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DESIGN AND IMPLEMENTATION OF A SMART PARKING SYSTEM WITH MULTI-LEVELS OF SAFETY BASED ON IOT TECHNOLOGY

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Master of Science

Supervisor

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The thesis titled DESIGN AND IMPLEMENTATION OF A SMART PARKING SYSTEM WITH MULTI-LEVELS OF SAFETY BASED ON IOT TECHNOLOGY prepared and presented by Usama ALSIGAR and submitted on 29/12/2021 has been **accepted unanimously of votes** for the degree of Master of Science Thesis in Information Technologies.

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Usama Shaker Hachim ALSIGAR

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Usama ALSIGAR

ABSTRACT

DESIGN AND IMPLEMENTATION OF A SMART PARKING SYSTEM WITH MULTI-LEVELS OF SAFETY BASED ON IOT TECHNOLOGY

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In recent years the concept of smart cities and employing new technologies have gained great popularity. In this work, we proposed a smart parking system comprised of three principal parts; the first part is the smart garage gate based on passive Radio Frequency Identification (RFID) reader and tags, once the user places his own tag on the RFID reader the garage gate is open. So that only the cardholder is authorised to enter the garage; this procedure is introduced to increase security. In addition, to increase the system security a laser beam with the Light Dependent Resistance (LDR) is used based Arduino Mega with a Liquid Crystal Display (LCD) to indicates if the user card is valid or not. When the thief is attempting to enter the garage and cutting off the laser line the warning system will be turned ON and a special warning message will be transmitted to the garage manager via the GSM system. The second part of the proposed system is the smart car parking system which based on the Internet of Things (IoT) technology; where each parking location contains a special infrared sensor to indicate if the location fill or empty. The infrared sensor output is analysed by the Arduino microcontroller board after that the microcontroller will be coupled to the NodeMCU microcontroller that supports the IoT technology through the digital pins. The last part of the proposed system is the garage safety scheme which made up based on the MQ-05 sensor that responsible to detect the leakage of the Liquid Propane Gas (LPG) emitted from the gas-based cars, a temperature sensor to monitor the garage temperature, and a flame sensor to detect the fires. In the case of fire detection and gas leak detection a special caution SMS will be sent to the garage manager. In order to monitor the parking locations, the granted local IP address by the NodeMCU microcontroller is placed in the internet browser to accessing a special GUI programmed by HTML that indicates the empty/fills parking locations and the weather temperature. This provides comfort and safety to the users as well as does not cause congestion or waste the time.

Keywords: Arduino, NodeMCU, MQ-05, LPG, Smart Parking System, RFID

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LIST OF ABBREVIATIONS

GPS : Global Position System
GSM : Global System Mobile
GUI : Graphical User Interface
IDE : Integrated Development Environment
IoT : Internet of Thing
IP : Internet Protocol
IR : Infrared
LCD : Liquid Crystal Display
LDR : Light Dependence Resistor
LED : Light Emitting Diode
LPG : Liquid Propane Gas
PIR : Passive Infrared Sensor
PWM : Pulse Width Modulation
RFID : Radio Frequency Identification
SCPS : Smart Car Parking System
SGG : Smart Garage Gate
SMS : Short Message Service
SPS : Safety of Parking System

GENERAL INTRODUCTION

1.1 INTRODUCTION TO RECENT TECHNOLOGIES

Recently, with the development of technology and the spread of microcontrollers in a wide field, researchers and developers have focused on designing smart cities, smart homes and even smart car parking systems. This is to reduce human effort and avoid accidents such as fires, for example, or gas leaks for cooking, in addition to preserving public or private property from theft. Where the smart city can be considered as an urban area which collects the various of the data by utilising the various types of the electronic components (i.e. sensors or modules), as illustrated in Figure 1.1.

Figure 1.1: The arrangement of the smart cities.

Insights gained from that data are utilised to effectively manage assets, resources, and services; in exchange, this information is used to improve city-wide operations. This comprises the data collected from citizens, equipment, buildings, and assets that are then treated and analysed for the traffic and transport systems, power plants, utilities, water supply networks, waste, crime detection, information systems, schools, libraries, hospitals, and other community services to monitor and manage. Besides the developments of the technology from time to time, in the recent years, the term of the Internet of Things (IoT) become very popular, it is a revolutionary paradigm of communication that aims to create an invisible and creative paradigm utilised in the smart homes, cities, and parking systems. It can be characterised as a structure for connecting the plethora of digital appliances to the Internet. Consequently, the Internet is dedicated to being more immersive and pervasive. As network operators, suppliers, manufacturers, and businesses begin to recognise the opportunities it offers, where the emerging IoT market is continuously gaining momentum. Following the advancements in sensors technology, various of the modern cities have chosen to deploy different IoT-based systems for monitoring applications in the cities [1], [2].

1.2 SMART PARKING SYSTEM

Due to increasing the problems in finding vacant spaces in the parking areas, the quickly finding an empty space in a multilevel parking garage is troublesome. Particularly on ends of the week or open occasions, and increase the problems that are related to safety. Discovering spaces amid ends of the week or open occasions can take over 10 minutes for around 66% of guests. Stadiums or shopping centre are swarmed at pinnacle periods, and trouble in finding empty openings at these spots is a noteworthy issue for clients. Inadequate car parking space \ prompt activity blockage and driver disappointment and waste of time [3]. The usage of IoT has become widespread with multiple types of sensors and different actuators. Therefore, we can implement and build an efficient parking system to solve the mentioned problems of parking in garages in the public or private parking at the peak times without the need to search for empty positions and waste more time as well as get rid of problems related to safety, especially fire and how to get a smart and safe garage [4]. Many of vital parts are made up the smart parking system, some of which can be listed as follows:

- **Safety Part:** The safety part is one of the most important parts of the smart car parking system, as it is responsible for the controlling and management of the fire detection /extinguishing system. Also, it is responsible for the monitoring of the temperature in the vicinity of the car park environment and lastly, it is responsible for the sensing of the gas is very important to protect the garage from the accidents [5].

leakage from the cars operating with liquid gas fuel. Where all of the mentioned previously is very important to protect the garage from the accidents [5].

- **Security Part:** The security part is also one of the important parts that must be available in the smart garage for the purpose of protecting the garage from tampering with its contents or theft of the cars parked inside. As this part contains a group of sensors, a microcontroller [6], as well as an alarm system, as illustrated in Figure 1.2.

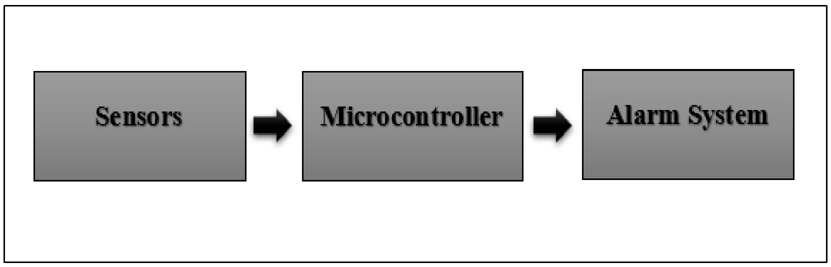

Figure 1.2: Block diagram of the garage security.

- **Finding Empty Space Part:** This part is the most important part in the design and construction of a smart garage, as this part contains the necessary sensors for the purpose of knowing the empty space to park the car in addition to the wireless means of communication that transmits information wirelessly to the user for the purpose of knowing the empty place as well as parking the car in it [7], as illustrated in Figure 1.3.

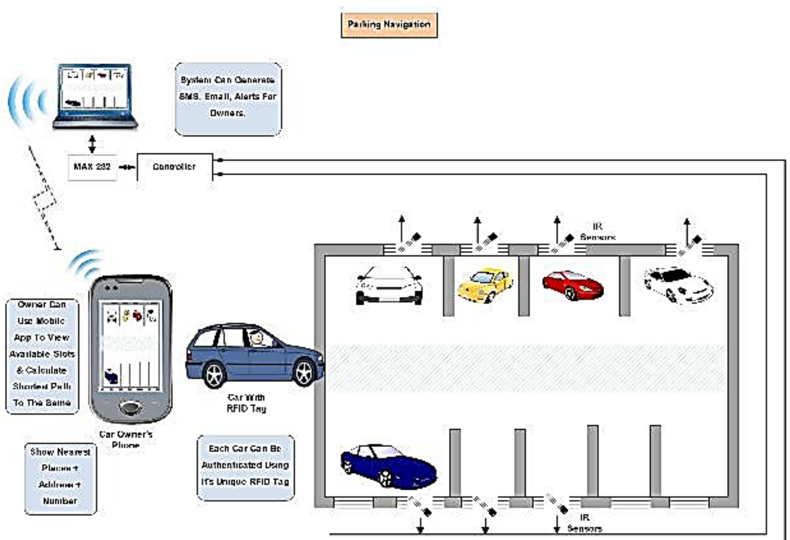

Figure 1.3: Smart parking system.

1.3 IoT-BASED PARKING SYSTEMS

IoT technology and cloud computing have been seen as great growth. Both of the technologies have their benefits, but it is possible to foresee several mutual benefits from their combination. On the other hand, by leveraging the extensive abilities and the resources of the Cloud, IoT can address its technological limitations such as storage, processing, and energy. Through the utilisation of the IoT technology, the cloud can also extend its reach to deal with real-world entities in a more distributed and dynamic way. Basically, in order to hide all the complexities and functionalities necessary to run the application, the Cloud acts as an intermediary between things and applications. Some of the factors that led to the amalgamation of Cloud and IoT are given below [8]:

- **Storage Capacity:** The IoT consists of a large number of sources of information (i.e. things) producing large quantities of non-structured or semi-structured data. As a result, large amounts of information need to be collected, accessed, processed, visualised, and shared through the IoT. Cloud offers endless, low-cost and on-demand storehouse capacity, giving it the greatest and most expensive storehouse capacity. An effective solution for dealing with IoT generated data.
- **Computational Power:** There are limited processing abilities for the appliances remaining utilised under the IoT technology. Usually, data gathered from different sensors is transmitted to more powerful nodes where it can be aggregated and processed. IoT computing needs can be addressed through the use of unlimited processing capabilities and the Cloud on-demand model. IoT systems can perform real-time data processing with the aid of cloud computing, thus facilitating highly responsive applications.
- **Resources for Communication:** IoT's primary functionality is to make IP-enabled machines cooperate with each other within a dedicated hardware group. Cloud computing provides economical and efficient ways to connect, track, and manage machines over the Internet from anywhere. IoT systems can monitor and control the things on the basis of the real-time via remote locations through the utilise of the built-in applications.
- **Scalability:** A scalable approach to IoT is provided by the cloud. It permits a dynamic fashion for a raise or decrease in the resources. When cloud integration is given, any number of "things" can be added or subtracted from the implemented system. In accordance with the demands of things and applications, the cloud allocates resources.

- **Availability:** With cloud integration, the availability of the resources become very simple at any time. The accessibility is guaranteed via various of the cloud providers. Besides the cloud, the apps are always up and running and the end-users are given with endless services.
- **Interoperability:** The utilise of the devices that are varied in nature includes the IoT. As a result of adaptability issues, these devices may have different hardware or software configurations. In an IoT setting, ensuring interoperability between these devices becomes very difficult. The Cloud helps to address this issue because it offers a common problem. A platform where various of the devices can be connected and communicated. In a format that is acceptable to them, devices are allowed to share and exchange data.

1.4 LITERATURE REVIEW

Many researchers have designed, implemented, and investigated the smart parking systems as well as smart homes. Some of these studies can be summarized as follows:

- In this paper, the authors have been utilised the Arduino microcontroller and Ultrasonic sensor; at each slot of the parking positions, there is an Ultrasonic sensor to check the availability of space in the intended, this method practically ineffective because the Ultrasonic sensor needs more current and the Arduino will be insufficient to feed more than six sensors. The user uses a temporary webpage to display data and in this way, the data will appear on the main screen. In the implemented design local IP approach has been applied so, each user can access the GUI to check the empty space [9].
- In [10] the authors have utilised the IR sensor at each slot of the parking area and send the data to android application through the GPS. In this method doesn't efficient and can't provide the required accuracy. In order to develop the implemented system, some additional development has been applied which summed by introducing intelligent garage gate based on RFID reader and RFID cards, this makes the design more secure.
- In [11] the authors simulate an automated parking system with Fee management utilising Arduino Uno microcontroller based on proteus software. The suggested system comprises of infrared sensor, servo motor, $RFID$ reader, and liquid crystal display to display the

empty spaces. The suggested work gives the assurance to build a smart, safe and fruitful parking system with the lowest possible cost.

- In this work, the researchers proposed a simple prototype of an Arduino-based automated two-tiered car park was designed and implemented which permits to entry/exit to only authorised persons by $RFID$ reader with its cards to open/close the garage gate that presented by the servo motor. In addition, a liquid crystal display (LCD) has been utilised to specify the empty number of the parking area. A special sensor was utilised to detect the empty space and display the available area on the LCD [12].
- In this work, the authors proposed a simple way of implementing a smart parking system that characterised by monitoring cars and incorrect parking. The authors were sung arts to work with some small items such as Arduino, Ultrasonic sensor, motion sensor, and smart screen to display the parking information. The fundamental aim of the proposed system can be summarised to solve one of the most important problems that a lot of people suffered the wrong parking, by making the parking intelligent and with it, will reach to the ideal efficiency with the low cost. The proposed smart parking system receives a signal from a three Ultrasonic sensors in a Moving Arduino, the Moving Arduino analysis the signal and converts the signal to code, then send the code by using a wireless radio frequency to the Fixed Arduino. The Fixed Arduino will display it using Nextion display touch screen telling us the results. If any problem with the parking car-like wrong park the display will show us a green car and red line, a vacant park will be a black car and correctly park will be a green car [13].
- About two new models were introduced by the authors in [14]. One is real-time booking (RTR). Other is the reservation of share time (STR). RTR can be utilised in this study by dynamically allocating resources from these drives before arriving at their destination by parking slot. The STR model could be used by allocating static resources based on-time scheduling, and preferred resources can be selected from this model driver with respect to the time frame referenced in the future.
- Many of the other techniques or systems are implemented that gives parking slots accessibility and some provide reservation facilities and some system gives a forecast of free parking spaces, but those systems are unable to solve all problems at a time. So

suggested provides real-time data on the availability of parking on your android mobile and also provides the prediction for the same. The suggested system by the authors is comprising of two main parts the first part is giving real-time information in the android app and the second part is giving the estimation of the availability of the parking slot to the users [15].

1.5 PROBLEM STATEMENT

The design of smart parking systems is a solution to two important problems which can be summarised as follows:

- Increase the accidents cases in public garages, such as theft or fires due to the high temperatures in the summer or leakage of liquid gas emitted from cars running on gas fuel especially in the some of the Middle East countries.
- Due to the problem of wasting more time to find an empty parking space, especially in multi-storey garages, and increasing the time lost on holidays.

1.6 Thesis Objectives

The major objectives from this study can be summarised as follows:

- Use the IoT technology to build the proposed parking system, where the user can find the empty space in the intended floor wirelessly via a special programmed graphical user interface (GUI).
- Implement a fire detection subsystem by using a flame sensor to detect the presence of fire in the garage floor and send an alarming system through the GSM to the garage manager as well as turning ON the extinguisher.
- Implement a gas detection subsystem by using a $MQ-05$ gas sensor to detect the presence of Liquid Propane Gas (LPG) in the garage floor and send an alarming system through the GSM to the garage manager.
- In order to increase the security, a smart gate will be implemented based on the Radio Frequency Identification ($RFID$) reader with its compatible card and servo motor, so that only the cardholder can enter the garage, otherwise the alarm will be turned ON and a

warning SMS will be sent to the garage manager. In addition, an LCD will be utilised to indicate whether the user card is valid or not. This section is based on Arduino Mega microcontroller to enhance the system reliability.

- Use the infrared sensor to indicate whether the parking location is empty or fill and display the status of the location on the programmed GUI.
- Given the presence of electric-powered cars or cars running on liquid gas fuel, there is a possibility of damage to electric car batteries or fire as a result of damage to the gas system in the gas-based cars. So that the temperature sensor will be utilised to automatically turning ON the cooling system when the temperature increased, thus safe the cars from the damage and save the energy.
- Implement a smart lighting system working automatically when the user enters to the park, this to save the energy

1.7 Thesis Outline

The organisation of this thesis can be listed as follows:

Chapter Two: All of the utilised hardware such as the microcontrollers, shields, and sensors that made up the proposed work will be presented and clarified.

Chapter Three: In this chapter, the design procedure of the implementation of the proposed system will be presented. Also, comprise the result that achieved after apply the test to the proposed system.

Chapter Four: Finally, this chapter illustrates the work conclusion and comprise also the future advices that can be utilised to develop this work.

SYSTEM HARDWARE

2.1 INTRODUCTION

In the next sections of this chapter, all the required hardware and software parts (e.g. shield and sensors) that utilised to construct this work will be briefly introduced.

2.2 Arduino IDE

The Arduino IDE is software that classified as open-source for writing and uploading programming code to the different Arduino modules. The IDE is compatible with various types of the known operating systems like Windows, Mac, and Linux. The programming languages such as C & C++ are utilised to building the language of the IDE. IDE stands here for the environment of integrated development. The term sketch is regularly utilised to describe the program or code that is written within the Arduino IDE. In order to upload the sketch that written within the IDE package, the Arduino should be connected via the computer USB port. The written code within the IDE is usually saved with the extension '.ino', Figure 2.1 illustrate the Arduino IDE user interface [16].

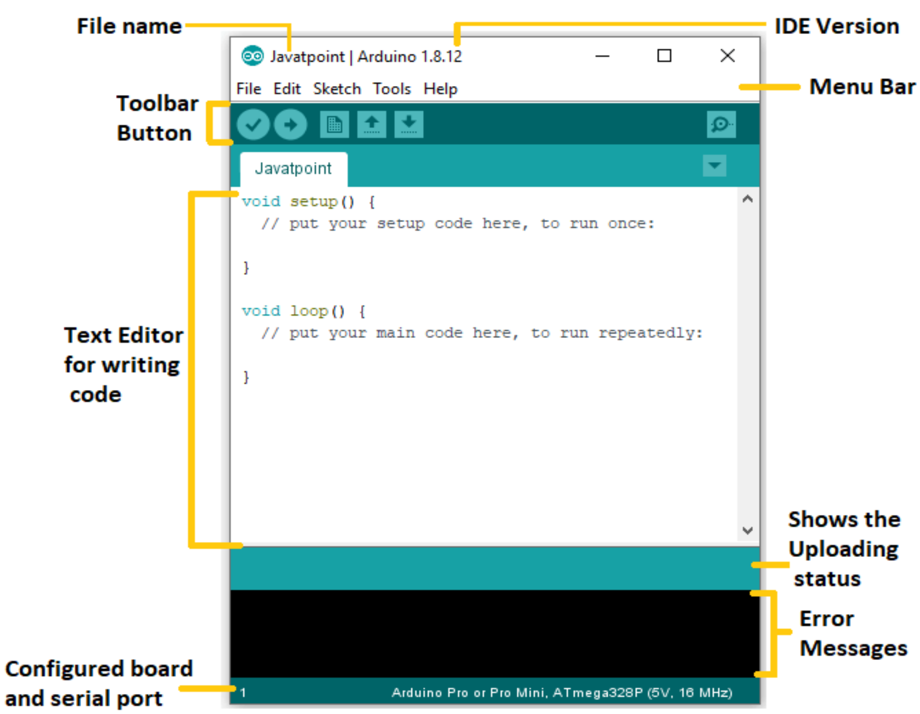

Figure 2.1: Arduino IDE user interface.

The Arduino IDE has toolbar buttons comprises of the New, Open, Save, Upload, and Verify icons, as illustrated in Figure 2.2.

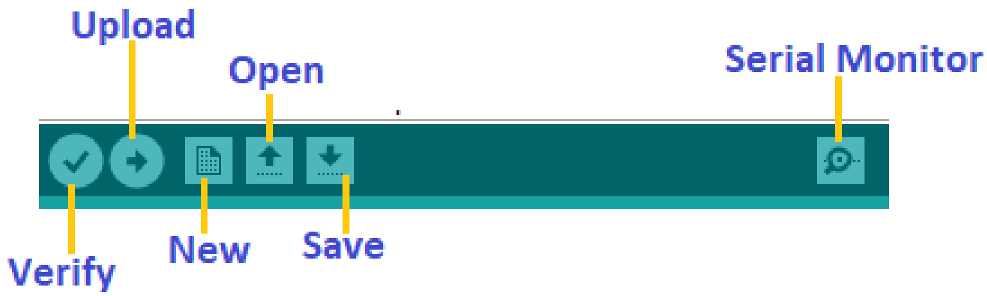

Figure 2.2: Toolbar of the Arduino IDE.

- **Upload Button**

The upload button organises and executes the written code inside the IDE. Where the connected Arduino module through the computer USB will be uploaded with a written code that has done inside the IDE. Before uploading the code must sure that the right board and ports are selected. Before starting the uploading of the sketch, the new Arduino modules can be automatically doing the reset operation but on the older modules, the reset button in the module must be pressed to restart it. Once the sketch is started to transfer to the module, the Tx and Rx LEDs will be blinked.

- **Open**

The open button is utilised to reopen a previously stored Arduino sketch. Whereas the chosen file will be opened in the layout window of the Arduino IDE.

- **Save**

The save button is utilised to store the written Arduino sketch in the computer of the user.

- **New**

In order to make a new Arduino sketch the "new" button is utilised to doing this task.

- **Verify**

In order to check the correctness of the written sketch in the Arduino IDE, the "Verify" button is utilised to doing this task. In case of an error is present a warning message will appear below the user layout in the "Error Message" section.

- **Serial Monitor**

On the right upper edge of the toolbar, the serial monitor button is present. The serial monitor can be utilised to show the output data or send commands to the Arduino module.

2.3 Boards and Shields

In this section, the utilised boards and shield will be described, such as NodeMCU microcontroller, Arduino Uno, Arduino Mega, Arduino Nano, GSM shield, and RFID.

2.3.1 NodeMCU Microcontroller

It is one of the embedded system boards classified as an open-source microcontroller that can be programmed for and set to provide the IoT technology. This signifies that the things in all smart or traditional devices such as TV, satellite receiver, mobile, air conditioning, watches, glasses, alarm, security, surveillance, and different other devices can be combined with each other across the Internet. Figure 2.3 illustrated the available NodeMCU microcontroller board in the electronic shops [17].

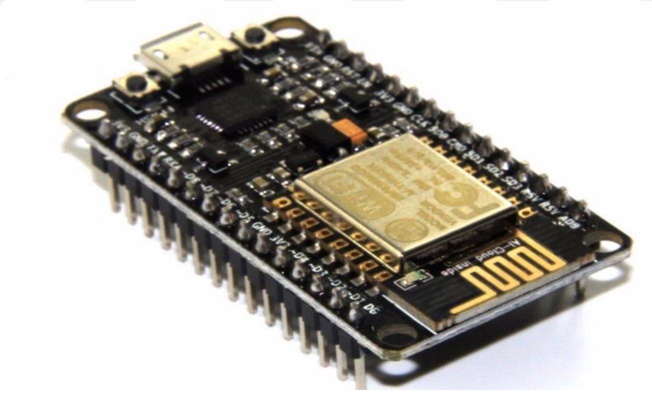

Figure 2.3: NodeMCU microcontroller board.

This microcontroller board originated with a built-in esp-8266 Wi-Fi module. The NodeMCU microcontroller board comprises ten digital pins (D1-D10) that can be utilised for the reading of the digital input or provide the digital output, in addition, all of these pins produce the pulse width modulation (PWM) mechanism that provides the analogue output voltage through varying the width of the digital pulse, knowing that just the pin (D0) does not back this property. The

NodeMCU also comprise an individual pin remarked as (A0) utilised to reading analogue signals, the arrangement of the pins for this board is shown in Figure 2.4.

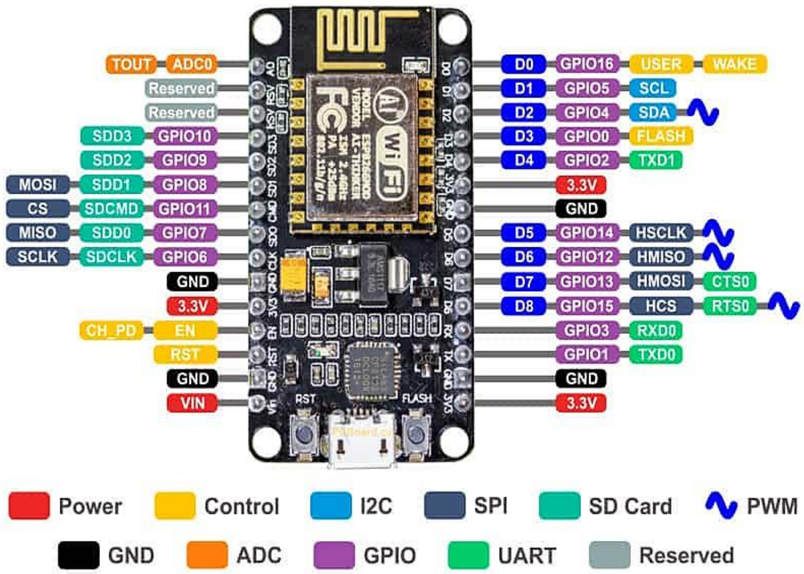

Figure 2.4: The organisation of the pins for the NodeMCU microcontroller.

The rated operated voltage for the ESP-8266 chipset is 3.3 volts and the digital pin's output (i.e. output voltage) is also 3.3 volts while the primary version of the NodeMCU microcontroller board able to operate in the range of 3.3V to 5V volts due to it contains an internal voltage regulator. In order to work with the later version, an external voltage regulator should be utilised to minimise the input voltage to 3.3V if the module feeds from the VIN pin [18].

2.3.2 Arduino Microcontroller Module

Arduino is a microcontroller module that has a special programming environment package designed to be an embedded system. The hardware of this module comprises a simplistic, open-source design for an AVR controller with on-board Input / Output (I/O) capability. The Arduino software environment comprises the standard programming languages, where this environment made up by utilising many of the known programming languages and a special boot loader operating on the microcontroller. The Arduino can be considered as a modest or a tiny computer that can be utilised to process the inputs/outputs through the programming among the microcontroller and the other peripheral segments (e.g. sensors) that can be directly attached with it. The Arduino module shall execute the written code and that can be solely be controlled as well as responded through the electricity (DC voltage) so that the module communicates with the actual components through the voltage. In general, the sensors work to convert some features of the physical world into electrical signals (digital or analogue) so that the Arduino module can interact with it. While the actuators catch the electric voltage from the Arduino module and convert it to another form that changes the world. For examples, sensors such as temperature, flame, and gas leak sensors. Actuators such as lights, motors, speakers, and display screens, all of the previously mentioned can be attached with the Arduino microcontroller module to perform many of the required tasks. The PWM technique provided by the Arduino module can be utilised for many applications such as light density controlling and DC motor speed control. The utilising of the Arduino module can be considered as one of the most convenient methods to accomplish the required tasks. There are many types of Arduino microcontroller module each of them is structurally similar but the difference between them can be summarised by the number of digital or analogue pins and the built-in components such as Bluetooth or Wi-Fi module, Figure 2.5 shows some of the Arduino module kinds [19].

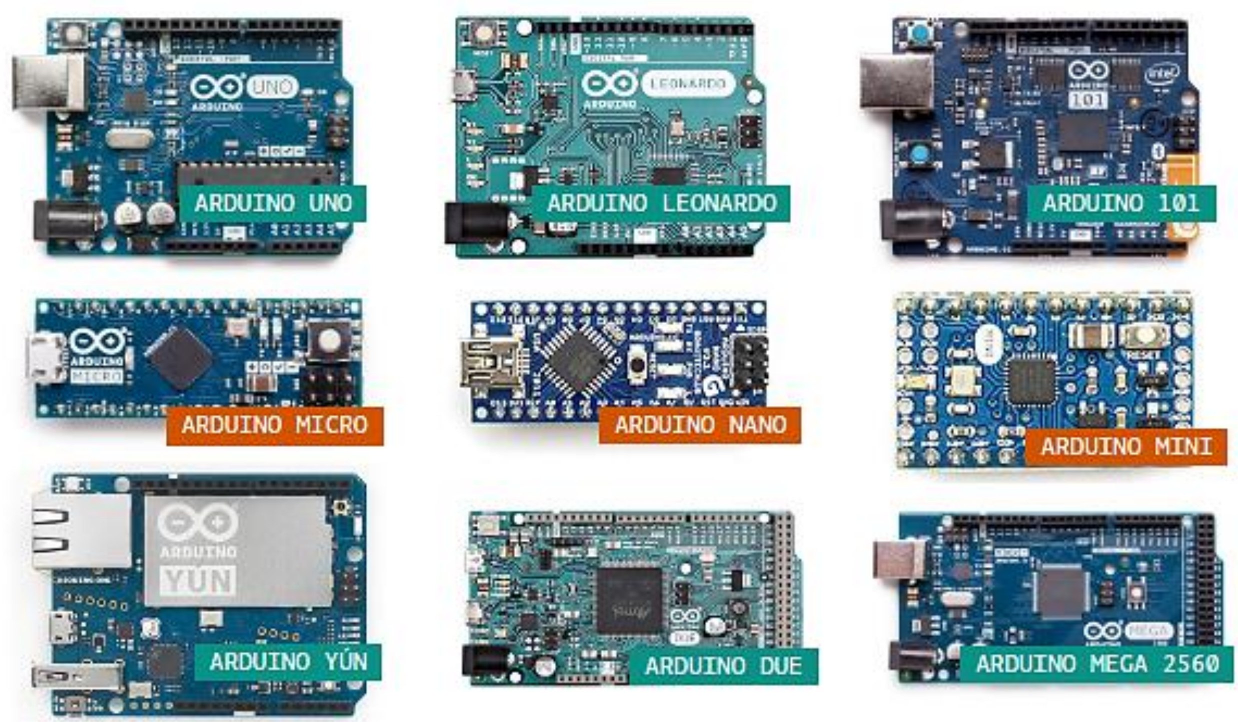

Figure 2.5: Some types of Arduino module.

The utilised of the Arduino microcontroller module offers numerous benefits, some of this can be summarised as follows:

- By utilising Arduino, it is possible to build low-cost systems
- It was made up by utilising an open-source hardware system, allowing the developers to produce their own customised board.
- The Arduino module programming environment is compatible with the known operating systems such as Linux, Windows, and etc.
- The Arduino module programming environment is also open-source software, this permits the developers to produce specific libraries for the sensors and shields to facilitate the programming process.
- For amateurs and beginners, the Arduino is simple to utilisation.
- The Arduino module is compatible with numerous of the sensors and shields.

Due to the previously mentioned benefits, the Arduino module has many applications and functions, some of which can be summed up as follows:

- It utilised to read the digital and the analog DC signals from the sensors as well as peripheral devices.
- It can be utilised to produce medical appliances.
- It can be utilised to make up different types of the robots.
- It can be utilised for the military applications.
- It can be utilised to construct smart cities and automation houses
- It can be utilised for smart irrigation in the green houses or in the agriculture applications.

2.3.2.1 Arduino UNO

The Arduino Uno is the most popular type of the Arduino family, this module is based on the ATmega328P microcontroller chip. The Arduino Uno module arrangement comprises 14 digital pins that can be utilised for the input or the output operation (6 pins can be utilised to get an analogue output via the PWM technique), 6 analogue input pins, a crystal oscillator with a frequency of 16 MHz, a USB association, a power jack, an ICSP, and the reset button that utilised to restart the module operation, as illustrated in Figure 2.6. In order to utilise the module Just need to connect it with the PC via the USB cable and start the programming. The Arduino Uno module can be fed from a USB cable, a VIN pin, via an AC-to-DC adapter or an external battery [20]. The specification of the Arduino Uno module can be summarised in Table 2.1.

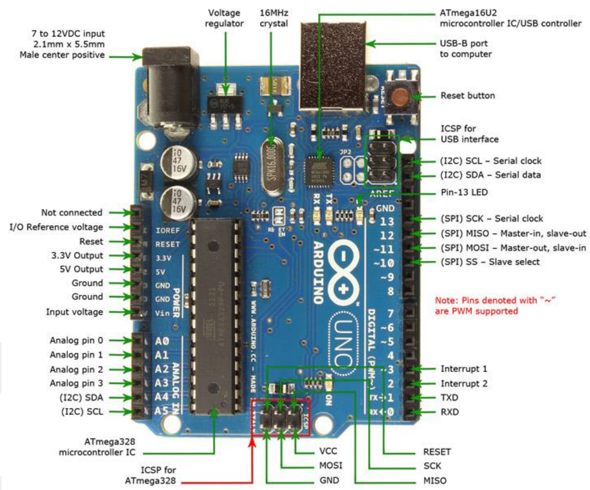

Figure 2.6: Arduino Uno module.

Table 2.1: Arduino Uno specifications.

Parameter	Description
The speed of the clock	16MHz
Rated working voltage	5V
Highest supply voltage	20V
Range of the supply voltage	7-12V
Number of the analogue input pin's	6 (A0-A5)
Number of the digital I/O Pin's	14
The output DC current for each I/O pin	40mA
The DC current of the 3.3V pin	50mA
The volume of the SRAM	2KB
The volume of the EEPROM	1KB
The volume of the flash memory	The total volume is 32 KB, a 0.5KB of which is utilised for boot loader

2.3.2.2 Arduino Mega Module

The Arduino Mega module is doing the same job as the other Arduino boards but is specially designed to construct the projects that requiring more I/O lines than the Arduino Uno based on the ATmega2560 chip. The Arduino Mega module comprises 54 digital I/O pins, 16 analogue inputs, and larger storage for your sketch. In addition, the Arduino Mega provides from the digital I/O pins a 15 pin can be utilised to generate the PWM also it comprises 4 UARTs (hardware serial ports), as illustrated in Figure 2.7.

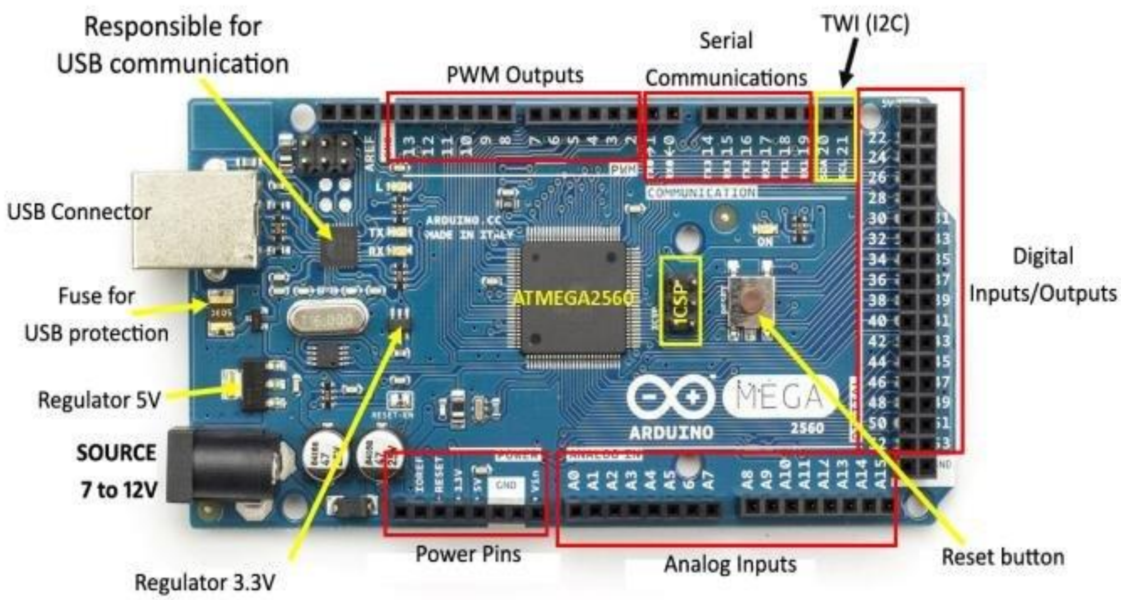

Figure 2.7: Arduino Mega module.

This module is the suggested board to develop the 3D printers, smart homes, robot projects, and any systems that required a large number of the I/O pins [21]. The specification of the Arduino Mega module can be summarised in Table 2.2.

Table 2.2: Arduino Mega specifications.

Parameter	Description
The speed of the clock	16MHz
Rated working voltage	5V
Highest supply voltage	20V
Range of the supply voltage (limits)	7-12V
Number of the analogue input pin's	16 (A0-A15)
Number of the digital I/O pin's	54
PWM pin's	2 - 13, 44 - 46
Default serial pin's	0(RX), 1(TX); 19(RX), 18(TX); 17(RX), 16(TX), and 15(RX), 14(TX)
The output DC current for each I/O pin	20mA
The DC current of the 3.3V pin	50mA
The volume of the SRAM	8KB
The volume of the EEPROM	4KB
The volume of the flash memory	The total volume is 256KB, a 8KB of which is utilised for boot loader

2.3.2.3 Arduino Nano Module

The Arduino Nano module is perfect for utilise in a number of projects that required a compact and easy-to-utilise microcontroller module. The tiny footprint and low manufacturing cost of this module make it particularly satisfactory for many of the applications such as wearable devices, low-cost robotics, electronic musical tools, and generally it utilised to construct as well as controlling the smaller parts of the larger schemes. This module can be built up by utilising the Atmega328 microcontroller chip and which is utilised to make the Arduino Uno module also. The Arduino Nano module and its pins configuration is illustrated in Figure 2.8 and Table 2.3 presents the specifications of the Arduino Nano module [22].

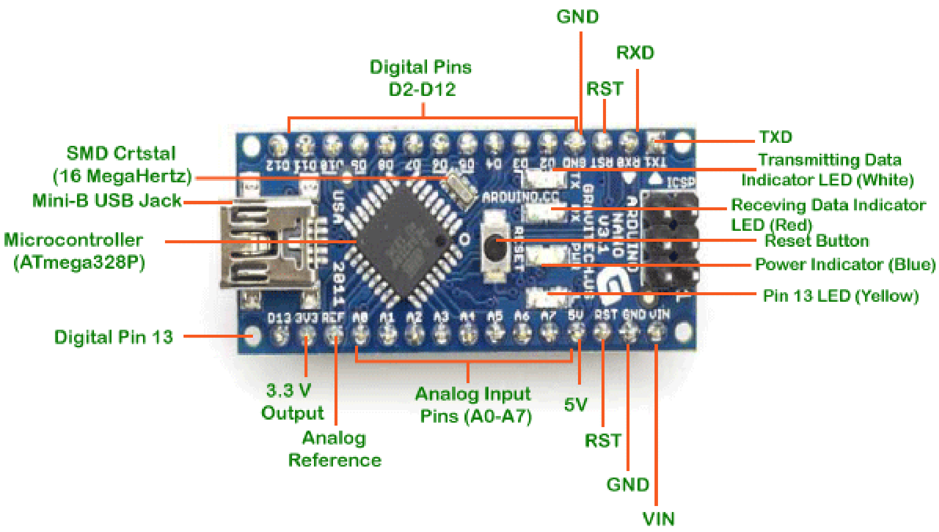

Figure 2.8: Arduino Nano module.

Table 2.3: Arduino Nano specifications.

Parameter	Description
The speed of the clock	16MHz
Rated working voltage	5V
Highest supply voltage	20V
Range of the supply voltage	7-12V
Number of the analogue input pin's	8 (A0-A7)
Number of the digital I/O Pin's	14
PWM pins	3, 5, 6, 9, and 11
The output DC current for each I/O pin	40mA
The DC current of the 5 V pin	50mA
The volume of the SRAM	2KB
The volume of the EEPROM	1KB
The volume of the flash memory	The total volume is 32 KB, a 0.5KB of which is utilised for boot loader

2.4 GSM Shield

The SIM900 GSM/GPRS module is one of the GSM board that be combined within a variety of IoT projects and the microcontroller board. This shield can be utilised to doing a job similar to ordinary mobile phones; such as sending/receiving SMS, make/receive telephone calls, GPRS, TCP/IP, and more. In addition, this shield supports the GSM/GPRS quad-band network, which means that it works almost everywhere. The SIM900 GSM shield is created to be compatible with all the necessary features for the Arduino microcontroller modules interface and to take benefit of the unique characteristics of the chip, as illustrated in Figure 2.9. In its small frame, the SIM900 packs a number of properties; some of which can be summarised as the following [23]:

- Backing the quadband: (i.e. GSM850, EGSM900, DCS1800, and PCS1900).
- Like ordinary mobile phones, this shield able to make /receive voice calls utilising exterior headphones.
- Make/receive SMS text.
- Serial-based AT command group can be applied.

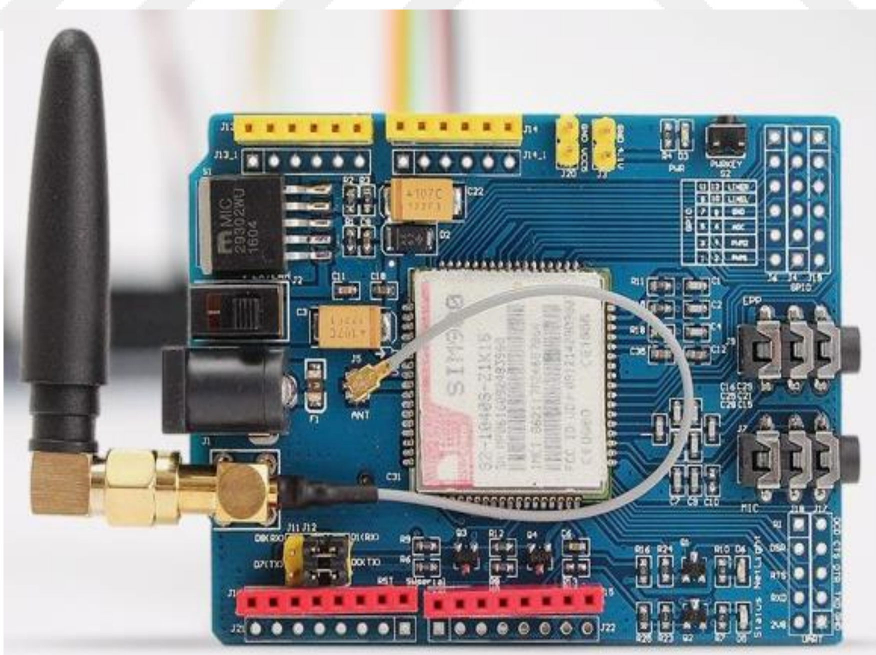

Figure 2.9: Arduino GSM shield.

As shown in Figure 2.10, the shield is comprised of three LEDs referred to as the connection or the power status (i.e. ON and OFF). The user can be gain the visual feedback on what happens with the shield by notice these LEDs.

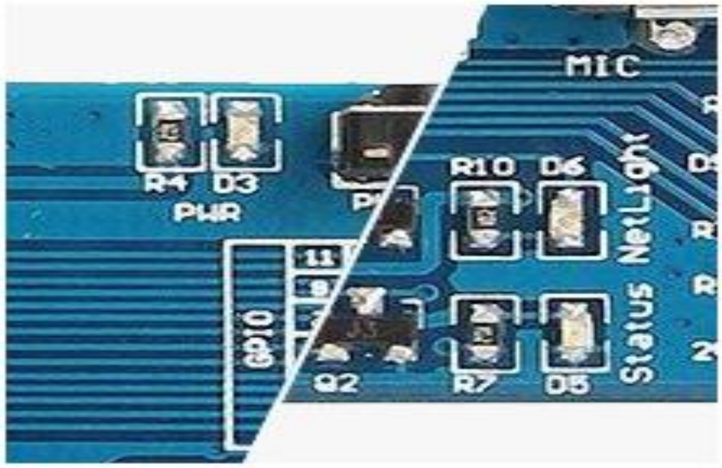

Figure 2.10: The status buttons of the SIM900 shield.

- **PWR:** This LED is linked with the power supply; when the LED in the ON state this means that the shield is connected with the power source.
- **Status:** This LED shows the operational status of the SIM900. In the case of the LED is in ON state this signifies that the shield is in working mode.
- **Netlight:** The status of the cellular network is indicated by this LED, where this LED will be blinking at various rates to show the state in which it present that can be summarised as follows:
  - OFF state: The SIM900 chip is not operating (I.e. power is switched OFF).
  - 64ms ON, 800ms OFF: The SIM900 shield is operating but not connect with the available cellular network still.
  - 64ms ON, 3 seconds OFF: This signifies that the SIM900 chip is connected with the available cellular network and is able to send/receive voice as well as the SMS.
  - 64ms ON, 300ms OFF: This signifies that the GPRS data connection that the user is requested is working.

Power feeding of the SIM900 shield it is one of the common essential elements to ensure that the SIM900 shield operating correctly, the supplying power must be sufficient. Through the transmission burst, the highest current draw of the chip is about 2A. It will regularly not pull that much, but during phone calls or in-network transmissions, it may take around 216mA or 80mA. The SIM900 chip's operating voltage is between 3.4V and 4.4V. The shield provides a high current, high precision and low-dropout voltage regulator, which can handle charging currents up to 3A, in order to maintain the supply-safe voltage at 4.1V.

2.5 Radio Identification Module

The Radio Frequency Identification (RFID) scheme comprises of two principal segments, as illustrated in Figure 2.11, the first segment is an RFID tag that can be directly attached to the object (e.g. device or clothes) to be identified, and the second segment is the transceiver and commonly known as an RFID reader.

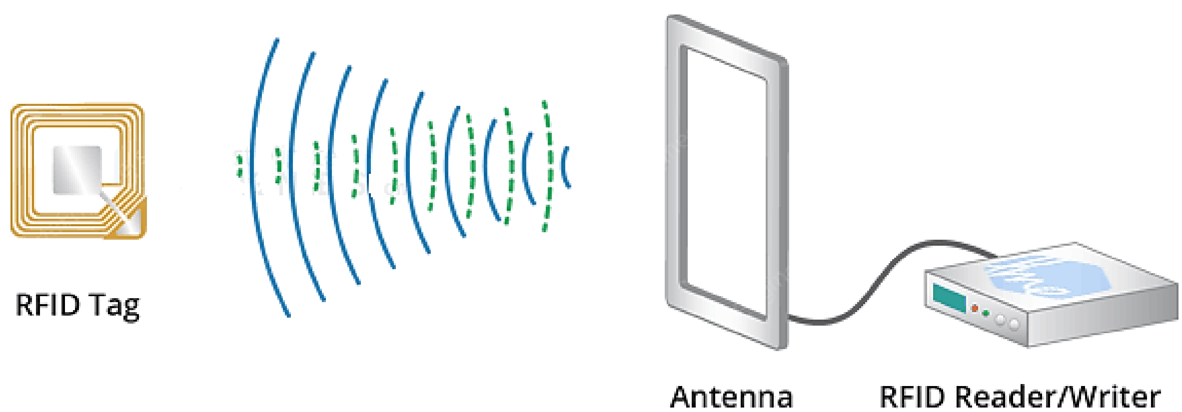

Figure 2.11: Fundamental segments of RFID system.

A radio frequency module with an antenna utilised to generate a high-frequency electromagnetic field is included in the RFID reader. The RFID tag is regularly a passive device, which means it not required a battery or any other voltage source for the feeding. It alternatively includes a microchip and an antenna for the receiving/sending of an information signal. It is situated nearby to the reader to interpret the information that is encoded inside the chip of the tag. An electromagnetic field is created by a reader, causing electrons to flow via the antenna and then powering up the chip, as illustrated in Figure 2.12. After that, the chip of the tag is responding with the received power from the reader and send its stored data as a radio wave back to the reader. Finally, the reader interprets the tag data and transfers it to the computer or microcontroller [24].

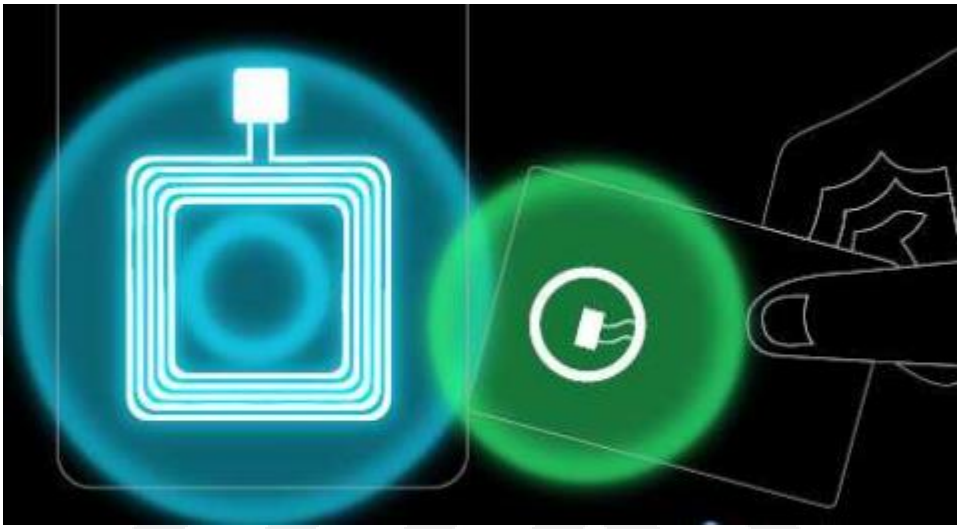

Figure 2.12: RFID working principle.

One of the cheapest RFID systems that are available in the electronic shops is the RC522 RFID module which is based on the MFRC522 IC of NXP. Normally it is supplied with an RFID card and a 1KB memory fob tag or normal card. A 13.56MHz electromagnetic field is prepared for the RC522 RFID reader module in order to interact amidst the RFID tags. A 4-pin serial interface (SPI) with a maximum data rate of 10Mbps can be utilised to interact with the reader by the microcontroller board. In addition, it promotes I2C and UART communication. An interrupt pin is given in the module design. The rated working voltage of this module is variated between 2.5 and 3.3V. The logic pins that are provided in the module required a 5V tolerant, so it can be simply coupled with the Arduino board or other microcontrollers that provide a 5V supply voltage without utilising the voltage regulators or converters, Figure 2.13 shows the RC522 RFID module. The module specifications can be sumarised as follows [25]:

- Operating frequency: 13.56 MHz ISM Band
- Rated operating voltage: 2.5 V to 3.3 V
- Rated operating current:13-26mA

- Reading distance: 5cm
- Minimum current (Power down): 10µA

Figure 2.13: RC522 RFID module (tags and reader).

RC522 RFID Module comprise of 8 pins, the configuration of these pins can be presented as follows:

- **VCC:** This pin is utilised to feeding the module with the power supply. This pin can be fed with a voltage in the range of 2.5 to 3.3 volts.
- **RST:** This pin is utilised as an input for the reset and the power-down purposes.
- **GND:** This pin is referred to as the Ground and should be to be connected with the GND pin that presence in the Arduino microcontroller board.
- **IRQ:** This pin is utilised for the interrupt and that can inform the Arduino microcontroller in the case an RFID tag gets in its region.
- **MISO / SCL / Tx:** This pin acts as a master in/slave out in the case of the SPI interface is permitted, functions as the serial clock and in the case of the I2C interface is permitted it acts as serial data output once the UART interface is permitted.
- **MOSI:** Is the master-out / slave-in pin acts as SPI input to the RC522 module.
- **SCK:** This is the serial clock pin that takes the clock pulses produced through the SPI bus master such as the Arduino microcontroller board.

- SS / SDA / Rx: This pin acts as the signal input in the case of the SPI interface is authorised, functions as the serial data in the case of the I2C interface is permitted and functions as the serial data input in the case of the UART interface is permitted. This pin is customarily considered by encasing the pin in a square so it could be utilised as a reference pin to recognising the other pins.

2.6 Arduino Sensors

In this section, the utilised sensors to construct this work will be illustrated, such as flame sensor, infrared sensor, gas leak sensor, servo motor, Light Dependent Resistor (LDR), Liquid Crystal Display (LCD), and passive infrared (PIR) sensor.

2.6.1 Flame Sensor

This model of the sensors is especially utilised to recognise and react with the appearance of the flame in enclosed spaces. This sensor can be ordinarily detected the flame fast and also accurately than the smoke or temperature detectors due to the utilised mechanisms that built up this sensor which based on the recognition of the emitted infrared from the flame. This sensor can be employed to recognise the origin of the fire or the ordinary light origins that lays in the wavelength range from 760nm to 1100 nm. An IR sensor, variable resistance, operational amplifier (Op-Amp) circuit, and an LED sign were make up this sensor [26], as illustrated in Figure 2.14.

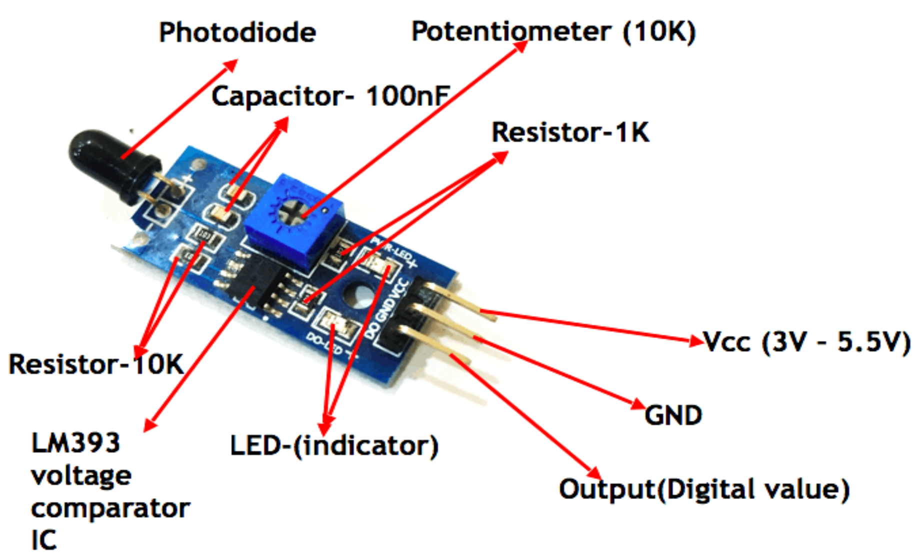

Figure 2.14: The flame sensor module.

Furthermore, it is built around the YG1006 sensor, which is a high-speed, extraordinary-sensitivity NPN silicon phototransistor. When the flame is detected, the module's red led will illuminate and a logic "1" sent from the output pin. This module is flame-sensitive, but it can also detect ambient light so that the sensor installation should be carefully selected. The detection angle of this sensor is up to a 60-degree. The flame sensor can be connected to the Arduino microcontroller to read the presence of the flame via the digital pins (i.e. $Vout$ equal High or Low) or via the analogue pins (i.e. $Vout$ equal 0 or 1023) [27]. In the case of the connection of the sensor with the analogue module, the $Vout$ value will be variated with the distance between the sensor and the flame source, as illustrated in Figure 2.15.

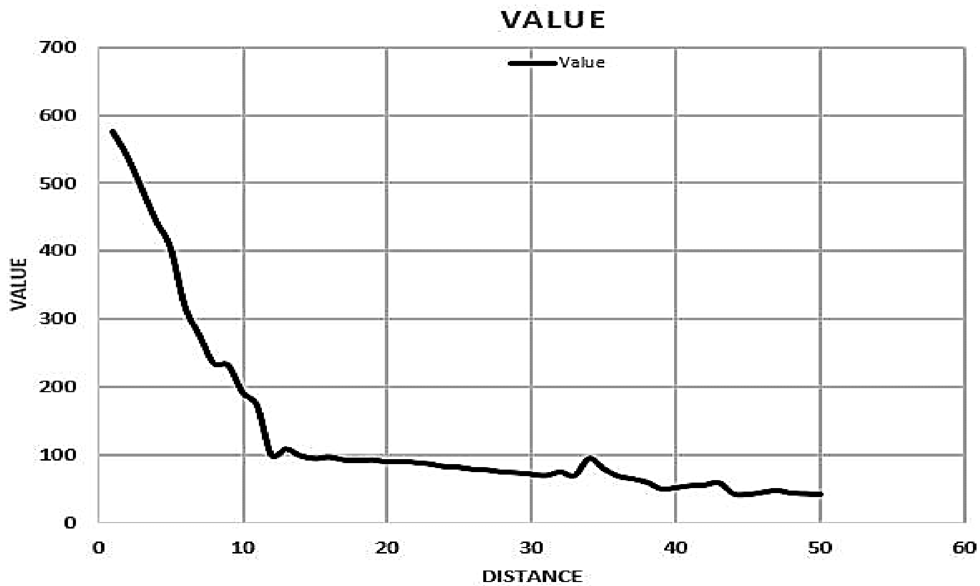

Figure 2.15: Flame sensor analogue output voltage against distance.

2.6.2 Infrared Sensor

The Infrared (IR) technique is utilised in the regular life and also in industries for different purposes. For example, TVs utilise the IR sensor to read the transmitted signals from the remote control. The low power use, simplistic design, and the useful characteristics are key advantages of the IR sensors. The human eye cannot see the IR signals. In the areas of the visible and the microwave, the IR radiation in the electromagnetic spectrum is present. The wavelengths of the waves regularly vary between 0.7 to1000µm. The spectrum of the IR can be split into three regions such as infrared, centre and infrared. The wavelength of the near IR Region is between 0.75 and

3μm, the wavelength of the middle infrared area is between 3 and 6μm and the far wavelength of the far-infrared region is over 6μm. The infrared sensor can be defined as a piece of electronic equipment, emits radiation to discernment the area that surrounded the sensor (i.e. the presence of the objects). An infrared sensor can detect motion as well as to measure the heat of an object. Such sensors can be employed to measure the infrared radiation only instead of emitting a passive IR sensor. In general, all of the things that radiate the thermal radiation in the infrared spectrum. This type of radiations classified as invisible to the human eyes, but an infrared sensor is designed to be able for the detection of this radiation. This sensor comprises of two main parts which is the transmitter and the receiver. The transmitter is a simple IR LED, and the receiver is a simple IR photodiode that recognises IR light of the same wavelength as the IR LED. When infrared light strikes the photodiode, the resistances and output voltages change in balance to the intensity of the IR light. The IR sensor has three terminal two of them is utilised for the supply voltage and the last terminal is the output voltage which is directly connected with the microcontroller [28], as illustrated in Figure 2.16.

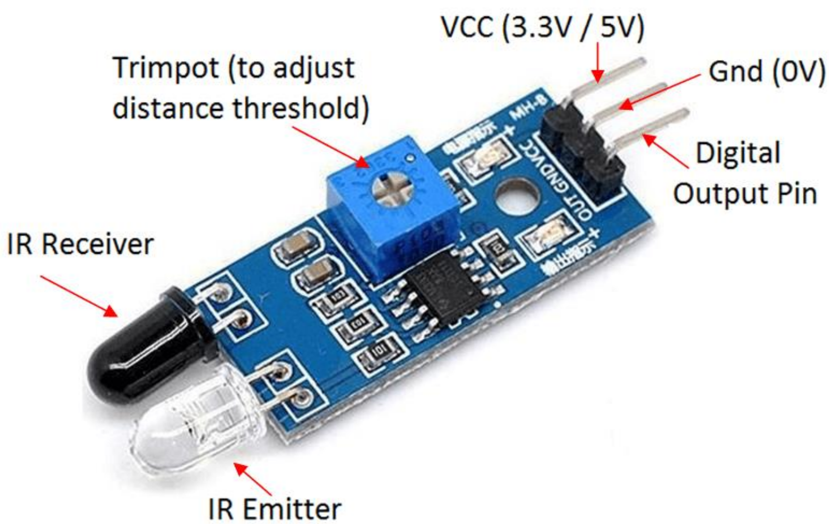

Figure 2.16: IR sensor module.

An infrared sensor works in the same way that a target detection sensor does. As, previously mentioned, this sensor contains an infrared LED and an infrared photodiode, which can be combined to form a photocoupler or an optocoupler. Planks radiation, Stephan Boltzmann, and Weins displacement are the physics laws adopted in this sensor. The one type of the transmitter that can be emits the infrared radiations is the IR LED. This LED has the appearance of a standard LED, and the radiation it emits is not visible to the naked eye. An infrared transmitter is utilised to detect the radiation by infrared receivers. Photodiodes are utilised to make these infrared receivers. IR Photodiodes are different from regular photodiodes in that they only detect IR radiation. Different types of infrared receivers exist based on voltage, wavelength, package, and other factors. When utilised as an IR transmitter and receiver, the wavelength of the receiver must match that of the transmitter. The transmitter is an infrared LED, and the receiver is an infrared photodiode. The infrared photodiode is activated by the infrared light produced by an infrared LED. The photodiode's resistance and the variation in the output voltage are proportional to the amount of infrared light captured. In many of the electronic device, the infrared sensor circuit is one of the most basic and widely utilised sensor modules. This sensor is similar to a human's visionary senses, and it can be utilised to detect obstacles, which is one of the most common real-time applications [29], Figure 2.17 illustrates the circuit diagram of this sensor. The following elements make up this circuit:

- LM358 IC IR transmitter and receiver pair
- Resistors of the range of kilo-ohms.
- Variable resistor.
- LED.

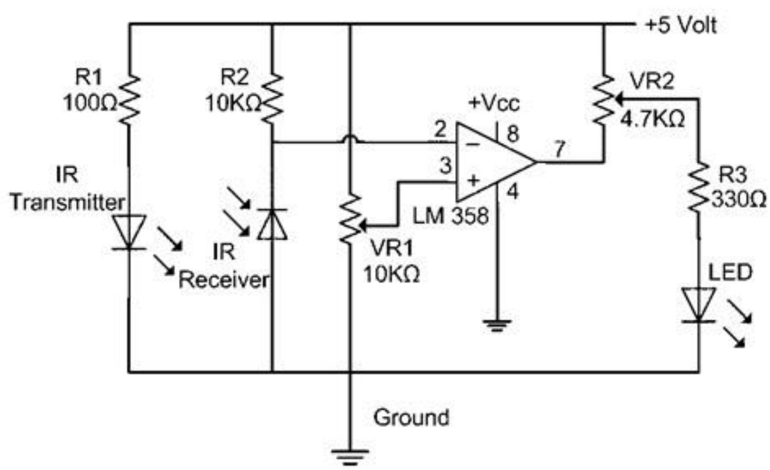

Figure 2.17: The circuit diagram of IR sensor.

2.6.3 MQ Gas Sensor

The MQ-02 gas sensor is one of the most widely utilised in the MQ sensor family. It's a Metal Oxide Semiconductor (MOS) type Gas Sensor, this type is also called "Chemiresistors" because the detection is based on a change in the sensing material's resistance during the gas comes into contact with it. The gas concentrations can be distinguished by utilising a simple voltage divider network. As illustrated in Figure 2.18 a specially designed anti-burst network (i.e. shielding network) from a two-layer fine stainless steel mesh is placed surrounding the sensor for safety purposes. This shield is introduced because the sensor is utilised to sensing the inflammable gases, it guarantees that the heater that presence inside the sensor does not lead to the burst during the gas detection [30].

Figure 2.18: MQ-02 gas sensor with the safety shielding network.

In addition, this shielding network act as a safeguard for the sensor and also it filtered out the present particles in the sensor installation area so that solely the gassy components can pass toward the sensor. The shielding network is tied with the rest of the structure through a clamping ring made from copper-plated. Figure 2.19 illustrates the internal structure of the sensor when an external shielding network is excluded. A sensing segment and 6 pins are organised in a star-shaped structure that stretches across the bakelite foundation. The two pins that remarked as H are responsible for the heating of the sensing segment and are joined via Nickel-Chromium coil. The left four pins A and B are responsible on the output signals that joined utilising the Platinum connectors. The sensor tube segment consists of ceramic-based on aluminium oxide (AL_2O_3) and covered by tin dioxide (SnO2), as illustrated in Figure 2.20. The most important material is tin dioxide, which is very sensitive to fuel gasses. The ceramic substrate utilised just to increases the heating efficiency and guarantees that the sensor region is constantly heated at the working temperature.

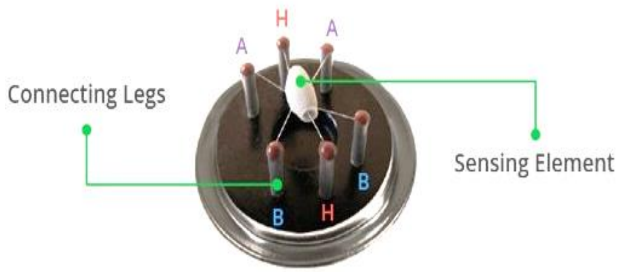

Figure 2.19: MQ-02 gas sensor without the safety shielding network.

In the case of gas detection, the tin dioxide is burned to high temperatures in the air, oxygen is adsorbed into the surface. The clean air attracts the donor electrons in tin dioxide to oxygen adsorbed on the sensing material surface. This prevents the flow of electricity. The surface density of adsorbed oxygen decreases in the presence of reduced gases since it reacts with reduced gasses. Electrons are then released into the tin dioxide, enabling the sensor to flow freely [31].

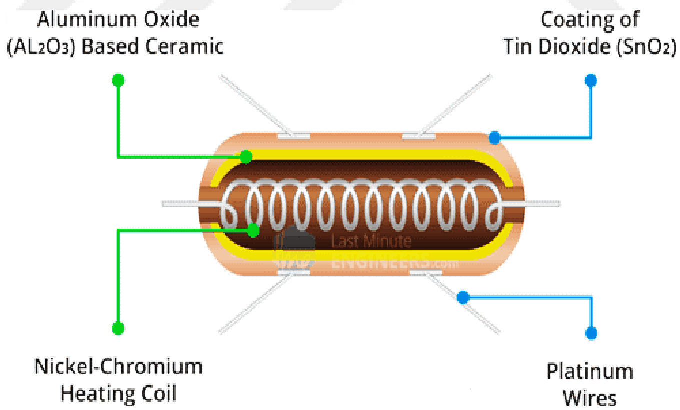

Figure 2.20: MQ-02 sensor tube segment.

The Mq-02 sensor module has four terminals, as illustrated in Figure 2.21. Two of them are utilised for the power supply and the left two pins are the digital and analogue output signal from the sensor.

Figure 2.21: MQ-02 gas sensor module.

2.6.4 Servo Motor

The servo motor is a compact output shaft machine. By transferring a code signal to the servo, this shaft can be moved to specific angular locations. The servo retains the angular location of the shaft, as long as the coded signal exists on the input line. The angular location of the shaft moves when the coded signal varied. In reality, the servo motors are widely utilised for special applications that require location control surfaces such as the elevators, smart garage gates, and rudders in radio-controlled aircraft. They are also utilised in cars, marionettes and naturally in robots that are wirelesly-controlled. The internal structure of the servo motor is illustrated in Figure 2.22. It comprises small control circuitry, the motor, a collection of gears, and the external cover. The servo motor has 3 wires that are connected to the outside world. Two of them are utilised for the power (i.e. 5V), and the left one is utilised for the control signal [32].

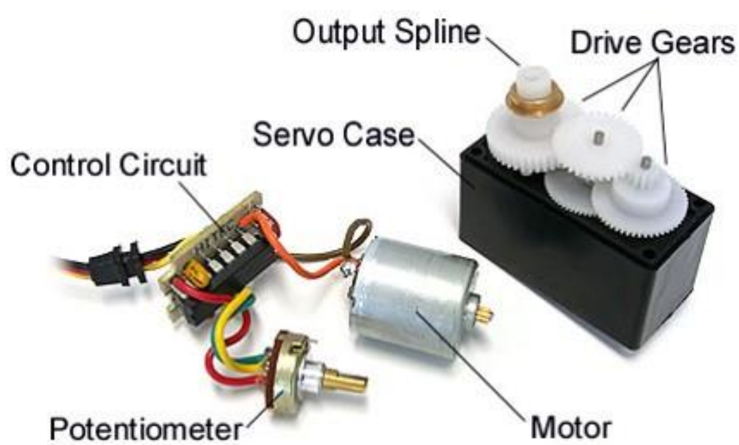

Figure 2.22: Internal structure of servo motor.

The Servo motor is joined to a power output shaft with some control circuits and a potentiometer (pot). The pot on the left view of the circuit board that illustrated in the previous Figure 2.22. This pot enables the circuit controller to control the servo engine's current angle. The motor shuts off if the shaft is on the right angle. If the circuit finds the angle is wrong, it turns the engine to the required angle. The servo's power shaft can travel approximately 180 degrees around. It is ordinarily in the 210-degree range but depends on the manufacturer. For control of angular movement is be 0 to 180 degrees, a regular servo is utilised. Due to the presence of a mechanical stop on the principal output gear, it is mechanically incapable to turn further. To controlling the rotate angle, the control wire is utilised. The angle of the control wire is linked to the duration of the pulse of the voltage (i.e. pulse width) where each pulse width corresponding to a specific angle [33], as illustrated in Figure 2.23. In other words, the pulse width determines to what extent the engine will be turning. The pins configuration and the completed structure of the servo motor is shown in Figure 2.24.

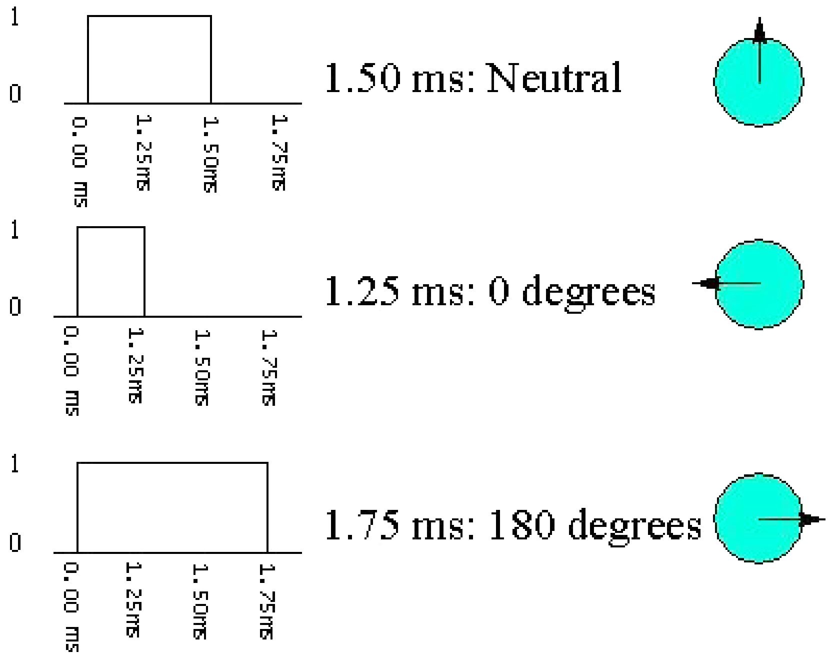

Figure 2.23: The pulse width against the rotating angle.

2.6.5 LDR Sensor

In the electronic circuit designs, the LDR or photoresistor are usually utilised wherever the existence of the light level must be detected. Such a sensor in electronics science can be defined with a range of denominations such as photoresistors, photocell, or photoconductor. Although other electronic components can also be utilised like photodiodes or phototransistors, the LDRs or photoresistors are especially suitable in many electronic circuit designs. They bring significant resistance changes to make a variation in the level of light. Due to the low cost, manufacturing facility, and comfortable of the utilisation of the LDRs, a range of various enforcements have been employed. Such as in the photographic light meters at one time LDRs were practised and still are utilised in a variety of applications where light levels need to be detected. The photoresistor or the LDR is a light-sensitive electronic element. The resistance value varies when the light drops on it. In various magnitude orders, the values of the resistance of the LDR can vary as the falls of the light increase. The LDR resistance value about many of the megohms in darkness and then drops to a few hundred ohms in bright light, as illustrated in Figure 2.24. The LDR are simple to utilise and numerous of the LDR circuits are possible, with such an extensive variety in resistance.

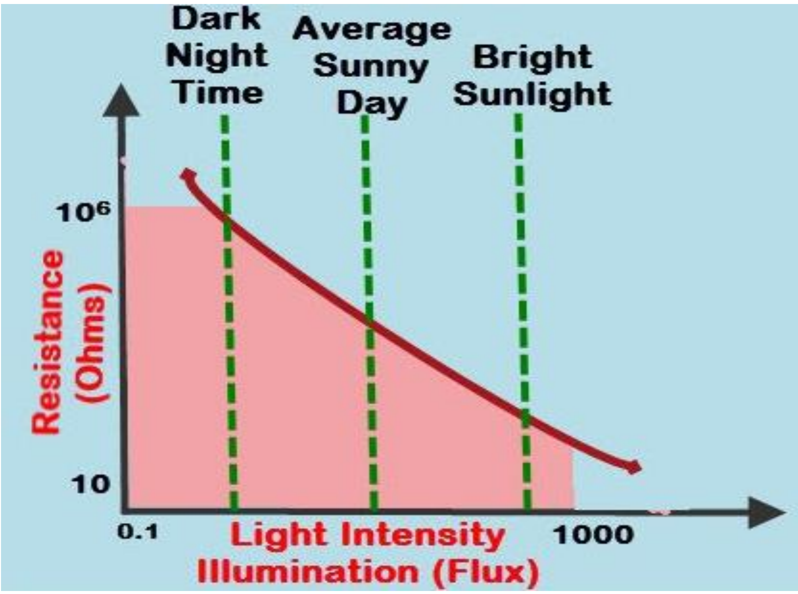

Figure 2.24: LDR resistance response versus the illumination.

The LDR is usually made from a semiconductor material to allow them to be light-sensitive. There are several materials that can be utilised, but cadmium Sulphide (CdS), which is a commonly utilised material for such photoresistors, Figure 2.25 illustrates the LDR module that is compatible with utilised in the microcontrollers [34].

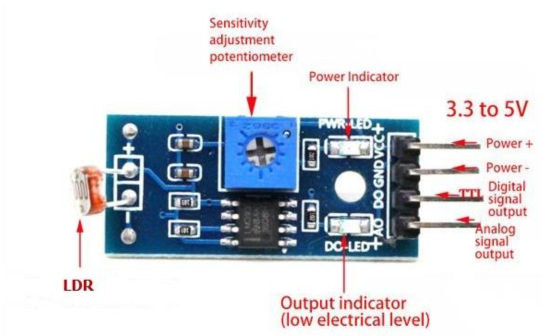

Figure 2.25: The LDR module.

2.6.6 PIR Sensor

The PIR sensor detects the presence of the motion and is almost employed to determine whether a human has entered or exited within the sensor's installation range. The PIR is compact in size, cheap, low-power consumption, and simple to utilise. As a result, the PIR has ordinarily seen in the household, commercial appliances and gadgets. The PIR motion sensor is also known as "Passive Infrared," "Pyroelectric," or "IR motion" sensor. PIRs are made up of a pyroelectric sensor, as illustrated in Figure 2.26, which looks like a round metal package with a rectangular crystal in the middle that can recognise infrared radiation levels. Every organism that is able to emit a small amount of low-level radiation and the more hot of the object emits more radiation.

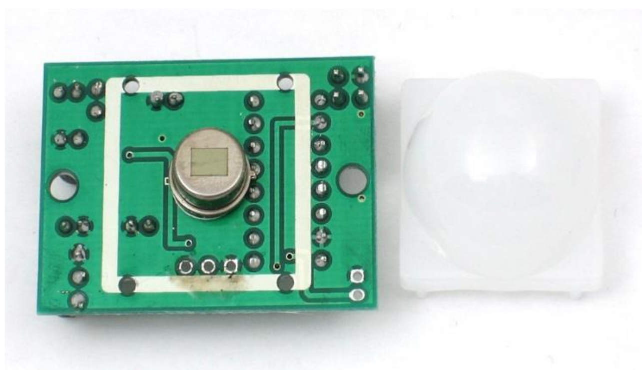

Figure 2.26: Internal PIR structure.

A motion detector's sensor is truly divided into two halves. This is because we want to detect motion rather than average IR levels. The two halves are wired in such a means that they cancel out one another. The output will fluctuate high or low if one half sees more or less IR radiation than the other. A collection of encouraging circuitry, resistors, and capacitors are included beside the pyroelectric sensor, as illustrated in Figure 2.27. PIR sensor is ideal for numerous of the essential projects or products that need to recognise when a person has left or entered an area or has approached, also useful to implement the security systems. Such sensor has many of features such as is low-power consumptio, cheap, and fairly rugged.

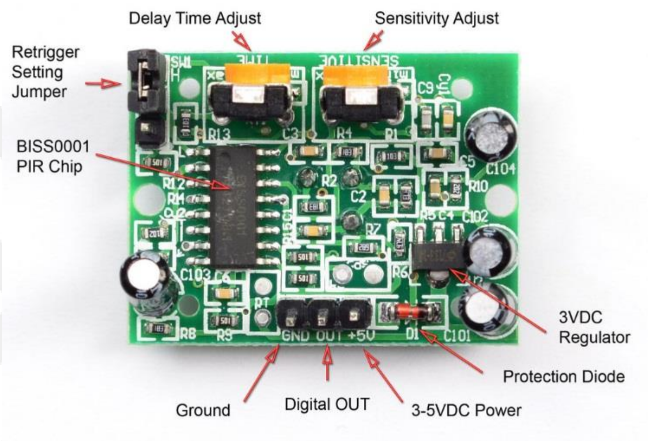

Figure 2.27: Electronic components of PIR sensor.

The PIR sensor has three pins two of them are utilised for the power feeding and the rest is the sensor output pin which indicates the logic "1" in the case of the motion detection and logic "0" in the steady-state. In order to increase the sensor detection performance, a small lens is attached to the sensor, which collects the radiation and directs it to the sensor, as illustrated in Figure 2.28 [35].

Figure 2.28: PIR sensor with the lens.

2.6.7 LCD Module

The LCD is an electronic device utilised as a display module that provides a visible image employing the liquid crystal. The 16x2 LCD display is a pretty fundamental module that can be found in many electronic projects and circuits. The 16x2 interprets to a 2-line for the display and 16-characters per each line. Each symbol or letter is presented in a 5x7 pixel matrix on this LCD, Figure 2.29 illustrates the 16x2 LCD module. The specifications of the 16×2 LCD module can be summarised as follows:

- Rated operating voltage: 4.7-5.3V
- The current expenditure: 1mA
- Alpha-numeric LCD module: Display letters and digits
- Able to work in both 8 or 4 bit
- Can display the custom formed characters
- The available backlight is the Green and Blue

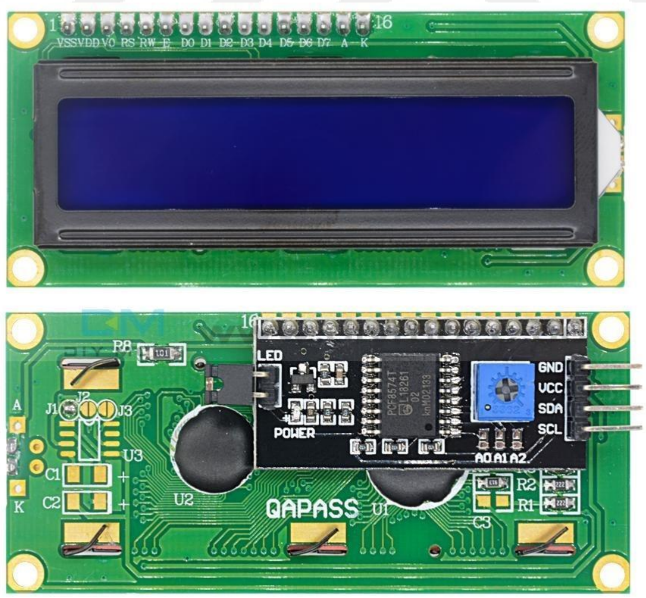

Figure 2.29: The 16x2 LCD module.

PROPOSED SYSTEM DESIGN

In this chapter, the design procedure for the proposed system segments will be explained and clarify. Also, this chapter includes a presentation for the obtained result after testing the proposed system virtually.

3.1 System Design

The proposed parking system comprises of three major segments which can be summed as the Smart Garage Gate (SGG), Safety of the Parking System (SPS), and Smart Car Parking System (SCPS). The design procedure for all of the previously mentioned segments will be presented and discussed in the next subsections.

3.1.1 Design and Implementation of SGG

This part of the proposed system is introduced to improve the parking system security based on the Arduino Mega microcontroller. In this part, an SGG is designed and implemented utilising the RFID reader with the tags, servo motor, and the laser module with LDR. When the authorised person would enter the garage he should places his own card on the RFID reader (i.e. RFID tag); after that the servo motor will open the garage gate and make the alarming system in the OFF mode. The laser module with the LDR is utilised to implement the security system, where the laser line is directed on the surface of the LDR; once the unauthorised person seeks to enter the garage and cutting off the laser line the LDR value will be increased due to the low falling light. After that, the Arduino Mega reads the LDR value variations that resulted from the cutting off the laser line and then make the buzzer (i.e. alarming system) in the ON mode as well as send a warning SMS to the garage manager for warning purposes by the GSM shield. In addition, the garage lighting system will be turned ON once the authorised persons enter the garage by utilising the infrared sensor this sensor also responsible on the closing of the garage gate once the car passed to the garage; thus making the garage more intelligent and saving energy. Figures 3.1-3.3, respectively, illustrates the flowchart of the SGG segment for the proposed system, the block diagram of the SGG segment, and the implemented circuit. More than one type of microcontroller boards are utilised in this work to improve the system reliability and make the system independent to the single failure point, in other words, once one of the microcontrollers suddenly degraded the other parts of the proposed system is not affected. Because the other system segments are based on an individual microcontroller board.

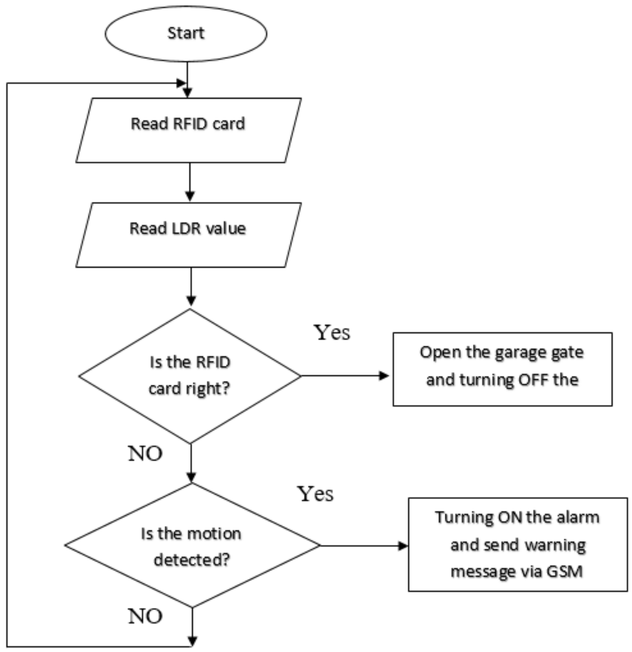

Figure 3.1: Flowchart of the SGG part.

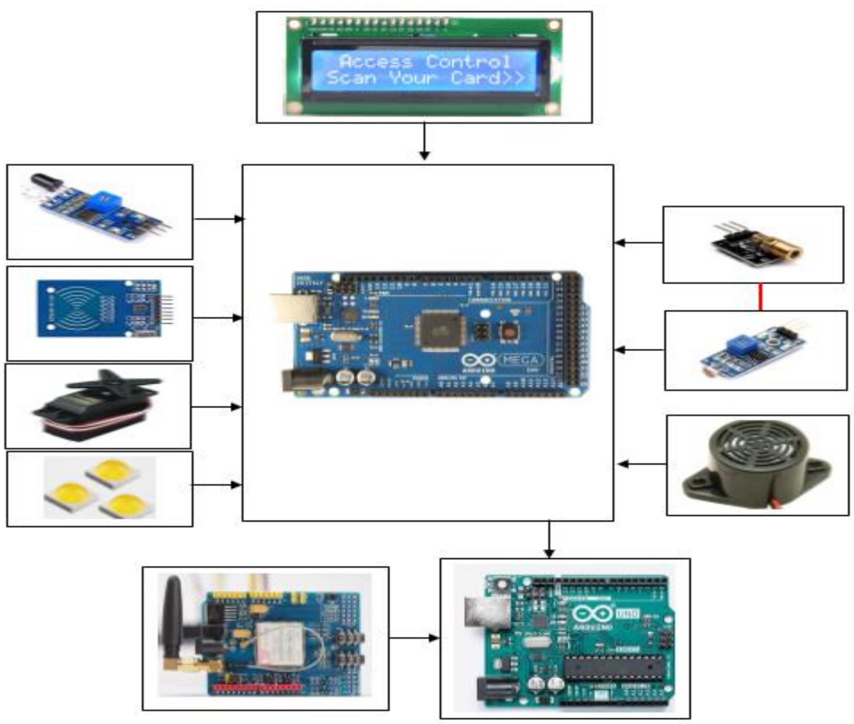

Figure 3.2: Block diagram of the SGG part.

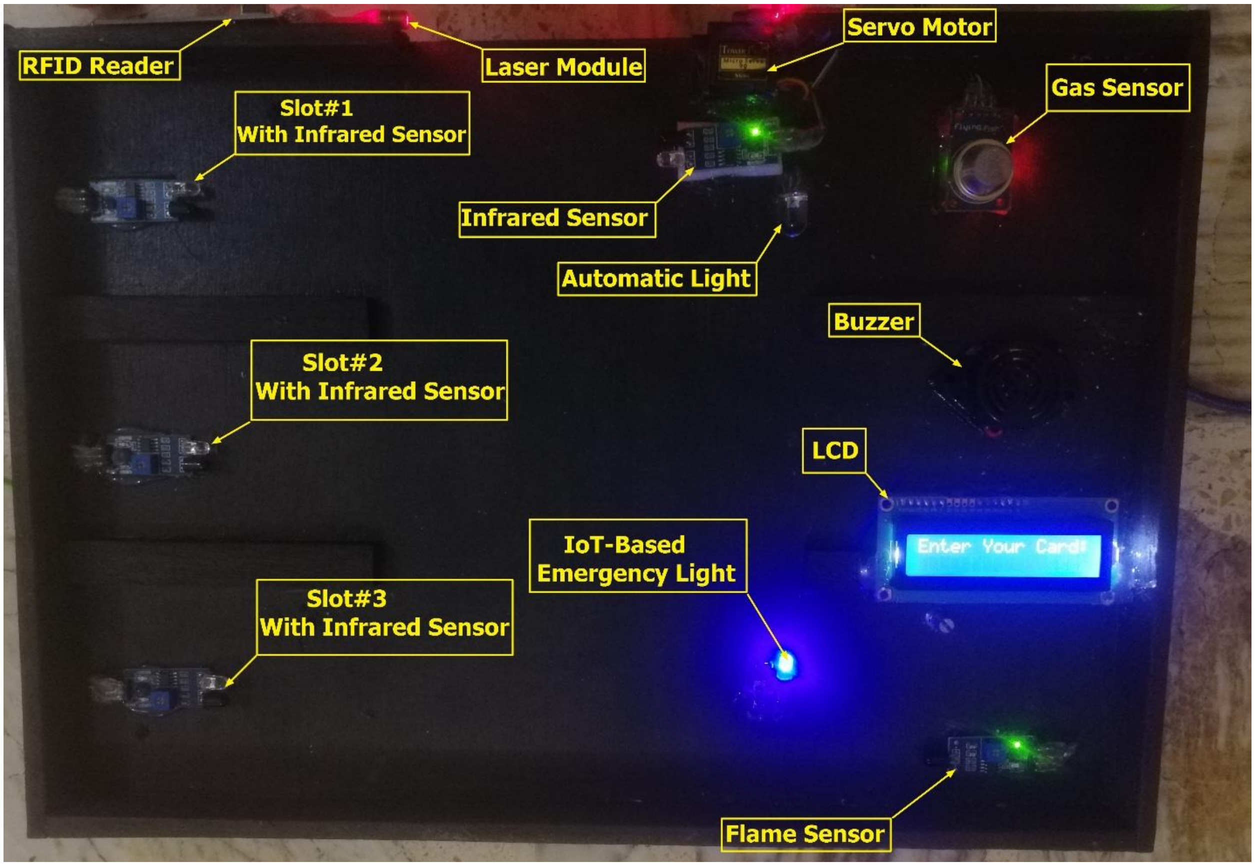

Figure 3.3: Implemented prototype for the proposed system.

3.1.2 Design and Implementation of SPS

This segment of the proposed parking system is responsible for the safety inside the garage. Since there are a lot of cars operated on the LPG so, the chance of the gas leak happen is high and this lead to the fires or suffocation. In this segment of the proposed system, the MQ-05 gas leak detection sensor is employed to monitor the gas leak inside the garage and the flame sensor is employed to monitor the fire presence. Once the gas leak or flame detected the Arduino Mega board switches ON the alarm system and transmit a warning SMS to the garage manager via the GSM shield. In this work, the GSM shield is connected to an individual microcontroller board, the reason for such connections is because of the more power consumption by this shield. This shield needs stable power and in the case of the power is reduced slightly the module is lost the connection with the mobile tower station. So that is connected with a separate Arduino Uno microcontroller to solve the power issues; the Arduino Uno is communicated with the Arduino Mega board via the logic signals (i.e. logic "1" and logic "0"), Figures 3.4 and 3.5, respectively, illustrates the block diagram of the proposed SPS and the implemented GSM circuit.

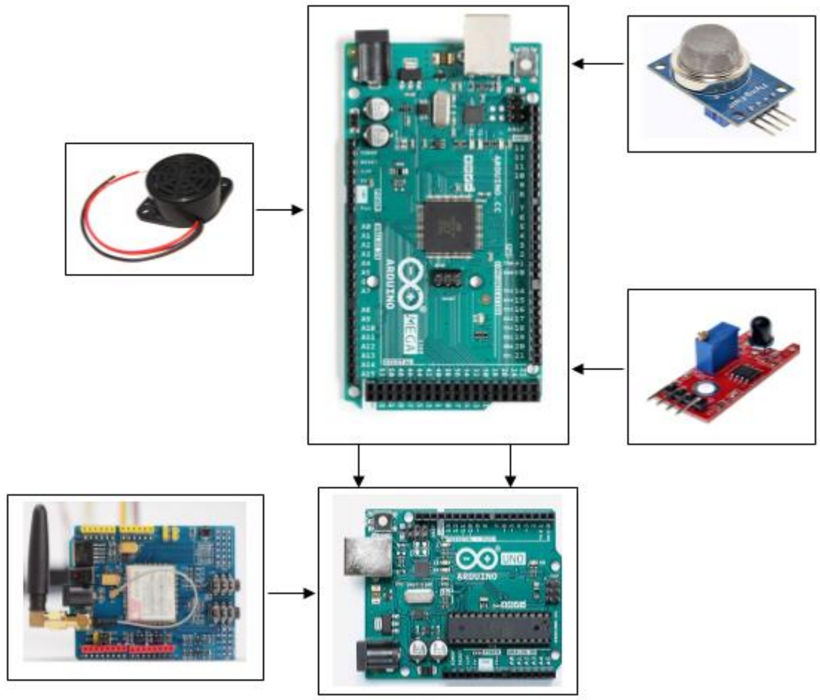

Figure 3.4: Block diagram of the SPS segment.

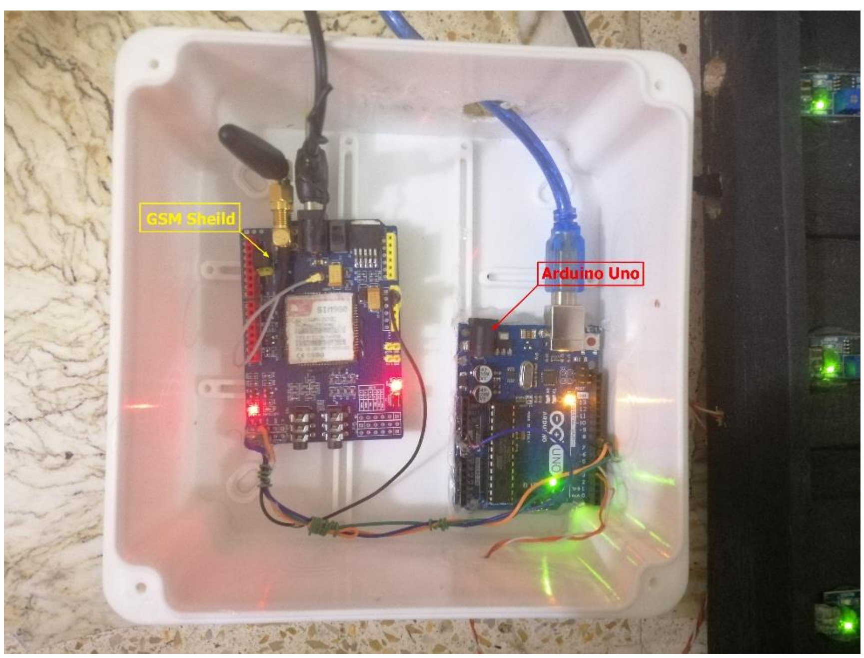

Figure 3.5: GSM prototype design.

3.1.3 Design and Implementation of SCPS

In this part of the proposed parking system, the SCPS will be implemented based on the infrared sensor and the IoT technology. The IoT technology will be utilised based on the NodeMCU microcontroller that has a built-in esp8266 Wi-Fi. Also, the Arduino Nano microcontroller board is employed to read and processes the value of the infrared sensor; once the car is present in the specific slot in the garage the infrared sensor will return logic "1" from its output pin. After that, the Arduino Nano sends logic "1" or logic "0" to the NodeMCU microcontroller board in order to display the parking space status (i.e. intended slot in the garage is filled or empty) on the programmed GUI, this connection increases the speed of the data processing since the NodeMCU microcontroller is affected by the internet quality. The programmed GUI is done by HTML instructions inside the Arduino IDE by installing the NodeMCU library. The programmed GUI is accessed by the users via a specific local IP address provided by the NodeMCU microcontroller, as illustrated in Figure 3.6. The block diagram of the proposed SCPS that previously discussed and clarified is illustrated in Figure 3.7.

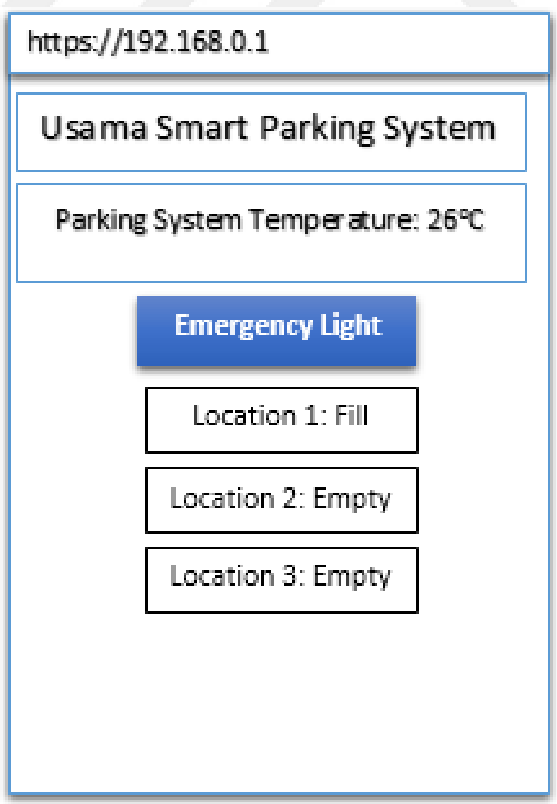

Figure 3.6: Proposed GUI for the SCPS.

Because of the presence of gas-powered and electric-powered vehicles, the garage's environmental temperature must be maintained at a normal level to ensure that the cars are not adversely affected by the rising temperature. So, that the temperature sensor is utilised to monitor the garage temperature and display the temperature degree on the GUI. After that, the user chooses the appropriate slot, depending on the temperature that his car is supposed to be in.

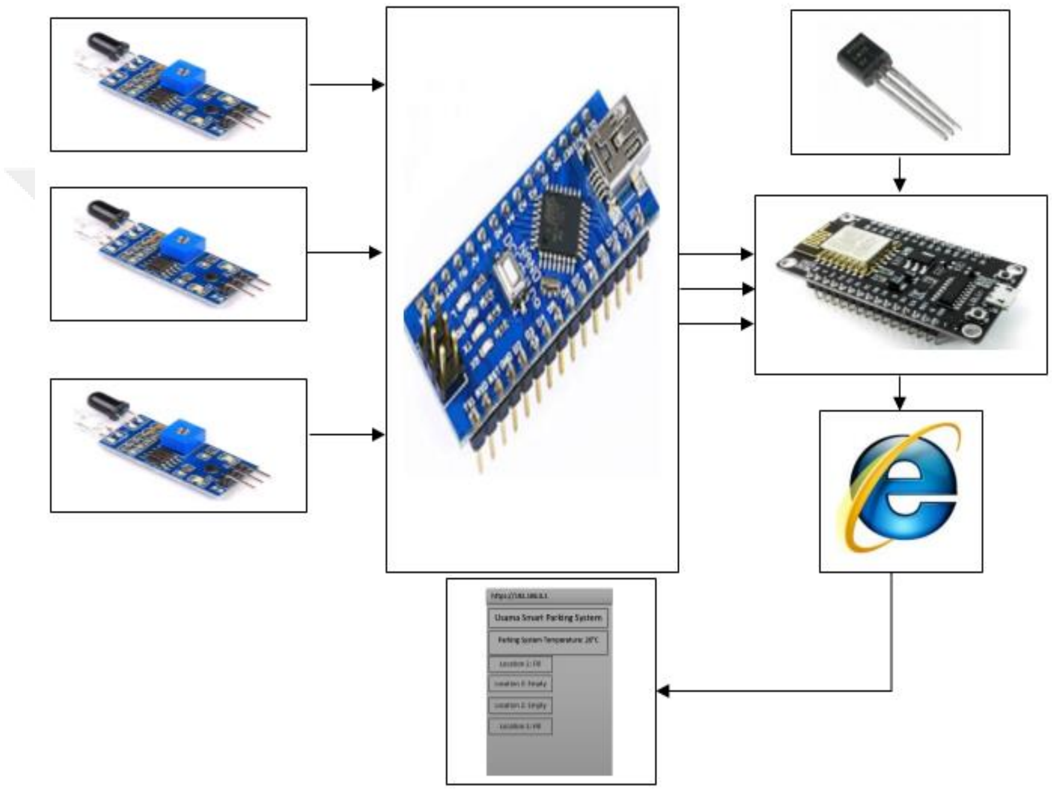

Figure 3.7: Block diagram for the proposed SCPS.

3.2 Results and Discussion

This part of the chapter illustrates the results of the implemented system after made the functional test. After feeding the microcontroller boards by the power from the USB of the computer the testing process is started.

3.2.1 SGG testing process

The garage gate is testing by putting the RFID card on the reader and noting the servo motor motion. After that we placed our hand from the front of the installed infrared sensor at the door then notice the servo motor closed the door. The next step is the testing of the security by cutting the laser line then the buzzer is be in the ON mode and a warning SMS received by the mobile phone, as illustrated in Figure 3.8.

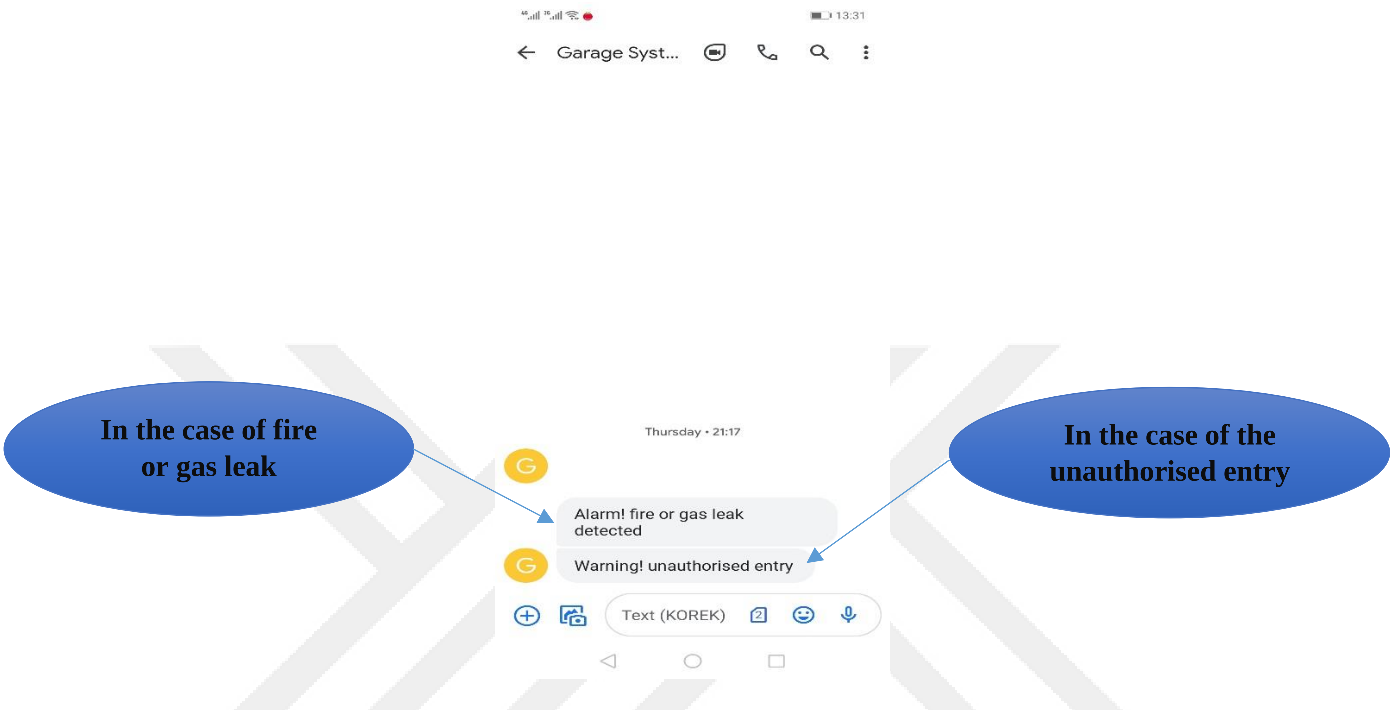

Figure 3.8: Received warning messages.

3.2.2 SPS testing process

At the beginning we starting the test of the MQ-03 gas leak sensor by utilising the lighter and subject its gas on the sensor after that the sensor will detect the gas presence and the Arduino Mega switch "ON" the buzzer and send SMS to the garage manager as well, as demonstrated in Figure 3.8. The second step is the testing of the fire detector sensor by utilising the lighter also and the same previously mentioned procedure is done.

3.2.3 SCPS testing process

The first step of the testing process is done by getting the IP from the NodeMCU, as illustrated in Figure 3.9. After that, the IP is placed on the web browser and access to the programmed GUI. Each parking slot contains an infrared sensor that responsible for the detection of the slot has a car or empty. The sensor is tested by place our hand in front of it after that the sensor return logic "1" to the microcontroller board then the parking status is showed on the GUI, as illustrated in Figure

3.9. The final step of the testing process is the test of the temperature sensor by putting a heat source near the sensor and read the temperature value on the GUI.

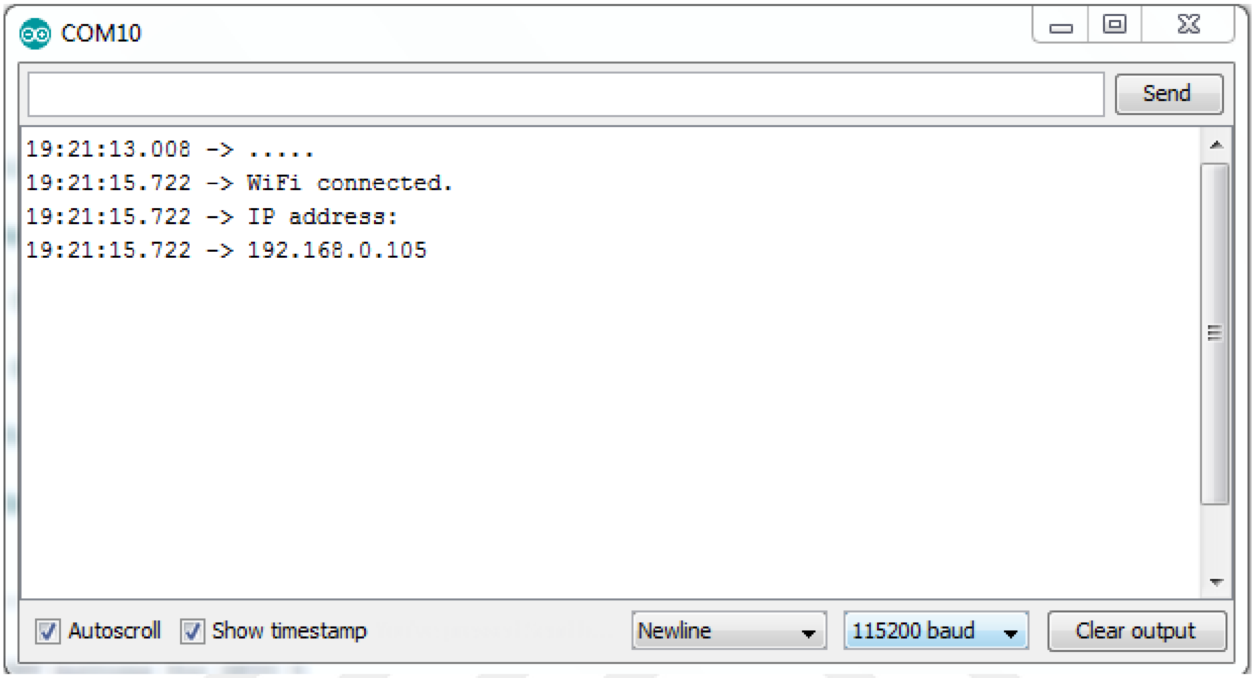

Figure 3.9: The granted IP by the NodeMCU.

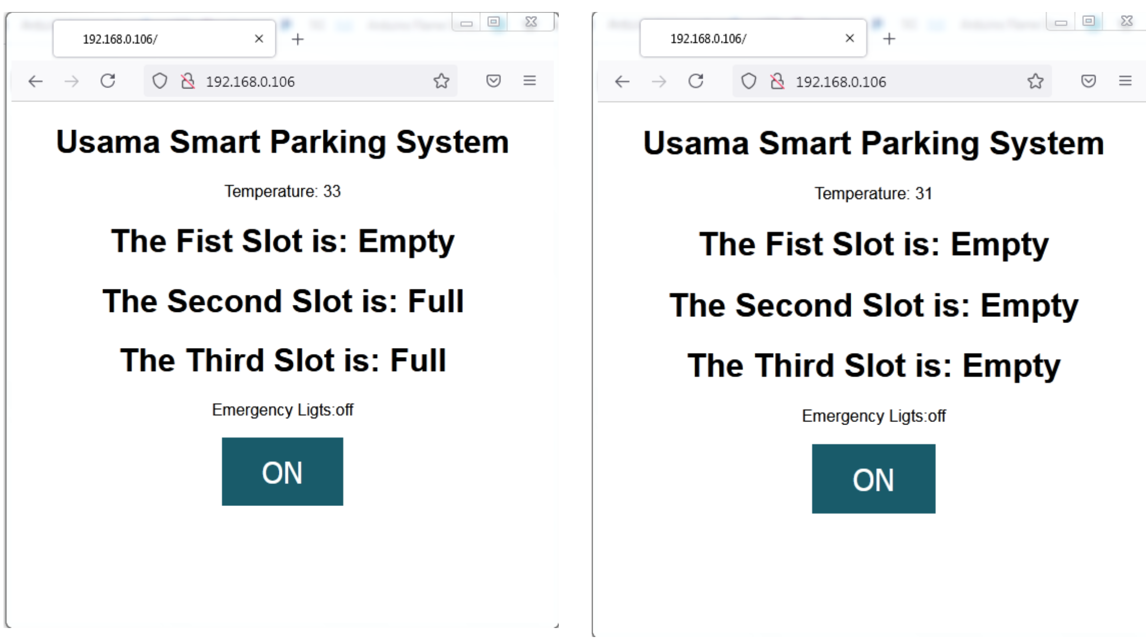

Figure 3.10: Obtained results on the GUI.

CONCLUSION AND FUTURE WORK

4.1 Conclusion

In this work, a novel of an intelligent car parking system with multi-levels of safety and security has been introduced. The proposed system covers all the essential parts that should be available inside the intelligent parking system. Since the proposed system comprised of an SGG, SPS, and SCPS. The SGG part was based on the LCD, laser module, LDR, buzzer, infrared sensor, RFID reader, servo motor, and GSM shield with the Arduino Uno. While the SPS was based on the flame sensor and gas leak sensor. The final part of the implemented system is based on a temperature sensor, Arduino Nano, infrared sensor, and NodeMCU. In order to obtain the best performance, the proposed parking subsystems was linked with the IoT technology while the security system linked with the GSM module to send all the emergency SMS to the garage manager. The proposed system has been tested practically a good performance achieved.

4.2 Future Work

In order to improve the proposed SPS, some modifications may be applied in the future, which can be summarised as follows:

- Utilising a finger print identification instead of RFID system
- Utilising the databases to store the data of the RFID cards and other sensors
- Utilising the car plate recognition can be introduced instead of the RFID cards and reader
- Link the proposed system with the civilian defence centre to obtain the best performance, where the parking system wirelessly connected with the mentioned centre.

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