BRAC UNIVERSITY

CSE360: Computer Interfacing

Lab Project Report

Title: IoT-Based Parking System with RFID Authentication

by

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Abstract

Automated, secure, smart parking is becoming an integral requirement in our busy cities. The work, titled "IoT Based Parking system Using RFID Authentication," combines automation, real-time monitoring and security in a comprehensive design that presents a solid and cost-effective solution for the modern parking system. The system allows for smooth vehicle entry and exit with servo controlled gates, increased safety with unauthorized access alerts and the most efficient utilization of parking slots through IR sensor detection. Authorized users are granted access using RFID cards and all action is tracked in real time on the Blynk IoT platform for open viewing and remote access.

The central goal is to shift the current parking facilities into smart intelligent IoT-enabled parking areas. An RFID reader recognizes permitted vehicles and sends a signal to the Arduino controller that will spin the servo motor to open the gate. IR sensors are deployed to monitor the parking slot occupancy continuously while sending their data to ESP32 module in real time over WiFi to Blynk dashboard. When someone is attempting to enter unlawfully, a buzzer sounds to cause an alert. Seamless integration amongst components through digital I/O and communication protocols while Blynk is integrated for scalability and convenience to users.

With the prototype developed at an estimated cost of 4778 BDT, this solution embodies the transformative potential of automation and the IoT in reshaping the management of parking systems for optimal efficiency, safety, and accessibility. With its modular structure and expandability, the project not only provides a smart city solution for the future, but can even become part of larger intelligent transportation systems.

Keywords

Microcontroller, RFID, IoT, Smart Parking, Automation

1. Introduction

Incoming parking space management in urban areas is an epidemically challenging task, especially in closed properties (such as underground parking, high traffic buildings etc.). Many existing parking facilities still depend largely on manual supervision, whose often time-consuming, inconsistent, and error-prone nature gives rise to vandalism. Another major concern is the security of such areas, as vehicles parked in these areas can be subject to unauthorized access or theft. In Bangladesh, there is no comprehensive and well-deployed automated car vault or smart parking system that automatically enables people to leave their vehicles at a safe place unattended for long periods. For example, those visiting the airport frequently have difficulty finding secure parking for their vehicles and therefore must rely on ride-sharing services to get to their flights. This is both inconvenient, and another source of cost and stress that can only be made worse when paired with luggage or little ones in crowded environments.

Our project solves these problems by presenting an IoT-based smart parking system authenticated via RFID tag along with automatic gate control. The system combines vehicle detection, parking slot detection, real-time access control (RFID-based security), and unauthorized use detection. By automating the process and streamlining operations, it is hoping to provide a seamless and secure parking experience

for users. In addition, the system can be extended with other functions such as an automatic billing system, an intelligent lighting system or even fire detection modules for future versions.

In practical terms, the proposed system could be carried out in airports, shopping malls, universities, big business complexes, where there is a high demand for parking, and efficiency and security are very important. By developing a scalable intelligent solution, this project is taking a step in establishing the building blocks for more intelligent and sustainable urban mobility infrastructures.

2. Related Work/ Inspiration

In recent years, all around the world, so many efforts have been made to modernize parking management systems. Effort has gone into deploying infrared, or ultrasonic sensors to try and implement parking slot detection, while others have worked on camera-based number plate recognition for automatic entry. Although such systems are partial solutions, most of them suffer from either high implementation costs, dependence on advanced hardware, or the lack of availability for adaptation to a more confined low-budget environment such as in Bangladesh.

Looking at those systems across the globe and the gap with substantially affordable, safe, and scalable parking solutions was the key factor for inspiring our hardware. Alongside some large-scale real-world smart parking systems found in developed countries, we observed that there is no proper cost-effective IoT-enabled parking model which echoes access control combined with real-time monitoring for small-scale infrastructures. This is why we designed a solution combining the safety provided by the RFID-based authentication system with the ESP32 IoT communication technology and the live updating provided by the Blynk IoT platform during this event. By doing so our system ensures only authorized users can access the parking facility and it also offers real time visibility for slot occupancy.

What makes our work unique is the simplicity, relative cheapness, and versatility of the materials and techniques used. Instead of using costly cameras or complicated recognition algorithms, we've used off-the-shelf parts like RFID modules, IR sensors and microcontrollers to develop a working model that is both efficient and economical. This will help to scale up the system and deploy it in application scenarios such as universities, shopping malls or airports in Bangladesh, areas where the need for safe and automated parking management is continuously growing.

3. Technical Approach

System Architecture:

The proposed system is an Arduino and RFID-based automated parking management system with integrated safety features. The core of the system is the Arduino Uno microcontroller, which coordinates all modules and ensures smooth operation.

- **RFID Module**: Handles vehicle authentication for both entry and exit.
- **Real time Slot status**: This module uses IR sensor to continuously monitor parking slots to detect availability in real time.
- **Servo Motors**: Control entry and exit gates, automatically opening and closing based on RFID authentication and other conditions.
- **LCD Display**: Provides real-time updates of parking slot status, entry/exit events, and warnings.
- **Buzzer**: Issues alerts for denied entry, parking full, or smoke detection.
- **Smoke Detection Module**: Using MQ2 sensors, this module helps to detect smoke in the parking space. It continuously checks if there is any smoke.
- **Alcohol Detection before Exit:** Using MQ3 sensor, our system detects
- **IoT Dashboard**: Using an **esp 32 module** we extended the system to an IoT dashboard. It makes our system efficient in terms of remote monitoring and slot availability tracking.

Combining all the modules and components together, the system manages parking and safety very well. The block diagram of the system architecture is added below for clear visualization.

Block Diagram

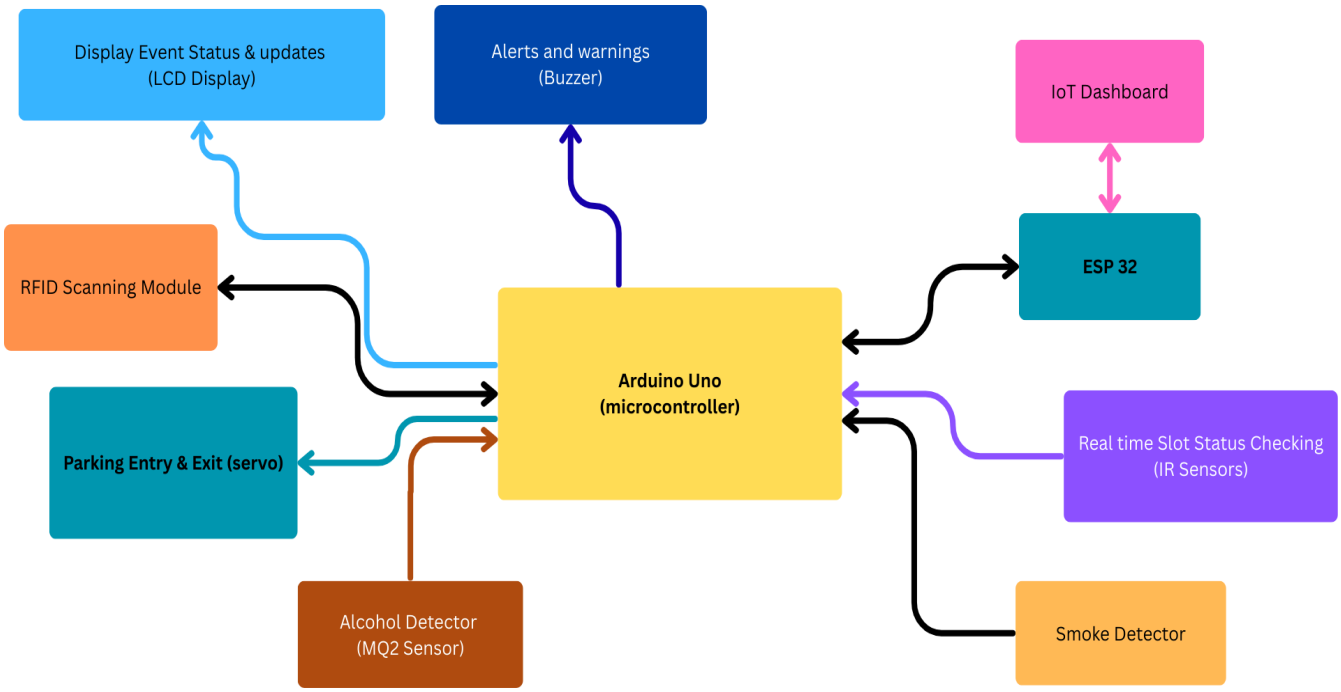


Fig: Block Diagram

Flowchart

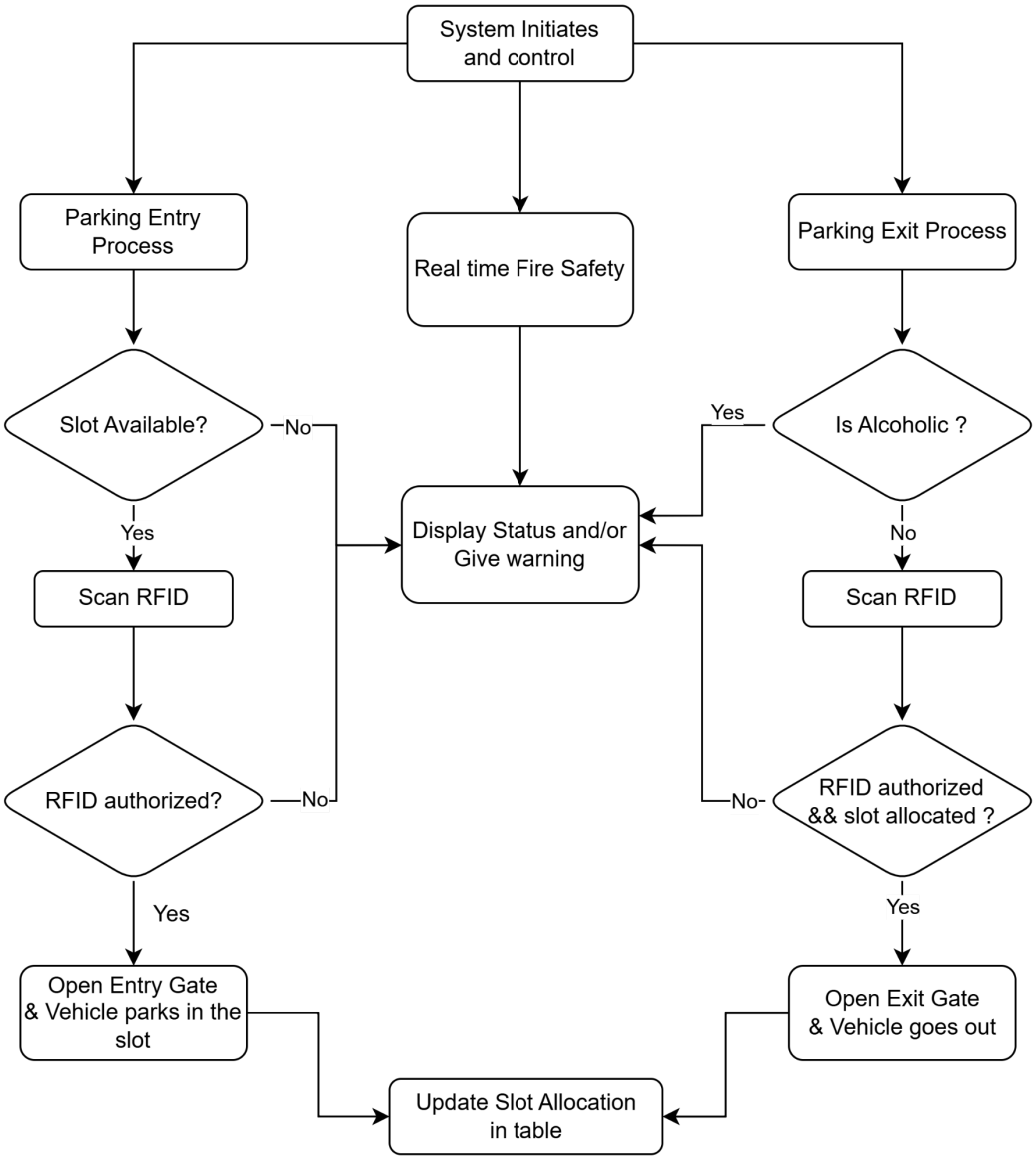


Fig: Flow Chart of our automated parking system

Components Used:

- **Arduino Uno:** Small but powerful micro controller, brain of the system
- **ESP 32:** A microcontroller with built-in wifi and bluetooth
- **MFRC 522:** RFID card scanner

- **MQ2:** Smoke or flammable gas detecting sensor.
- **MQ3:** Alcohol detecting sensor
- **Buzzer:** Small active buzzer used to make siren sound.
- **IR sensor:** Using IR rays it detects if something is in front of it or not.
- **I2C LCD:** It's a 16X4 LCD display used to display different types of writings.
- **Blynk App:** Popular tool for making IoT dashboard or interactive virtual buttons for circuit control.

Cost Breakdown:

Components	Price (BDT)
Arduino Uno	990
ESP 32	440
MFRC 522 x2	380
MQ2	146
MQ3	145
Buzzer	15
I2C LCD Display	692
IR Obstacle sensor X4	220
Servo motor X2	600
Wires	100
Bread Board (830 & 400 point)	215
Battery	315
Battery holder (4 cell X2 & 2 cell X1)	160
RTC DS3231	360
Total =	4778

Communication Protocol:

The system is built around a mix of communication protocols used to keep all modules in sync with one another. The RFID reader is interfaced with the arduino using SPI protocol, SPI protocol is fast and reliable data transfer protocol. Communication is accomplished using UART between Arduino and ESP32 for authenticating ESP32 and Arduino for IoT. Finally, the ESP32 is connected with Wi-Fi to the internet

and sends data to the Blynk platform where the real-time results are presented. Multiprotocol allows all portions of the system to communicate in a consistent and properly sequenced fashion, all the time.

Circuit/Schematic:

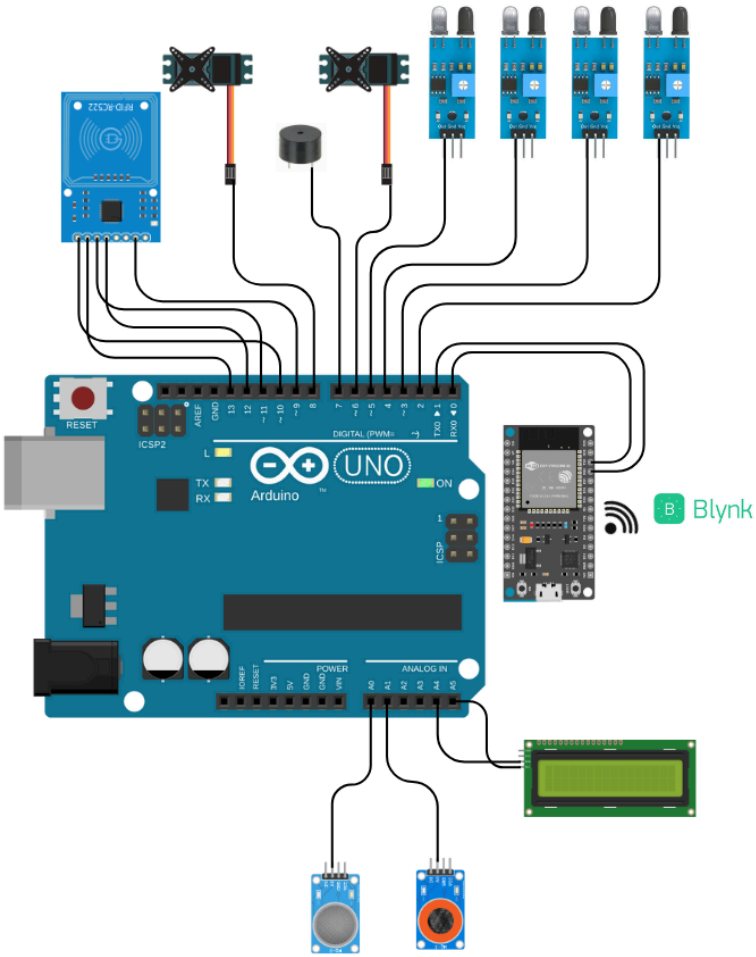
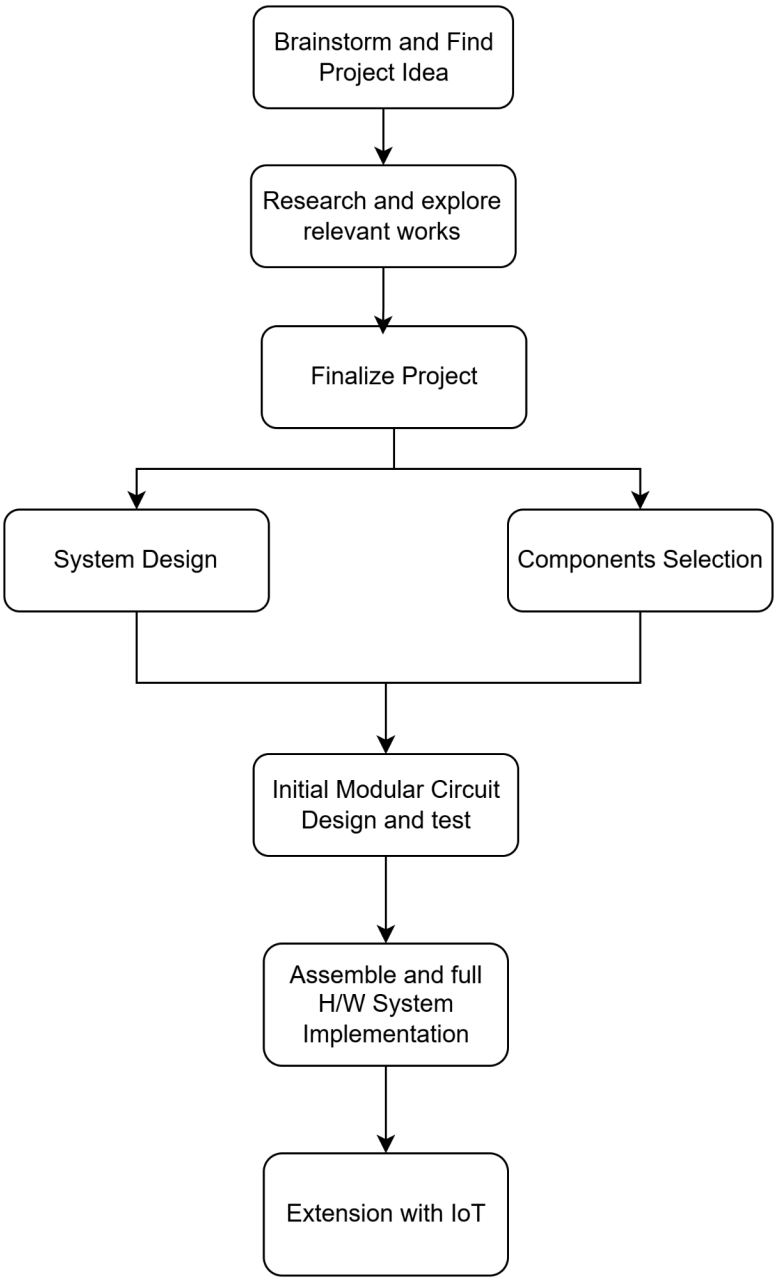


Fig: Circuit Diagram

Implementation:



Challenges:

The biggest challenge was to make sure that different components working on different volts are getting connected to the right connection. Like MFRC and ESP32 uses 3.3V to operate but all the other sensors and actuators use 5V for operation. To solve this problem we used the built-in 3.3V and 5V pin of Arduino Uno for power for the rest of the components.

Another challenge was to have an always ready and reliable wifi connection for the ESP 32 since the SSID and password are written in the code and pushed in the ESP32. To solve this we used a mobile hotspot that we can have anywhere with our prototype.

Lastly, among the components used we faced a problem making the RFID sensor work. It was getting connected but we were getting no reading from the sensor. After going through a lot of videos and forums we got the solution to this. Instead of connection with the recommended 3.3v power source, connecting it with a 5v power source was enough to solve this problem. The actual problem was the RFID sensor was not getting enough current from the 3.3v source that's why it was not working properly.

4. Sustainability & Impact

A major strength of this project is its sustainability: The design was intentionally kept low power, through the choice of microcontrollers and sensors, to allow reliable operation continuously for emerging markets that would not benefit from extra environmental impact through the ongoing use of inductive identification readers. Modular and reusable components - Components like the Arduino, ESP32, RFID reader, and IR sensors can be easily used in future projects, or upgraded with advancements in technology. Not only does this modularity reduce e-waste but it also means that the system could be economically viable in the long run. With some initial fine-tuning, the design can even be adapted to run on renewable energy replenished by solar panels, which can pave the way for a more sustainable and eco-friendly smart parking infrastructure.

The effect of such a system is also of great importance. On a societal level, it alleviates the reliance on manual work for regulation of the car park system, simplifies access to the system for cars entering or leaving, and minimizes the frustrations of the driving public that can spend a lot of time looking for a free space in a garage. From a security standpoint, RFID authentication ensures that only authorized vehicles are allowed access to the parking lot directly addressing the problem of unauthorized entry or misuse of parking hours. From a more macro standpoint, the project also serves to illustrate the impact that smarter, small-scale, low-cost IoT solutions can have on creating smarter cities.

In future the system can be scaled with features like automatic billing, mobile notifications, and camera-based license plate recognition to manage larger parking infrastructures. But there are still limitations to it, like the system relies heavily on Wi-Fi connectivity in order to get IoT updates, and its current prototype stage is more suited for small environments rather than large commercial lots. Despite these challenges, the project shows a clear example of how sustainable design, cost-efficiency and intelligent technology can work together to provide a parking solution that not only responds to the needs of today, but also helps to set in motion a smarter portfolio of more connected urban mobility.

5. Results & Discussion

After assembling all the hardware and software units, the system was tested under various conditions to judge its accuracy, reliability and other performances. We have also experienced the most flawless RFID authentication, where authoritative cards appear in unnoticeable time and serve to activate the servo

motors that can open the entry or exit gates without any noticeable delay. This showed that the system could deliver secure and efficient access control (one of its key goals). In all cases the unauthorized cards were rejected, and the buzzer properly sounded; in this way the design exhibited the security clearances.

The IR sensors performed well as well, with 100% accuracy in identifying whether or not a vehicle is present. This enabled the system to correctly keep track of parking slot availability. The information captured by the sensors was sent to the ESP32 which will in turn send real-time updates to Blynk IoT dashboard. The dashboard accurately and realistically shows the information of slot status during testing to provide users with a remote sense of parking status. This integration between the hardware components and the IoT platform demonstrated that the system was capable of performing live monitoring in a real-world setting.

Overall, the findings indicate that the project was able to achieve its main objectives of unifying security, automation, and real-time monitoring. The combination of the RFID module, arduino UNO, esp32, servo motors and IR sensors was smooth and led to a solid and integral prototype. It is noted that while there were a few stability problems of the Wi-Fi such as occasional connection breaks, this did not significantly impact usability of the system. The results obtained show that the proposed system is technically viable and applicable to real-world scenarios and that it has room for future development into a larger parking infrastructure with more capabilities.

6. Conclusion

Funded in response to ineffective parking provision, security issues and lack of automation in existing parking systems, this project aimed to overcome these barriers by creating a parking solution to benefit both drivers and operators. We constructed a prototype to show how RFIDs with access control, IR slot detection, and smart sensors can be combined with IoT via the ESP32 and Blynk platform to solve these issues at a low cost and with scale. In addition to ensuring that only authorized users can access the parking lot, the system also serves to provide real-time updates on slot availability, ensuring both security and convenience for users.

The system proved to be reliable, gate operation is correctly smooth, area is correctly detected and successful monitoring of vehicles in live using the IoT dashboard was achieved. While there are challenges ahead like Wi-Fi dependency and the scalability of the prototypes, the results prove that the system is practical and can be expanded to real-world locations such as universities, shopping malls and airports.

Apart from its technical achievements, the project also bears witness to the importance of sustainability and efficiency. By utilizing lower power, modular, reconfigurable and upgradeable components, the system illustrates an environmentally minded design. At the same time, the social and economic value action is derived from the potential for reduced manual supervision, the resulting efficiency improvement, and the use of secure parking. In addition to resolving an impasse, this project serves as a prototype for intelligent infrastructure necessary to build cities of the future.

7. Contribution

Name	ID	Role(s) / Responsibilities	Specific Contributions
Syed Faysel Ahammad Rajo	21101078	Circuit building, Software Design	● Hands on circuit building ● Wrote code for Arduino
Mehedi Hasan Shahed	21301436	Hardware design, Software Design	● Selected the required components and design the connections ● Wrote code for ESP32
Zarin Tasnim Raisa	21301022	Circuit building, Report Writing	● Hands on Circuit building ● Did research and report writing

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