11:24:22 and 11:24:29 hour. Hence, the level of background radiation in the laboratory on day 3 remains safe.

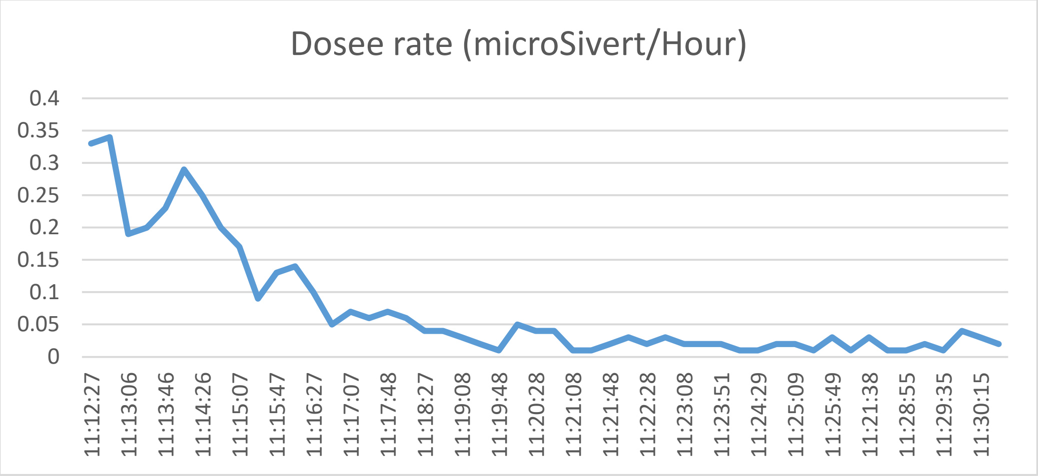
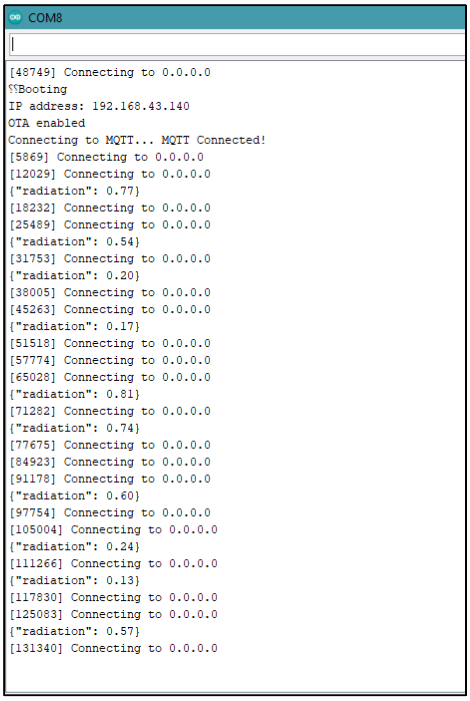


Figure 6: Graph of result for day 3

3.2 System testing for wireless network system and monitoring interfaces

The background radiation reading will be displayed in the serial monitor of Arduino IDE software since the system is using ESP8266 NodeMCU for transferring real time data. Figure 7 shows the result of the successful data transmitted.



```
[48749] Connecting to 0.0.0.0
⸮⸮Booting
IP address: 192.168.43.140
OTA enabled
Connecting to MQTT... MQTT Connected!
[5869] Connecting to 0.0.0.0
[12029] Connecting to 0.0.0.0
{"radiation": 0.77}
[18232] Connecting to 0.0.0.0
[25489] Connecting to 0.0.0.0
{"radiation": 0.54}
[31753] Connecting to 0.0.0.0
{"radiation": 0.20}
[38005] Connecting to 0.0.0.0
[45263] Connecting to 0.0.0.0
{"radiation": 0.17}
[51518] Connecting to 0.0.0.0
[57774] Connecting to 0.0.0.0
[65028] Connecting to 0.0.0.0
{"radiation": 0.81}
[71282] Connecting to 0.0.0.0
{"radiation": 0.74}
[77675] Connecting to 0.0.0.0
[84923] Connecting to 0.0.0.0
[91178] Connecting to 0.0.0.0
{"radiation": 0.60}
[97754] Connecting to 0.0.0.0
[105004] Connecting to 0.0.0.0
{"radiation": 0.24}
[111266] Connecting to 0.0.0.0
{"radiation": 0.13}
[117830] Connecting to 0.0.0.0
[125083] Connecting to 0.0.0.0
{"radiation": 0.57}
[131340] Connecting to 0.0.0.0
```

Figure 7: Serial monitor of successful data transmitted

Both the monitoring interfaces system and the wireless network system are tested simultaneously. Figure 8 shows the outcomes of this test that are displayed on the LCD print.

Figure 8: LCD print the count rate in CPM and µSv/hour

3.3 Percentage error

Table 1 shows the value of percentage error for 3 days,

Table 1: Presenting the value of percentage error for 3 days

Day	Percentage error (%)
1	5
2	4.9
3	4.9

The percentage error for each day is shown as in Table 4.0 which is less than 4 percent. Day 1 is 4% while day 2 and day 3 have the same percentage error which is 3.9, the value was calculated based on the Eq.1.

$$\% \, error = \frac{average}{total} \times 100\% \qquad Eq.1$$

3.4 Network testing for wireless wide-area radiation monitoring

The completed apparatus is put through one last test. According to the test, the radiation data may be effectively communicated in real-time by the ESP8266 NodeMCU utilising a Wi-Fi connection from the sensor system to the Blynk channel as shown in Figure 9. The radiation count per minute (CPM) and dosage rate (Sv/hr) are the data that are available on the public platform. It's important to note that the data displayed on the Blynk platform and the serial monitor are the same, indicating that real-time data transfer is taking place.

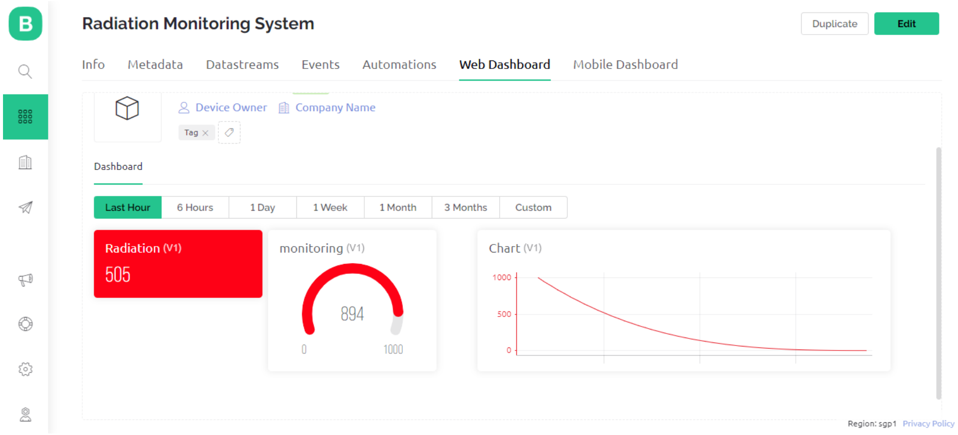


Figure 9: Wireless wide-area radiation monitoring network public platform interfaces

4. Conclusion

In a conclusion, this research purpose considers successfully achieved which to develop an alert radiation monitoring system for the workplace. The project has a useful design and work system for them radiation monitoring system installation or production companies. It can help read radiation levels around the workplace The first objective was to integrate the hardware for detection of radiation using high sensitivity radiation detector which is an SBM-20 Geiger Muller Compatibility kit. The Geiger Muller kit is able to detect low-level radiation and normal background radiation. The second objective also was achieved due to the system is able to read the level of background radiation in the workplace which is very important to know the radiation level each second for safety. Blynk application was used to achieve the third and fourth objective which is to develop a website application that can alert the user for emergency cases. The Blynk will be displayed a data stream of the dose rate and count rate of radiation.

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