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RFID Tracking Evacuation System

Muhammad Adam Danial[1], Muhammad Nafis[1]*

[1] *Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, Johor, MALAYSIA*

*Corresponding Author: nafis@uthm.edu.my
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Abstract

Ensuring the safety of building occupants and keeping track of their presence during emergencies can be a challenging task, especially in office or high-traffic environments. This project presents a practical and cost-effective RFID-based system designed to manage attendance and support evacuation processes. Using the ESP8266 microcontroller and long-range UHF RFID readers, the system records check-in and check-out data in real time, identifying individuals who are still inside during an evacuation. The data is stored locally using SPIFFS, allowing the system to function reliably even without internet access. A simple web-based interface is used to display the status of occupants and access attendance logs. Additionally, the system includes an automatic control logic that focuses on managing energy consumption, particularly for air conditioning units, based on occupancy. The system promotes electricity savings by integrating automatic load switching, particularly for air conditioning units. This ensures that electrical loads are only active when necessary, helping to reduce energy consumption in unoccupied areas.

1. Introduction

Managing people in a building during emergencies has always been a challenge, especially in large spaces with high occupant turnover. Traditional methods like manual headcounts are time-consuming and prone to errors. Occupational Safety and Health Administration guidelines emphasize the importance of real-time headcounts and location tracking to enhance safety during emergencies [1]. Integrating IoT solutions and RFID technology addresses these inefficiencies by automating the monitoring of individuals and ensuring data accuracy in real-time.

In addition to improve emergency preparedness, building energy management has become a growing concern. Office appliances such as air conditioning units and lights are often left running unnecessarily, resulting in increased electricity bills and wasted energy. Through IoT-based automation, devices can be controlled based on occupancy. Using microcontrollers such as the ESP8266, which provides built-in Wi-Fi capabilities, these systems can be easily integrated to automate control of appliances through the cloud or local network.

Existing evacuation systems often lack the ability to track individuals in real time, creating delays and increasing the risk during emergency situations. Under these circumstances, it becomes challenging to ascertain whether people have safely left the building or are still within. Manual headcounts and other conventional approaches are labor-intensive and prone to human mistakes, therefore possibly leaving people invisible. Occupational Safety and Health Administration (OSHA) rules provide that accurate and current headcount policies must be part of evacuation plans to guarantee the general safety of all residents [1].

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Furthermore, many offices buildings deal with energy waste from equipment such air-conditioning systems and lights left on needlessly. This can greatly raise running costs for power and promote ineffective energy consumption. Automating occupancy-based control of these appliances using a smart system will help to guarantee that they only activate when absolutely required. With the advancement of the Internet of Things (IoT), it is now possible to connect and automate office appliances through wireless communication.

This project intends to offer a real-time monitoring and automation solution by combining ESP8266-based control systems with RFID technology for personnel tracking. This system not only enhances safety during evacuations by identifying individuals who are still inside the building but also reduces energy consumption by automatically controlling devices based on presence, thereby improving overall building management and operational efficiency [2][3][4]. Objective of the project are designing a real-time RFID-based attendance system that identify individual in a workplace and provide employers with precise attendance records, including headcount verification during emergency evacuations. Next, Integrate the RFID system with an automatic load switching mechanism to regulate electrical equipment based on user presence, hence enhancing office energy efficiency. Next, analyse the potential energy savings achieved by implementing RFID-linked automatic switching in an office configuration.

2. Methodology

This chapter describes the methodology and approach to this project. The methodology focused on the methods of the project implementation, including the description of devices, software development, flow chart of design and explanation regarding hardware development. This system's configuration incorporates both hardware and software design, along with the RFID system.

2.1 Flowchart of the RFID system

Fig. 1 illustrates the flowchart of the RFID-based Tracking Building Evacuation and Energy Management System. The system begins with employee registration and RFID tag assignments. Upon approaching the building, the long-range RFID reader detects the tag and records the entry time only if the tag is registered. If not, the system shows the id tag. The Arduino processes the tag data and wirelessly transmits it to a centralized database. Attendance records are stored in CSV file format, allowing real-time updates and offline access. Energy systems are toggled ON when the user enters and OFF upon exit. During evacuations, the system identifies individuals still inside the building, enhancing emergency response, energy efficiency, and safety management.

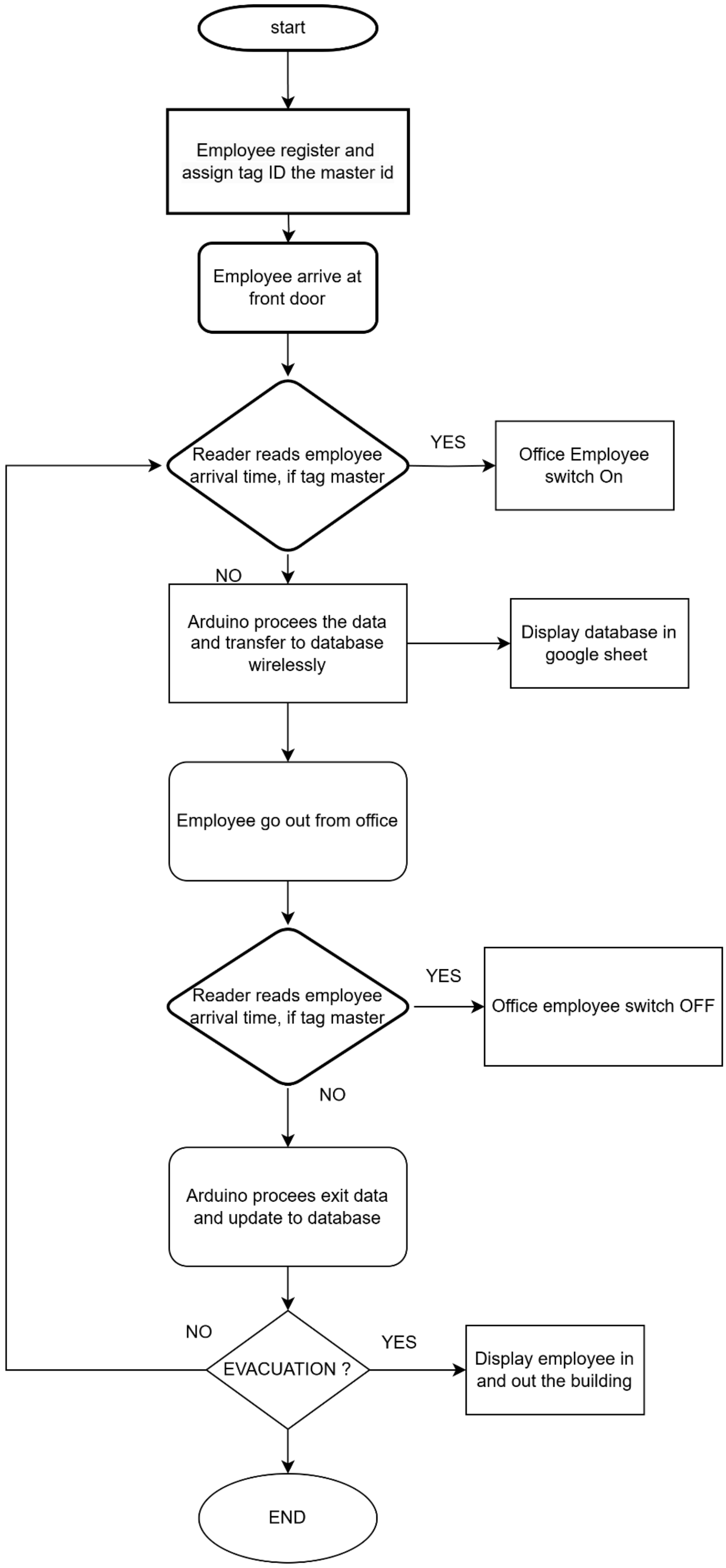


Fig. 1 *Flow chart of the project*

2.2 Design Project

The overall system of this project comprises four major components shown in the figure 2 RFID Tags, RFID Reader, ESP8266 module, and the Database, as illustrated in the Figure. The first part of the system, the hardware interface, consists of passive RFID tags and a long-range RFID reader. Passive RFID tags are powered by the radio frequency (RF) signal received from the RFID reader as shown in Fig. 2. These tags capture the RF signal energy to activate the transceiver and transmit encoded identity information.

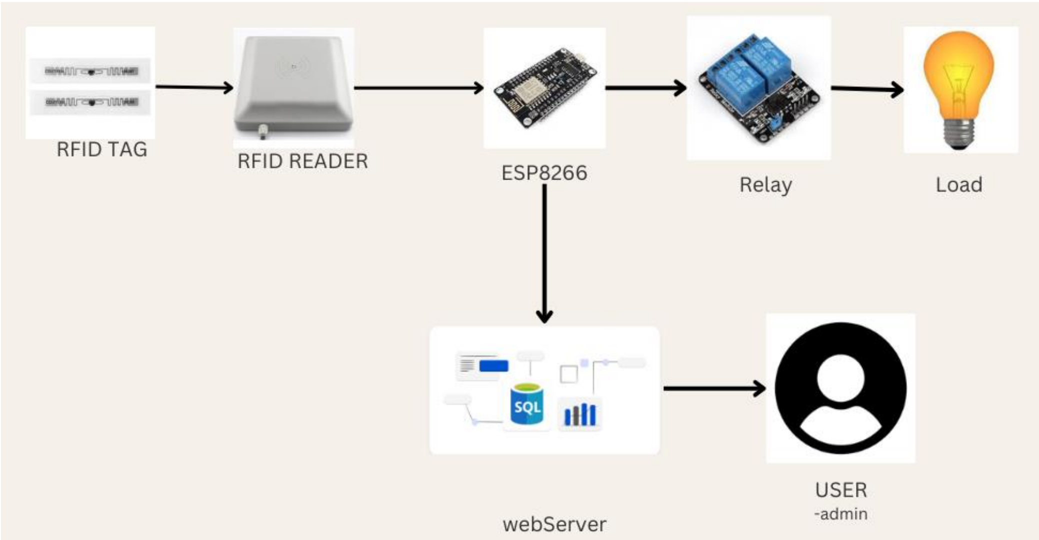


Fig. 2 *Overall system of this project both hardware and software*

2.3 Selection of Hardware

Circuit diagram of the RFID-based evacuation tracking and load control system show in Fig. 3. The system integrates an ESP8266 NodeMCU microcontroller, an MFRC522 RFID reader, a 2-channel relay module, and a Fotek SSR-40DA solid-state relay to control an air conditioning unit. The RFID reader detects tag presence and sends UID data to ESP8266 via SPI interface. Upon verifying a master UID, the ESP8266 triggers the relay module, which in turn activates the solid-state relay to supply AC power to the air conditioner. This configuration enables non-contact personnel tracking and automatic energy management based on real-time occupancy.

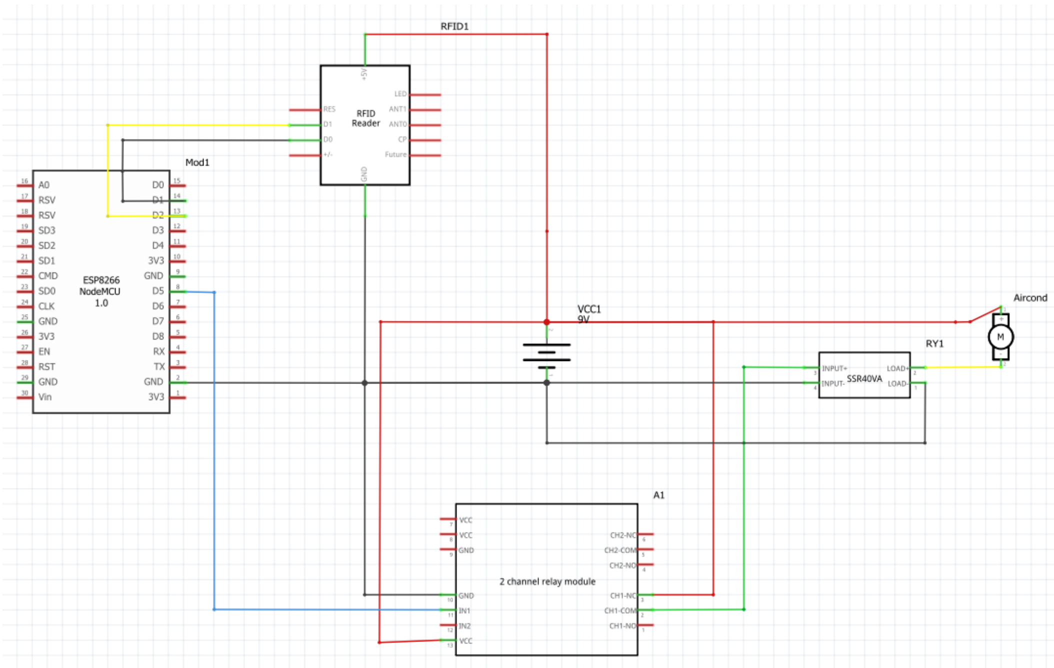


Fig. 3 *Schematic diagram of the connection*

3. Result and Discussion

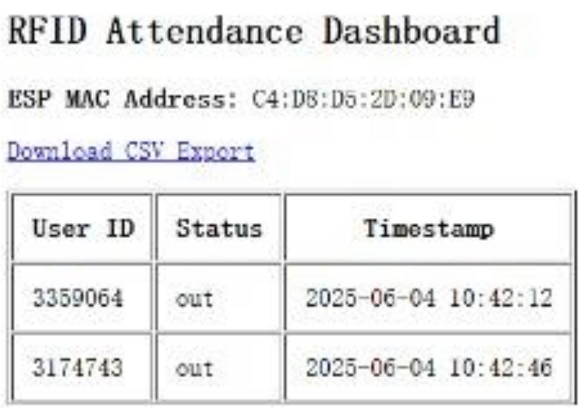
The system was tested in an office simulation environment. All RFID scans were accurately logged, and the web dashboard correctly reflected IN/OUT status in real-time. The relay system successfully toggled based on the presence of a Master UID. Energy consumption data showed a weekly saving of up to 65.4% after system installation. Voltage readings remained stable before and after relay automation, demonstrating the system's reliability.

Unlike systems that rely on internet/cloud platforms like Blynk, this system functions fully offline and stores all logs locally. RFID tags are scanned to determine personnel entry and exit. Data is logged in CSV format using the onboard SPIFFS file system. A CSV export feature allows administrators to download attendance and evacuation reports via browser show in Table 1.

Table 1 *Attendance log database*

	A	B	C
1	UID	Status	Timestamp
2	3359064	in	6/4/2025 10:42
3	3359064	out	6/4/2025 10:42
4	3174743	in	6/4/2025 10:42
5	3174743	out	6/4/2025 10:42
6	3174743	in	6/4/2025 10:42
7	3174743	out	6/4/2025 10:42
8	3174743	in	6/4/2025 10:43
9	3174743	out	6/4/2025 10:43
10	3174743	in	6/4/2025 10:44
11	3174743	out	6/4/2025 10:44
12	3174743	in	6/4/2025 10:44
13	12649881	in	6/4/2025 10:46
14	3174743	out	6/4/2025 10:47
15	12649881	in	6/4/2025 10:48

Interfacing design program is used to test the connection between RFID readers with the system using Arduino platform. The hardware is connected to the system wirelessly using Wi-Fi. The system is ready to read and transmit the data from RFID Tag when readers and ESP receive power supply and connect to the Wi-Fi. RFID Tag contains raw data such as the Tag ID, information which can be acknowledged in the Arduino programming environment. The unique serial number of the tag is associated with more related data stored in the database system upon the reader reading the tag. The date and time are stamped together with the tag information in the database as a recorded attendance show in Fig. 4.


RFID Attendance Dashboard

ESP MAC Address: C4:D8:D5:2D:09:E9

Download CSV Export

User ID	Status	Timestamp
3359064	out	2025-06-04 10:42:12
3174743	out	2025-06-04 10:42:46

Fig. 4 *Webdashboard shows the status and timestamp of the user ID*

3.1 Hardware Setup

Fig. 5 show there are only three hardware required in this project which are ESP8266, RFID long range reader and relay that control electrical appliance. RFID long range reader will scan UHF sticker and card. The ESP helps to connect with the RFID reader to collect UID data and send to web server to display in the web dashboard. Also, the relay will be controlled by the ESP when the reader scan tag id. The hardware for this system is switching and collecting data from RFID.

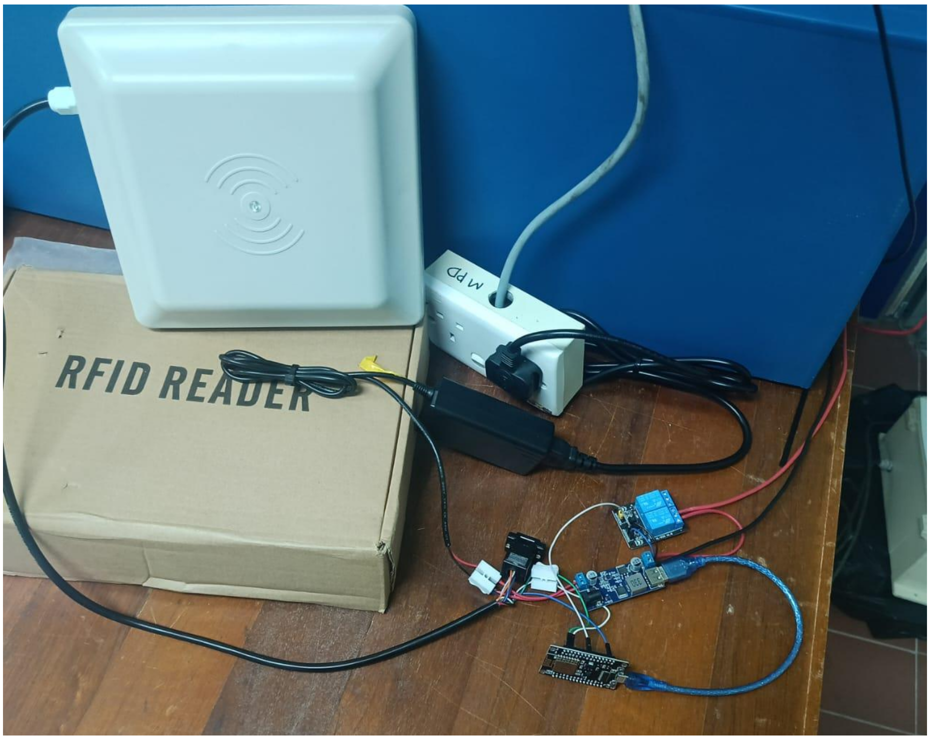


Fig. 5 *Final Design of the Project*

3.2 Energy Saving Analysis

Fig. 6 shows a clear comparison of power consumption before and after applying the auto-switching RFID tag technology on five weekdays. Before installation, energy consumption ranged from 1,557.3 kWh to 5,879 kWh, but after implementation, it decreased dramatically to between 672 kWh and 1,915.48 kWh. The greatest savings were made on Thursday (3,448 kWh saved, 83.7% decrease), followed by Wednesday (4,220.32 kWh saved, 71.8% reduction). The total energy saved this week was 14,266.28 kWh, reflecting a 65.4% reduction. These results show a steady and significant decrease in daily power usage when RFID technology was implemented.

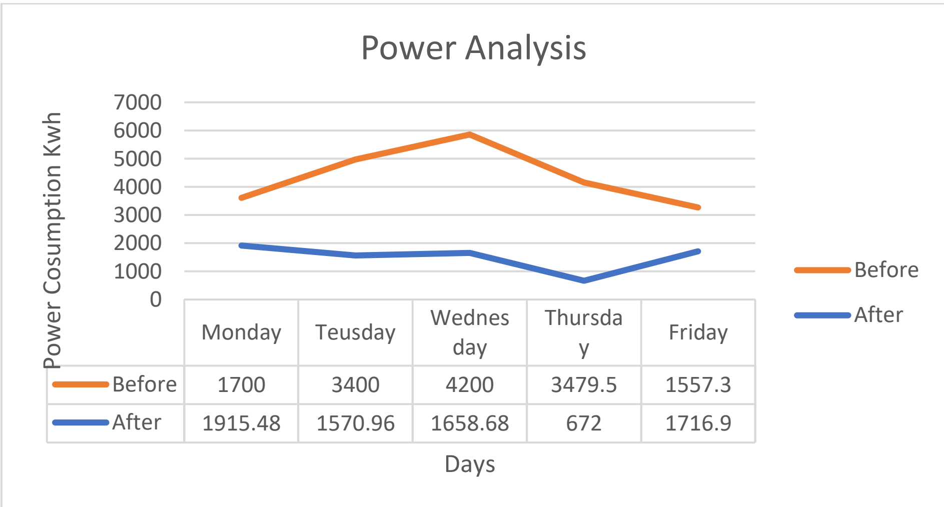


Fig. 6 *Power Analysis before and after automatic switching*

4. Conclusion

As a direct outcome of this project, a smart evacuation and energy control system was successfully developed using RFID and IoT technologies. The prototype enables real-time user tracking and load switching through the ESP8266 module, eliminating the need for internet connectivity by utilizing local storage (SPIFFS) and a browser-accessible dashboard. The system can be expanded beyond small-scale usage to larger office buildings or institutional environments where efficient evacuation and energy-saving processes are critical.

Although the current system focuses primarily on standalone offline functionality, the integration of a full-stack environment with Node.js and MySQL would allow centralized data handling and user registration. This improvement, along with more advanced RFID readers and predictive AI algorithms, would enhance real-time control, monitoring, and decision-making. The system has strong potential to evolve into a scalable platform for intelligent building management systems, offering tangible benefits in energy conservation and safety automation across broader applications.

The proposed RFID-based system for tracking evacuations and managing energy has a lot of potential in a lot of different fields. In schools, it can help keep track of who is present and make sure that everyone is accounted for during emergency exercises or real evacuations. In corporate offices, the system may automatically adjust HVAC and lighting systems based on how many people are in the building at the time, while still following the correct evacuation procedures. Factories and warehouses could be able to make their workers safer by using automated machinery shutdown operations during emergencies. The technology is a dependable way to keep an eye on and track vulnerable people, such patients or elderly people, in hospitals and nursing homes. It also makes sure that energy is used efficiently in important areas. Government facilities can be better prepared for emergencies by using real-time staff tracking and energy-saving features at the same time. The system's help with smart load switching and evacuation support will also help smart buildings and green infrastructure projects. Overall, this solution improves emergency response capabilities while also promoting energy saving, in line with national goals such as Malaysia's Green Technology Master Plan and Industry 4.0 programs.

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Conflict of Interest

Authors declare that there is no conflict of interest regarding the publication of the paper.

Author Contribution

The authors confirm contribution to the paper as follows: study conception and design: Muhammad Adam Danial, Muhammad Nafis; data collection: Muhammad Adam Danial; analysis and interpretation of results: Muhammad Adam Danial, Muhammad Nafis; draft manuscript preparation: Muhammad Adam Danial, Muhammad Nafis. All authors reviewed the results and approved the final version of the manuscript.

References

[1] Chao, Elane L., and John L. Henshaw. "How to plan for workplace emergencies and evacuations." US Department of Labor Occupational Safety and Health Administration, Washington DC (2001)

[2] Ferdous, Raquib Md, Ahmed Wasif Reza, and Muhammad Faisal Siddiqui. "Renewable energy harvesting for wireless sensors using passive RFID tag technology: A review." Renewable and Sustainable Energy Reviews 58 (2016): 1114-1128.

[3] Satapathy, L. M., Bastia, S. K., & Mohanty, N. Satapathy, Lalit Mohan, Samir Kumar Bastia, and Nihar Mohanty. "Arduino based home automation using Internet of things (IoT)." International Journal of Pure and Applied Mathematics 118.17 (2018): 769-778.

[4] Pervez, F., Qadir, J., Khalil, M., Yaqoob, T., Ashraf, U., & Younis, S. "Wireless technologies for emergency response: A comprehensive review and some guidelines." IEEE Access 6 (2018): 71814-71838.