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POWER SAVING, SAFETY AND REMOTE CONTROLLING OF SMART BUILDING BASED ON IoT

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The study on "**Power Saving, Safety and Remote Controlling of Smart Building Based on IoT**" prepared by farhad MOHAMMED-AMEEN under the consultancy of Asst.Prof.Dr.Mehmet Bilal ER has been accepted as a MASTER'S THESIS in Harran University Graduate Office by the following jury unanimously on 29/07/2022.

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I confirm that this thesis was prepared in the Department of Computer Engineering and is organized according to the rules of the Institute.

Prof. Dr. İsmail HİLALİ
Director of the Institution

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IoT'ye Dayalı AKILLI BİNALARIN GÜÇ TASARRUFU, GÜVENLİK VE UZAKTAN KONTROLÜ

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Günümüzde teknolojinin ilerlemesiyle birlikte internet ve akıllı teknoloji başta olmak üzere hayatın her alanında her şey dijitalleşiyor. Teknolojinin bu hızlı gelişimi, akıllı bina kontrol sistemleri gibi otomasyon sistemlerini (AS) de kapsamaktadır. Bu çalışma akıllı binalardaki elektrikli aletlerin güç tüketimini ve güvenliğini kontrol etmek için bir model önermektedir. Bu yöntem, yapı aletleri uzaktan kumandası ve bina güvenliği olmak üzere iki modelden oluşmaktadır. İlk model, cihazların uzaktan kontrolü ve binalardaki güç tüketimini azaltmak için tasarlanırken, ikinci model ise binalarda sıcaklık, nem (DHT22) ve gazın sensorlar ile kontrolü ile bina güvenliğini artırmak için tasarlanmıştır. Tasarlanan sistem, Nesnelerin İnterneti (IoT) teknolojisine dayanmaktadır. Bu sistemde mikrodenetleyici olarak NodeMCU kartı ve Blynk uygulama yazılımı kullanılmıştır. Klima (A/C), TV, Lambalar ve şofben (W-H) gibi bina elektrikli cihazları sistem Kontrol Panosuna (CB) bağlanarak kontrol edilmektedir. Bina sahibi, internet bağlantısı üzerinden Blynk mobil uygulamasını kullanarak cihazların durumunu izleyebilecek ve kontrol edebilecektir. Ayrıca bu sistemde, bina güvenliği Blynk mobil uygulaması üzerinden gerçek zamanlı olarak kontorol edilebilmekte olup binadaki bazı hassas yerlere yerleştirilen sıcaklık & nem (DHT22), ve gaz sensörlerinden algılanan anormal değerler bina sahibine e-mail yoluyla bildirilmektedir. Önerilen sistemden elde sonuçlar, binalardaki enerji tüketiminin önemli ölçüde azaldığını ve bina güvenliğinin arttığını göstermektedir.

ANAHTAR KELİMELER: Nesnelerin İnterneti (IoT), akıllı bina, Blynk mobil uygulaması, NodeMCU mikrodenetleyici, güvenlik.

ABSTRACT

MSc Thesis

POWER SAVING, SAFETY AND REMOTE CONTROLLING OF SMART BUILDING BASED ON IoT

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Nowadays, due to the advancement of technology everything becomes digitalized in all sectors of life especially in this areas internet and smart technology. This rapid advancement of technology also covers automation system (AS) due to various applications such as control systems of smart building. This work will study for control and monitor system of smart buildings, which monitor and control electrical appliances to manage consumption of power and safety monitoring. It consists of two models named building appliances remote control and building safety. The first model is used to decrease consumption of power in buildings by remotely controlling of appliances, and while the second model is contain of some sensors, such as temperature and humidity (DHT22), gas and flare in buildings to increase the building safety. The design system is based on the technology of Internet of Things (IoT) through employing NodeMCU board as a microcontroller and Blynk application software via connection of internet. The building electrical appliances like air-condition (A/C), TV, Lights and water heater (W-H) are controlled by connecting to the system Control Board (CB). The building owner will be capable to monitor and control appliances status by using Blynk mobile application through connection of internet. Moreover, building safety is based on temperature and humidity (DHT22), flare and gas sensors, which are placed in some sensitive places in the building for monitoring and alerting building owner by sending e-mail and notification in real-time through Blynk mobile application if any abnormal values sensed by sensors. The proposed system implementation results are shows a majority on power saving that decrease consumption of power in buildings as well as improving building safety.

KEYWORDS: Internet of things (IoT), smart building, Blynk mobile app, NodeMCU microcontroller, safety.

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LIST of SYMBOLS and ABBRIVATIONS

A	Analog
A/C	Air-Condition
AS	Automation systems
CB	Control board
CCTV	Closed-circuit television
D	Digital
DC	Direct Current
DHT	Digital Temperature and Humidity
GND	Ground
GPIO	Global Purpose Input Output
GPS	Global Positioning System
GSM	Global System for Mobile
GUI	Graphical User Interface
HUM	Humidity
IDE	Integrated Development Environment
INT	Input
IoE	Internet of Everything
IoT	Internet of Things
IP	Internet Protocol
LAN	Local Area Network
LCD	Liquid crystal display
LED	Light Emitting Diode
MIT	Massachusetts Institute of Technology
MQTT	Message Queuing Telemetry Transport
NC	Normally Close
NO	Normally Open
NodeMCU	Node Micro Controller Unit
OUT	Output
PIR	Passive Infrared
PPM	Parts Per Million
PWM	Pulse Width Modulation
RFID	Radio Frequency Identification (RFID)
SCL	Serial Clock
SDA	Serial Data
SoC	System-on-a-Chip
TCP/IP	Transmission Control Protocol/ Internet Protocol
TEMP	Temperature
TV	Television
USB	Universal Serial Bus
WAN	Wide Area Network
W-H	Water Heater
WI-FI	Wireless fidelity
WSN	Wireless sensor network
WSP8266	Espressif8266

1. INTRODUCTION

1.1 Overview

Nowadays, due to development of technologies the quality of life is improved (Isa et al, 2015). In order to make people's lives simpler and smarter; industrialists and academics are developing "smart buildings," which offer residents convenience, comfort, safety, security, and energy efficiency (K. Vinay et al, 2015). Automation systems are replacing manual systems; this is seen in the development of automation systems that enable monitoring and controlling various physical objects utilized in many areas such as industry, health, farming, military, buildings, and so on (Kumar et al, 2012). In order to achieve automation systems, several hardware devices and software applications are combined together (Javale et al, 2013). Automation systems are developed in a variety of methods to achieve two basic goals: "controlling" and "monitoring" electrical devices remotely via smartphones over the internet, as well as building safety and security via the use of various sensors. The automation systems in building based on internet focused on controlling and monitoring of appliances anywhere and anytime (Ajah et al, 2013). This approach is highly valuable for assisting disabled and elderly persons in using their devices more conveniently and effectively (Sagar et al, 2015). It may also be used to save energy, which is a major concern nowadays, while also lowering costs (Vijay, 2016).

The building automation system controls the building appliances and monitor building by utilizing sensors for safety and security purpose. Power saving, safety and security are the main purposes of smart building. This thesis focused on two models power saving and safety. The sufficient use of electricity is important in daily routine life. Various types of wireless technologies are used in this field. a number of wireless technologies, including GSM, ZIGBEE, WI-FI, and Bluetooth, are introduced. Automation systems (AS) saves time, money even electricity, man workforce as well as, improving safety and security of the building. The AS's specifications are secured, reliable, user friendly, flexible and affordable. The wireless technology is more famous in automation process. Any kind of building appliances can be controlled and monitored through the AS via internet. In some works Bluetooth and GSM technology is used. GSM technology building appliance is controlled by message services and in Bluetooth technology building appliance is controlled using android apps application (Deepali, 2013). In this thesis Wi-Fi technology is used for controlling building appliances remotely and provides safety based on IoT.

In recent years, due to exponentially growth of internet, the human's life changed by connecting to anyone from anywhere and anytime. The internet technology is extended further by connecting physical objects that used in humans daily life in all areas. This expansion is called Internet of Things (IoT). In 1985, Peter T. Lewis invented the term IoT. He defines IoT as "combining connected devices and sensors with people, processes, and technology to provide remote monitoring, status view/manipulation, and trend evaluation (Banerjee et al, 2017).

Remotely controlling and monitoring equipment is primarily made possible by IoT. The IoT is a technique for managing interactions between the physical objects that surround us (Khan et al, 2012). The microcontroller is the core of any automation systems with compatible of actuators and sensors. Usually, the controlling process of automation systems are performed by employing actuators such as relay and monitoring part is done by employing different sensors such as motion, gas, flame, temperature, etc (Banerjee et al, 2010).

Energy management systems are important for minimizing energy usage in buildings. There is always more need for thermal and visual comfort. Systems are employed to control energy use and save money (Doukas et al, 2007). Buildings are one of the visible areas for measuring the impact of energy consumption. In the Internet of Things, wireless technologies are suggested for controlling and monitoring objects (Barbato et al, 2009). The automation system controls the conditions of indoor appliances automatically. The major objective is to discover considerable energy and cost reductions (Kastner et al, 2015).

The automation system involves of two sides. The first one is the control board (CB) which is consist of many hardware components such NodeMCU microcontroller, relay, sensors and electrical appliances. The second one is the building appliances monitor and control by turning them ON and OFF as well as measuring sensor value levels using the Blynk application. As a result, this work proposes a building automation system that combines building energy efficiency with building safety. This is possible due to the internet, which connects the control board and the blynk application.

1.2 Research Problem

Controlling appliance's switches by manually makes problem for owners who are out of building or cannot access to the appliance's switches, thereby the disability or elderly to use them. Despite of that, high power consumption consider as a problem. This is because of wasting energy consumption by switching ON appliances for long time. Also, when no one is at building for a period of time, when returning building, the building might be completely dark, cold or hot due to low or high temperature in different seasons. In addition to the above issues, building safety is also considered as problem due to high temperature and humidity, fire accidents and gas leakage. All the above problems will be solved by applying a system to monitor and control electrical appliances remotely and employ sensors in sensitive places in the building for monitoring. This thesis deals with how to apply steps to create a system to remotely monitor and control appliances and increase building safety depending on sensors, by using NodeMCU microcontroller, Blynk application and mobile phone to manage the status of appliances over internet connection. In addition, to monitor the building by sensors for increasing safety by informing building owner by alert message and E-mail when any unexpected value detect by sensors, such as high temperature and humidity, gas leakage and fire detection.

1.3 Objectives of the Thesis

The purpose of thesis is to create a system by utilizing NodeMCU microcontroller and Blynk application through internet connection to monitor and control building appliances remotely and monitor building sensitive places by employ sensors, in order to reduce consumption power, increase safety and comfortable in the building.

1.4 Research Scope

The scope of this study is summarized as:

- The domain of this study is smart building based on IoT by using NodeMCU microcontroller and Blynk mobile application.
- Appliances are utilized for testing the proposed system are (A/C, Lights, TV and W/H) and while for safety, sensors are utilized such as (DHT22, Flame, and Gas).
- The system is implemented and tested using C++ programing language through arduino IDE.
- The evaluation performance of the thesis is based on power saving and safety.

1.5 Thesis Layout

The rest of the chapters are outlined as follows:

Chapter Two: this chapter presents the summarized idea of the previous work that related power saving and safety of the building / home environments.

Chapter Three: this chapter deals with the background theory, including concepts of hardware and software used to design a proposed system such as, NodeMCU microcontroller, sensors, relay, Blynk IoT platform, DC-DC power booster and battery charger. Also it covers the design and Structure of the Proposed System's models (appliances remote control and safety) that includes design concept and connection of hardware components.

Chapter Four: Presents the implementation results of both models.

Chapter Five: presents the overall conclusions and recommendations works.

2. LITERATURE REVIEW

Academic researchers are proposed many automation systems (AS) with internet of things (IoT) for monitoring and controlling physical items (objects) in different area. Different wireless technologies have taken advantages in automation system (AS) such as GSM protocol, Wi-Fi, Bluetooth, and ZigBee. Each of the mentioned technologies has advantages and disadvantages. This thesis focused on remotely controlling and monitoring electrical appliances and real time safety sensors gauge levels in smart buildings. In this chapter some recent researches have been summarized that are related to this work.

The authors proposed a real-time home control system based on Arduino that would allow them to remotely monitor and control individual household appliances. They relied on four appliances: a washing machine, a television, a light, and a refrigerator. In addition, two programs (a smartphone app and a web-based app) have been created to monitor and control physical objects. The results are show they have ability to control various devices simply, as well as monitor appliance power consumption. It also keeps real-time produced data on the cloud, making it accessible to users at any time and from anywhere (SARHAN et al, 2016).

Proposed a smart home automation system based on IoT devices such as related to monitoring environment, collecting data and controlling. Their work addressed three important issues which are the basic fundamentals of any home automation system. Those issues are: home security, safety monitoring and energy management. Moreover, their system is flexible, as it has the ability to include new objects easily. In addition, they present the results for user using a web interface which enable the user to remotely monitor and control the physical nodes that are connected to the system (Tayan et al, 2019).

Presented a real time home automation system as well as security system based on IoT. In their work they depended on Arduino UNO and Wi-Fi module

(ESP8266) which will make a cost-effective system. Moreover, the appliances that connected to the Arduino for testing the system are (Fans, Lights and others). Also, the sensors that adopted in this work related to humidity and temperature to auto-switching air conditioner as well as the PIR sensor (human motion) for security reason. In order to control and monitor objects that are connected to the system anywhere in the world they utilized a MQTT server (Kishore et al, 2017).

A smart home power management system was proposed. The Z-Wave technology home automation system has been depended for experiments. Their study aimed to analyze the power consumption in any standard home (4 houses considered) which contain various electrical appliances. Hence, it shows the controlling of the home automation system as well as cost and power saving. Using such technology for home appliance management decreased energy consumption by 18.70% (Tejani et al, 2011).

addressed and created an AS that monitor and control a number of home appliances, such as temperature, humidity, gas leak, fire, and rain, and also controlling lighting with motions. Hardware and software make up their system.
Among the hardware components are smartphones, PC, an Arduino Mega, Ethernet shield, relay board and buzzer, and also some sensors such as temperature and humidity, flame, gas, PIR motion, light, and rain. The Arduino Mega is the main hardware device, and it uses the Internet to regulate the state of the other units. The Arduino IDE code is utilized as software, which uses a webpage and a smartphone application to operate and monitor the system (all units) through the internet. Temperature and humidity, Gas, flame, light, and other factors all have an impact (Almali et al, 2016).

The Authors Proposed Thing Speak Platform in order to control household appliances. They used Arduino board as a microcontroller and admin can control appliances by connected to the cloud server. Their study focused on different things such as household appliances, lighting, computers etc., and their study give capability to the user to monitor and control the electrical appliances status remotely through internet connection. The result provides low cost with 100% efficiency (Prasad et al, 2018).

Their research presents a low-cost Wi-Fi power monitoring appliances. For monitoring electricity use of household equipment such as refrigerators and water dispensers. On a daily and weekly basis, such equipment examines the electricity use. The findings of the investigation revealed that energy use on weekends is higher than on other days of the week. In addition, the investigation revealed that power use at night is lower than during the day (Luechaphonthara et al, 2019).

The authors proposed that the Internet of Things (IoT) be utilized to build a smart automated housing application system. Through an internet connection, the NodeMCU and Blynk application software are utilized to monitor and control the connected home electrical equipment's such as lighting, fans, air conditioning, water pumps, and water gardening. The suggested system might be used for real-time home security, remote monitoring, and control. It may also be expanded and enhanced (Durani et al, 2018).

The suggested algorithm for a smart home automation system makes advantage of IoT. Sensors are the main component of the system, and an Arduino Nano is their point of connection. Simple features include a gas sensor alert and the ability to turn lights ON and OFF based on motion. The suggested system's Arduino Mega is linked to the internet through Wi-Fi, enabling it to track the energy use of various connected home equipment. The results showed that the system is capable of handling all home management and monitoring tasks. However, it is affordable and offers a good substitute for a home automation system (Khan et al, 2016).

An innovative internet-based smart home system control with a low-cost design and execution was presented, which was primarily centered to control appliances, home security, and weather conditions, all of which were managed via an android application. A smart phone running the Android operating system, the Internet, a home server, and an Arduino are among the technologies required to create such a system. Wi-Fi connects to the components of the house. The user controls the appliances via a mobile application by sending commands over the Internet to the home server, which is then processed by the Arduino. As a result, the user is able to monitor and control any connected appliances as well as security-related sensors. Aside from monitoring ambient sensors (temperature, motion), the system also contained a sensor that turned appliances ON and OFF automatically (Vinod et al, 2016).

Authors presented a system for building protection based on IoT through using cloud. In their work they are utilizing arduino microcontroller and cloud moreover some sensors are used and mobile is used to monitor the real time gauge level of sensors. The idea of this work is taken from health monitoring systems that are used by Japan, Korea and other developed countries in the world. The system is useful to monitor the building from flood, Earth Quake especially for the some cities that are near to the sea like Kolkata Chennai, and Mumbai also it's useful for the very old buildings. In this work the database is used to store the building data. After server receive data, it will analyze the received data then it will monitor the real time condition of building from water level, air, earth quake and other safety conditions, after server received and analyzed data the data will be send to the user via mobile device to monitor the condition of building (Zhanger et al, 2022).

The authors suggested an IoT-based home AS. IoT is integrated with cloud computing and rule-based event processing in the automation of smart homes and buildings to make sure that anyone using any space can benefit from their security, comfort, and convenience. Their study focused on controlling appliances remotely as well as home safety through using both cloud computing and rule-based events. They focused on the performance of appliances remotely and fire preventing, CCTV camera, door, humidity, and gas system. Their study confirms that through using IoT in home AS can ensure that the system provide the effective, remotely controlling, safety, comfort, and convenience (Abdulraheem et al, 2020).

They proposed AS energy efficient based in IoT. The system is rely on IoT due to internet availability in everywhere in the world. In this cutting-edge technology, the use of web-based and android technologies has increased to make the application more user-friendly. Their study focused on monitoring and controlling of appliances anywhere in world. A main supply unit with an internet-accessible connectivity module is attached in their study, while static IP address is used for Wi-Fi connectivity. The proposed system in based on voice recognition through using multimodal application for the uses that using web based application or google assistant. The main purpose of their work is to make AS more secure and smarter (Vishwakarma et al, 2019).

Authors proposed a smart building based on technology of IoT system. Due to rapid advancement in technologies it allows people to monitor and access objects from anywhere. The interaction of things through employing networks such as LoRaWAN, Wi-Fi, ZigBee, etc typically referred to as the IoT. In this study they used IoT sensors and relay (actuator) to in order to monitor and control appliances at home, office, apartments, etc. which help owners to reduce usage energy, security and safety. Their study relies on IoT, Wireless technology and cloud to monitor and control actuator and sensors. Finally the project outcomes utilizing Node Red and Bluemix are presented (Havard et al, 2018).

Authors proposed intelligent building power monitor based on IoT technology system. With the advancement of intelligent buildings, issues including insufficient scalability, coordination issues amongst systems, and challenges with system integration have all become issues. The IoT technology is helpful to solve mentioned issue by providing new and smart ideas. In this study they proposed an intelligent building architecture that relies on IoT. The system use big data and decision support to compare the through using intelligent power monitor system to check the supply power, after that the obtain data from main supply power will compared with the actual data if the power isn’t effects the appliances the load will receive power from main supply power this will be done by decision support if the power isn’t suitable for appliances the load will be cut and appliances cant receive power from main supply power till the suitable power is received (Nazir et al, 2020).

The author proposed voice control energy efficiency management and security based on IoT. The author used voice with mobile phone to control the status of electrical appliances. The arduino mega microcontroller is used in their study to execute the instructions from the owner when the owner wants to control appliances status he/she send a right voice trough mobile phone to microcontroller through using Bluetooth to change the status of appliances. This system is helpful to reduce power consumption in the smart home (Gideon, 2019).

Authors proposed a system by using the Internet of Things (IoT) and mobile applications, conventional homes can become smart homes.in their work they try to control electrical appliances through employing IoT with Android app on phone and cloud computing. The design system is used to remotely control appliances in order to save energy, cost, and replace manual work with automation work also sensors are used in their work to automatically change the status of some appliances such as lights and fans. The cloud network in this work is used to provide easy way to the owner to control appliances status remotely, also used to store the data of sensors to keep as an archive (Govindraj et al, 2017).

The authors proposed a low cost and energy management system to monitor and control smart buildings through utilize IoT technology. The proposed system is used to monitor real time energy usage in building also controlling the status of connected appliances to the system. Some hardware’s are used such as ATmega8 microcontroller, ADE7753 energy meter IC, CS, etc. the error rate is 0.66% as compare the energy measurement by this study with the commercial energy meter. As the result of energy reduction for five week is 12% as compare with the five weeks without using the proposed system (Sohaib et al, 2016).

The authors proposed a system to implement smart home through using Arduino and Android system. Their work provide low cost, flexible, monitor and control appliance remotely with the integration of micro-web server with TCP/IP connectivity also android app is used to remotely access and change the status of connected appliances. Beside of controlling the status of appliances by using smart energy meter the owner can manage the usage energy and see the usage energy level in real time through using android app (Jabbar et al, 2016).

The authors present a system based on IoT and wireless for controlling smart homes remotely. The aim of their work is to control and monitor home appliances remotely to save energy, protect home from electrical shorts as well as they present work is also protect the appliances from overload voltage when the voltage is not stable. Hardware components used in their work are ATMEGA328P, NodeMCU microcontroller, 4 module relay, temperature sensor, and LCD as well as the Blynk mobile app is sued as software to create a dashboard and connect to the NodeMCU through Wi-Fi connection to dive the ability to the user to monitor and control connected appliances to the microcontroller (Vijay et al, 2017).

3. MATERIAL and METHOD

3.1 Introduction

This chapter is split into two sections. The first one deals with the concept of some terms such as internet of things, smart building, etc. and materials used to design a system for power saving and safety in smart building. Hardware and software materials are used such as NodeMCU microcontroller platform, sensors, relay, Blynk IoT platform, DC-DC power booster and battery charger, etc.

While, the second part is deals with the methodology of the proposed system's models (building appliances remote control and safety) that contains design concept and hardware components. Also, the principle operations of models and connecting various subsystems to monitor and control electrical appliances. Moreover, this chapter covers mechanism of the subsystem operation.

3.2 Materials

Nowadays, buildings are become a part of IoT. To design a system in IoT especially for smart buildings or any other areas, being familiar with the concept of IoT is the top priority and the technologies used within IoT. As well as, to design a system for smart building have to be familiar with the hardware and software components used to design a system such as NodeMCU microcontroller platform, sensors, relay, Blynk IoT platform, DC-DC power booster and battery charger, etc.

All above topics will be theoretically explain in details in below sections to be familiar with the concept of all of them, and can be implement them in coming chapters.

3.2.1 Internet of things (IoT)

The Internet of Everything (IoE) is another name for the Internet of Things (IoT). The common concepts of “anytime” and “anywhere” to the connectivity for “anything” (Conley, 2016; Friedli et al, 2016). It is collects data by combination of sensing and communication capabilities between different objects (Luechaphonthara et al., 2009). Firstly in 1999 Kevin Ashton thought about the concept of IoT (Tzafestas, 2018). The British technology that helped to build the Auto-ID center for MIT (Bassi et al, 2013). As he looked for possibilities for Proctor and Gamble to grow its company by employing radio frequency identification (RFID) and connecting it to the Internet, Ashton examined this notion (Mobin et al, 2016).

Nowadays, IoT covers most sectors of life such as smart home, building, city, grid, health, agriculture, military, etc. The IoT includes any objects or “things” that can be connected to the Internet. Mostly wireless communication technology is use for interconnecting objects to each other and to the Internet. Once IoT devices collect and transmit data, and then the received data will analyse by microcontroller and act a task. With the minimal effort of human, from factory equipment, cars to mobile devices, smart watches and our homes, offices, and connected devices are becoming smarter, faster, and much more efficient (Bhayani et al, 2016).

Connecting across IoT enabled objects facilitates the fast and efficient transfer of data required to provide various activities and operations. In this way, IoT technology applications can allow to significant operational developments such as efficiency, performance, improved safety and security, developments in health, education, and many other areas of life (Conley, 2016; Bhayani et al, 2016).

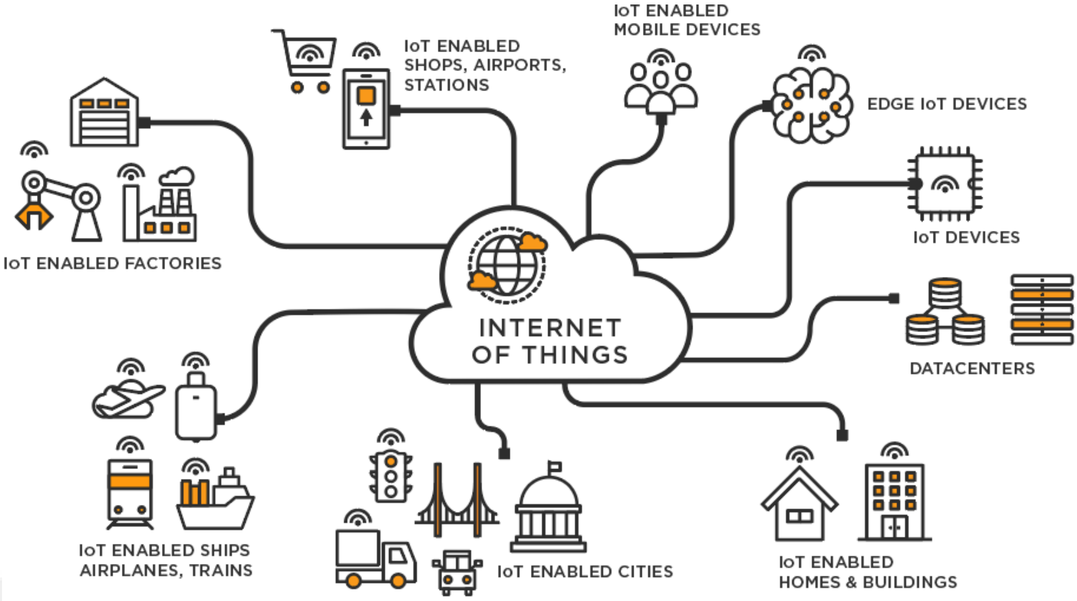

Figure 3. 1. Internet of things (IoT) (TIBCO, 2022).

3.2.2 Definition of internet of things (IoT)

The IoT term is generally refers to the scenarios that extend of Internet connectivity and computing capability into physical things and daily items in order to connecting and exchanging data with each other locally or globally through cloud (Aliero et al, 2020). Equipped with hardware devices such as sensors, actuators, etc., software and Internet connectivity. As well as other technologies that allow that objects to exchange data among them or other objects over the internet connectivity (Brown, 2016). Over Internet access, these physical things may converse and exchange data with others, and it's possible to control and monitor remotely (Gillis, 2021).

Cisco definition about IoT the IoT is the network of objects accessed through the internet connection mostly through wireless communication technologies. These things include equipped technology to interconnect with internal or external environment states. In other view when things available to sense and communicate, it changes the state and act an action from inside or outside of that environment (Zennaro, 2017).

3.2.3 Things in IoT

Things are the objects in the network of physical and virtual objects which have the ability to be defined and integrated into internet connectivity.

Physical things: are the things that related in the physical world that can be seen around us and have the ability to be sensed, actuated and network connectivity. Physical things cover the robotic industrial, sensors and electrical appliances.

Virtual things: are the things related in the information world and are capable to read sensors value, stored, processed, computed and accessed through any ways of internet connectivity. Virtual things cover digital representation can be analysed and application software that performs end-users tasks (Gillis, 2021; Saeed et al, 2018).

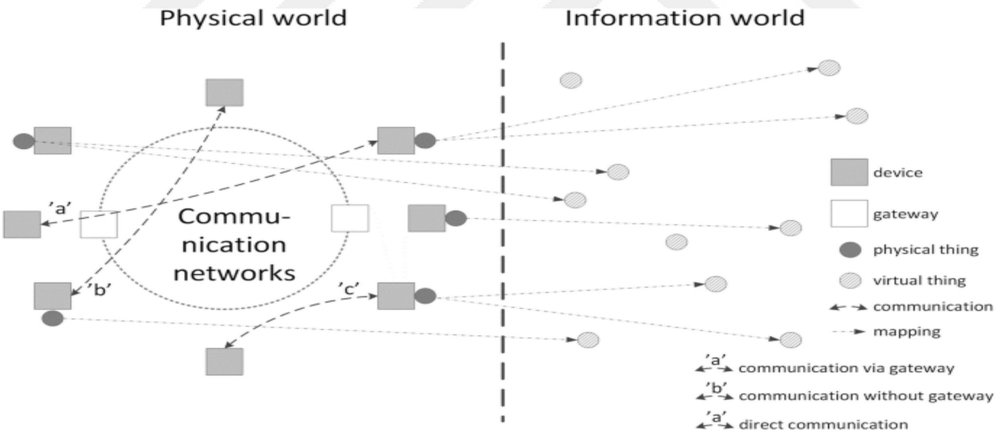

Figure 3. 2. Physical and virtual things in IoT (RUAMBO et al, 2019).

3.2.4 Principle working of IoT systems

An Internet of Things (IoT) system is a network of connected smart devices, such as processors, actuators, sensors and connectivity hardware ways, to accumulate data, receive, send and do a task according to the accumulated data from the around environments (McClelland, 2017).

After devices accumulate data from objects such as sensors they are share accumulated data by connecting to the IoT gateway for edge devices to be analyze either by the cloud or locally, also IoT devices analyze accumulated data by communicating with each other without human efforts or with few human efforts for example initiate them, or give them instruction to act a task in IoT system (Rouse, 2020; Silva et al, 2019).

Process Working of IoT Devices Covers Four Stages:

1. **Data Capturing:** Sensors or devices are used to accumulate data from their environment in every minute. These devices could be a simple sensor like temperature sensor flame sensor, motion sensor, etc or maybe complex real time video feed and Real Time Face Recognition video feed.
2. **Connectivity:** After data accumulated by sensors or device the data will send either to cloud by any connectivity ways like cellular network, WAN network, and satellite network or to local server by LAN network.
3. **Data Processing:** Once the accumulated data received by cloud from public or private network the received data can be processed and do something based on the received data. For example to turn ON/OFF Appliances or sent alert message.
4. **User Interface:** After data processed an action will be done or alert message will be send on their phones or notifying through text or E-mail. Moreover, maybe there is an interface, user can control or monitor connected devices to the IoT system for example may user has connect a camera he/she want to monitor his/her home, office or any other places, or may want to control the status of electrical appliances remotely.

Figure 3. 3. Working stages of IoT system (Anni, 2018).

3.2.5 IoT applications

Internet of things has wide applications that are developing day by day and It includes every aspect of people's daily lives. (Shah et al, 2016).

IoT applications broadly cover industries, society, and environment. All of the IoT applications that have been created so far fall into one of the three categories listed above (Porkodi et al, 2016). This thesis focus on smart building application implement a system how to save consumption of power by remotely controlling building electrical appliances and also focused on building safety by employing some safety sensors to monitor some vulnerable places of the building. IoT has many applications some of themes are listed below (Haje, 2018).

- Smart home.
- Smart parks.
- Smart water sources.
- Smart health.
- Smart buildings.
- Smart transport.
- Smart cars.
- Smart cities.
- Smart Factory.
- Smart grid.
- Maintenance industrial and agricultural equipment.
- Automatic electronic maps.

3.2.6 Smart building

The smart buildings concept could be describe as a set of technologies installing in buildings, that enabling many things, sensors and functionalities that interact and communicate with one another, and also can be monitor, control and automatic remotely (Bonneau et al, 2018).

The IoT application in the smart buildings describes the functionality provided by the control of a building (Oliveira et al, 2017). The monitor and control system is an intelligent system, designed for smart areas like smart building, home, office, etc. (Khine et al, 2019). These IoT applications will reduce human's intervention to manage and maintenance of the building system (Oliveira et al, 2017). This system is being used to monitor and control the lighting systems of a smart buildings and it's used by buildings management team to manage building system (Oliveira et al, 2017). The smart building system keeps monitoring of devices status and provides email and/or text notification failure to the building management team and reducing power consumption in building is more important because buildings, are one of the most energy-intensive industries on the planet, and maintenance of building and also safe building from critical problems such as fire, gas leakage and also building security to install CCTV camera and motion detection (Khine et al, 2013; Moreno et al, 2014).

3.2.7 Power saving in IoT

In present, electricity wasting is one of the main issues that facing in everywhere. The huge power is consumed in the building by two systems which are heating and cooling which are widely used in buildings in both residential and commercial (Moreno et al, 2014). In the developed countries, the huge power is consumed in buildings with is between 20% and 40% of the total consumed power (Dane et al, 2009). Hence, saving power consumption of both systems is important topic for improving power efficiency in globally. To save power consumption in buildings Internet of Things (IoT) applications are very useful to build a system in order to be able to control the status of building appliances remotely when someone forget to turn off appliances (Gupta et al, 2019) . There are many IoT control systems can employ to save power in buildings such as smart meter, smart control board, and cloud computing modules in this study smart control board has been used to monitor and control status of building appliances remotely (paredes et al, 2020; song et al, 2017).

3.2.8 Safety in IoT

The people's life style was change in many ways because of the different factors that are cover living style. Nowadays peoples are coming to life urban areas or big cities, it's impossible for today's life every family has its own house. The building is the only solution to solve this problem. But building put peoples live into dangers without safety systems in the building this case also raise problem in the building. Due to advance technology, internet of things covers safety systems in building to save and alert peoples who life in the building. By using IoT can utilize some systems in the buildings for informing peoples such as fire, earthquake, gas leak, vibrations, and flood. In this study the peoples who life in the building will be alert by notifications and email also beeping buzzer when there is a fire, or gas leak in the building (Kiran et al, 2020).

3.2.9 Internet of things impacts on society

In the first evolution of internet technology the computers are connecting to the network through World Wide Web. The next evolution that interconnect people to the internet and to the other people. The internet of things is the third evolution of the internet, this evolution is developed widely which is interconnects devices, environment, people, virtual world, and etc. Every business, government, and consumer will interact with the physical world differently as a result of the Internet of Things (Attaran, 2017). IoT applications make the life smarter and easier than before. IoT applications have a significant impact on society. By monitor and control the electrical appliances while a person is away from home or work, smart buildings can reduce consumed power by using such proposed system. They can also provide improved safety by continuously monitoring the building or any other places that employ safety devices through such proposed systems in IoT. IoT will positively impact business, the economy, employment skills, and social life overall (Parise et al, 2018). Benefits of this research for society will help peoples who live in buildings even in normal homes they will be able to manage appliances status remotely this will add a skill in society. Also helpful to the elderly or disability peoples who can't access to the appliances switch. As well as remotely switching appliances especially when owner is outside or they travel and forgot to turn appliances OFF as the result it can reduce the consumed power, electrical bill, electrical shorts. Also this study will add safety in the building through employing sensors, the building owner can monitor the sensors gauge level in real time, also will be aware when there is a fire in the building. As well as when there is a gas in the sensitive places of the building. Additionally, the building's owner can regulate the temperature and humidity in the space by turning on and off the air conditioning during various seasons of the year.

3.2.10 NodeMCU microcontroller

The NodeMCU (**N**ode **M**icro **C**ontroller **U**nit) is an open-source, low-cost internet of things platform. (Zennaro, 2017; Conley, 2016). Rather than development kits (dev kits), it includes firmware; The Lua programming language is used in the firmware (Bassi et al, 2013). It is depending on the eLua project, which is run on System-on-a-Chip (SoC) called ESP8266 Wi-Fi with full TCP/IP stack (Bassi et al, 2013). The ESP8266, designed and manufactured by Espress-if Systems and hardware, it's an excellent choice to use in IoT applications (Bhayani, 2016). Figure 3.4. Shows the NodeMCU ESP8266 Wi-Fi module (Aliero et al, 2020).

NodeMCU is a microcontroller that may be used as a sensing node to collect data from multiple wirelessly connected IoT system nodes and transfer it to a central server (Ooko, 2019).

NodeMCU is a small microcontroller board can be connect with computer by USB plug and also its programmed by computer and has number of pins can connect external electronics devices of it such as sensors, relays, motors, buzzer, displays, etc. NodeMCU may be charged through USB from a computer or by using mobile chargers and DC batteries (Zeebaree et al, 2014).

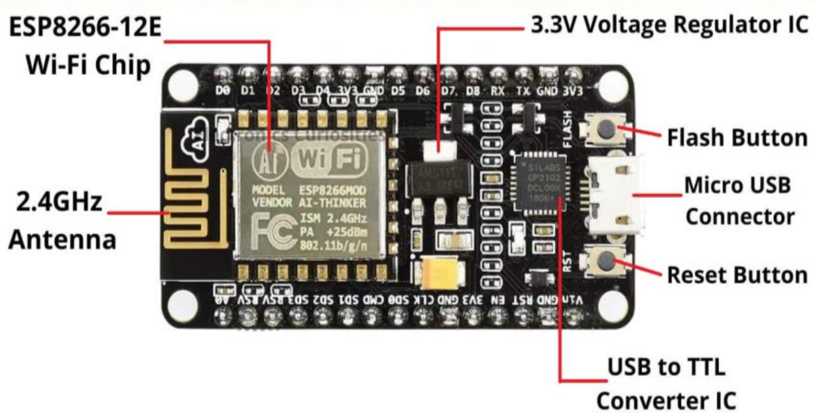

Figure 3. 4. NodeMCU with ESP8266-12E Wi-Fi module (KODALI er al, 2016).

The NodeMCU module's interface is separated into two sections including NodeMCU firmware which comes up with Lua development and execution environment and it can run on all modules of ESP8266 with at least 251 Kb flash memories and the NodeMCU Inc. manufactured dev kits (Kodali, 2016). There are low-cost modules providing to configure and set up, hardware platform for expanding ESP8266-based Lua internet of thing projects (Bassi et al, 2013; Gupta et al, 2019; Hassan et al., 2019).

3.2.10.1 NodeMCU specifications

There are different models of NodeMCU microcontroller available in different packages that contain all computer components on a small chip (microcontroller) (Zeebaree et al, 2014). Commonly all package styles are design based on ESP8266 module. Architecture designs based on standard layout which are consist of 30-pins in which 9 of the pins are digital, while one is analog. It is a tool that is used for Wi-Fi networking based on 802.11 b/g/n wireless standard. It has low power consumption (Raaju et al, 2019).

The common NodeMCU models are Amica NodeMCU which has standard narrow pin-spacing, official Amica NodeMCU and the last one LoLin NodeMCU models which larger in size and has wider pin-spacing. Figure 3.5. Shows different NodeMCU modules (Kodali, 2016).

(A)

(B)

(C)

Figure 3. 5. NodeMCU microcontroller boards: (Prayogo et al, 2019)

(A) LoLin. (B) Amica (C) Official Amica

Table 3.1. presents a comparison among different boards of NodeMCU microcontroller in terms of (microcontroller, model, size, pin spacing, flash memory, input voltage, Wi-Fi Built-In, etc) (Ooko, 2019; Kodali, 2016). Official Amica NodeMCU is used in this thesis.

Table 3. 1. A Comparison among different boards of NodeMCU.

Components	Official NodeMCU	Amica NodeMCU	LoLin NodeMCU
Microcontroller	ESP-8266 32-bit	ESP-8266 32-bit	ESP-8266 32-bit
NodeMCU Model	**Amica**	**Amica**	Clone LoLin
NodeMCU Size	49mm x 26mm	49mm x 26mm	58mm x 32mm
Carrier Board Size	n/a	102mm x 51mm	n/a
Pin Spacing	**0.9" (22.86mm)**	**0.9" (22.86mm)**	1.1" (27.94mm)
Clock Speed	80 MHz	80 MHz	80 MHz
USB to Serial	**CP2102**	**CP2102**	CH340G
USB Connector	Micro USB	Micro USB	Micro USB
Operating Voltage	3.3V	3.3V	3.3V

Table 3.1 (Continue)

Input Voltage	4.5V-10V	4.5V-10V	4.5V-10V
Flash Memory/SRAM	4 MB / 64 KB	4 MB / 64 KB	4 MB / 64 KB
Digital I/O Pins	9	9	9
Analog In Pins	1	1	1
ADC Range	0-3.3V	0-3.3V	0-3.3V
UART/SPI/I2C	1/1/2001	1/1/2001	1/1/2001
Wi-Fi Built-In	802.11 b/g/n	802.11 b/g/n	802.11 b/g/n
Temperature Range	-40C - 125C	-40C - 125C	-40C - 125C
Product Link	NodeMCU	NodeMCU	NodeMCU

3.2.10.2 NodeMCU pinout and functions explained

NodeMCU microcontroller board like any other boards has many pins. Many actions could be done with NodeMCU board through these pins. The NodeMCU board contains a total of 30 pins. 8 pins are used for power, while two pins are retained. The remaining pins (20 pins) are tied to the ESP-12E Module's pins. Figure 3.6. Shows the pinout of NodeMCU microcontroller board (Karen Blixen, 2015; Ravi, 2021; Sara, 2019).

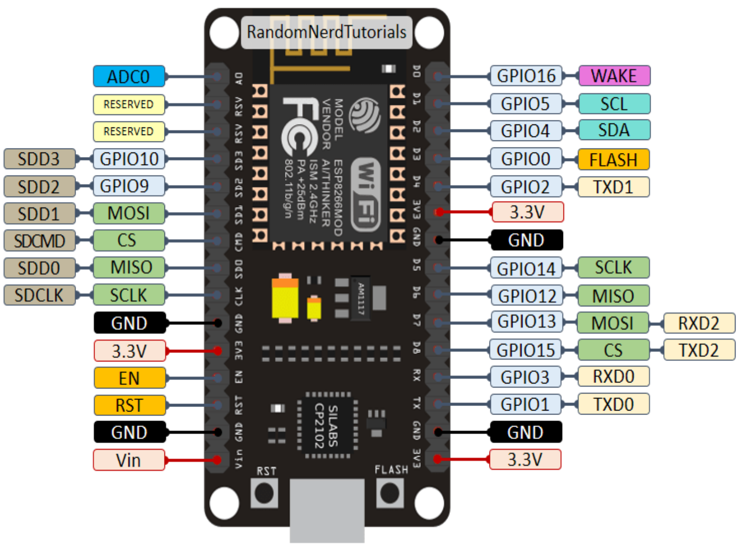

Figure 3. 6. Pinout of NodeMCU microcontroller (ESP8266 12E Module Pinout, 2021).

The function of useful pins of NodeMCU microcontroller board are illustrate below.

- **Power Pins:** It has four power pins.

VIN: The board can be supply power directly by using this power pin. The delivered power is regulated to 3.3V by the onboard regulator on NodeMCU board.

- **GND:** are the NodeMCU board's ground pins.
- **GPIO Pins**: there are 17 GPIO pins, many functions can be done on NodeMCU through these pins such as LED light, PWM,UART, IR remote, or connect some peripherals like sensors, relay, actuators, etc
- **D pins:** there are 9 digital pins on NodeMCU board start from (D0 to D8) which are used to connect peripherals to the board such as sensors, relay, DC motors.
- **PWM Pins**: stands for Pulse Width Modulation has 4 pins of PWM on NodeMCU board with are used to control LED brightness, controlling DC motor.
- **Control Pins:** these pins are used to control NodeMCU board, there are 3 control pins on NodeMCU board which are:
  - **EN:** this pins show the performance work level of NodeMCU board when its high it mean board is enable and when its low it means board work at minimum level of power.
  - **RST**: the ESP8266 chip could be reset by using this pin.
  - **WAKE**: the function of this pin is return chip from deep-sleep mode.

3.2.10.3 Uses and advantages of NodeMCU

Due to rapid advance in IoT application and electronics projects as well as connecting objects to the internet. There are many ways to connect objects such as Wi-Fi, Bluetooth, Zigbee, etc. for this case microcontroller is need, the best microcontroller used for connecting objects to the internet and allow them to transfer data through internet is the NodeMCU (Github, 2015). It is has an ESP8266 based System on a Chip and is designed for electronics and IoT Projects

Reason of choosing NodeMCU microcontroller over the other microcontroller boards in IoT application and electronics is that, it has many advantages over other boards such as:

1- Low cost.
2- Low Energy usage.
3- Has small board size.
4- Ease to use and programming.
5- Includes a built-in TCP/IP stack
6- It has Better Processor and Memory
7- Have internal antenna and İntegrated with Wi-Fi for network connection (Parihar, 2019 and Beno, 2018).

3.2.10.4 NodeMCU programing software

NodeMCU microcontroller like other microcontrollers can be programmed within software. The programming is done through using the Arduino IDE software. The arduino IDE software is also commonly utilized by a variety of arduino microcontroller modules. including UNO, Mega, Leonardo, Micro and others and other numbers of microcontrollers such as Feather of Adafruit or ArduCam ESP32S etc (Fezari et al, 2018).

"Integrated Development Environment" is what the Arduino IDE stands for. Arduino.cc was introducing this software as an open source, which is written by using java programming language. This software is compatible with operating systems such as Linux, Windows, and Mac OS. And also this software is used to write, compile, and upload codes to the microcontrollers. (Fezari et al, 2018).

The programs in Arduino IDE software is written in C and C++ languages. A written program is called sketch and a text files are save with the file extension .ino (David et al, 2015).

Creating new sketch in arduino IDE, two basic functions are required to writing codes which are (Ara et al, 2019; David et al, 2015).

Void setup ( ) function: this function called once when program starts. Main function is to initialize input/output pin modes, begin serial, etc.
Void loop ( ) function: a function called repeatedly until the board powers off.

3.2.11 Blynk platform

Blynk mobile application is a platform utilized for Internet of Things (IoT) applications. Microcontrollers such as the Raspberry Pi, Arduino, NodeMCU, ESP32, and others can be run on it. Connect the hardware module device to the internet and can monitor and control physical objects remotely. It's compatible with both Android and iOS systems (Binti, 2019; Asra et al, 2020).

Creating graphical user interface (GUI) dashboard on smart phone by Blynk application is very simple by dragging and dropping widgets available in this application to the main screen to control and monitor devices via connectivity for instant Wi-Fi connection (Asra et al, 2020). The collected data of sensors are display and store in Blynk application. Also it provides library for hardware devices and microcontrollers boards such as NodeMCU, arduino, raspberry pi, etc. (Sharma, 2020).

Blynk server is available freely for users, they can use as global server to connect with a public internet to control and monitor connected devices to the used board such as arduino or NodeMCU from anywhere in the world with internet connection, or can use it as a local server they can control and monitor device from the range of local network connection (Binti, 2019).

Blynk platform has three major components, are illustrated below and shown in figure 3.7.

Blynk Application: Used to create GUI dashboard on smart phones by dragging and dropping widgets to the project main screen.

Blynk Server: It's responsible to establish and handle the communication between smartphone and hardware devices connected to the control board, can be used either as a public or local server.

Blynk Libraries: It's responsible of allowing all microcontrollers and hardware platforms to communicate with the Blynk server, as well as processing all commands among the Blynk application, cloud, and control board. (Karthikeyan et al, 2018).

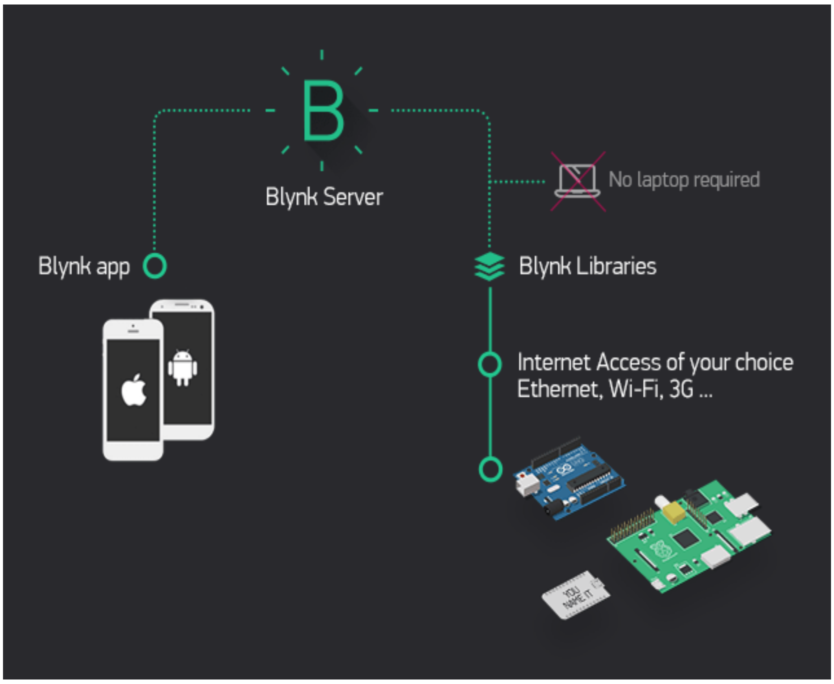

Figure 3. 7. Principle working of Blynk platform (NAYYEF, 2018).

3.2.11.1 Uses and advantages of blynk application

Blynk application is a platform which is design for IoT application used to remotely control and monitor hardware's such as NodeMCU, arduino, raspberry Pi, etc. also receiving data from objects through internet connection; in addition it has ability to store received data from objects such as sensors. As well as it has digital dashboard the user can create a graphical interface simply by drag and drop available widgets (Bohara et al, 2020; Seneviratne, 2018).

The application has many advantages such as:

1- Ease to use and build a digital dashboard.
2- User doesn’t needs to be a mobile app developer
3- Can connect to the cloud through Wi-Fi, Bluetooth, ethernet, and GSM.
4- No code writing, just direct pin manipulation.
5- It is simple to integrate and add new features using virtual pins.
6- Bridge Widget-based device-to-device communication
7- Sending notifications, emails, tweets, etc.
8- Ability to monitor history data through super chart widget
9- Possibility to share it in App store/Google Play.

3.2.12 Relay

A relay is device can be controlled by electrical signal without manually changing status of it, which is mean can change its status from normally close (NC) to normally open (NO) or vice versa, and letting current go through or not. It’s easy to control relay with platform boards such as arduino, NodeMCU, and raspberry Pi etc (David et al., 2015). It has three common pins namely: common (COM) pin, Normally Open (NO) pin, and Normally Close (NC) pin, at normal situation COM is connect with (OC) and there is no connection between COM and (NO), So, when trigger relay by 5V DC (NO) will be connect to th COM and current will be provide to the load (Haje., 2018). Figure 3.8. Shows the schematic of 5V 4-channel relay which is consist of four 5V relays and this one is used in this work.

Figure 3. 8. Schematic of 5V 4-channel relay (Visan et al, 2021).

3.2.13 Sensors

Sensors are low-powered wireless electronic devices. It's the main important key for IoT system applications. Which can be employ everywhere that is designed to monitor a specific physical, electrical or chemical element (Tejani et al, 2011).

They are sense and measures physical elements and convert the received signals from physical element into suitable analogue or digital form, to be readable by machines and humans (Porkodi et al., 2014). There are many different sensors used in IoT applications here DHT22, flame, and gas sensor are used in this work they are illustrate in below sections (Conley, 2016).

3.2.13.1 Digital temperature and humidity (DHT22) sensor

DHT22 sensor is a device which is designed to measure the hotness or coldness of the environment. DHT11 and DHT22 are the two most common varieties of DHT sensor. In this work, the DHT22 is utilized (Haje, 2018).

DHT22 sensor is measure temperature and humidity in digital form in surrounding air by using capacitive humidity and thermistor (Raaju et al, 2019). Figure 3.9. Shows the DHT22 sensor.

DHT22 was chosen over DHT11 for this work because it has better specifications than DHT11. The measurement range of temperature and humidity of DHT22 is wider with better accuracy which is (-40 C^o to +125 C^o) degree with the (± 0.5) accuracy degree of temperature and humidity accuracy range is (0 to 100%) with (2 – 5 %), while temperature measurement range in DHT11 is (0 C^o to +50 C^o) degree with (± 2) accuracy degree and (20 to 80 %) with (5%) accuracy is the humidity measurement range. both of them are operate under 3 to 5 volts. in two specifications DHT11 is better than DHT22 which are in sampling rate it has 1Hz reading per second, while DHT22 has 0.5Hz reading. in second specification DHT11 is smaller in size (Bhadani et al, 2019).

Figure 3. 9. DHT22 Sensor (KUSRIYANTO, 2018)

3.2.13.2 MQ2 gas sensor

MQ2 gas sensor is design for sensing and measuring the concentration of some gases in air such as methane, propane, LPG, hydrogen, carbon monoxide, alcohol. It has many features such as: high sensitivity, fast response, wide detection rate, stable performance and long life and it can operate at a temperature range from -10 to 50 C^{o}, operating voltage is 5V and consumes less than 150mA.

MQ2 is a part of safety system. It can be connect with the system to alert by sound or automatically shut down or operate something connecting to the system when gas leak detect. This kind of sensor is important to employ in some sensitive places because some gases are harmful for humans or animals (Haje, 2018).

The sensor can leak gases available in the air based on gas concentration range in the air which is from 100 ppm to 10,000 ppm as illustrated in figure 3.10.

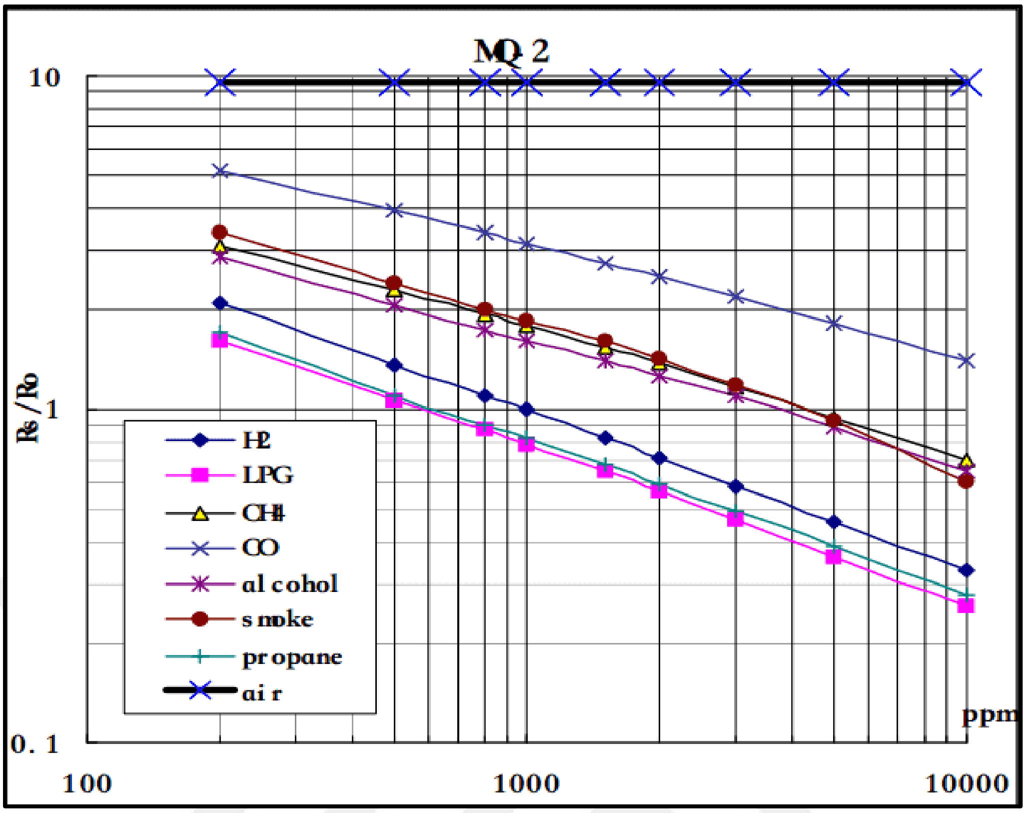

Figure 3. 10. Graphical illustrate of gas concentration (cdaviddav, 2021).

The Minimum concentration of all gases is 200 ppm, while the maximum concentration is 10,000 ppm as illustrated in figure 2.10. The ppm unit of gas is stands for parts per million (cdaviddav, 2021).

The sensors module has many electronic parts which are:

- Four pins for connecting with microcontrollers:
  - **A0:** To transfer an analog signal to microcontroller.
  - **GND:** Connect with the ground of microcontroller.
  - **VCC:** connect to 5V of microcontroller to voltage supply.
  - **D0:** measure the gases concentration in digital form based on threshold that is predefined through potentiometer.
- **Potentiometer:** to set a value for the digital output pin's threshold.
- **2 LEDs:**
  - POWER_LED**:** show the status of the module is it ON or OFF.
  - DOUT_LED**:** show the status of digital pin.

- **5 Resistors** LEDs are prevented from high voltage by these resistors and make it to operate as voltage dividers.
- **LM393 dual comparator** this part work when D0 pin is connect to measure the gas concentration in digital form its compere the current gas concentration with the potentiometer predefined value and also control the LED status of digital output.
- **2 Capacitors** they are act as a voltage stabilizer for input voltages.

Figure 3. 11. MQ2 gas sensor (KODALI. 2019).

3.2.13.3 Flame sensor

A flame-sensor is one kind of electronic detector device which is primarily used to detect fire. This module can detect flame or light sources with the wavelength range (760 nm – 1,100 nm). High temperature is damaging the sensor it should be in a certain distance to avoid from damaging (Mobin et al, 2016).

This sensor is mainly used in fire-fighting robot, heat seeking robot, the most commonly occurring fire accident is an electrical fire, which may be avoided with the use of a fire warning system. The LED will light up after fire detect by sensor (Chen et al, 2020).

Figure 3. 12. Flame Sensor Module (WADHWANI. 2018).

Sensor fire sensitivity is up to 100cm as a distance with the 60 degree of angle (Zeebaree et al, 2014). Figure 3.13. Shows the detecting distance and angle of the sensor.

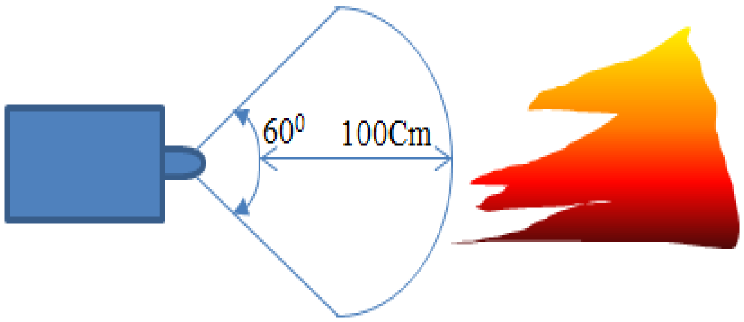

Figure 3. 13. Distance and angle detection of flame sensor (Zeebaree et al, 2014).

3.2.14 Piezo buzzer

Is a piezoelectric transducer, used to create tones by converting electrical signals into sound signal (Herreros, 2017). It's usually powered by 3-24V DC power supply. Typical uses of it include alarm devices, timers, computers, electronic toys, telephone, etc. It consists of two wires, red and black. Polarity matters: red to DC power supply and black to ground.

Figure 3. 14. Piezo Buzzer (Gabriel et al, 2020).

3.2.15 Liquid crystal display (LCD) 20*4 Display.

LCD is usually use in microcontroller-based systems to display the measurement output of variables, sensors value, and status of devices. Different ways are use to display data such as LEDs, 7-segment and LCD types. LCDs has advantages over others ways it can display alphanumeric, graphical data and graphical images. Some LCD types has more than 40 character length has ability to display data in more lines (Ibrahim, 2019; GIDEON, 2019).

In this work LCD 20*4 has been used, it is connected with NodeMCU microcontroller to display the sensors value and Wi-Fi connection status. Figure 3.15. Shows the LCD 20*4 display.

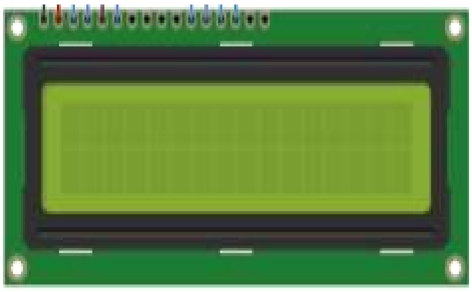

Figure 3. 15. Liquid crystal display (Clary, 2015).

3.2.16 DC-DC step-up (booster) converter

A DC-to-DC booster converter is an electrical component that includes a switch, diode, inductor, and capacitor. That converts a source voltage from one level to another stable voltage level and provides stable regulated output voltage to supply electric and electronic circuits (Florescu et al, 2015).

In some electronic devices different input voltage required from the input voltage supplier by external voltage supplier or battery supplier. The output required voltage maybe not the same of input voltage, in this cases voltage converter is required (Barrow, 2012). There are many different types of voltage converter available in this work MT3608 DC-DC step up booster module is used. The DC-DC booster power module is shown in Figure 3.16.

Figure 3. 16. DC-DC booster converter power module (Djamel et al, 2019)

3.2.17 Battery charger module

Battery charger is a small electronic device module. Which is designed for charging 3.7v lithium batteries with fixed charge voltage of 4.2 volts and 1Ah or higher charging current, use constant-current and constant-voltage method to charging batteries? Provide necessary protection to safely charging a battery and cuts off charging current when finished by battery protection Integrated Circuit TP4056. When discharging voltage is drops to lower than 2.4V, the load will be switched off by the IC protector in order to prevent the cell from running on low voltage and also IC protect the batteries from over-voltage and reverse the polarity connection (in abnormal situation it always destroy itself to protect battery) (admin., 2020; Richard., 2020). There are many different types of module are available in this work type-C is used as shown in figure 3.17.

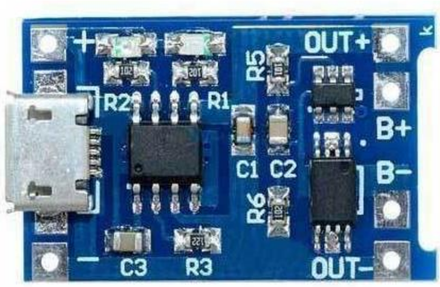

Figure 3. 17. Pinout diagram of battery charger type-C module (Sabarimuthu et al, 2020).

3.3 Method

This part deals with the design and structure of the proposed system’s models (electrical appliances remote control and safety) which includes design concept and hardware components. Also, the principle operation of subsystems and connecting various subsystems to monitor and control electrical appliances is presented in this chapter. Moreover, this chapter covers mechanism of the subsystem operation such as read/writes, and sends data to the application. Furthermore, software requirements for the system are illustrated.

3.3.1 Design Concept

The proposed system concept is to save the consumption of power by remotely controlling of electrical appliances for instance A/C, TV, W-H and lights as well as increasing building safety by employing some sensors like flame (Fire), DHT22 and Gas. The designed system has been controlled by Blynk IoT platform and Wi-Fi technology. The C++ language is used to program the system by using Arduino IDE software. Real time sensors gauge level as well as up-to-date electrical appliance status will be display on Blynk application screen after interconnection of CB to Wi-Fi building and Blynk application platform to CB.

This will provide easiest way to the building owner to switching the connected electrical appliances to CB, this process will be done by sending a signal request from virtual switches of Blynk application to CB in order to change the status of relay from (NO) to (NC) and vice versa this will switching the status of appliances instead of doing it manually.

3.3.2 Structure of the proposed system

The proposed system is made up via using some hardware components and software's that allow owner to monitoring and controlling of both models and also establish the connection and communication between CB and Blynk mobile application via internet connection. The used components are listed below and shown in figure 3.18.

Proposed System Hardware Components:

1. NodeMCU1.0 (ESP-12E Module.
2. LCD (20*4).
3. Four Relays Module.
4. DHT22 Sensor.
5. GAS Sensor.
6. Flame (fire) Sensor.
7. Buzzer.
8. Breadboard.
9. Jumper wires.
10. DC-DC voltage step-up booster module.
11. Type-C battery charging board.
12. 3.7V lithium battery.

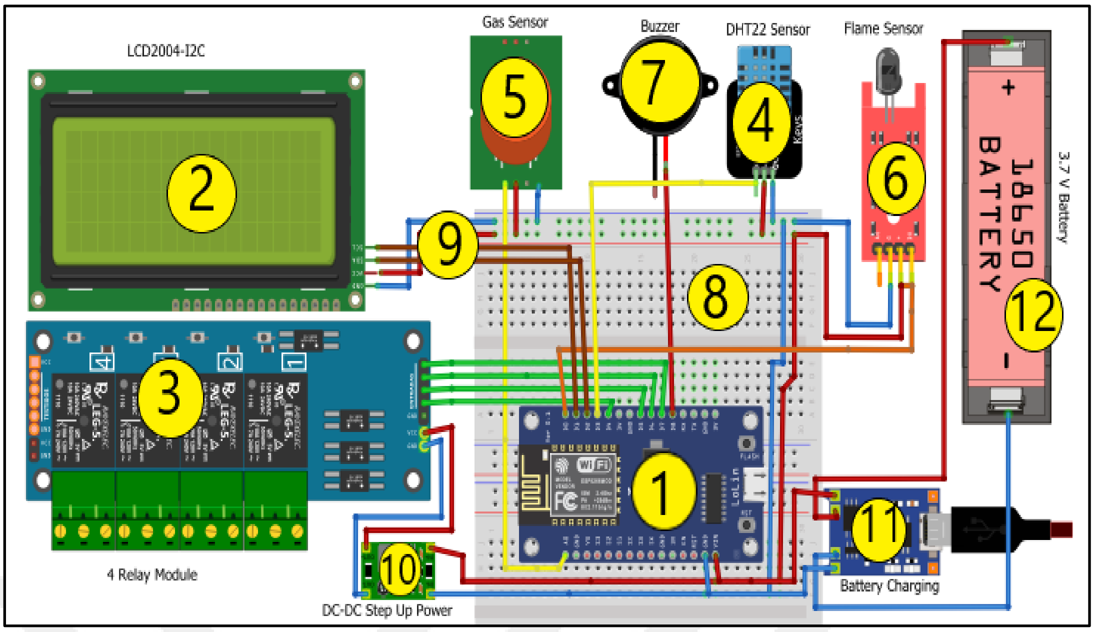

Figure 3. 18. Control board and related sensors

Proposed System Software:

1- Arduino IDE:

Arduino IDE is software that is used for coding the proposed system. "Integrated Development Environment" is what it stands for. Arduino.cc introduces this open source software. However, Java language was used for write this software as well as it's available for all operating systems such as Linux, mac and Windows. Which is use C++ languages for coding, as well as provide the compiling option and uploading codes to the microcontroller boards such as NodeMCU, Arduino, Raspberry Pi (Fezari et al, 2018).

2- Blynk Application

Blynk is a platform created specifically for Internet of Things (IoT) applications. It can run different microcontrollers such as NodeMCU, Raspberry Pi, ESP32, Arduino, etc. Also, it also enables a connection to the internet as well as remote monitoring and controlling of physical devices. Also, it's existing for both systems android and IOS (Binti, 2019; Asra et al, 2020).

As it has been mentioned before the proposed system classified into two main models namely building appliances remote control and safety models. Each of the models consists of various devices as it is illustrated in Figure 3.19.

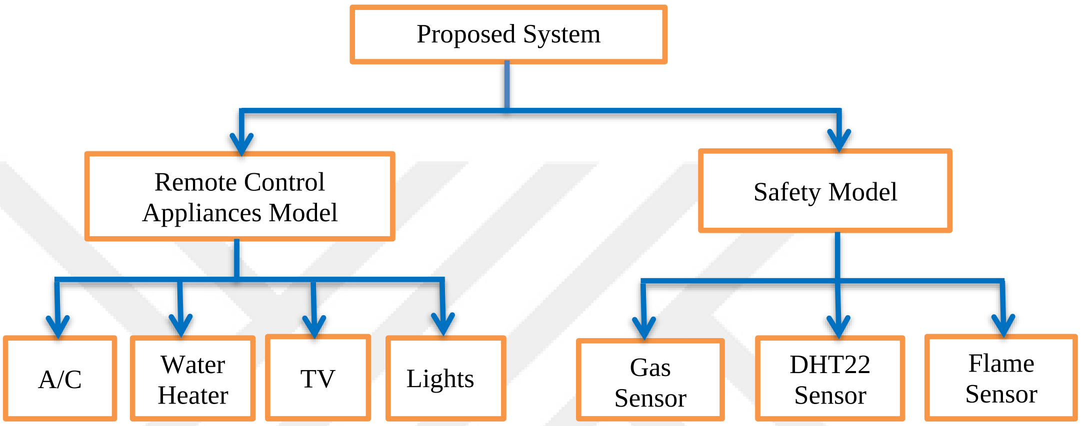

Figure 3. 19. Proposed System Classification.

Furthermore, the proposed system wiring connection circuit diagram is shown in figure 3.20. In order to read analog data by NodeMCU microcontroller, the used sensor should be connect to A0 pin of microcontroller as well as to read digital data, the used sensors should be connect to digital pins of microcontroller. For instant, gas sensor read data in analog form it must be connected to the microcontroller's A0 pin and while the electrical appliances and other sensors are working in digital form they must be connect to digital pins of microcontroller.

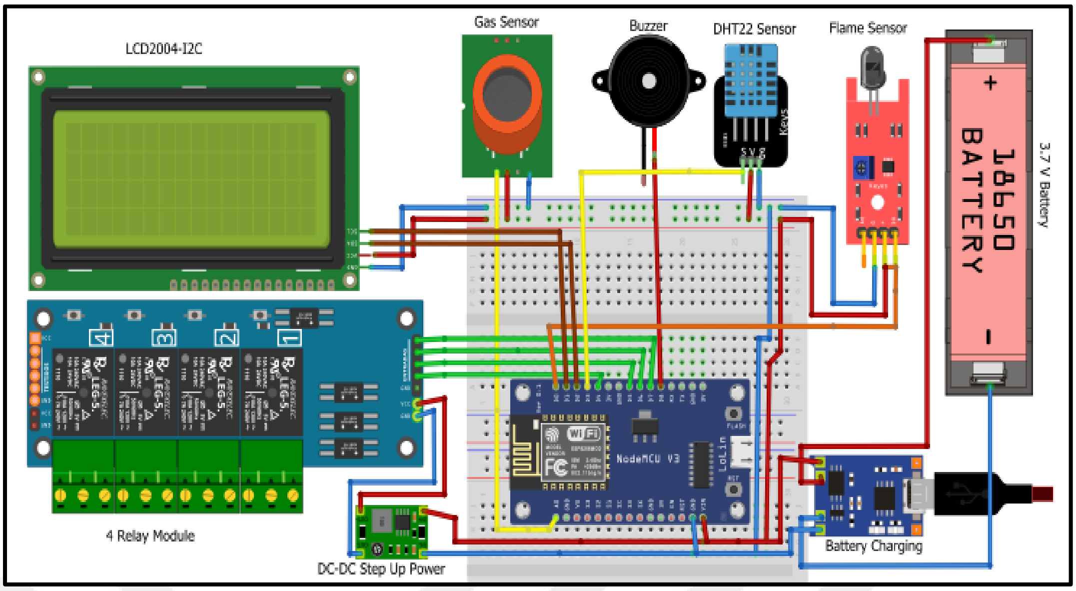

Figure 3. 20. Proposed system circuit diagram.

Table 3.2. Shows the reservation pins of NodeMCU microcontroller to hardware components of both models used in the proposed system.

Table 3. 2. Connecting hardware components with NodeMCU pins.

No.	Device Name	Pin Name of device	Pin Name of NodeMCU
1	Flame Sensor	D0 GND VCC	D0 G VIN
2	GAS Sensor	A0 D0 GND VCC	A0 --- G VIN
3	DHT22 sensor	+ OUT -	VIN D3 G
4	Buzzer	+ -	D8 G
5	4 Relay Module	VCC → Vout+ of DC-DC booster IN1 IN2 IN3 IN4 GND→ Vout- of DC-DC booster	D4 D5 D6 D7

Table 3.2 (Continue)

6	LCD 20*4	GND VCC SDA SCL	G VIN D2 D1
7	Battery charging	Vout+ Vout-	VIN G
8	DC-DC voltage step up module With battery charging module	DC-DC step up booster Vin+ Vin-	battery charging Vout+ Vout-

Table 3.3. Illustrates the pin connection between NodeMCU microcontroller and Blynk platform. Digital pins of NodeMCU and Blynk IoT platform are used to establish logical connection between them. Also, for safety model the digital pins of NodeMCU and virtual pins of Blynk IoT platform are used.

Table 3. 3. Pin connection between NodeMCU and Blynk platform.

No.	Device Name	Digital and Analog pins of NodeMCU	Digital pins of Blynk platform	Virtual pins of Blynk platform
1	A/C	D4	D4 (gp2)	------
2	Light	D5	D5 (gp14)	------
3	TV	D6	D6 (gp12)	------
4	Water heater	D7	D7 (gp13)	------
5	DHT22 Sensor Temperature Humidity	D3	--------	----- V1 V2
6	Gas Sensor	A0	-------	V4 V3: To turn ON/OFF gas subsystem
7	Flame sensor	D0	------	V5 To turn ON/OFF flame subsystem

The proposed system general block diagram is shown in Figure 3.21. The system consist of two main models, remote controlling of building appliances model, and safety model. Moreover, figure 3.22. Display the general flowchart of the proposed system

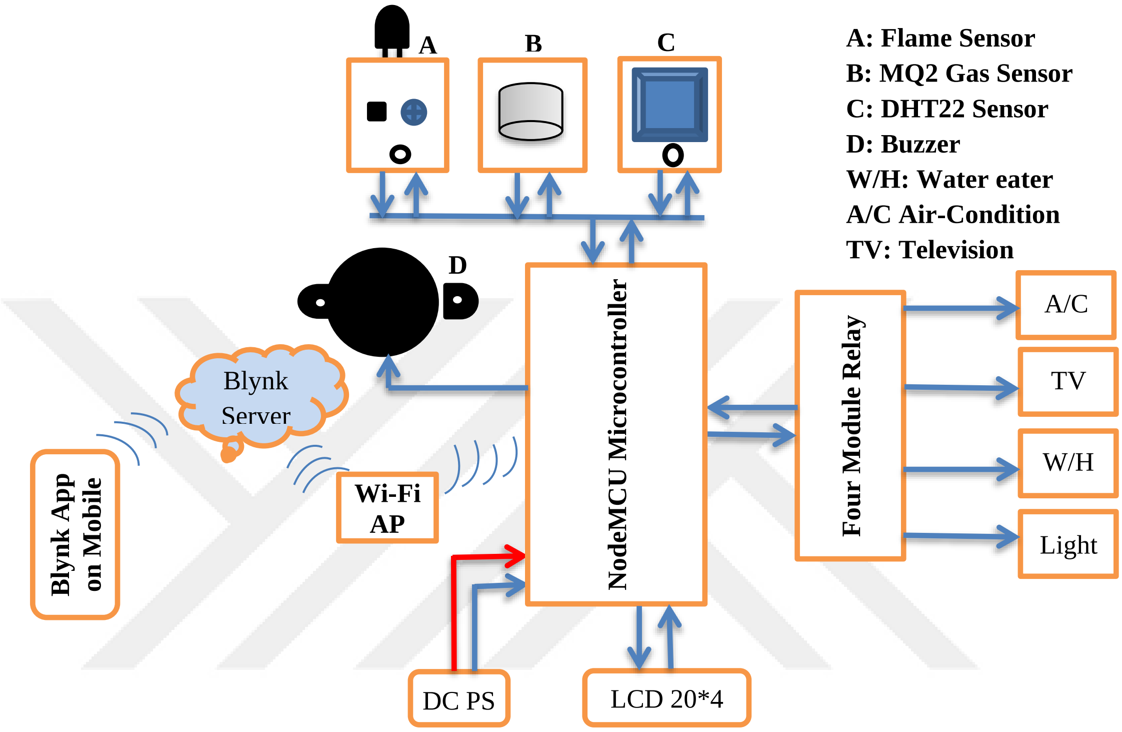

Figure 3. 21. Proposed System General Block Diagram

Figure 3.22. Illustrate the operation mechanism of the proposed system in term of monitor and sending request to switching status of appliances, as well as monitoring environment by safety sensors. And also, sending alert notifications to the mobile phone and E-mail.

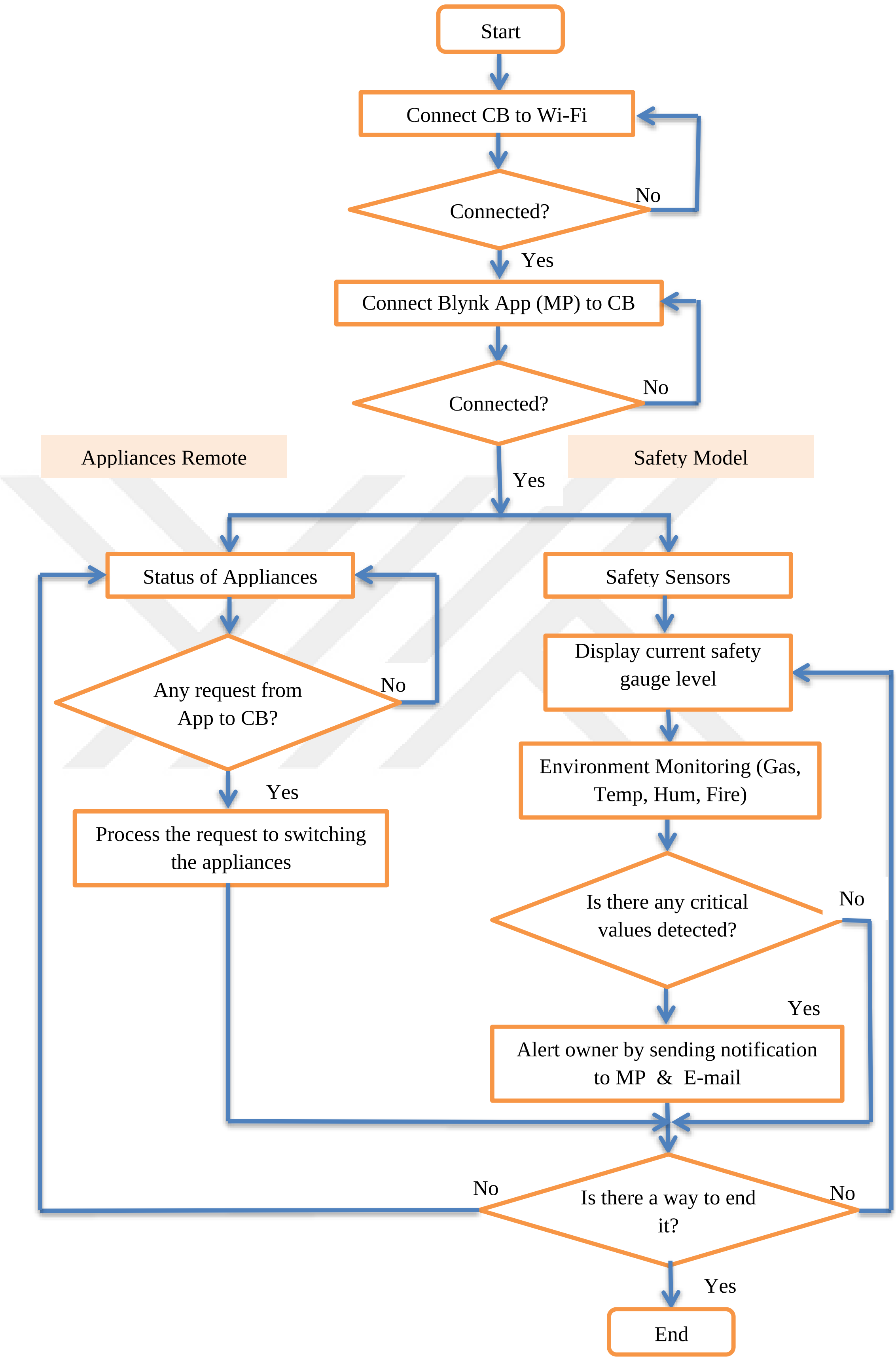

Figure 3. 22. General flowchart of the proposed system.

The first step of the proposed system is to initialize the connection process between the CB and the Blynk application via internet as shown in figure 3.23. It starts by searching Wi-Fi and connect CB to Wi-Fi. Then, connect Blynk application to CB. After that the status of the connected appliances, as well as the gauge value level of safety sensors, will be displayed on the Blynk dashboard screen. Hence, the building owner will be capable to monitor as well as control the models.

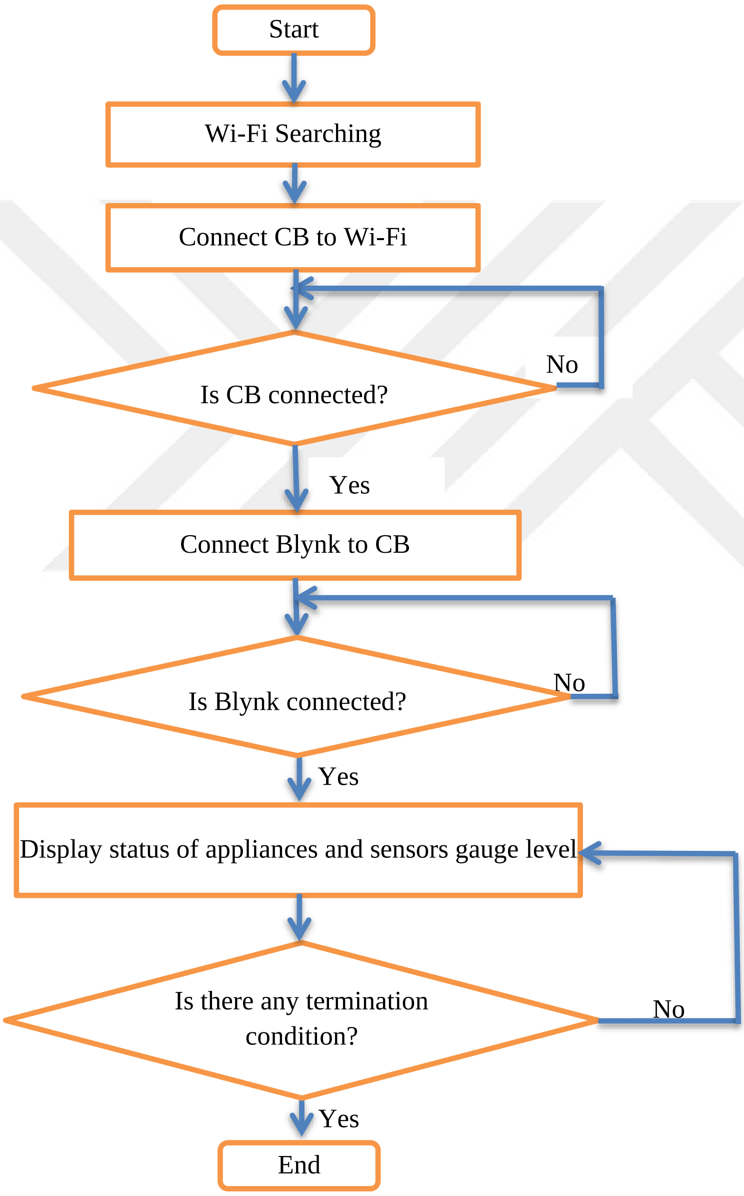

Figure 3. 23. Initializing connection between CB and Blynk app flowchart.

3.3.2.1 Building appliances remote control model

In this model, the building electrical appliances have been connected to the CB. Then, the owner will be capable to remotely monitor and control appliances via Blynk application through internet connection. The model block diagram is shown in Figure 3.24.

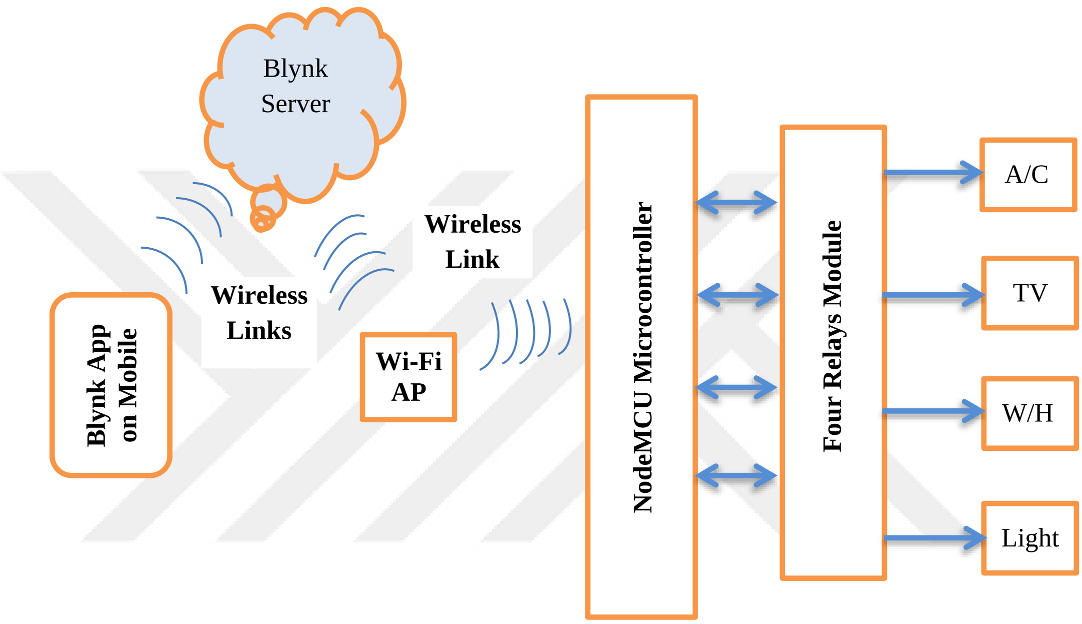

Figure 3. 24. Building appliances remote control block diagram

Furthermore, the figure 3.25. Represents flowchart of mechanism performed by the structure shown in Figure 3.24.

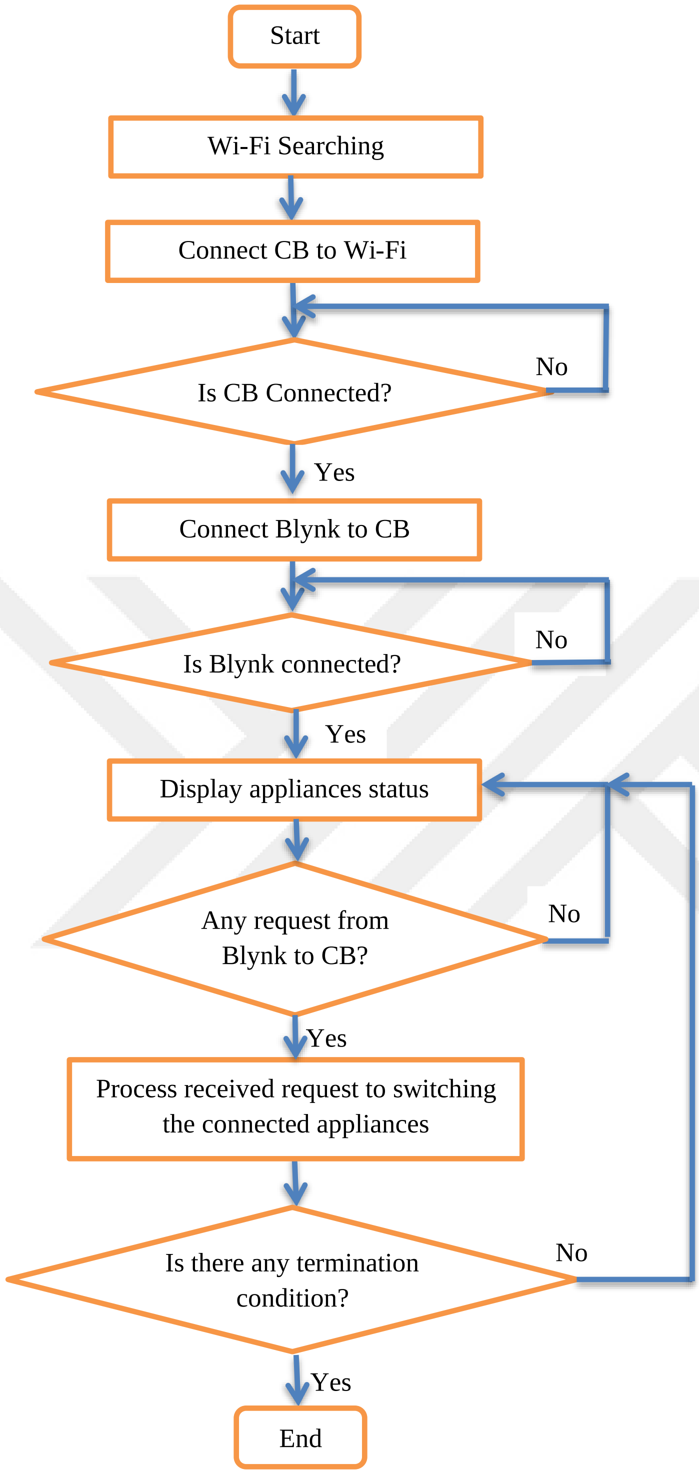

Figure 3. 25. Building Appliances Remote Control model flowchart.

The mechanism of Figure (3.25) can be summarized by the following steps:

i- Connecting control board to the Wi-Fi.

ii- Is control board connected to Wi-Fi?

- If its connected Then go to next step
- If not, go to step (i)

iii-Connecting Blynk application to the control board.

- If its connected Then go to next step
- If not, waiting to connect

iv-Use Blynk virtual pins to control status of appliances by sending signal to C.B.

v- Change status of appliances and display on Blynk application.

3.3.2.1.1 Wiring connection of control appliances model

Wiring connection of connected building electrical appliances to the control board is shown in figure 3.26. By controlling electrical appliances status remotely it will solve many issues such as saving power consumption, sometimes people went out and forget to switching OFF the appliances especially when they travel for a period of time it will consume high power and beside that may it cause of electrical accidents.

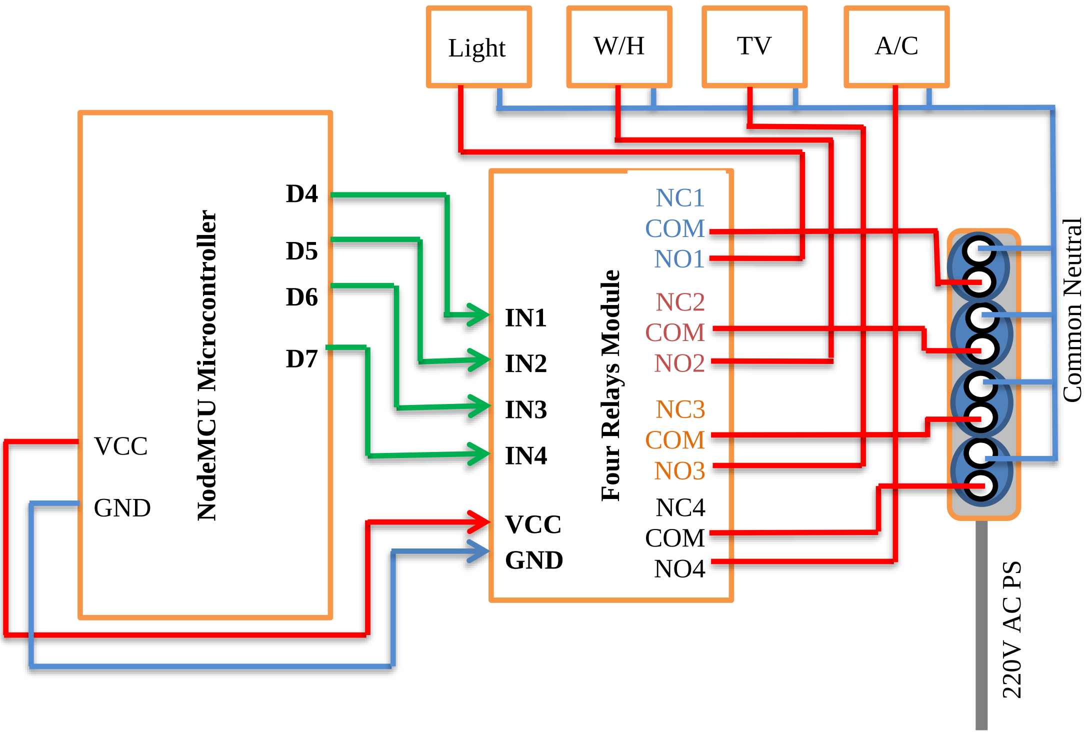

Figure 3. 26. Controlling appliances Schematic wiring.

As shown in figure 3.26. The status of appliances can be controlled remotely; the Blynk application can control the appliances by turning it ON/OFF. The Blynk dashboard contains switches which connected remotely to the specified appliances which are used to turn ON/OFF appliances and display its status. When switching ON/OFF any connected appliances the signal is send from Blynk application to the CB which will process the signal, then the 5V DC will pass to the digital pin of NodeMCU and the relay input pin status will be changed from NO to NC which in turn will pass 220 V AC (turning ON) to the required appliance.

3.3.2.2 Safety model

Internet of Things is used in this model to monitor safety sensors gauge level remotely. In order to monitor the sensitive places in the building some sensors are installed in those sensitive places such as DHT22 which is used to measure the humidity and temperature in the building. The gas sensor is used to detect the gas leakage in the installed placed and while the fire in the building is detected by flame sensor. Figure 3.27 shows the model block diagram.

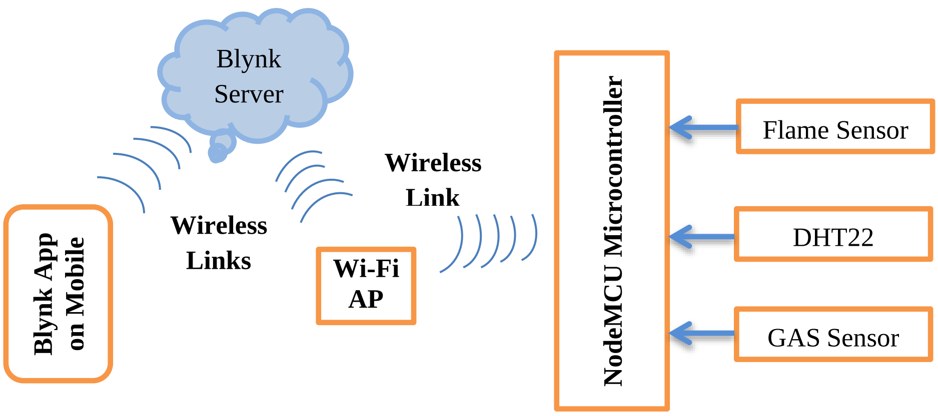

Figure 3. 27. Block diagram of safety model

The main function of safety sensors is to data collecting from the installed place in the building and converting to suitable data then send the collected data to the microcontroller. After that, microcontroller compared the data to the critical values which are programed by the user. Finally alert notification and E-mail will be sent to the building owner when detecting unexpected values by the safety sensors. Figure 3.28 - 3.29. Demonstrates the flowchart of the safety sensors.

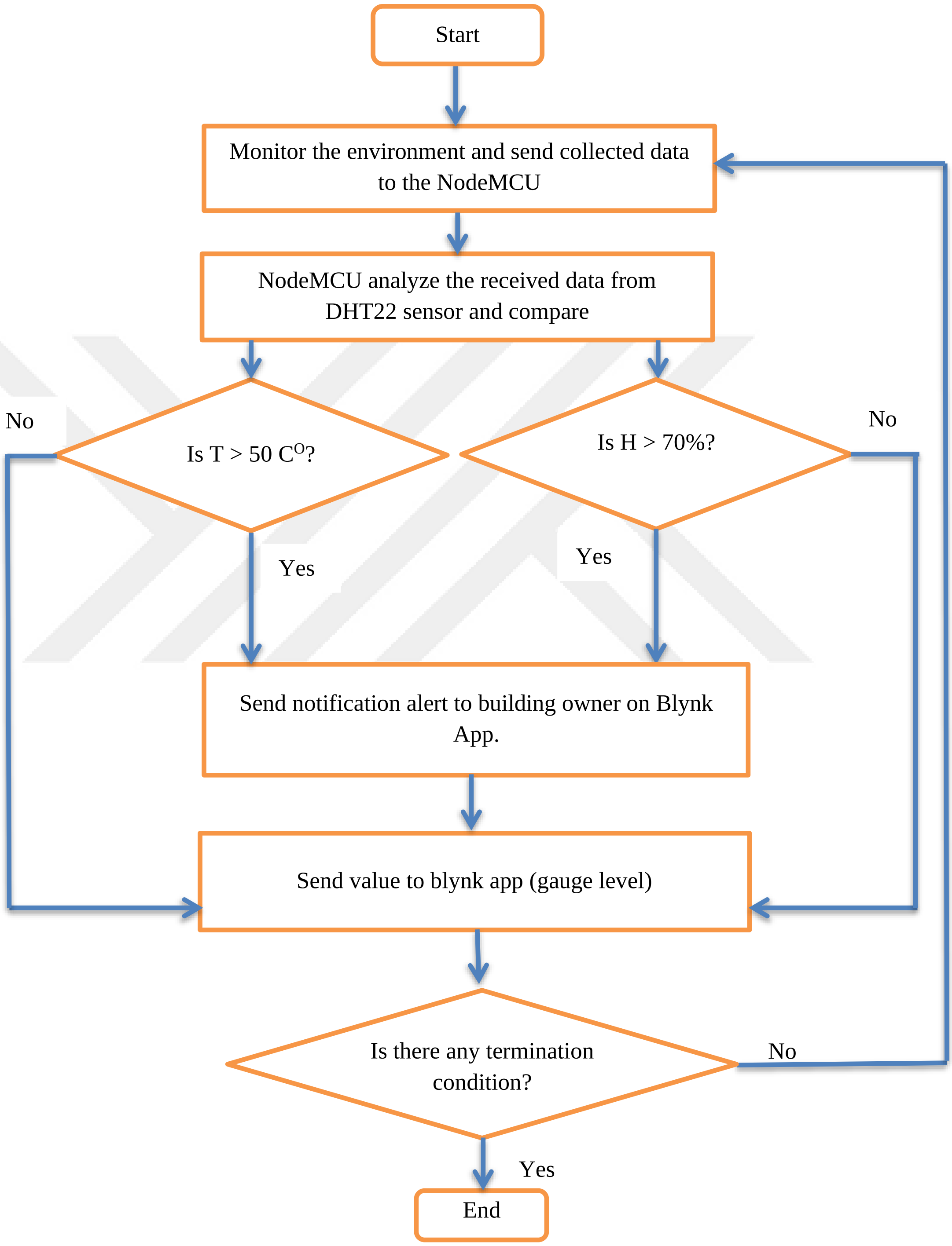

Figure 3. 28. Flowchart of DHT22 sensor

The mechanism of figure 3.28 can be summarized by the following steps:

i. DHT22 sensor starts to monitor the environment and send the collected data to the NodeMCU.
ii. NodeMCU analyze the received data from DHT22 and compare them.
    - Is temperature is > 50 then go to next step (iii). If it's less than or equal to 50 go to step (iv)
    - Is humidity is > 70 then go to next step. If it's less than or equal to 70 go to step (iv)
iii. Send notification alert to the owner through Blynk application and send data to Blynk application.
iv. Sends data to Blynk application and display normal value on Blynk dashboard screen.
v. Is there any termination condition?
    - If No, go to step (i).
    - If yes, the sensor won't be able to monitor the environment.

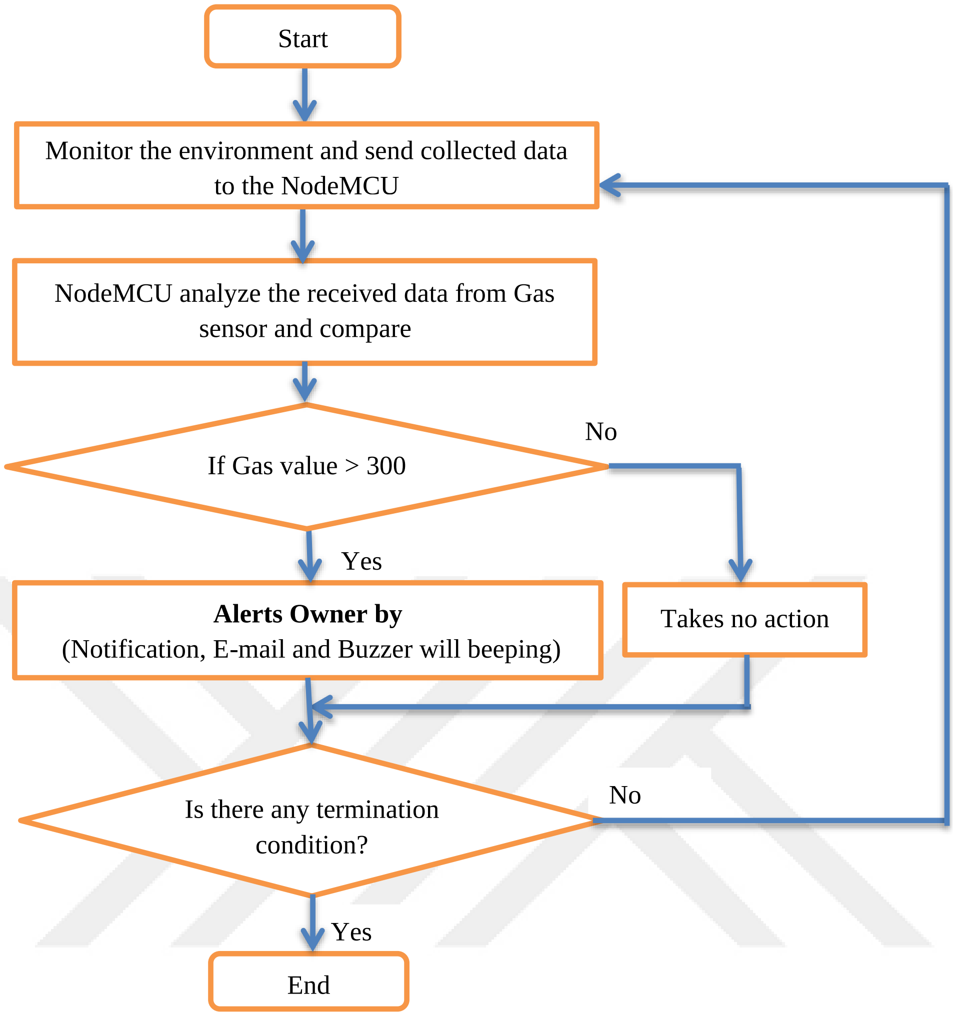

Figure 3. 29. Flowchart of Gas leakage detection sensor.

The mechanism of figure 3.29 can be summarized by the following steps:

i. Gas sensor starts to monitor the environment and send the collected data to the NodeMCU.
ii. NodeMCU analyze the received data from the Gas sensor and compare it.
   - If the gas value is > 300 go to next step (iii)
   - If the gas value is <= 300 go to step (iv)
iii. Send notification alert and email to building owner and beeping the buzzer.
iv. Take no action.
v. Is there any termination condition?
   - If No, go to step (i).
   - If yes, the sensor won't be able to monitor the environment.

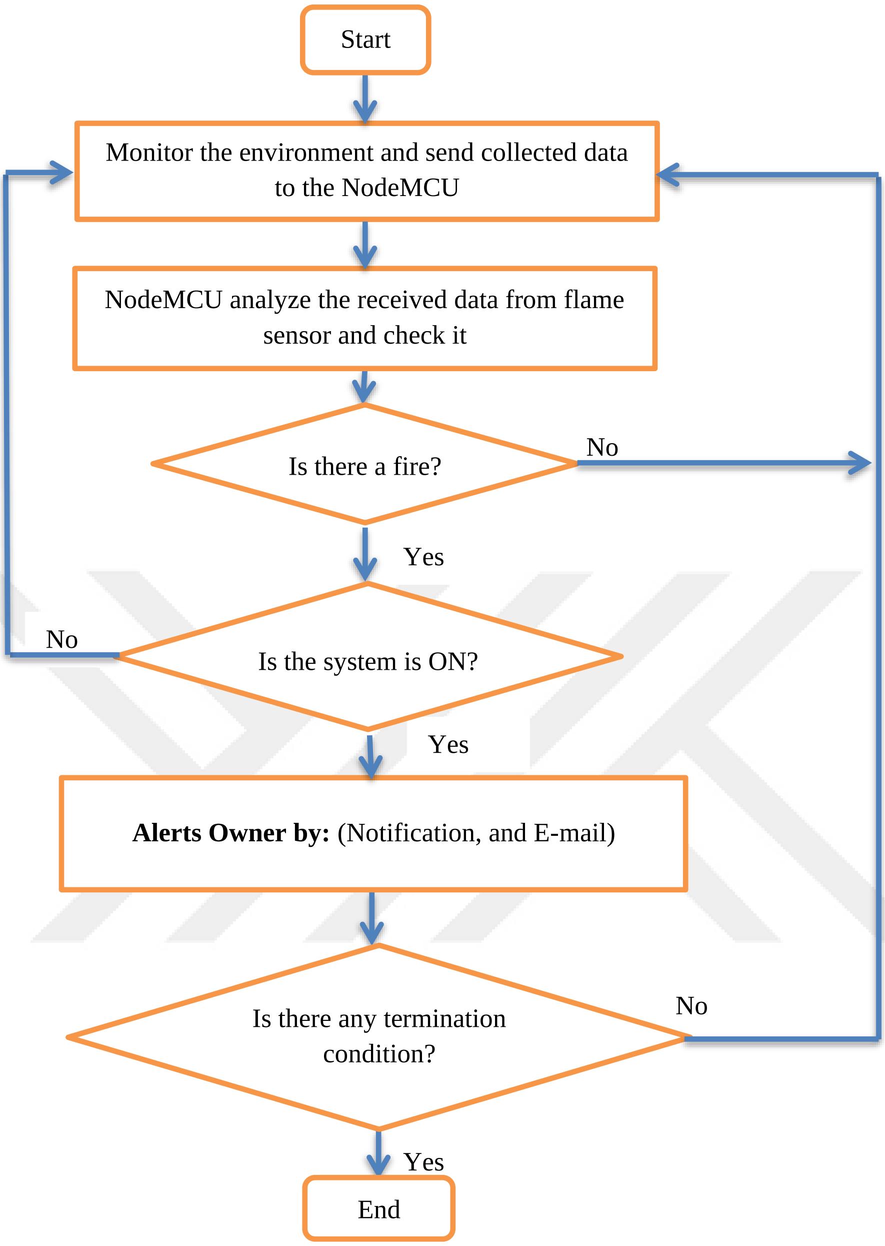

Figure 3. 30. Flowchart of Flame sensor.

The mechanism of figure 3.30 can be summarized by the following steps:

i. Flame sensor starts to monitor the environment and send the collected data to the NodeMCU.
ii. NodeMCU analyze the received data from the Gas sensor and check it.
iii. Is there a fire?
    - If there is a fire, then go to next step.
    - If there isn’t, go to step (i)

iv. Is the subsystem is ON from Blynk application side?
    - If its ON, go to step (v)
    - If it's OFF, to go step (i)

v. Send Notification alert and E-mail to the owner.

vi. Is there any termination condition?
    - If No, go to step (i).
    - If yes, the sensor won't be able to monitor the environment.

3.3.2.2.1 Wiring connection of safety model sensors:

Safety is the important part in smart buildings because they avoiding accidents in the building. The model is done by connecting different sensors like: gas sensor, DHT22 sensor, flame sensor, etc. there are many sensitive places at buildings need to be aware about the safety of these places to be avoid from any accidents, they can connect safety sensors according to the human desire they want to be aware about gas leakage, fire detection, and temperature of the home or office, etc.in below section schematic wiring diagram of sensors used in safety model will illustrated.

3.3.2.2.1.1 Digital humidity and temperature DHT22 sensor

The DHT22 sensor is used to gauge the temperature in the building's installed locations, there are many sensitive places need to know the temperature of these placed at any time. The DHT22 sensor can be used in office, home, and room to monitor the temperature. After monitoring if the temperature is not the desired one the owner can turn ON/OFF A/C of the office, home, room, and also can be employing in some cold places the temperature of these places always should be in low degree or can be used in warm places the temperature of these places always should be high degree. Also there are many devices are working in cold environment the DHT22 sensor can be employ to measure the temperature of these places as well as there are sensitive from high degree of humidity they can also monitor these places by using this sensor.

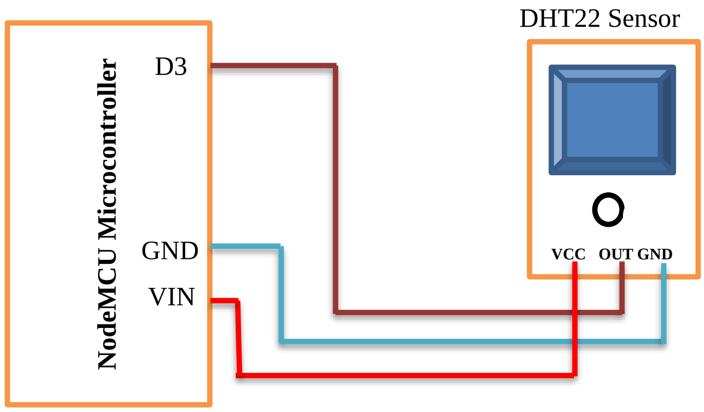

Figure 3. 31. Wiring diagram of DHT22 sensor.

As shown in figure 3.31 the DHT22 sensor used in this system has three pins. VCC, OUT, and GND. The VCC is used for input voltage to supply the DHT22 sensor by 3.5 - 5V which connect to 5V on NodeMCU microcontroller or other 5V supplier. The OUT pin of sensor is connecting to the digital (D5) pin of NodeMCU, which is used to send the collected data to the microcontroller board, and then the NodeMCU sent this data to the Blynk mobile application through the internet connection. And the GND pin of the sensor is connects to the ground pin of NodeMCU microcontroller.

3.3.2.2.1.2 Gas sensor

A gas sensor is a device used to measure the concentration of gases in the air. There are many types of gas sensor available, all of them used to detect gas leakage based on the sensing of the gas concentration in the air. These gas sensors must be located in the kitchen and any other places where gas sources exist. The gas sensor used in this system is MQ-2 which detects the concentration of methane, LPG, hydrogen, propane, alcohol, and smoke in the air, for this system it’s used to concentration of methane gas.

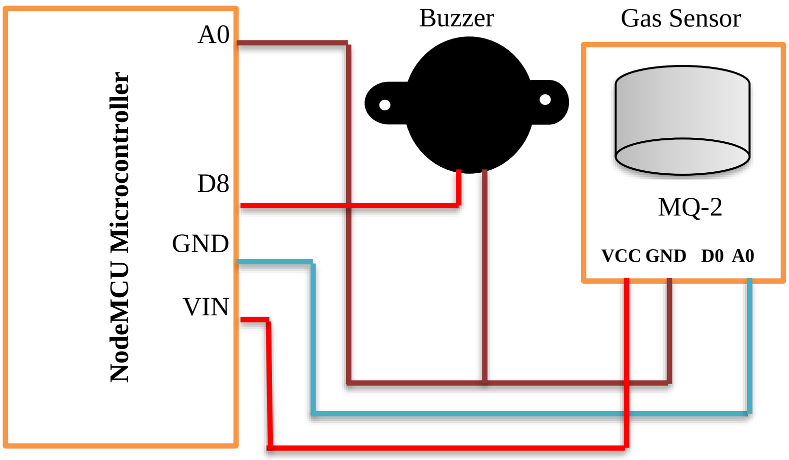

Figure 3. 32. Wiring diagram of Gas sensor.

As shown in figure 3.32. The MQ2 sensor is used in this system it has four pins: VCC, GND, D0 and A0. The VCC pin is used for input voltage to supply the gas sensor by 4.5 - 5V which is connect to 5V on NodeMCU microcontroller or other 5V supplier. The GND pin of the sensor is connected to the microcontrollers GND pin. The digital (D0) pin of sensor not connects in this system. The analog (A0) pin of sensor in connects to the A0 pin of NodeMCU microcontroller which is used to sense the concentration of gas in the air and sent it as a data to the NodeMCU. Then NodeMCU send this data to the Blynk mobile application through the internet connection as well as the owner will be alert by buzzer, notification and E-mail during gas concentration.

3.3.2.2.1.3 Flame sensor

The flame sensor is mainly designed for detecting the fire. When a fire detect by sensor the D0 led on the module will turn ON and sent data to the NodeMCU microcontroller through D0 pin. The detection point is 60 degrees. The sensitivity of this sensor is adjustable, can change the sensitivity of it by using potentiometer. There are many sensitive places in the building or home like kitchen, electrical board, living room, etc.

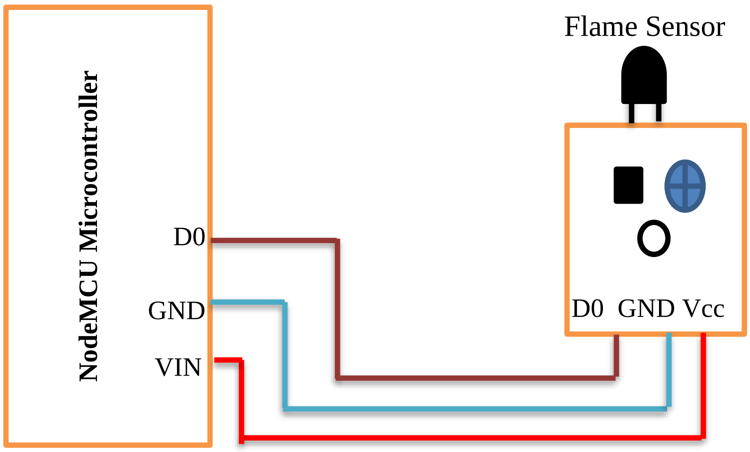

Figure 3. 33. Flame Sensor Schematic Wiring Diagram.

As shown in figure 3.33. The flame sensor used in this system has three pins namely: D0, GND, and VCC. The digital (D0) pin is connects to the digital (D4) pin of NodeMCU microcontroller, this pin is used to detect the fire, if the fire it detect the sensor send data through D0 pin to the NodeMCU microcontroller, and then NodeMCU microcontroller send alert notification through the Blynk application to the owner of the building and also send an E-mail to the building owner. The VCC pin is used for input voltage to supply the gas sensor by 4.5 - 5V which is connect to 5V on NodeMCU microcontroller or other 5V supplier. The GND pin of the sensor is connects to the ground pin of microcontroller.

3.3.3 Wiring diagram of LCD

Liquid Cristal Display (LCD) is used to display the value of DHT22 sensor, gas sensor, the alert notification when fire detected by flame sensor and also display the status of Wi-Fi connection. The schematic wiring diagram of LCD is shown in figure 3.34.

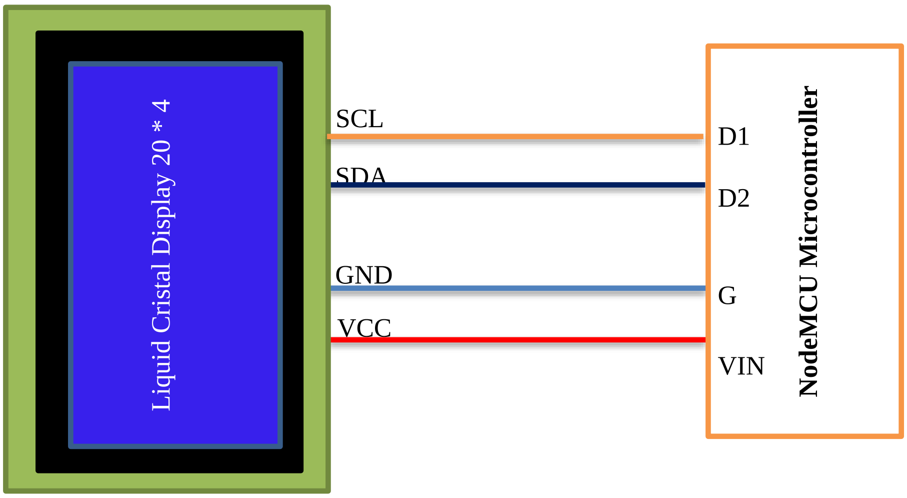

Figure 3. 34. LCD 20*4 Schematic Wiring Diagram.

As shown in figure 3.34. The LCD used in this work has four pins, VCC, GND, SCL, and SDA. The wiring connection of LCD with NodeMCU microcontroller should be like that connect VCC of LCD to VIN of NodeMCU microcontroller, GND to G, SCL to digital D1, and SDA to digital D2.

3.3.4 Installing blynk application and dashboard creation

Blynk application is an IoT platform used to create a dashboard of IoT applications to monitor and control physical objects that connected to the microcontroller. In this proposed system the electrical devices and safety sensors are wired to the NodeMCU microcontroller.

Dashboard creation of proposed system is illustrated in below steps.
Downloading Blynk application on mobile phone in **Play Store** for android system and in **iTunes** for IOS system

After downloading application, an account should be creating to login to the application and create new project. All steps are summarized below:

Select new project and gives a name to the project, name of this project is ***Remote and safety model***. Then select NodeMCU as a hardware board and connection type is Wi-Fi because in this proposed system Wi-Fi is used as a connection type. After new project created the Blynk mobile app send authentication token to the E-mail used in account creation, the Authentication token is unique and used in programing code to setup connection between Blynk and NodeMCU microcontroller through Blynk server. Figure 3.35 shows the screenshot of creation new Blynk project.

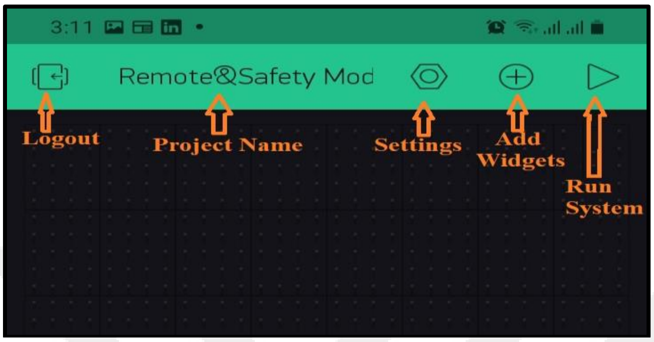

Figure 3. 35. New Blynk Project Main Screen.

After new project created. User can add desire widgets for both models to the application main screen such as button, gauge, notification and E-mail. The proposed system dashboard consist of four sub-systems which are control appliances, DHT22 sensor to measure humidity and temperature, gas sensor to measure concentration of gas in the air and flame sensor to detect fire. As shown in figure 3.36.

Figure 3. 36. Proposed System Dashboard

After proposed system dashboard created and all hardware components are connected to each other, proposed system code should be uploading to NodeMCU microcontroller to connect to your Wi-Fi and Blynk server to control and monitor both models. After that the proposed system will be ready to implementation. The uploading code process is shown in figure 3.37.

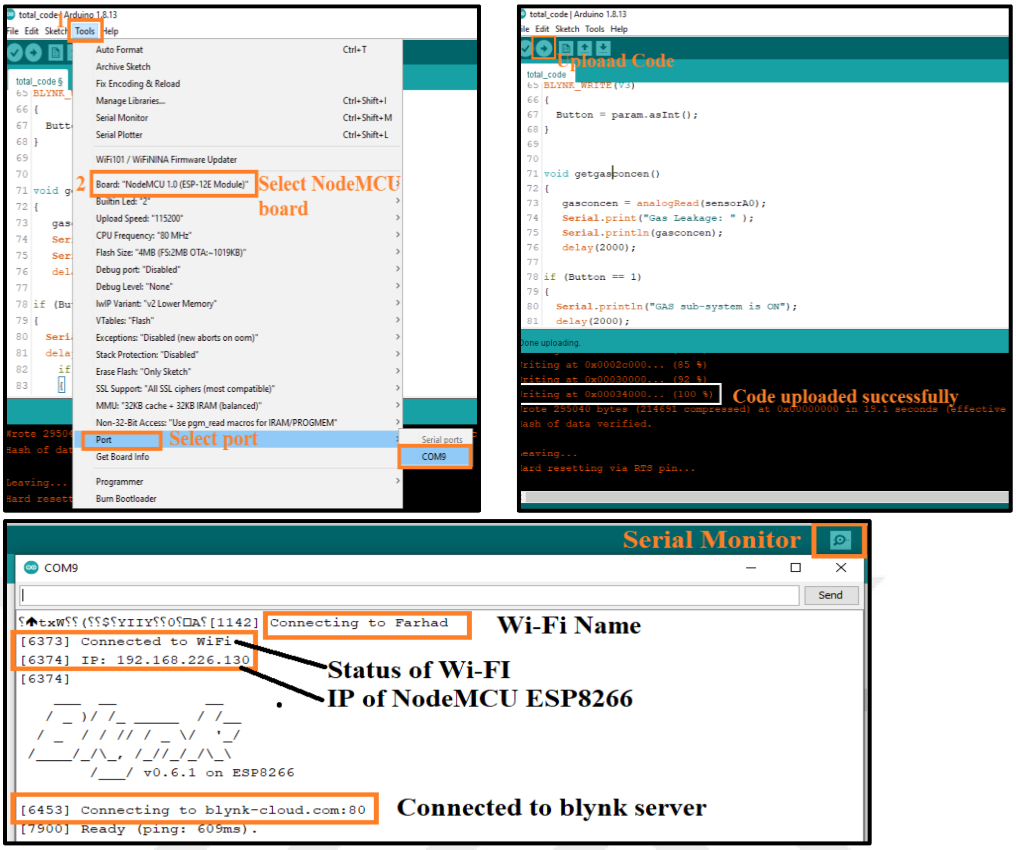

Figure 3. 37. Code uploading process.

After code uploaded to NodeMCU microcontroller the status of Wi-Fi connection between NodeMCU microcontroller and building Wi-Fi router will display on LCD screen as shown in figure 3.38.

(A) (B)

Figure 3. 38. Status of Wi-Fi connection

(A)Wi-Fi not connected.

(B)Wi-Fi connected.

4. RESULT and DISCUSSION

4.1 Introduction

In this chapter the proposed system has been implemented. Its consists of many equipment's like electrical appliances of the building and some safety sensors such as temperature and humidity (DHT22), flame and gas, that are presented in chapter three. There are two models in the proposed system, the first model is about building appliances remote control and the second one is building safety. The implementation results are obtained from the practical studies. The implementation results are explained in below sections.

4.2 Implementation Results of Two Models

The proposed system consists of two models as illustrated in chapter three: the remote control of appliances model the main aim of this model is to saving power and safety model the main aim of this one is to monitor the sensitive places of building from high temperature and humidity, fire and gas leak. Figure 4.1 shows the proposed system control board.

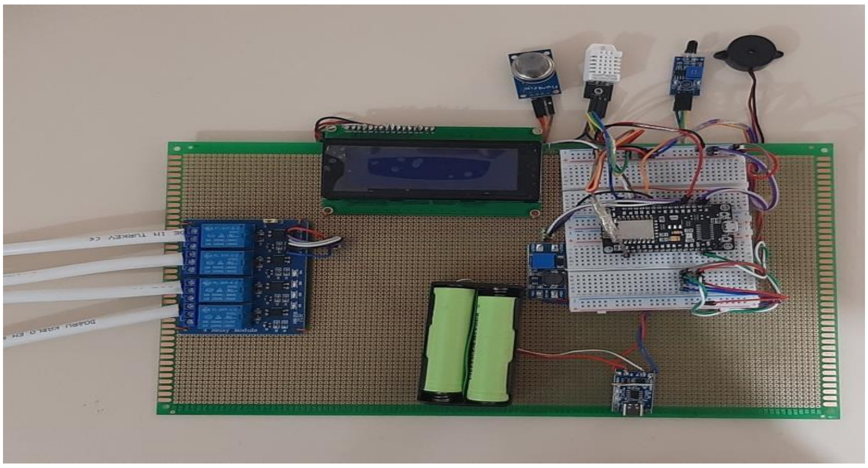

Figure 4. 1. Proposed System Control Board.

4.2.1 Implementation result of remote control model of appliances

One of the key components of smart buildings is the ability to manage appliances remotely via wireless communication technology. The proposed system has been implemented through using Wi-Fi technology. The main aim of this model is to remotely control the building appliances, that's why will be able to reduce the consumed power, reducing the electrical bill pay, reducing electrical accidents, reducing peoples effort, and comfortable.

The system will operate and initialize after applied 5V DC to the system and the status of electrical appliances will be display on the Blynk mobile application, and LEDs of relay as shown in figure 4.2.

(a) (b)

Figure 4. 2. status of electrical appliances.

(a) Status of electrical appliances on Blynk mobile application.

(b) Status of electrical appliances on relay LEDs.

The status of electrical appliances as shown in figure 4.2. In figure (A) shown the status of appliances on Blynk mobile application as shown the status of A/C and light is ON and others are OFF. And in figure (B) shows the status of appliances on LEDs of relay as shown the status of IN1, 2 are ON which are reserved for A/C and light respectively and the statuses of others are OFF. The appliances name in both Blynk dashboard and relay are shown in table 4.1.

Table 4. 1. Illustrate electrical appliances name on Blynk, and relay module.

Device Name on Blynk	A/C	Light	TV	Water heater
Status of device on relay	IN1	IN2	IN3	IN4

4.2.1.1 Controlling electrical appliances

This section is illustrating how to control status of electrical appliances those connected to CB. Blynk application is used to control electrical appliances status remotely via virtual switches. There is a connection between virtual switches and microcontroller digitals pins. The digital pins are established a wireless channel between Blynk mobile application and hardware equipment's also exchanging data between theme; to change the status of electrical appliances by Blynk mobile application should change the status of virtual switch on Blynk screen from ON to OFF or vice versa. As illustrated in table 4.1. The name of electrical appliances is written on virtual switches of Blynk mobile application. If building owner desire to change the status of A/C should pressed that virtual switch which written A/C on it after pressed the status of A/C will be change As shown in figure 4.3. And also status of it will change on the LED of relay. It's the procedure for all electrical appliances those are connected to the system.

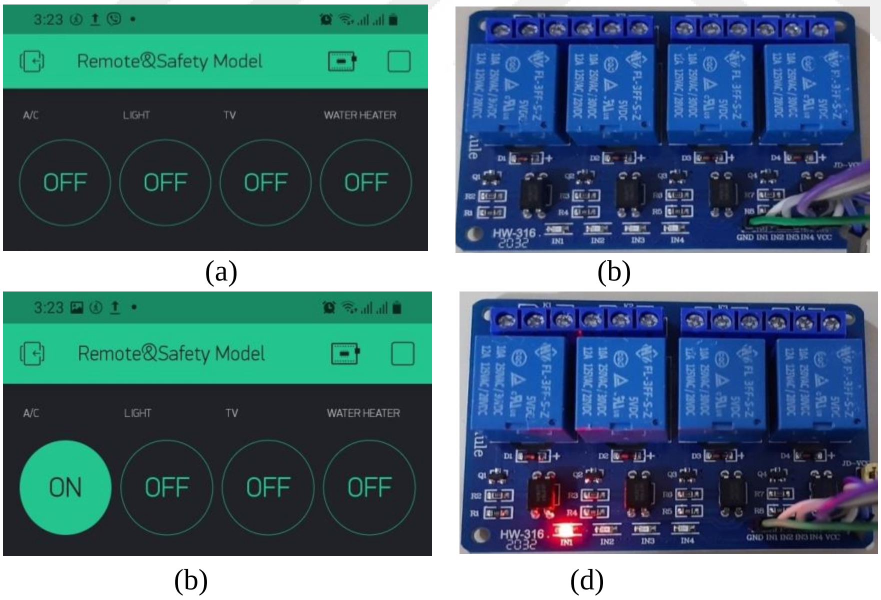

Figure 4. 3. Controlling status of appliances by blynk mobile application.

(a), (b): shows the status of A/C on blynk and relay before status change.

(c), (d): shows the status of A/C on blynk and relay after status change.

4.2.1.2 Monitoring electrical appliances

In this system there are two ways to monitor the status of electrical appliances those connected to the CB which are Blynk application, and relay LEDs. If Blynk is use for monitoring the status of appliances the virtual switches are used to monitor if any virtual switches status is ON it means this appliances is ON and any virtual switches status is OFF it mean this appliance is OFF as shown in figure 4.4.

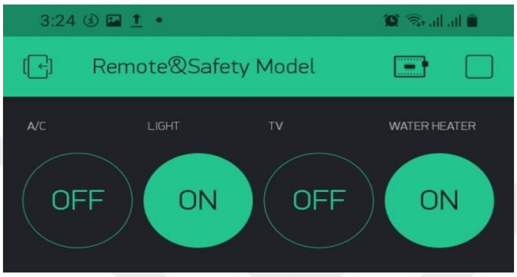

Figure 4. 4. Monitor status of appliances on blynk

As shown in figure 4.4. the status of light and water heater is “ON” on blynk mobile application screen which means both are switched “ON”, and the status of A/C and TV are “OFF” on Blynk mobile application screen which mean both are switched “OFF”.

And if building owner use relay to monitor the electrical appliances status, the LEDs status of relay are used to monitor the electrical appliances status. As shown in table 4.1. Each INs of relay is reserved to a specific appliance. if relay is at NC they will provide 220V AC to appliances and if it’s at NO the 220V AC will not pass to appliances, if any LEDs is ON it means that the relay is at NC state and appliance is ON and if any LEDs is OFF it means the relay is at NO state and appliance is OFF as shown in figure 4.5.

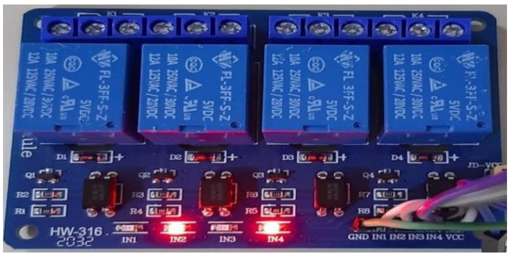

Figure 4. 5. Monitor status of appliances on relay

As shown in figure 4.5. The state of IN2 and IN4 are “ON” which means the relay is at NC State and the 220V AC is passed to appliances, as shown in table 4.1. IN2 and IN4 are reserved for light and water heater the status of both are “ON” and IN1, and IN3 are reserved for A/C and TV the state of both INs are “OFF” which mean the relay is at NO state and 220V AC doesn’t pass to appliances.

4.2.1.3 Determining result of power saving

This study depends on four electrical appliances those connected to the CB which are: A/C, water heater, TV and lights (here 10 lamps are taken). By using equation (4.1 , 4.2) can calculate the power consumption of devices separately and also total power consumption. Table 4.2. Shows the power usage in Watt of each appliances for one (Hour, Day and Week).

The power consumption of each connected devices could be calculate separately by using this equation

$$Pc = Pu * T \quad (4.1)$$

Where

Pc is total power consumed by a specific connected device.

Pu is the usage power of device.

T is the time in hour that device is switched ON.

The total consumed power of all connected devices can be found by using equation (4.2) which can be found by calculate by the summation of power consumption of all devices that found in equation (4.1)

$$Pt = \sum_{1}^{n} Pn \tag{4.2}$$

Where

Pt is the total power consumption by connected devices to the control board.

Pn is the total power of specific device.

n is the number of connected devices to the control board.

Table 4. 2. Electrical Appliances Power Consumption

Appliance Name	Power Consumption in (Watt)		
	Watt/Hour	Watt/Day	Watt/Week
A/C	2,500	60,000	420,000
Water heater	3,000	72,000	504,000
TV	150	3,600	25,200
Lights	(30*10) = 300	7,200	50,400
Total (Watt)	5,950	142,800	999,600

In order to test and analyze the power consumption results of a building we assumed two scenarios. Firstly; without connecting the building appliances to the CB system. When the owner left the building between the hours of 7AM and 7PM (12 hours), the appliances were switched ON. The power consumption result is illustrated in table 4.3. Shows the consumed power during 24 hours.

Table 4. 3. Power consumption during 24 hours (one day)

Appliances / Hours	A/C	Water Heater	TV	Lights	T (Watt)/ Hour
1	2,500	3,000	150	300	5,950
2	5,000	6,000	300	600	11,900
3	7,500	9,000	450	900	17,850
4	10,000	12,000	600	1,200	23,800
5	12,500	15,000	750	1,500	29,750
6	15,000	18,000	900	1,800	35,700
7	17,500	21,000	1,050	2,100	41,650

Table 4.3 (Continue)

8	20,000	24,000	1,200	2,400	47,600
9	22,500	27,000	1,350	2,700	53,550
10	25,000	30,000	1,500	3,000	59,500
11	27,500	33,000	1,650	3,300	65,450
12	30,000	36,000	1,800	3,600	71,400
13	32,500	39,000	1,950	3,900	77,350
14	35,000	42,000	2,100	4,200	83,300
15	37,500	45,000	2,250	4,500	89,250
16	40,000	48,000	2,400	4,800	95,200
17	42,500	51,000	2,550	5,100	101,150
18	45,000	54,000	2,700	5,400	107,100
19	47,500	57,000	2,850	5,700	113,050
20	50,000	60,000	3,000	6,000	119,000
21	52,000	63,000	3,150	6,300	124,450
22	55,000	66,000	3,300	6,600	130,900
23	57,500	69,000	3,450	6,900	136,850
24	60,000	72,000	3,600	7,200	142,800

While in second one, if the owner left the building between the hours of 7AM and 7PM (12 hours) and appliances switch are ON, in this scenario the appliances are connected to the remote CB system, here the owner will have remotely access to appliances and powering it OFF. Hence, this will result in power saving. In this scenario 50% of power is saved, as shown in table 4.4.

Table 4. 4. Power consumption during 24 hours (one day)

Appliances / Hours	A/C	Water Heater	TV	Lights	T (Watt)/ Hour
1	2,500	3,000	150	300	5,950
2	5,000	6,000	300	600	11,900
3	7,500	9,000	450	900	17,850

Table 4.4 (Continue)

4	10,000	12,000	600	1,200	23,800
5	12,500	15,000	750	1,500	29,750
6	15,000	18,000	900	1,800	35,700
7	17,500	21,000	1,050	2,100	41,650
8	20,000	24,000	1,200	2,400	47,600
9	22,500	27,000	1,350	2,700	53,550
10	25,000	30,000	1,500	3,000	59,500
11	27,500	33,000	1,650	3,300	65,450
12	30,000	36,000	1,800	3,600	71,400
13	30,000	36,000	1,800	3,600	71,400
14	30,000	36,000	1,800	3,600	71,400
15	30,000	36,000	1,800	3,600	71,400
16	30,000	36,000	1,800	3,600	71,400
17	30,000	36,000	1,800	3,600	71,400
18	30,000	36,000	1,800	3,600	71,400
19	30,000	36,000	1,800	3,600	71,400
20	30,000	36,000	1,800	3,600	71,400
21	30,000	36,000	1,800	3,600	71,400
22	30,000	36,000	1,800	3,600	71,400
23	30,000	36,000	1,800	3,600	71,400
24	30,000	36,000	1,800	3,600	71,400

The following figures (charts) analyze the results that determined from both scenarios. Figure 4.6. Display the result from the table 4.3. And the figure 4.7. Display the result of power saving from table 4.4.

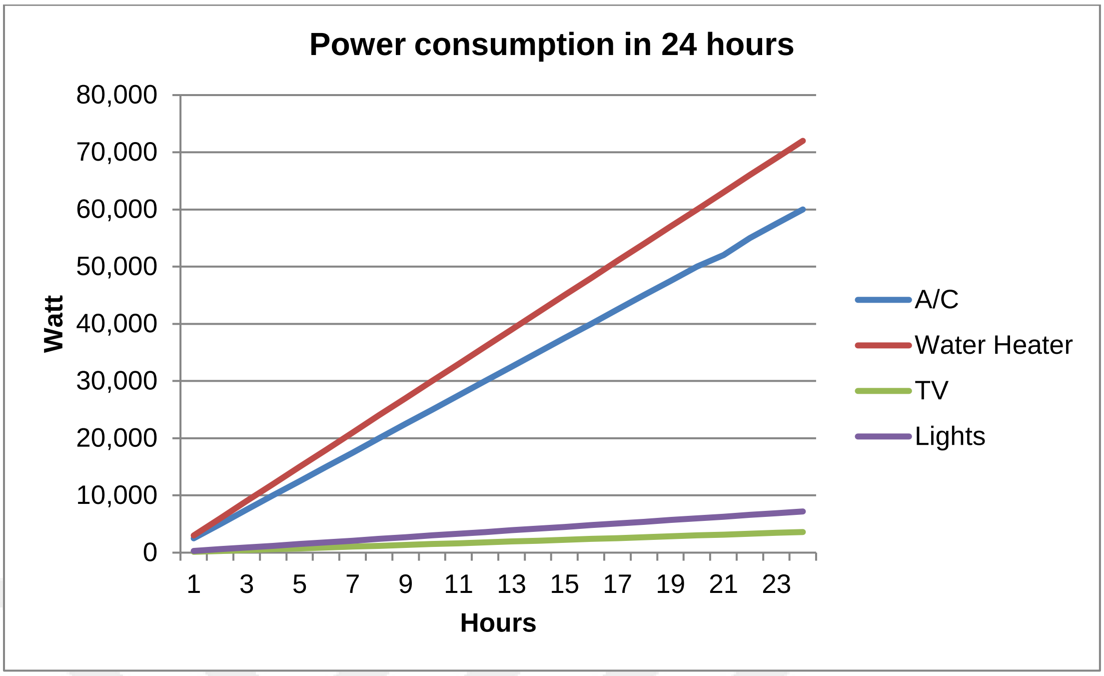

Figure 4. 6. Consumption of power in 24 Hrs without using remote board control system.

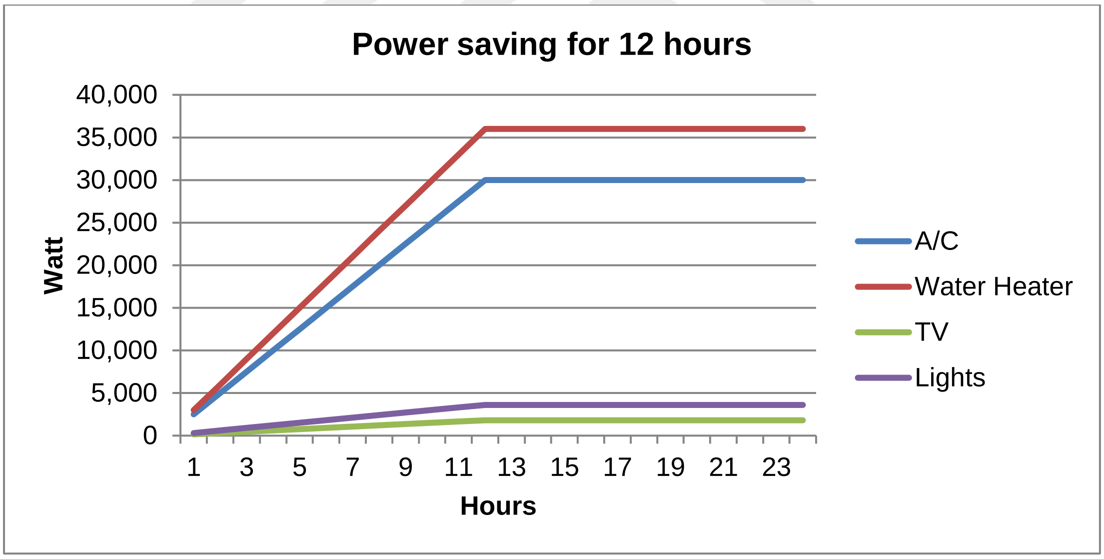

Figure 4. 7. Saving Power consumption in 24 Hrs with using remote board control system

The above tables and figures are illustrating that when using the remote control board system in the building the consumption of the power will reduce. When the building owner left and forgets for any reason to switch off the appliances, by using system, building owner can remotely access and switching off the connected devices. This in turn will produce saving power. Figure 4.8. Shows the power consumption and saving of both scenarios. The power consumption in first scenario is 142,800 watt/day, while in second one is reduce to 71,400 watt/day.

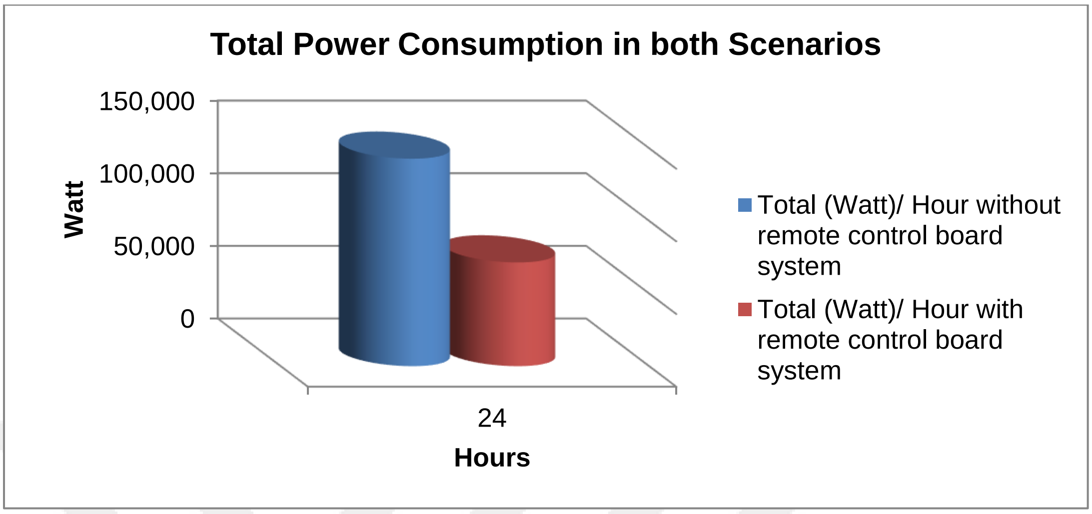

Figure 4. 8. Power consumption in both scenarios

4.2.2 Implementation results of safety model

Three sensors are utilized in the safety model implementation, including: DHT22, gas, and flame. Building Sensitive places are monitor by these sensors. By using Blynk application on mobile and LCD's CB The building owner can monitor the sensors value. More so, The Blynk program allows the owner to individually toggle ON/OFF the subsystem of each gas and flame. Below section illustrate the implementation result of safety sensors.

4.2.2.1 Implementation result of gas sensor

The gas concentration in the air is detected by using a gas sensor, which sends the gas leakage value to the microcontroller. The microcontroller then compares the leakage value obtained with the (300 PPM) value set in the NodeMCU microcontroller. An E-mail and notification will be sending to the building owner through Blynk server once the received value is greater than the 300 PPM. Also, the people around the place in the building will be aware by beeping buzzer. Figure 4.9. Shows the implementation result of gas sensor.

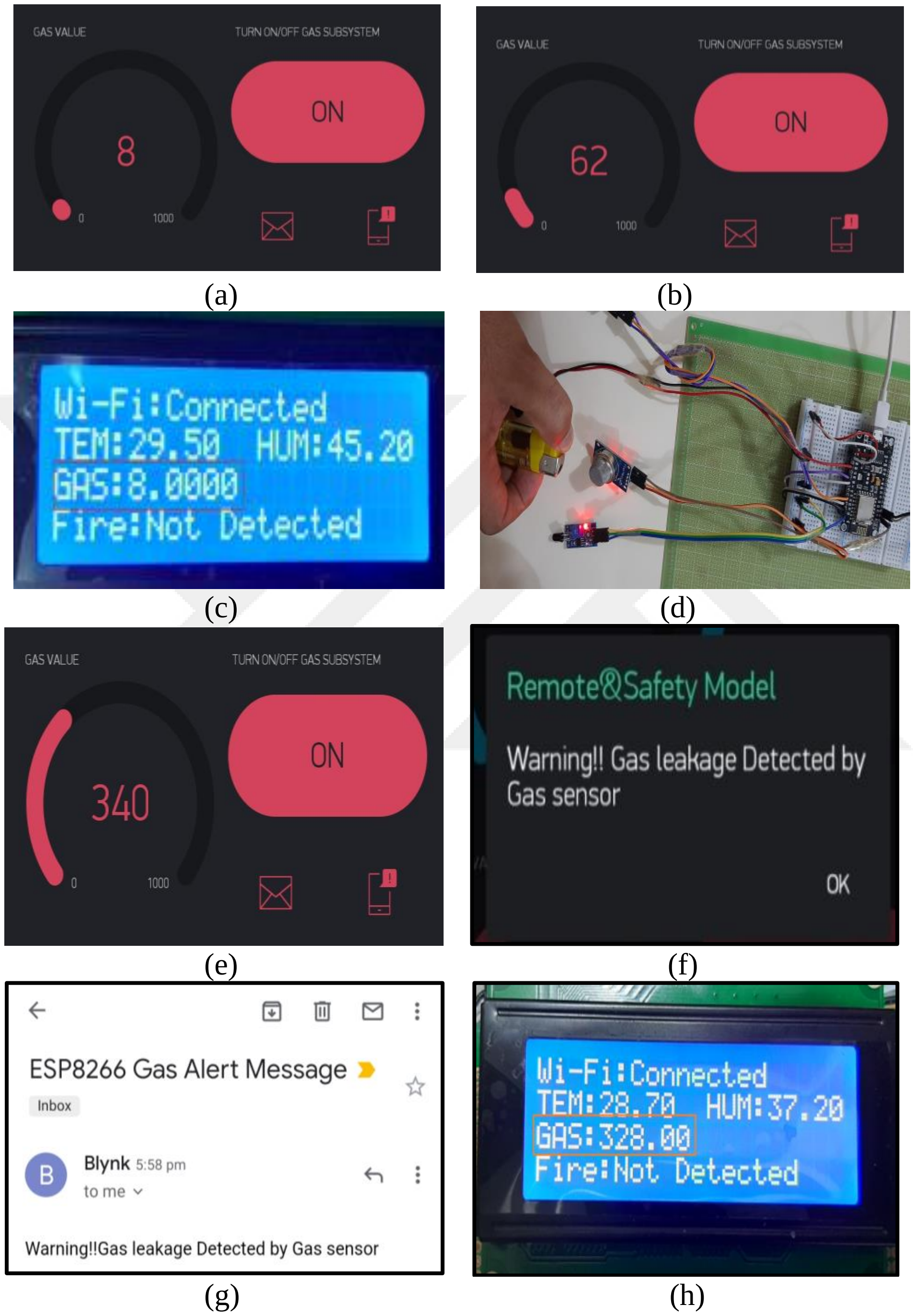

Figure 4. 9. Implementation result of gas sensor

(a) and (b) Normal environment with low gas leakage detect.

(c) Display Gas value on LCD when it has low gas leakage.

(d) Sprite gas in the air to detect by gas sensor.

(e) Gas leakage detect shown in Blynk mobile application.

(f) Send notification alert message to building owner.

(g) Received E-mail alert by building owner.

(h) Display gas leakage on LCD.

4.2.2.2 Implementation result of flame sensor

The flame sensor was employed in the proposed system to detect a fire in the building. It will send a signal to microcontroller when it sensing fire, then it will send notification with an E-mail to the owner. Finally, LCD's CB will display a massage with Fire Detected. Figure 4.10 shows the flame sensor implementation result.

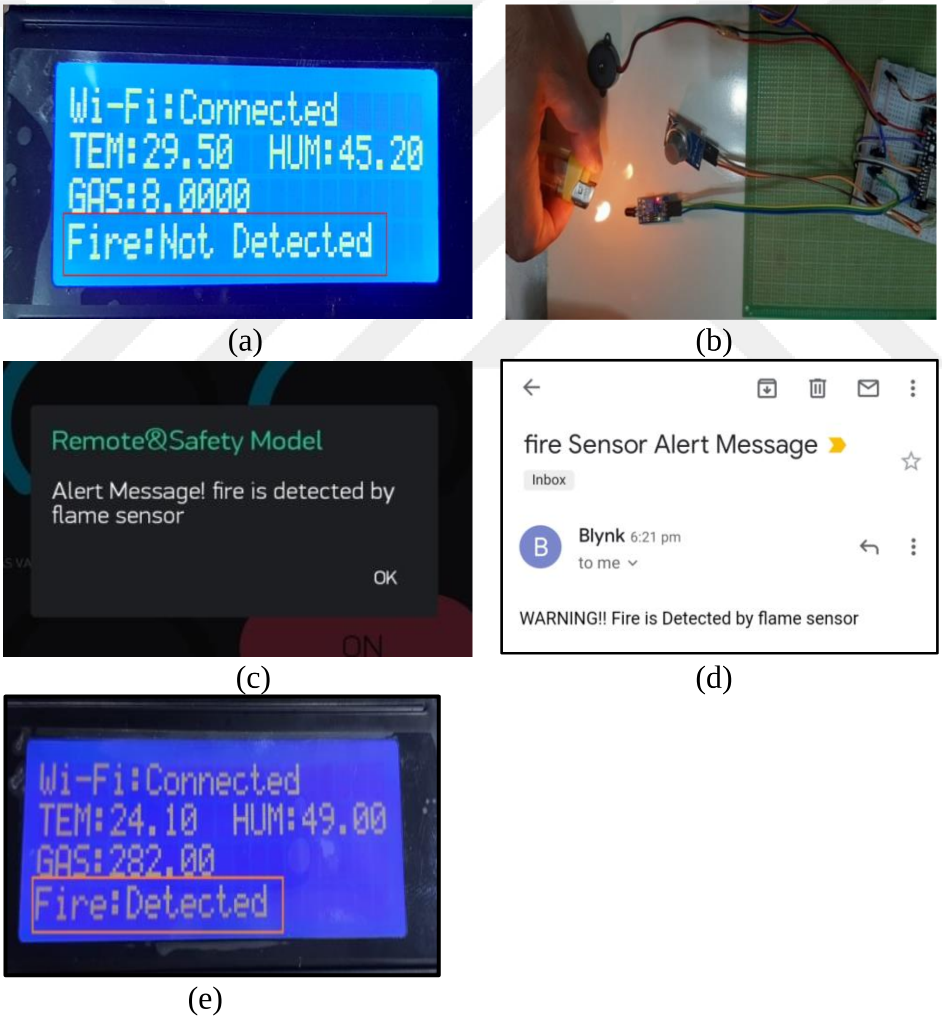

Figure 4. 10. Implementation result of flame sensor

(a) When there is no fire display on LCD

(b) Flame sensor detect fire

(c) Send alert notification to the building owner.

(d) Received E-mail alert by building owner.

(e) Display fire detected on LCD.

4.2.2.3 Implementation result of DHT22 sensor

The building temperature and humidity is monitor by using DHT22 sensor. When the temperature is crossed the determined value that was programmed by user (50 C^0), a notification alert will send to the application. Also, when the humidity is crossed the determined value that was programmed by user (70%) a notification alert will send to the application. Figure 4.11. and 4.12. Shows the implementation result of both Temperature and humidity respectively.

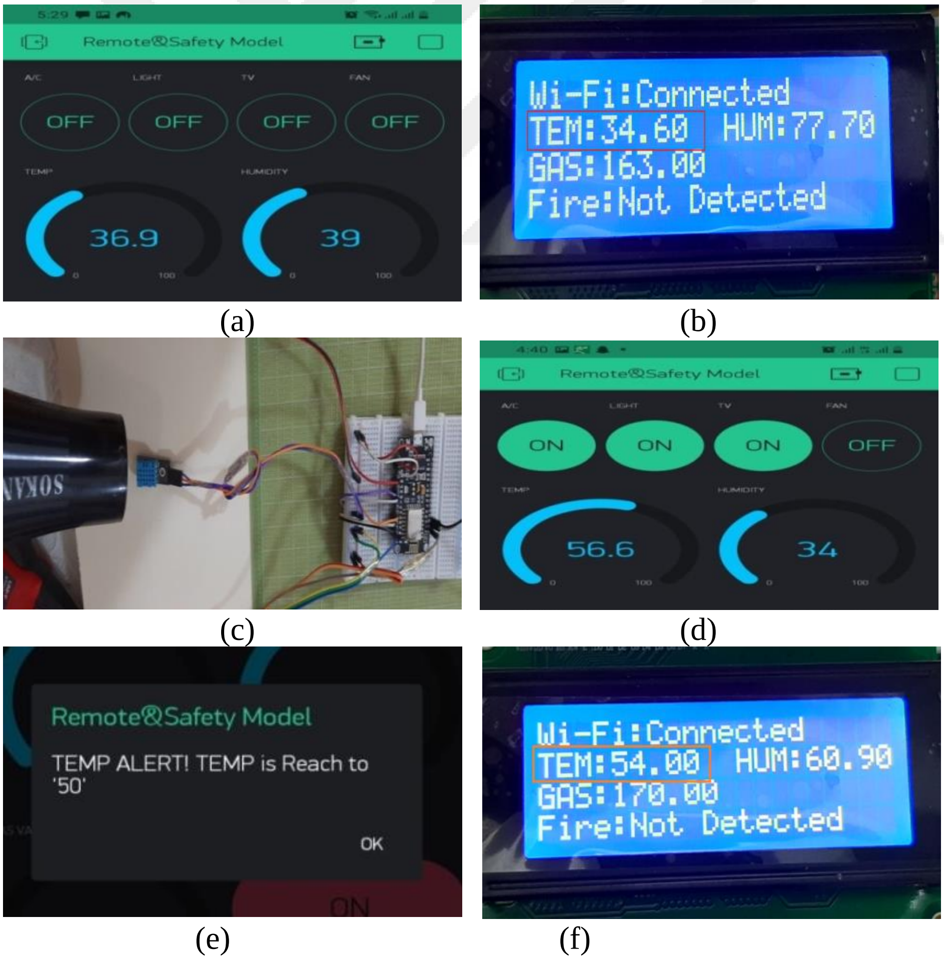

Figure 4. 11. Implementation result of temperature sensor

(a) Display normal value of TEMP on Blynk application.

(b) Display normal value of TEMP on LCD.

(C) When DHT 22 sense in hot environment

(c) Display critical value of temp on Blynk application.

(d) Send notification to the building owner.

(e) Display critical value of temp on LCD.

Implementations screenshot result of humidity is shown in figure 4.12.

(a) (b) (c) (d) (e)

Figure 4. 12. Implementation result of humidity sensor

(a) Monitor humidity at normal environment and display on Blynk application.

(b) Display normal value to Humidity on LCD.

(c) DHT22 sensing and display critical value at blynk application

(d) Send notification to the building owner.

(e) Display critical value of humidity on LCD.

5. CONCLUSIONS and RECOMMENDATIONS

5.1 Conclusion

A smart building based on IoT technology has been proposed in this study. The system is reducing the consumption of power, according to the token scenarios 50% of power can be saved if the system is utilize in building as compare to a building without using this system. Moreover, it improves safety of building in real time by utilizing sensors to remotely monitor (TEMP, HUM, Gas, and Fire) throughout the building such as DHT22, Gas, and Flame sensor; it also offers remote monitoring and controlling of building equipment like A/C, Water heater, TV, and lighting. The NodeMCU microcontroller board is used to design and control the system. The building electrical appliances and sensors used for safety are connected to the control board. Moreover, a Blynk application is connect to the control board through internet connection to be utilized by the building owner. The current state of the appliances, as well as the level of real-time safety sensors gauges, will be displayed on the Blynk mobile application. The owner of the building will be capable to remotely control and monitor the status of connected electrical appliances to the control board through Blynk application. Additionally, when any critical values is detect by any safety sensors the application will receives the notification alert and also an E-mail will be send to owner. At the same time, the owner will be informing by application in real time anywhere in the world with internet connection when any accident related to gas leakage, fire, high temperature and humidity happened in the building.

5.2 Recommendations

The proposed system can be improve to:

1- Automatically switching OFF the appliances and informing the owner by e-mail and notification when each connected device reach to the limited level of energy usage.
2- Also notify the fire department by sending e-mail that includes the building location with the owner phone number when there is a fire in building.
3- In addition to enhancing building security from unwanted entry by deploying security sensors.

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