Department of Electrical Engineering and Computer Science

Howard University

100/100

Washington, DC 20059

EECE 404 – Senior Design II

Spring 2025

Final Report – The Detectors – RF Detector

By

Chima Nwughala @03071154

Lance Hinds @03045386

Antoino Jackson@03028274

Darnyieh Brewer@0289668

Instructor: Dr. Charles Kim

Advisor: Dr. Charles Kim

Date Assigned: 04/01/2025

Date Submitted: 04/23/20254

Abstract

This report will cover the general process and understanding of the project. The project required a problem to be identified based on knowledge in the engineering field. The problem that was decided on was the dangers of frequent interacting with the human body. Frequencies cannot be seen or detected by the typical person, making it possible for them to interact with a person without their knowledge. Specific frequencies can cause damage to the human body after prolonged exposure. After research was completed, the problem was specified to be a certain range of frequency. The range chosen was radio frequency (RF).

RF was chosen due to past incidents involving radio frequency. The most notable of these incidents is Havana syndrome. The dangers of radio frequency will be discussed further in the problem statement section of this report. The project was implemented using the idea of being able to detect radio frequency values from a given atmosphere. The project would then be able to relay to a person the danger level of frequencies in the vicinity of them. The project was designed to make a safe environment for people and to be able to measure frequencies using output from different devices.

Problem Statement

While RF waves are used in most of our everyday lives, large amounts of RF power can cause radiation which can lead to damaged tissue and overheating. Using an antenna and a microcontroller, the RF detector would be able to pick up all ambient RF waves and detect the power density from the signals. The final product should be capable of detecting RF waves in a surrounding area and alert the user when harmful RF levels are reached.

Design Requirement

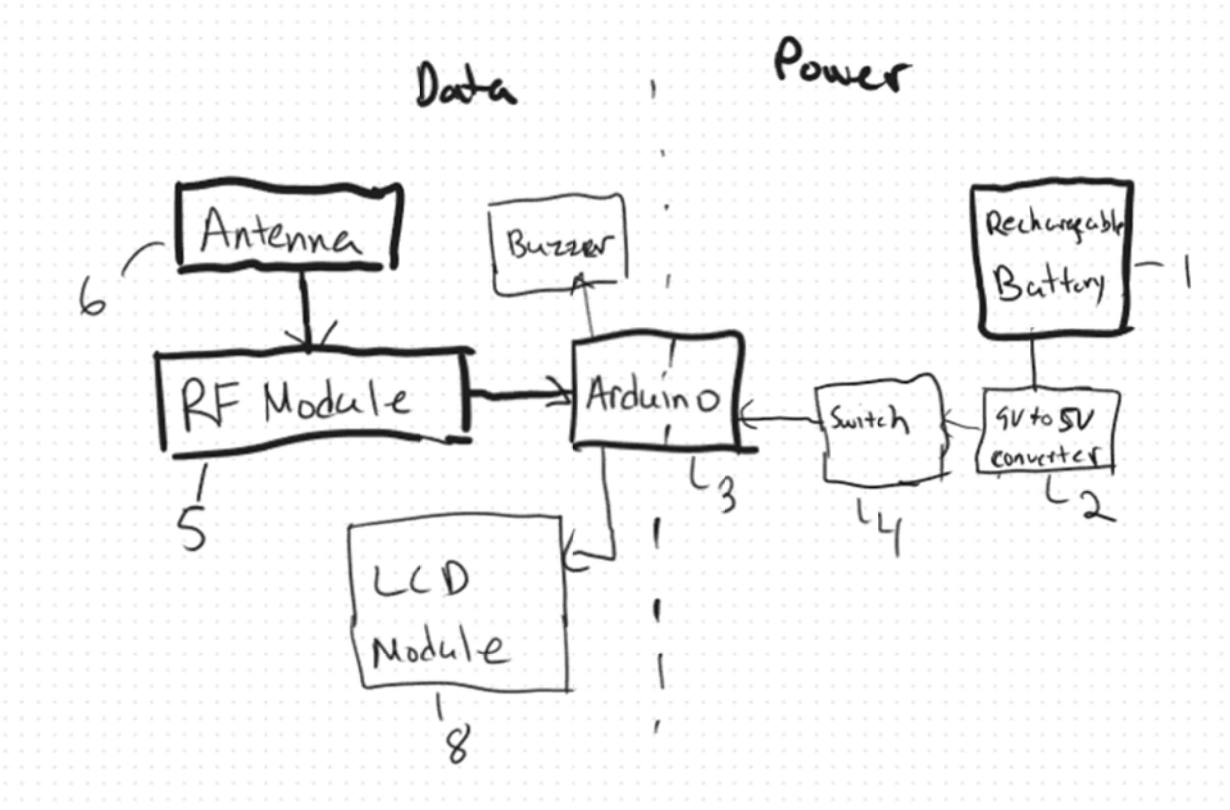
The Radio Frequency detector design incorporates several key components carefully selected to ensure optimal functionality and performance. At its core is an antenna with a frequency range of 2.4 GHz, a very common frequency range for everyday signals. This is complemented by an Arduino microcontroller which serves as the brain of the device, processing detected signals and executing the programmed logic. Power management is handled through a 6-24V to 5V 1.5A regulator connected to a rechargeable 9V lithium-ion battery via a standard 2-pin connector, providing reliable and consistent power to all components while enabling convenient recharging for extended field use.

For prototyping and final assembly, a PCB solderable breadboard offers the perfect balance between development flexibility and permanent implementation. User interaction is facilitated through a 1.8" LCD display screen, providing real-time visual feedback of detected signals and system status. All components are housed within a rectangular plastic case, offering protection for the internal electronics while maintaining portability and ease of use in field applications.

The RF detector design carefully addresses several key constraints to ensure both compliance and user satisfaction. From an environmental perspective, the implementation of a rechargeable lithium-ion battery significantly reduces environmental footprint by minimizing disposable battery waste. The power management system has been optimized for energy efficiency through the 6-24V to 5V 1.5A regulator, which ensures minimal power consumption while maintaining reliable performance, further supporting sustainable operation throughout the device's lifecycle.

Socio-cultural considerations have been integrated through a sleek, unobtrusive rectangular case design that prioritizes user comfort and acceptance. This aesthetic approach helps ensure clients feel comfortable using the device in various settings without drawing unwanted attention or creating user discomfort. Additionally, the design adheres to strict regulatory requirements, particularly Part 15 of the FCC regulations, which mandates that even as an unintentional radiator, the detector must comply with specified emission limits. This compliance is achieved through careful circuit design, appropriate shielding measures, and strategic component placement within the enclosure to minimize any potential electromagnetic interference that could be generated by the detection circuitry itself.

Solution Design

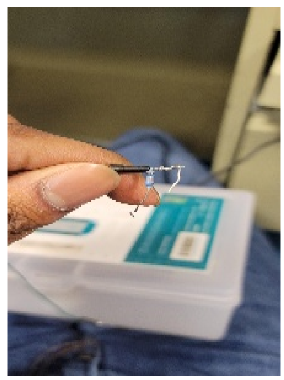


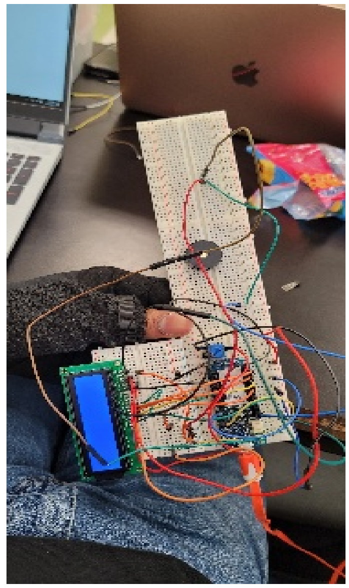
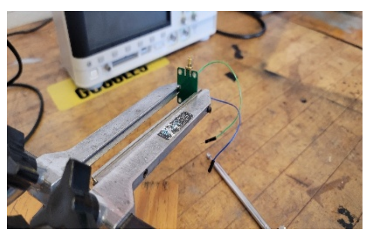
The radio frequency detector, powered by a rechargeable battery pack, **(1)**, will have an antenna **(6)** that can detect the specific RF waves in the environment. The antenna **(6)** is connected to a RF Module **(5)** to create electrical signals from the EM waves. The numerical value of the signals will be represented by the LCD board **(8)** and the buzzer **(7)** will alert when a strong signal is being picked up. The sensor will be controlled using an Arduino Board **(3)** for data collection. The power switch **(4)** will control the power coming to the Arduino board **(6)**. The 9V to 5V converter/regulator **(2)** will make sure the Arduino **(3)** does not receive excessive power which could damage the board.

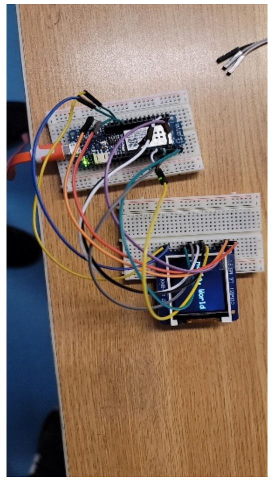
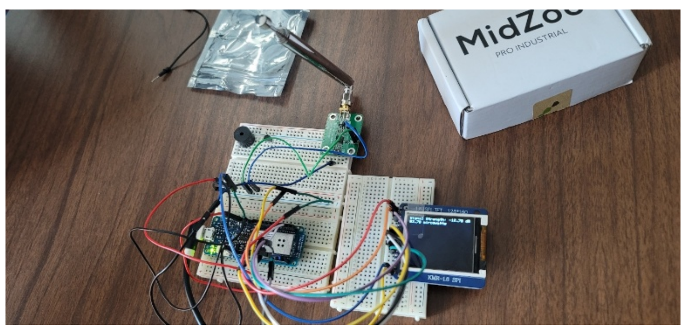
Project Implementation

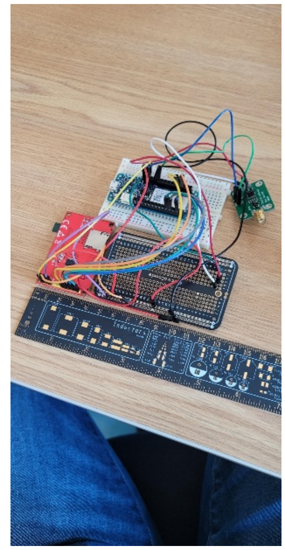
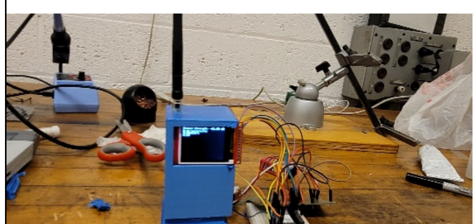
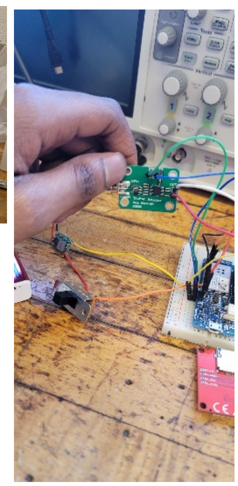
Starting Day of the Week	Sprint #	Increment (or intermediate working component)	Weekly Development Tasks
01/27/2025	**1**	Create the main function of the product, make sure the buzzer works properly, and set a "danger" level for the sensor.	Make the circuity for the buzzer.
02/03/2025			Make the buzzer react to the Arduino
02/10/2025			Decide on a proper level for the buzzer to sound off
02/17/2025	**2**	Set up the LCD to give value to the electrical readings	Install the antenna and RF module system and gain reading from it.
02/24/2025			Work on LCD system and check for functionality
03/03/2025	**SB**		Spring Break
03/10/2025	**2**		Combine the two systems together and have the LCD read values from the RF module.
03/17/2025	**3**	Create the box for the device and set up the battery power for it.	Set the 9V battery for the device with the converter
03/24/2025			Take the measurements for the device
03/31/2025			3D printing the Case

Project Implementation Process

Fridays (Meeting Days)	Weekly Development Tasks	Work and Division of Labor
01/31/2025	Make the circuit for the buzzer	All four of us made a circuit for the buzzer. We attempted to make a makeshift to no avail.  *Figure 1 - Failed Makeshift Antenna*
02/07/2025	Make the buzzer react to the Arduino	All four of us worked together to develop the program for the buzzer to function.

02/13/2025	Decide on a proper level for the buzzer to sound off	Using the temperature module, all four of us recreated the circuit and tested the buzzer and Arduino.  *Figure 2 - Full Temperature Reading Device*
02/21/2025	Install the antenna and RF module system and gain reading from it.	Chima installed the RF module and antenna. We set up the code to test the functionality of the antenna. (Our materials were received this sprint)  *Figure 3 - RF Module*

02/28/2025	Work on LCD system and check for functionality	Lance and Chima worked on the LCD system on a separate Arduino  *Figure 4 - Completed LCD Circuit* board.
03/07/2025	Spring Break	
03/14/2025	Combine the two systems together and have the LCD read values from the RF module.	All four of us combined the two systems together so that the LCD could report values from the antenna and RF module.  *Figure 5 - LCD and Antenna Module Connected*
03/21/2025	Set the 9V battery for the device with the converter	We had to use a non-rechargeable battery for testing. We need to buy the converter, and the order was delayed. Darnyieh bought and distributed the rest of the required materials
03/28/2025	Take the measurements for the device	Antoino, Lance and Chima took the measurements device for us to accurately print a 3D case.

		 *Figure 6 - Measuring Parts*
04/04/2025 onward	3D printing the case and solder the rest of the board	Antoino designed the box in CAD and sent the model to David (no member) for him to 3D print it.  *Figure 8 - Antenna and LCD in Box*  *Figure 7 - RF Module Soldered with Regulator and LCD*

Conclusion

The completion of the project was successful. The concept of protecting individuals from RF was utilized in the design of the product. The design of the project required learning of Arduino coding and wiring in order to create an implementation that utilizes the necessary components. Knowledge of essential components of RF measuring such as the RF module and antenna was also required in testing the product. Finally, the product casing was used to provide protection and aesthetic value to the design. The project was a beneficial experience in learning further implementations of the Arduino software. The project also strengthened the collaboration skills of the team that was involved in the process.

References

Admin. “The Electromagnetic Spectrum - Radio Waves.” *BYJUS*, BYJU’S, 5 Dec. 2022, byjus.com/physics/electromagnetic-spectrum-radio-waves/#:~:text=Radio%20waves%3A%20It%20is%20a,1%20mm%20to%20100%20km.

Cartwright, Anthony. “TUTORIAL: How to Work with a 1.8" SPI TFT with Strange Incorrect Labelling!” *YouTube*, YouTube, 18 Nov. 2017, www.youtube.com/watch?v=FGqRiPqg4Ds.

“Cuban Embassy Attacks and the Microwave Auditory Effect.” *Hackaday*, 29 Sept. 2017, hackaday.com/2017/09/25/cuban-embassy-attacks-and-the-microwave-auditory-effect/.

News, BBC. “‘Havana Syndrome’ Likely Caused by Directed Microwaves - US Report.” *BBC News*, BBC, 6 Dec. 2020, www.bbc.com/news/world-us-canada-55203844.