SMART ENERGY MANAGEMENT SYSTEM FOR AUDITORIUMS USING VISITOR COUNT ANALYTICS

O. Saritha[1], D. Sumalatha[1], V. Ravi Kumar[1]

[1]Department of Electronics and Communication Engineering

[1]Sree Dattha Institute of Engineering and Science, Sheriguda, Hyderabad, Telangana

ABSTRACT

With the increasing standard of living, there is a growing demand for automation to simplify daily life. This work aims to develop a microcontroller-based system that automatically counts the number of people entering and exiting a room and displays the count on an IoT platform. The system utilizes two IR sensors placed at a fixed distance apart to detect the movement of individuals. When a person interrupts the first sensor, the count increases, and when they cross the second sensor, the count decreases. This real-time count determines the activation of electrical appliances like lights and fans. If the room is occupied, the system automatically switches on the lights and fans, and when the count drops to zero, the appliances turn off to conserve energy. The microcontroller processes the input from the IR sensors and communicates with the IoT module to display the occupancy count. This intelligent automation enhances convenience and energy efficiency, making it suitable for various applications in homes, offices, and public spaces.

Keywords: Visitor Count, Auditorium, Smart Power Saving System, Iot, Automatic Appliances, IR Sensors, Controller-Based Model, Crowd Detection, Energy Efficiency

1.INTRODUCTION

In the pursuit of sustainable and energy-efficient solutions, this project presents an innovative Visitor Count-Based Auditorium Smart Power Saving System to optimize energy consumption in public spaces. Auditoriums often experience fluctuating occupancy levels, making conventional energy management inefficient. To address this challenge, the system dynamically adjusts power usage by continuously monitoring real-time visitor counts. Using advanced technologies such as motion sensors and occupancy detectors, the system accurately tracks audience presence and autonomously regulates lighting and climate control. When occupancy increases, the system ensures adequate illumination and ventilation, and when the auditorium is empty or partially occupied, it reduces power consumption to conserve energy. A centralized control system acts as the core of this smart infrastructure, enabling seamless monitoring and automated adjustments to enhance efficiency. By integrating IoT-based data analysis, the system optimizes energy usage, reducing operational costs while promoting sustainability. This intelligent power-saving solution is ideal for auditoriums, conference halls, and large venues, ensuring an eco-friendly, cost-effective, and technologically advanced approach to energy management. This project not only contributes to environmental sustainability but also promises tangible cost savings for auditoriums. The introduction of this smart power-saving system marks a significant leap towards efficient resource management in public spaces, embodying a commitment to both technological innovation and ecological responsibility. As we delve into the details of our methodology, implementation, and results, the transformation potential of this system becomes evident in shaping the future of energy-conscious auditorium operations.

In today's world, there is a continuous need for automatic appliances. With the increase in standard of living, there is a sense of urgency for developing circuits that would ease the complexity of life. Many times we need to monitor the people visiting some place like an auditorium or shopping malls.

To provide solution for this we are going to implement a project called “Bi Directional Digital Building Automation Visitor Counter” with automatic room light control. This project has a “Building Automation Visitor Counter”. Basic concept behind this project is to measure and display the number of persons entering in any room like seminar hall, conference room etc. LCD displays number of person inside the room. We can use this project to count and display the number of visitors entering inside any conference room or seminar hall. This works in a two way.

PROBLEM STATEMENT

Developing a smart power-saving system for auditoriums based on visitor count faces challenges such as accurately tracking occupancy, integrating IoT sensors seamlessly, ensuring real-time data communication, and implementing an intelligent power management algorithm. Addressing these issues is crucial to create an efficient and reliable solution that optimizes energy usage in auditoriums while providing a comfortable environment for occupants.

In today's technologically advanced world, there is a growing demand for efficient energy consumption in various sectors. One critical area where energy optimization is crucial is in electronic devices and systems. The goal of this project is to design and implement a Bidirectional Count Based Smart Power Saving System for electronic devices, with a focus on improving energy efficiency without compromising performance.

Inadequate Real-time Monitoring:

•Existing systems may not offer comprehensive real-time monitoring capabilities. Without accurate and up-to-date information on device usage, it becomes challenging to implement dynamic and effective power-saving measures**.**

Security Concerns:

• Security is a critical aspect, especially as power-saving systems may involve the collection and analysis of user data. Existing systems might not have robust security measures, exposing users to potential privacy risks.

Insufficient Unidirectional Analysis:

• Unidirectional power-saving systems often focus on minimizing power consumption during idle periods but may neglect scenarios where the user needs rapid responsiveness. A bidirectional approach that considers both low and high usage scenarios is essential for optimal performance.

User Frustration:

•Users may find power-saving mechanisms intrusive or too restrictive, leading to frustration and potential disengagement from energy-saving practices.

Inaccurate Power Profiling:

•Lack of accurate profiling of power usage patterns may result in inefficient power-saving decisions, leading to subpar energy conservation.

2. LITERATURE REVIEW

Our main aim in this paper adds constructing a Building Automation Visitor Counter which will make a controller circuit model to count and calculate the number of guest in a building or room at a particular time and all the electrical appliances will be turned on and off accordingly.It is also our aim that this controller base circuit model beeps a warning alarm for safety purposes when the capacity of the building and the temperature exceeds.

[1].**Yang, et.al** developed Visitor counting had been attractive to various applications, like business management and marketing investigation. In recent years, many studies had employed wireless signals to achieve visitor counting without people's active participation and privacy intrusion. However, existing systems mainly counted the overall visitors inside a certain area, which failed to provide the fine-grained information of the coming and leaving visitor flow. Unlike previous studies, this article proposed to count the in-and-out visitors to monitor visiting frequency and population, which could be applied for many indoor places, such as shops and restaurants. Therefore, the first WiFi-based in-and-out visitor counting system, Door-Monitor, was presented, which obtained the direction (enter or exit) and the number of visitors passing by the door. The WiFi signals enabled us to count the visitors in a low-cost and non intrusive way, and it could tell the exact number of visitors even when multiple persons passed by the door simultaneously. To detect the visitors' passing direction, it was shown that the patterns in the phase difference series could indicate the entering and exiting passing directions by analyzing the effects of the passing behavior on the signal's phase information. To count the passing visitors, a short time Fourier transformation was performed on the phase difference series to generate the spectrogram, on which the convolutional neural network was applied to build a counting model. The experimental results showed that the average accuracies of passing direction detection and visitor counting were 95.2% and 94.5%, respectively.

[2].**Cao, et.al** developed The standardized IPv6 Routing Protocol for Low-power and Lossy Networks (RPL) enabled efficient communications between thousands of smart devices, sensors, and actuators in a bi-directional and end-to-end manner, allowing the connection of resource-constrained devices in multi-hop IoT infrastructures. RPL faced severe congestion and load balancing problems, leading to a low Packet Delivery Ratio (PDR) in the network. For the first time since the declaration of RPL, in this literature, it was explained that ignoring the specifications of the reception and transmission buffers in heterogeneous networks caused these unbalanced traffic loads, leading to congestion and consequently the loss of packets in RPL. To resolve this problem, this literature introduced CBR-RPL; a lightweight RPL-based routing mechanism that organized the nodes into logical clusters and routed the packets through a novel drop-aware Objective Function (OF). The newly defined OF considered the queue occupancy of the nodes' transceivers along with their drop rate simultaneously. According to an extensive set of experiments conducted via the Cooja simulator, it was observed that CBR-RPL improved the reliability in terms of PDR by 38.2% and 75% compared to RPL and QURPL, respectively. Additionally, CBR-RPL also improved the amount of energy consumption in the nodes by up to 3× compared to the state-of-the-art, mainly due to imposing fewer control packets on the network.

[3].**Zhang, et.al** developed The proliferation of the Internet of Things (IoT) fostered growing attention to real-time locating systems (RTLSs) using radio frequency identification (RFID) for asset management, which could automatically identify and track physical objects within indoor or confined environments. Various RFID indoor locating systems were proposed. However, most of them were inappropriate for large-scale IoT applications owing to severe radio multipath, diffraction, and reflection. In this literature, a newly fashioned RTLS using active RFID for the IoT, i.e., iLocate, was proposed, which located objects at high levels of accuracy up to 30 cm with ultra long distance transmission. To achieve fine-grained localization accuracy, iLocate presented the concept of virtual reference tags. To overcome signal multipath, iLocate employed a frequency-hopping technique to schedule RFID communication. To support large-scale RFID networks, iLocate leveraged ZigBee. All hardware was implemented using 2.45-GHz RFID chips so that each active tag could communicate

with readers that were around 1000 m away in a free space. An empirical study and real project deployment showed the superiority of the proposed system with respect to the localization accuracy and the data transmission rate for large-scale active RFID networks.

[4].**Rivera, et.al** development in **2020,** the Philippines succumbed to the pandemic brought by the COVID-19 virus. Businesses were forced to shut down, and lockdown protocols, like social distancing and limited capacity, were implemented. Despite the closing of recreational establishments, electricity consumption in households spiked since people were mandated to stay at home and have a virtual setup for employees and students. With these in mind, the researchers conducted a study on the development of an Energy-Saving Wireless Bidirectional People Counter with Notification and Data Storing Systems to aid people in making energy-saving efforts, implement a maximum capacity of establishments, and provide information to business owners about their foot traffic. The prototype utilized ultrasonic sensors for detecting the number of people entering and leaving an area, light-dependent resistors for detecting ample amounts of light energy present in an area, LED lights and speakers for notification and alarm systems, relay modules for controlling the connected bulb and fan, and Arduino Uno for controlling the other components of the prototype. Through the data from the prototype, the bulb and fan were controlled; when there was human presence in an area, the bulb and fan were on and, otherwise, off. The prototype was 100% accurate in controlling the LED lights, alarm, bulb, and fan. On the other hand, a success rate of 86.27% and an error of 13.72% regarding ultrasonic sensors were recorded. Overall, the prototype saved energy, and a return on investment was theoretically possible if the controlled loads were 36-Watt bulbs and 48-Watt fans or higher.

[5].**Therib, et.al** developed this research presented the design of a smart digital bidirectional visitor counter (SDBVC). The million religious visits, especially in Iraq, increased the need for accurate smart counting systems for humans to count the largest gathering of people in one place. The major focus was on counting a huge number of humans entering one place from multiple entrance gates. The central processing unit (CPU) received all the data from these gates and finally made studies about the overall human number, men number, women number, the period of the day that this number reached the highest and smallest number, and so on. The proposed project hardware contained multiple Wi-Fi-based Arduino micro controllers (like Node-MCU Arduino): one Arduino in each gate, which was called a transmitter, and one in the CPU, which was called a receiver. Multiple ultrasonic sensors for each transmitter were placed on the entrance gates (men gates data separated from women gates data). ThingSpeak.com was used to save the large recorded data for a long time, for example, many days, and give results and records about the number, such as the Arba'een Pilgrimage for Imam Hussein shrine in Iraq. The proposed system gave accurate results on the number of entered and exited people to and from one place.

[6].**Choi, et.al** developed in this literature, a system based on impulse radio ultra-wide band (IR-UWB) radar sensors was proposed for counting multiple people passing through a passage or a wide door. The proposed counting system utilized two IR-UWB radar sensors equipped with antennas that had a narrow beam width to form two invisible electronic layers in the path. The two electronic layers were used for sensing and direction recognition of multiple people passing by. Algorithmically, sensing and direction recognition of a person passing through a path were performed considering both information of a received signal in each radar and mutual information between two radar signals. The proposed counting system was implemented with two radar modules designed using commercial radar ICs and a Raspberry Pi 2 module. The designed modules were installed in a subway station to verify their performance. Data were acquired for one week, and the counting performance was verified for various time intervals, such

as 2 minutes, 1 hour, and 1 day. Except for a few cases, counting results with errors less than 10% were obtained.

[7].**Anuradha, et.al** developed The objective of this literature was to make a controller-based model to count the number of vehicles in and out of a corporate company, with data being sent to the concerned person through GSM. In this literature, RFID Reader was used to detect the presence of a vehicle. According to this, if an RFID card was placed, it worked as an in count. The gate would automatically open and close depending on the vehicle's presence, and if scanned again, it would be counted as a down count. This count value was sent via SMS through GSM. Depending on the count inside the room, the lights would turn on, and when the count in the room decreased, the lights would automatically turn off. When the data corresponded to the data on the microcontroller, the load was switched, controlled by the relay from the output of the microcontroller. If the correct tag was disabled, the system would display the message "AUTHORIZED" or "UNAUTHORIZED" and would not allow access. In addition to LCD screens, bulbs were used as lamps. The project could be further improved by integrating it with GSM technology, where any unauthorized entry could be reported to the security staff via SMS.

3.PROPOSED SYSTEM

In this bidirectional circuit two infrared (IR) sensor components are used for up and down counting, respectively. Whenever an interruption is observed by the IR sensor then the IR sensors increment the value of counter and whenever the second sensor detects any obstacle, the counter is decremented. The number of interruption count depend upon the sensor's input and displayed on a set of seven segment displays by using the concept of multiplexing (for concept of multiplexing refer seven segment multiplexing).

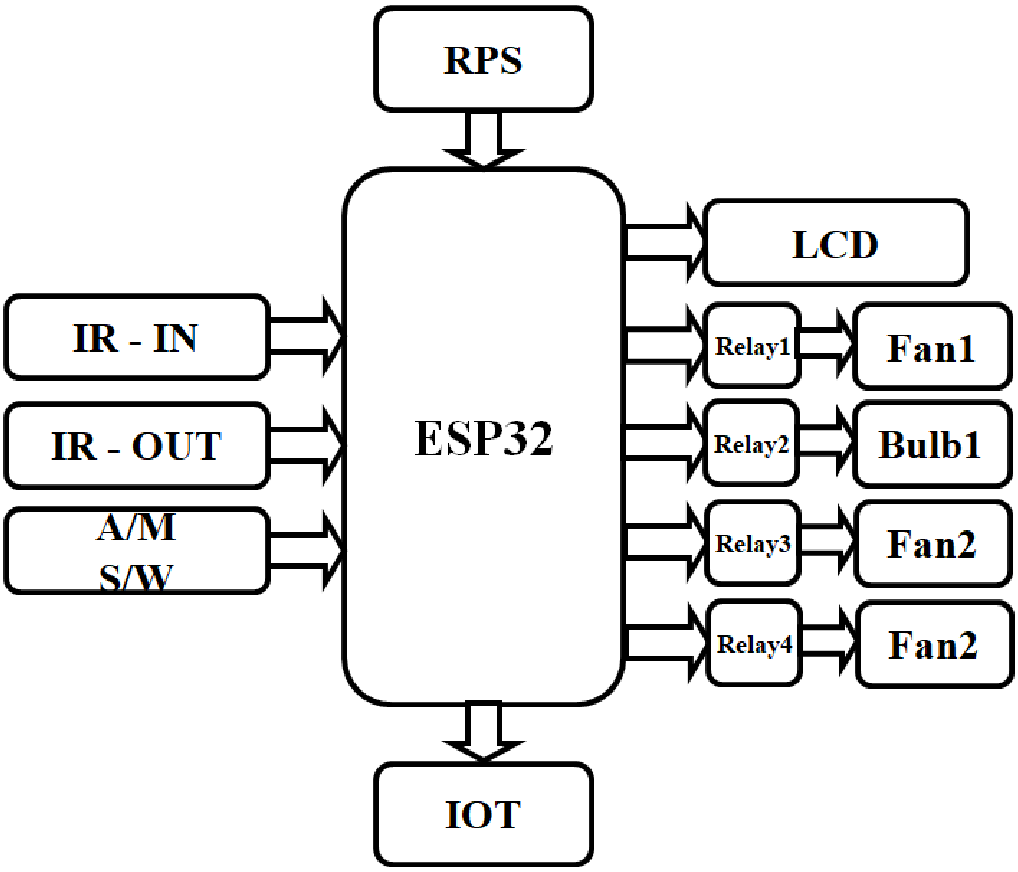
The IR sensor input is defined as up and down selector mode for the counter in the code. Every time the first sensor is blocked, the first sensor gives a high voltage signals and the count the value gets incremented. The value of second sensor gets decremented when connected to second a sensor, gives high input. At every setup, the value of the counter is sent and Digital Building Automation Visitor Counter displayed it on the Sensor, gives high input. At every setup, the value of the counter is sent and displayed it on the LCD module.

The visitor counting mechanism serves as the foundation of the system, employing cutting-edge technologies such as computer vision or advanced sensors. This involves the utilization of image processing algorithms or sensor data analysis to accurately determine the real-time occupancy levels within the auditorium.

The heart of the system lies in its energy optimization algorithms, designed to dynamically adjust various parameters such as lighting, HVAC systems, and other electrical appliances based on the bidirectional analysis of visitor counts. These algorithms ensure a balance between energy conservation during low occupancy periods and meeting the demands of high occupancy scenarios.

The user-friendly interface provides administrators with a visual representation of the auditorium'scurrent occupancy and power settings. This interface incorporates data visualization techniques to present real-time insights into energy consumption patterns, empowering administrators to make inform

BLOCK DIAGRAM:



The above block diagram consists of IR-IN ,and IR-OUT sensors which sense the persons entering and exiting the auditorium .And provided with two mode switch either automatic or manual mode, ON-OFF switch also given at input side.

And the LCD is used to display to data which is sensed by the given IR sensors.

It consists of four relays R1,R2,R3,R4 which are connected to fan 1,fan 2 ,bulb1 and bulb2.

To control the device from web application we are using IOT which provides accurate data.

A new version Raspberry pi pico /ESP32 is used in this model .

Modern Trends

Earlier attempts of counter Systems were harder to program and larger complex circuits.These designs were not completely automated as a user is required to manually increase or decrease the values by pressing the buttons, and this serve as a great limitation to the system.

Arduino

Arduino is simply an open hardware development board used by tinkerers, software developers, innovators, and inventors to design and build devices that communicate with the real-time situations. It was originally developed in Ivrea, Italy .Arduino boards can convert inputs like light on a sensor or a finger on a button and convert them to outputs like triggering an engine or turning on an LED. Boards are programmed by giving a series of commands to the board's micro controller .

Project Working:

There are five modules in the project they are:

1)REGULATED POWER SUPPLY

2)INPUT SECTION

IR-IN
IR-OUT
Mode Switch
ON/OFF

3)OUTPUT SECTION

LCD
Relay1, Relay2, Relay3, Relay4
Fan1, Fan2
Bulb1, Bulb2

4)IOT

5)SOFTWARE

Power Supply (RPS): This provides power for the entire system.IR Sensors (Sensor 1 and Sensor 2): These sensors continuously monitor the presence of people (obstacles). Sensor 1 detects entry, while Sensor 2 detects exit. if sensor 1 senses a person it informs controller that a person has entered so that controller can increment the count at the same time it gives a delay of 1sec so that the person can cross the sensor 2 and the count is maintained correctly. when a person exits, the sensor 2informs the controller to decrement the count. Similarly, it also provides a delay of 1sec to maintain count properly.

Controller: The controller manages the entire system. When Sensor 1 detects a person entering, it informs the controller to increment the count after a 1-second delay, allowing the person to cross Sensor 2. Similarly, when Sensor 2 detects a person exiting, it informs the controller to decrement the count after a 1-second delay.

Count Display (LCD): A 16x2 Liquid Crystal Display (LCD) is used to show the current count of people inside the auditorium.The LCD (Liquid Crystal Display) serves as a vital interface for conveying real-time information to users. Its primary function is to display the current count of visitors inside the auditorium, which is continually updated based on inputs from IR sensors and the system controller. Additionally, the LCD indicates the operating mode of the system, whether it's in Automatic Mode, Manual Mode, or Web Count Mode, offering users clear feedback on the system's status. It also displays status messages, such as system initialization or mode changes, and provides error messages to alert users of any malfunctions.

LED Indicator: An LED indicator is used to show if there's at least one person inside the auditorium. It will glow if there's at least one person, and remain off otherwise.

Modes of Operation:

1.Automatic mode

2.Manual mode

3.Web count

Automatic Mode: Data including count increments and decrements is uploaded to a server. Based on this data, other equipment such as lights and fans can be automatically controlled.

Manual Mode: In this mode, a Wi-Fi module is used to allow operators to control the system remotely.The operator controls the mechanism of ON/OFF using mobile phone or laptop from anywhere

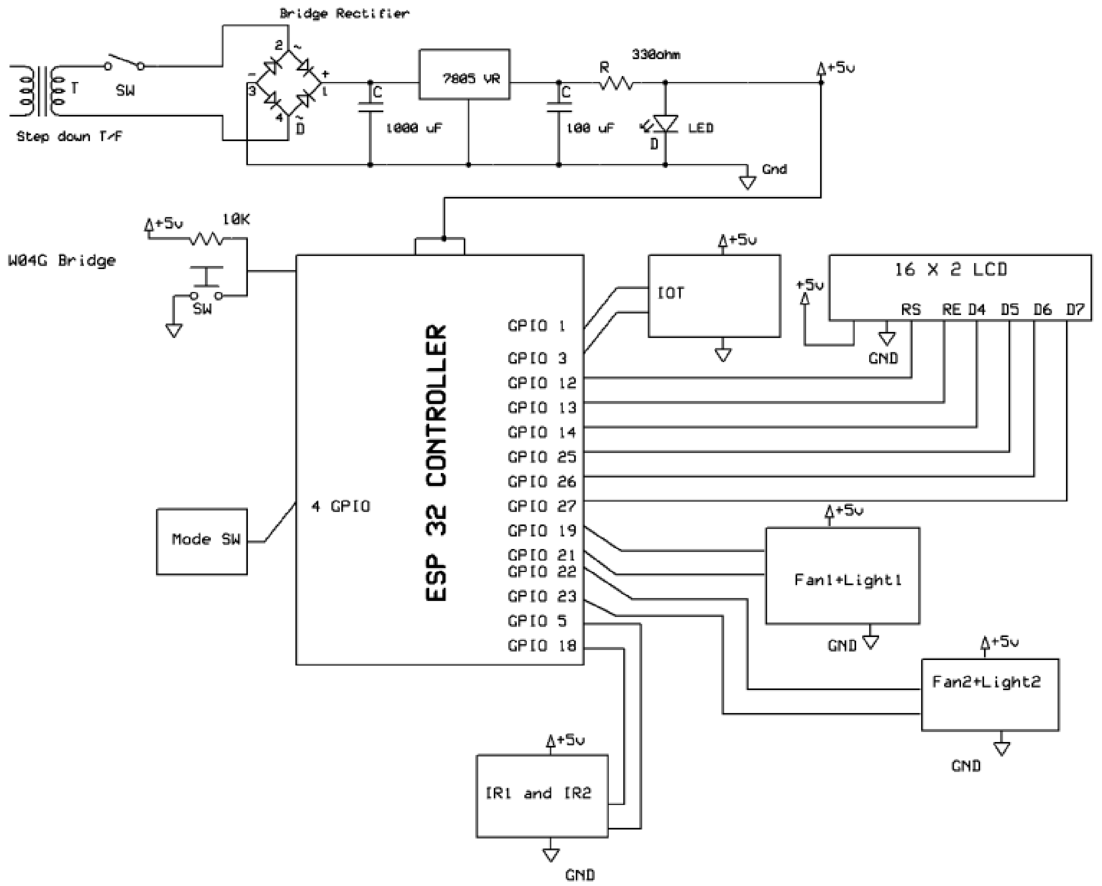
Web Count: Presumably, in this mode, the system provides data on occupancy via a web interface. ESP32 WIFI module is used in the web-based application.

Relays: Relays are used as electrically operated switches to control other equipment like fans and bulbs. The delay serves as a switching operation, presumably to avoid rapid cycling of the devices.

IOT: In this project, IoT plays a crucial role by using sensors to track the number of people in the auditorium. Based on the visitor count, the system can adjust lighting, temperature, and other power-consuming elements to optimize energy usage. This helps in reducing energy waste and lowering costs while ensuring a comfortable environment for the audience. It's a smart way to make the auditorium more efficient and eco-friendly.

Overall, this system efficiently manages the occupancy of the auditorium, provides real-time information about the number of people inside, and allows for automatic or manual control of associated equipment based on occupancy data.

CIRCUIT DIAGRAM:



DESCRIPTION:

For IoT projects, we need to use a microcontroller. ESP32 is one such microcontroller that can be used to start learning IOT and making IOT circuits. ESP32 is used for a variety of applications including the use of wifi, transmitters, and receiver devices, Serial Peripheral Interfaces, analog and digital devices, and lots of sensors. **ESP32** is a series of low-cost, low-power system on a chip microcontrollers with integrated Wi-Fi and dual-mode Bluetooth. The ESP32 series employs either a Tensilica Xtensa LX6 microprocessor in both dual-core and single-core variations, Xtensa LX7 dual-core microprocessor or a single-core RISC-V microprocessor and includes built-in antenna switches, RF balun, power amplifier, low-noise receive amplifier, filters, and power-management modules.

GPIO pins is called general purpose input output pins.

Mode switch is connected to pin 4.

16*2 LCD Monitor has connected with the GPIO pins 12,13,14,25,26,27.

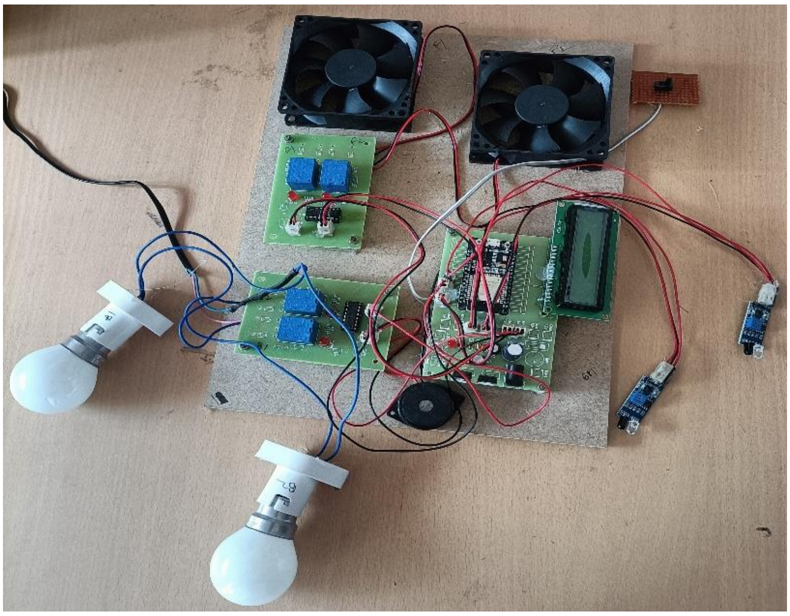
Iot is connected to GPIO pin 1,3.

Fan1 and light1 is connected to pins 19,21.

Fan 2 and light 2 is connected to pin 22,23.

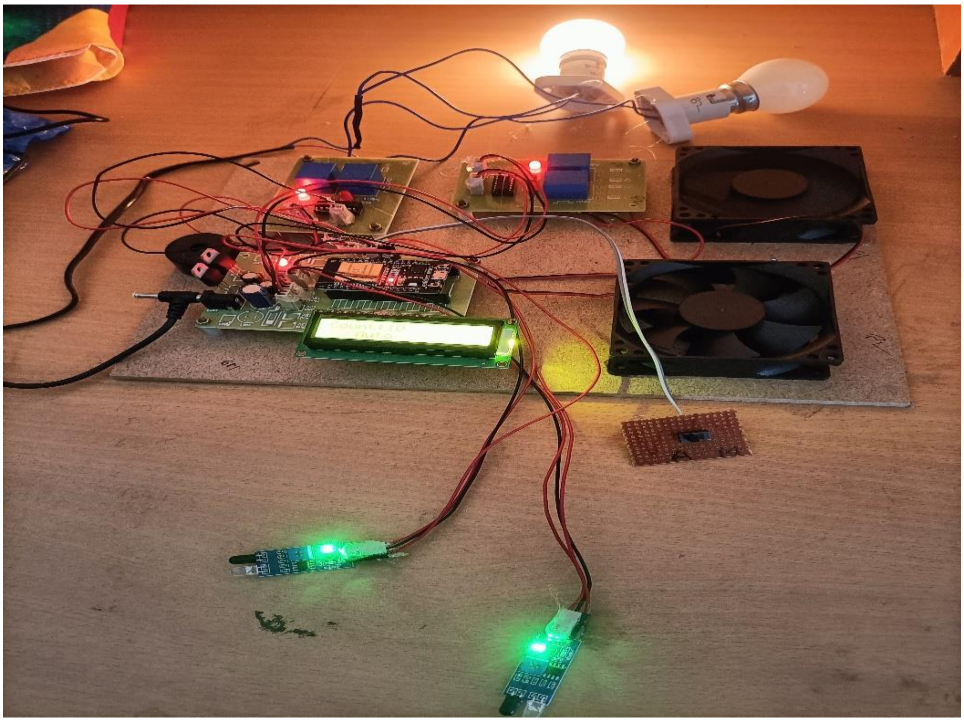
And the IR sensors are connected to GPIO 5,18 pins.

4.RESULTS

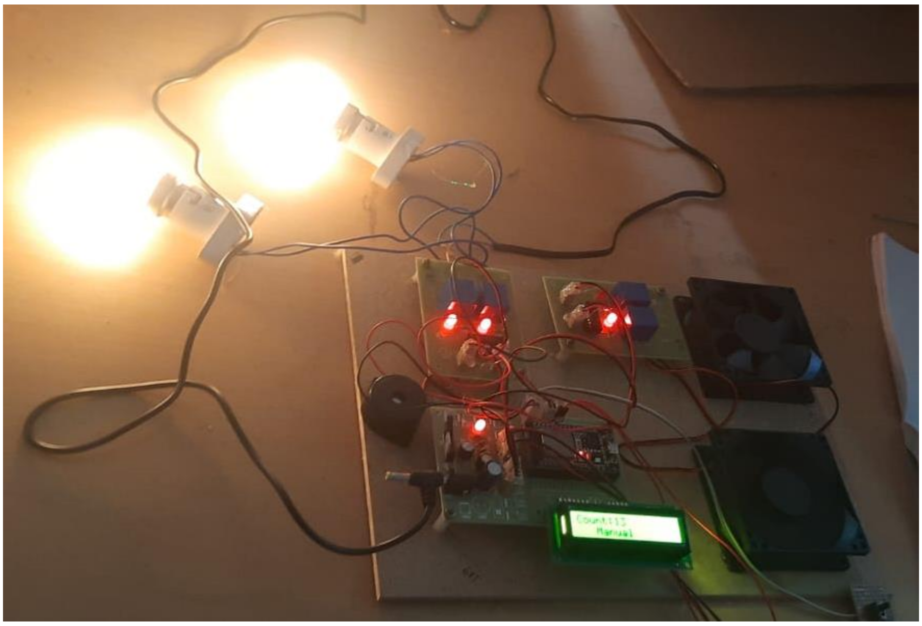


The above image shows the hardware equipment of the project. The kit is turned ON by giving the regulated power supply of 12v which is then converted to 5v dc current. The LED is the indication for 5v current so, if there is 5v current then automatically the LED glows. The generated 5v dc current passes to every hardware component in the circuit

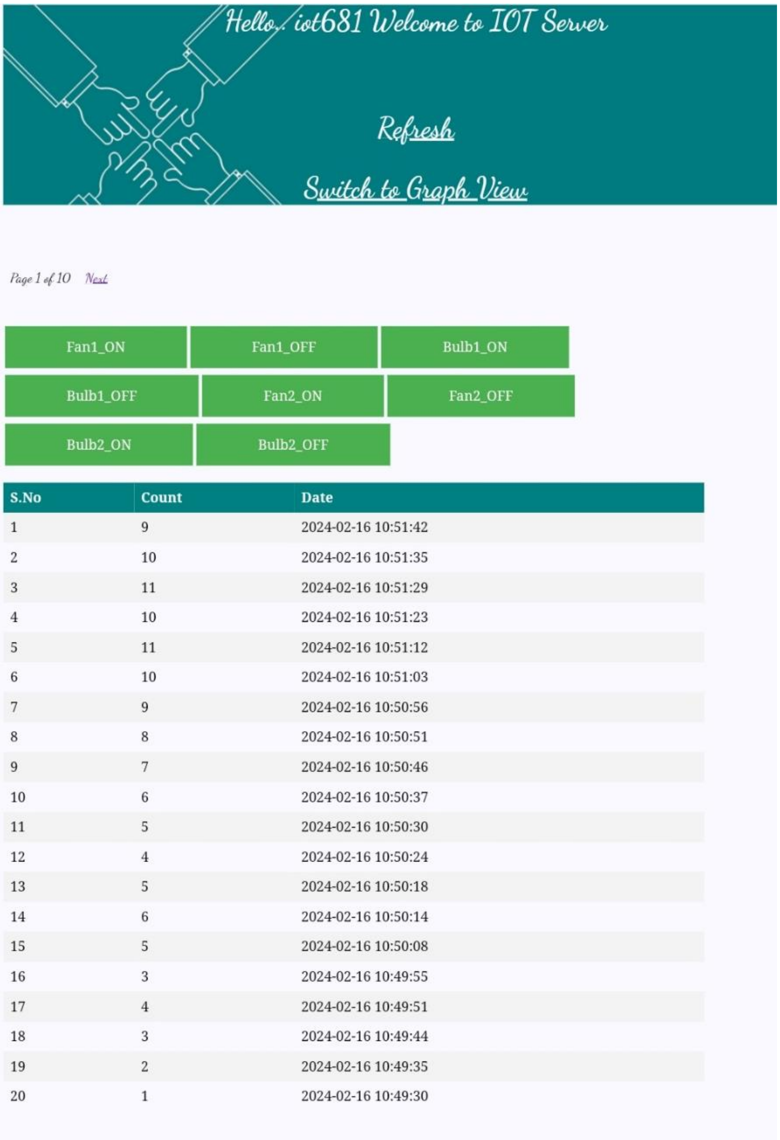
After providing power supply the title of the project will be displayed. The output is seen in the following image after we have connected the IoT module via a WIFI connection.



As shown in the above figure only one light and one fan is turned on as the count value is in the range between 1 to 10 members when it is in either automatic or manual mode.



The above figure shows the circuitry is under manual mode. If the range exceeds more than10 members, then two bulbs and two fans will be turned On. If again the people are decreased then the bulb and light will be turned off.



S.No	Count	Date
1	9	2024-02-16 10:51:42
2	10	2024-02-16 10:51:35
3	11	2024-02-16 10:51:29
4	10	2024-02-16 10:51:23
5	11	2024-02-16 10:51:12
6	10	2024-02-16 10:51:03
7	9	2024-02-16 10:50:56
8	8	2024-02-16 10:50:51
9	7	2024-02-16 10:50:46
10	6	2024-02-16 10:50:37
11	5	2024-02-16 10:50:30
12	4	2024-02-16 10:50:24
13	5	2024-02-16 10:50:18
14	6	2024-02-16 10:50:14
15	5	2024-02-16 10:50:08
16	3	2024-02-16 10:49:55
17	4	2024-02-16 10:49:51
18	3	2024-02-16 10:49:44
19	2	2024-02-16 10:49:35
20	1	2024-02-16 10:49:30

The entries of each and every person data is uploaded in the website by using ESP8266 IoT module. The entry and exit of the person is uploaded from time to time in the server and we can see and operate it at anytime from anywhere.

5.CONCLUSION

This project deals with the usage of the energy in this competitive world of electricity. This project saves more electric power than it seems and also collaborates the knowledge of electric and digital study. The functioning also teaches us how we can preserve electricity even in the electricity-based project. This system is an effective way for the power management, automatic device control and together count and power consumption. Controlling circuit used in this project controls the devices like fans, lights etc. This system can be used to operate other devices for the effective power usage.

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