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**M.Sc. in Electrical and Electronics Engineering**

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**DESIGN AND IMPLEMENTATION OF SMART HOME MODEL  
USING SOLAR ENERGY**

**M.Sc. THESIS  
IN  
ELECTRICAL AND ELECTRONICS ENGINEERING**

**BY  
MUSTAFA ADNAN AL-JANABI  
FEBRUARY 2018**

**Design and Implementation of Smart Home Model Using Solar  
Energy**

**M.Sc. Thesis  
in  
Electrical and Electronics Engineering  
University of Gaziantep**

**Supervisor  
Assoc. Prof. Dr. Sema KOÇ KAYHAN**

**by  
Mustafa Adnan AL-JANABI  
February 2018**



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**Mustafa Adnan Al-JANABI**

## **ABSTRACT**

### **DESIGN AND IMPLEMENTATION OF SMART HOME MODEL USING SOLAR ENERGY**

**AL-JANABI, MUSTAFA**

**M.Sc. in Electrical and Electronic Engineering**

**Supervisor: Assoc. Prof. Dr. Sema KOÇ KAYHAN**

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This project presents a low cost smart home security system for securing and monitoring homes powered by green energy. The system is flexible and users can install this system easily in their houses and use it without any difficulty. It is activated with any smart devices that can use WIFI connection and having a web browser. The proposed automation system consists of hardware and software parts. The hardware can be divided in to two sections, first section is the Smart Home system which consists of many units: microcontrollers (Arduino Mega 2560 and Arduino Uno), RFID modem, finger print detection system, PIR sensor, gas sensor, temperature sensor, photocell sensor, servo motor, router (Ethernet system), camera and LCD screen. Second section is the green energy system which consists of solar cells, battery and power inverter. The software part aims to control and to monitor the system using Arduino integrated development environment (IDE) which compile the code in the microcontroller using C, HTML and C++ programming languages.

**Key words:** Smart House, Home Automation.

## ÖZET

### GÜNEŞ ENERJİSİNİ KULLANARAK AKILLI EV MODELİNİN DİZAYNI VE UYGULAMASI

AL-JANABI, MUSTAFA

Yüksek Lisans Tezi, Elektrik - Elektornik Mühendisliği Bölümü

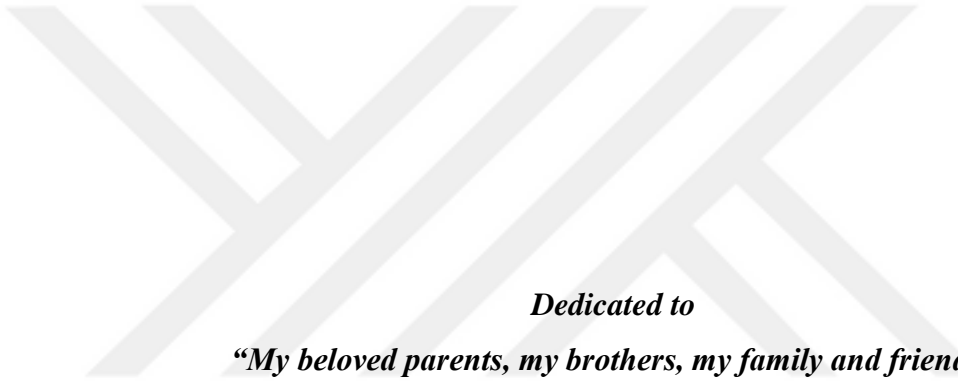
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Şubat 2017

50 Sayfa

Bu proje, yeşil enerji ile güçlendirilmiş evleri koruma ve izleme için düşük maliyetli akıllı bir ev güvenlik sistemini sunmaktadır. Sistem esnek ve kullanıcılar bu sistemi evlerine kolaylıkla kurabilir ve hiçbir zorluk olmadan kullanabilirler. WIFI bağlantısını kullanabilen ve bir web tarayıcısına sahip olan herhangi bir akıllı cihazla etkinleştirilir. Önerilen otomasyon sistemi donanım ve yazılım parçalarından oluşur. Donanım iki bölüme ayrılabilir; birinci bölüm mikrodenetleyiciler (Arduino Mega 2560 and Arduino Uno), RFID modem, parmak izi tespit (algılama) sistemi, PIR sensörü, gaz sensörü, sıcaklık sensörü, fotosel (ışık gözü) sensörü, servo motor, yönlendirici (Ethernet sistemi), kamera ve LCD ekran gibi birçok birimden oluşan Akıllı Ev sistemidir. İkinci bölüm, güneş pilleri, bataryalar (piller) ve güç dönüştürücüsünden (çeviricisinden) oluşan yeşil enerji sistemidir. Yazılım bölümü C, HTML ve C++ programlama dillerini kullanarak mikrodenetleyicide kodu derleyen Arduino entegre geliştirme ortamını (Arduino integrated development environment (IDE) ) kullanarak sistemi kontrol etmeyi ve izlemeyi amaçlamaktadır.

**Anahtar kelimeler:** Akıllı Ev, Ev Otomasyonu.



*Dedicated to*

*“My beloved parents, my brothers, my family and friends”*

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## LIST OF SYMBOLS / ABBREVIATIONS

Wi-Fi	Wireless Fidelity
RFID	Radio Frequency Identification Device
ENIAC	Electronic Numerical Integrator and Calculator
UNIAC	Universal Automatic Computer
ECHO IV	Electronic Computing Home Operator IV
IBM	International Business Machine
PC	Personal Computer
IOS	Internetwork Operating System
VHSIC	Very High-Speed Integrated Circuit
VHDL	VHSIC Hardware Description Language
FPGA	Field Programmable Gate Array
GSM	Global System for Mobile Communications
MQTT	Message Queuing Telemetry Transport
IDE	Integrated Development Environment
USB	Universal Serial Port
PWM	Pulse Width Modulation

AC	Alternating Current
DC	Direct Current
HTML	Hyper Text Markup Language
PIR	Passive Infra-Red
IP	Internet Protocol



## **CHAPTER 1**

### **INTRODUCTION**

#### **1.1 Introduction**

Automation plays an important role in today's human life which is gradually changing with smart living due to modern technology and smart devices development. The aim of this project is to produce an easy user friendly system controlled by modern technology with high efficiency and security with low cost.

Usage of idea of Smart Home has three basic advantages: First, mechanisms that deal with communication between appliances provide remote access and automation. Secondly, user interfaces that can be accessed using end user devices such as computers and smart phones that have Wi-Fi and web browser. Finally, security and monitoring are achieved using network of sensors to obtain data and information about the house.

The smart home has advanced systems that can control many things in the house such as doors, heating, ventilation, lights and many other tasks using sensors. Generally, the main goal of using smart home technology is serving the elderly and disabled people in order to make their daily life easier and more comfortable in controlling their houses. Nowadays the Smart home system is becoming popular and widely spread day by day, it is used in many houses and buildings worldwide, people want their life to be more safe and comfortable by saving their time through decreasing the daily home responsibilities.

Smart home system can either wirelessly or wired connected. Appliances of the wireless automation system will be linked to a central controlling unit (router), on the other hand these appliances can be linked by wires to a central controlling unit if the medium was wired connecting method. Wireless smart home automation system will be more comfortable and more easy to use by getting rid of wires.



**Figure 1.1** Smart Home System.

## **1.2 Smart home automation system benefits**

Smart home systems are intelligent enough that it can think by itself and take decisions at the exact time in a smart way. This smart system has many benefits, they are as follows:

1. **Security:** smart home system can add safety for both family and home. With smart automation system user will secure his home smartly by using intelligent systems like finger print detection system that will give high level of security for the house, RFID card reader will make house more secure, gas leakage detector will protect the house from gas leaking that may cause fire and suffocation, and using of video cameras will give live monitoring for the house. Using of these parameters and even more will increase house security level, protecting home from theft and fire, will make people live more safely and comfortably.
2. **Monitoring:** smart home system can provide to user both real time status and historical monitoring. This system will give to user statistics about house temperature, security system, heating and cooling systems status and house

lightening system status, a software application that is accessible from any smart device will be used for monitoring process.

3. Controlling: term of “smart” in smart home system means that this system has the ability to control itself without needing human controlling, although the system is smart enough but in emergency cases there will be need for human intervention if anything goes wrong.
4. Efficiency: smart house will not be smart if it is not efficient more than the normal house, it will provide many advantages to increase house efficiency such as energy consumption, intelligent security system, smart heating and cooling system turn ON/OFF according to the weather condition.
5. Saving time and money and increase convenience: users will save their time by reducing daily home responsibilities, it will increase user peace of mind because they don't have to take care of everything in the house, smart home system will give comfort for users especially elders and disabled, smart home system will also save money through decreasing energy consumption and reducing electricity bills, it will save more money if green energy (solar cells system) was added to the smart home system.

### **1.3 Green energy (solar cell system)**

Green energy or green power is renewable energy collected from natural sources such as sunlight, winds, waterfalls and etc... . Green power is electric energy generated and collected from renewable sources. The demand for green energy is growing day by day, this system will produce clean and nature friendly energy. Solar cell system is a type of green energy aimed to reduce the environmental pollution and decrease the electrical power costs by saving money through cancelation of electricity bills.

Main advantages of solar cell system are as follows:

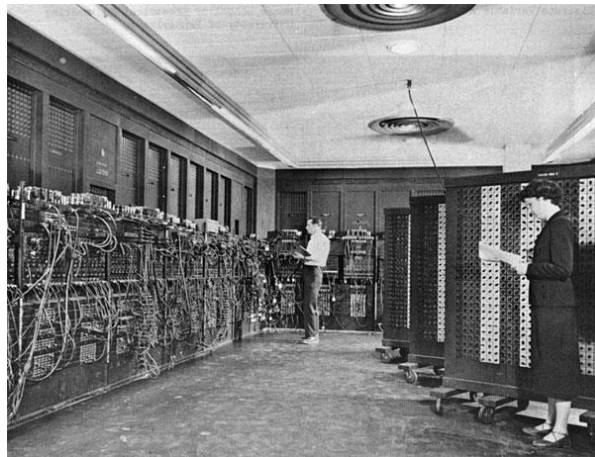
- Save the environment by its green energy system, this will give clean nature friendly system by reducing percentage of pollution.
- Saving money by canceling electrical monthly bills.
- Create an energy independence reliable source for the house.
- Increase the home value and make a good investment because, house with solar cell system will be more attractive to buyers than the normal electrically supplied home.
- Solar cell technology is continue in developing and growing, prices of these systems are decreasing day by day due to the market competition, this thing pushed people to install it more and more in their homes.

#### **1.4 Evolution of home automation**

For many years scientists and inventors have been working on in inventing a system that can think by itself. The evolution of home automation started from the beginning of 20<sup>th</sup> century and it is in constant evolution to this day. Smart automation evolution stages can be divided as follows:

- Early 1900s: the industrial revolution and the development of technology paved the way for inventing first home devices, definitely these appliances were not smart, but they were a revolution in technology. In year of 1901 industry witnessed the manufacturing of the world 1<sup>st</sup> vacuum cleaner, a few years later home appliances inventions started to increase gradually, washing machine was invented, refrigerator, clothes iron, dishwasher machine and many other home devices were invented. Although these inventions were a revolution in technology, but they were very expensive and it was a luxurious things only wealthy people can buy it.
- 1930s: in 1930s scientists and inventors continue their researches and inventions, they started turning their thoughts to home automation technology.

- 1950: Jack Kibly and Robert Noyce they invented the 1<sup>st</sup> computer chip, which is the main part and the manufacturing block of today's smart home automation technology. Many electronic devices will not have been without this computer chip, this chip was the reason for inventing and manufacturing the computer.
- 1943- late of 1950s: in the year of 1946 J. Presper Eckert and John Mauchly they invented ENIAC (Electronic Numerical Integrator and Calculator), it was the world 1<sup>st</sup> general purpose computer, the reason behind its manufacturing was to do electronic numerical integrations and mathematical computations for the US army. This giant computer cost approximately 500,000\$, with a building area 18,000 feet, consist of 6000 switches, 17,4608 vacuum tubes, 10,000 capacitors, 70,000 resistors, 1500 relays, weighted approximately 30 tons, consumed electrical power 150 KW, this giant computer used punched cards as a way for inputting and storing data. The manufacturing of this giant computer took three years from 1943 to 1946. The ENIAC computer shown in figure (1.2).



**Figure 1.2** ENIAC Computer.

In the year 1951 UNIAC (Universal Automatic Computer) was born, it was the world 1<sup>st</sup> commercial computer that introduced to the market, although it was smaller and faster than ENIAC but still it was giant computer. UNIAC was also developed by J. Presper Eckert and John Mauchly, this giant computer used magnetic tapes as a way for inputting and storing data.

UNIAC used 5000 vacuum tubes, weighted 7.3 tons, consumed electrical power 125 KW, and performs about 1905 operations per second. The UNIAC computer shown in figure (1.3).



**Figure 1.3** UNIAC Computer.

- 1964: in this year the Uniscope 300 was invented, it was the world first computer monitor, without the Uniscope 300 today's computers and smart devices will be nothing without digital displays.
- 1966: ECHO IV (Electronic Computing Home Operator) the world first automation system was invented by the engineer James Sutherland in 1966. It was the real beginning for home automation systems, ECHO IV can do several jobs like controlling the temperature, turn ON/OFF devices, making grocery list, and relay messages. This home automation system was never sold in the market.
- 1969: Honeywell kitchen computer was designed by Neiman Marcus in 1969. It was a computer that can create and save food recipes, but it didn't find the commercial success because of its very high cost was 10,000\$ (approximately 78,000\$ in 2017 dollars), its weight was 45 KG.
- 1971: in the year 1971 first microprocessor was invented by Intel, by inventing the microprocessor prices of electronic devices started to fall, that means technology will start to spread faster and reach everyone. Later,

inventing of microprocessor paved the way for the manufacturing of first PC in 1981 by IBM.

- 1980s: smart home automation became common place, it was used in the form of house security systems, motion sensors, thermostat controllers, garage doors and more.

1981: this year witnessed a big change in technology field, the world first personal computer was born, IBM 5150 was a revolution in technology, with its small size and its rather price (1500\$) made it spread quickly, one the same day of IBM 5150 announcement more than 40,000 PC were ordered by the eager clients. In the first year IBM company sold nearly 100,000 pc. IBM 5150 PC shown in figure (1.4).



**Figure 1.4** IBM 5150 PC.

- 1984: in this year “Smart Home” term was coined by the American Association of house builders.
- 1985: in this year IEEE (802.11) wireless technology was released by the U.S. Federal Communications Commission, the inventing of this technology was the precursor of the present wireless systems.
- 1990s: through the 90s of the 20<sup>th</sup> century there was focusing on “Gerontechnology” which is the combining of gerontology with technology, this technology helped in improving elderly and disabled people living.

- 1998: in this year “Integer Millennium House” was built in Watford city in England. This demonstration house was opened for the public in 1998. This smart automation house included a green roof and environmental technology can control heating, security system, doors, and lights. This smart house shown in figure (1.5).



**Figure 1.5** Integer Millennium House.

- 2000s: gradually technology became more affordable, in 2000s home automation systems became more popular and slowly was integrated with people homes.
- Present time: nowadays smart home automation systems are everywhere, everybody can install these systems in their houses and control home appliances through smart devices.



**Figure 1.6** Modern Smart Home System.

- Future: imaginations are limited with the current technology, with present technology we can do almost everything, but in technology there is no stopping point, only time will tell us what hidden undiscovered technologies will come to us.

### **1.5 Problem statement**

Nowadays, smart home system is becoming extremely important in order to make our life more comfortable and flexible. expediency and ease of using home devices are offered by home automation system, it also offer a comfortable way of living in which user can control his entire home by using a smart device, user can control everything from open/close house doors to turning ON/OFF rooms lights, it also reduce power consumption. This degree of comfort and ease of use will be very helpful for elderly and disabled people.

### **1.6 Objective of study**

- Assembling a smart home system controlled by smart devices such as smartphones or computer.
- Designing and implementing a low cost smart home system.
- Designing a practical easy to use system with high security targeted mainly to disabled and elderly people.
- Developing a smart home automation system that can saves energy by reducing electricity wasting.
- Building a nature friendly low cost system powered by green energy by using solar cells system.

## **1.7 Scope of study**

In order to achieve the desired objectives many steps must be done. These steps include hardware implement and software programming.

Steps are as follows:

- Constructing a communication network between the smart device (Android, IOS and computer) and the smart home system, by using a microcontroller and an Ethernet wireless system.
- Establishing an effective dependable smart home system by using Arduino Mega and UNO as microcontrollers in which they will be the medium between user smart device and home appliances.
- Finding a suitable user interface application that work perfectly with microcontroller boards in order to monitor and control house devices.

## **1.8 Significance of study**

This study will design and implement a cost effective smart house system, this system will bring benefit both the constructor and the customer. It will help the constructor by making it cheaper to manufacture and easy to install, and it will also bring benefit to the customer by making it low cost and the main advantage for client will be that it makes the house a much comfortable place especially for disabled and elders clients because they are unable to control house devices by moving all over the house, absolutely they will suffer from switching ON/OFF home appliances. This problem can be solved by building flexible easy to use system, in which it can be controlled and monitored remotely by using smart devices such as a smartphone, because smartphones nowadays are becoming very necessary devices in every person daily life not only for communication and making calls, but also for many other purposes.



**Figure 1.7** Types of disabled people and their percentages.

### 1.9 Thesis outline

Smart home system powered by green energy thesis is organized in five chapters including main topics such as introduction, literature review, system architecture, experiment and results and conclusion. Chapters are as follows:

**Chapter 1:** Introduction. This chapter gives the introduction of the project, explanation of the project will be given in general titles such as problem statement, objective of study, scope of study and it is followed by significance of study (aim of study).

**Chapter 2:** Literature Review. This chapter contains the literature review of the study for building and developing a smart home automation system. It will also show smart house exiting current researches and projects.

**Chapter 3:** System Architecture. This chapter contains system architecture both hardware and software architecture, describe and explain each part of the project and how these parts are connected to each other.

**Chapter 4:** Experiment and Results. This chapter contains experiment and results, it explain the obtained results.

**Chapter 5:** Conclusion. This chapter contains conclusion and future work, it also will give recommendation that can be added to the project for further development.



## CHAPTER 2

### LITERATURE SURVEY

#### 2.1 Introduction

Many papers and researches have been carried out in the field of the smart home automation.

#### 2.2 Related work in the literature

A brief review of some preceding researches is as follows:

**Kim Baraka, [2013].** this research make use of smart home techniques to implement and design an energy-efficient , remotely controlled, and highly scalable Smart Home with normal characteristic that protection the residents' security and comfort. The system consists of a house network (appliance and sensors). For a central controller, this project used an Arduino (MEGA2560) microcontroller. This smart house network using together both wired X10 and wireless Zigbee technologies, thus making it a cost-efficient hybrid system.

**Pooja S. Chinchansure, [2014].** This paper presents the design and implementation of a smart house automation system. The design is described using VHSIC Hardware Description Language (VHDL) and implemented using hardware using Field Programmable Gate Array (FPGA). This smart home system is depending on SMS technology. This system is uses Global System for Mobile communication (GSM) network to do the connection between mobile and controller.

**Shubhi sharma., [2015].** In recent years, the home automation has seen a rapid introduction of network enabled digital technologies. These technologies offer new and exciting opportunities to increase the connectivity of devices within the home for the purpose of home automation. In this paper, we present the design and implementation of home automation system. The design has been described using Verilog and implemented in hardware using FPGA (Field Programmable Gate Array). This system uses sensors for controlling home appliances. The system uses wireless technology to improve the standards of living

**Mattia Gamba. , [2015].** The main goal of this research paper is to provide a new design of a real smart home automation system. This design is depend on a creating real remote control smart home automation system and the practical experience gained by it. This research study is focused on two main problems: the user interface and the wireless communicating appliances. The first part of this research paper provides a summarized analysis on main problem in existing home automation systems.

**Manikandan J., [2016].** Smart homes automation Systems are in huge request in shops. The home automation systems and smart homes are widely used with reference to a wide range of solutions that includes monitoring, automating and controlling various functions inside a house. In this research paper, implement and design a smart home automation system using different technologies is proposed and. The proposed work is an outcome of a funded project and the systems proposed, implemented and designed in this research, and it can be easily deals with different applications and devices inside the home.

**Semanur K., [2016].** The development in embedded system technology and smart automation devices makes the human daily life easier. In this paper research study, a smart automation home system is presented an application including sensors and controller nodes connected to the local wireless network. Users can reach to the smart home automation system by using a web-base – interface or by using end devises such as smart phone application and pc. The system tested through conducted experiments and the results will be presented in that paper. The main aim of this system is design a low cost and a friendly smart system for monitoring and security purposes.

**Yuvraj U., [2016].** This paper is talk about how to create a MQTT based to Secured a smart home automation system, by using sensors and using Raspberry pi microcontroller as the network gateway. The main aim of implemented MQTT Protocol is for receiving and transferring sensor data and finally getting access to those sensor data. Raspberry -pi microcontroller is used for a gateway or the main controller for the whole system, which has different sensors connected to it through the wireless communication or by wired.



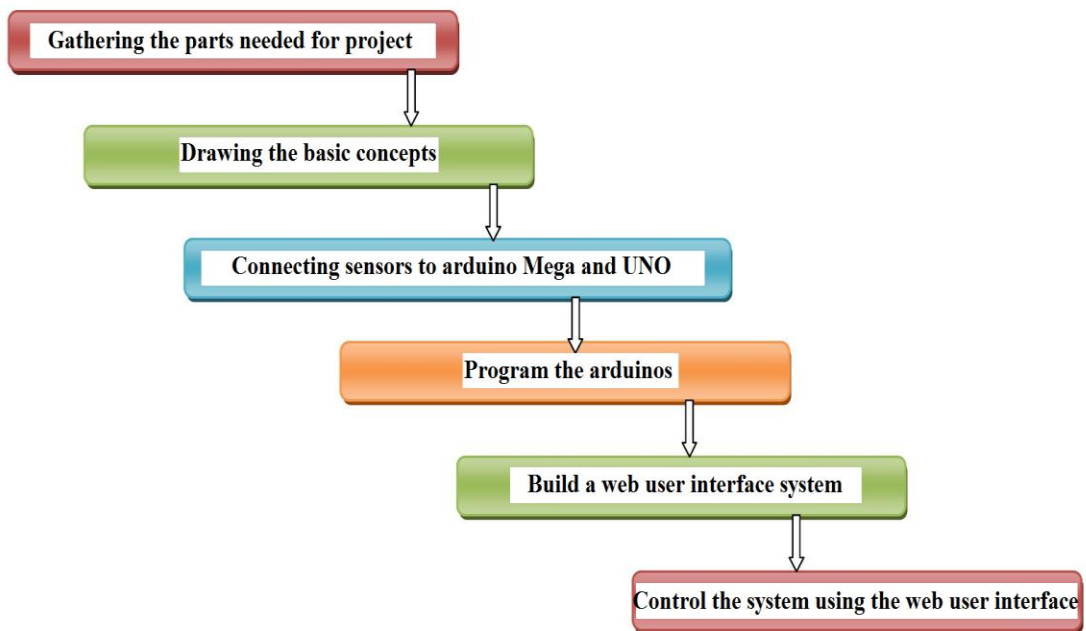
## CHAPTER 3

### SYSTEM ARCHITECTURE

#### 3.1 Introduction

In this part of project the architecture of the smart home system will be explained. This system consist of two parts, first is hardware and the second is software. These parts will be connected to each other in order to build the smart home system.

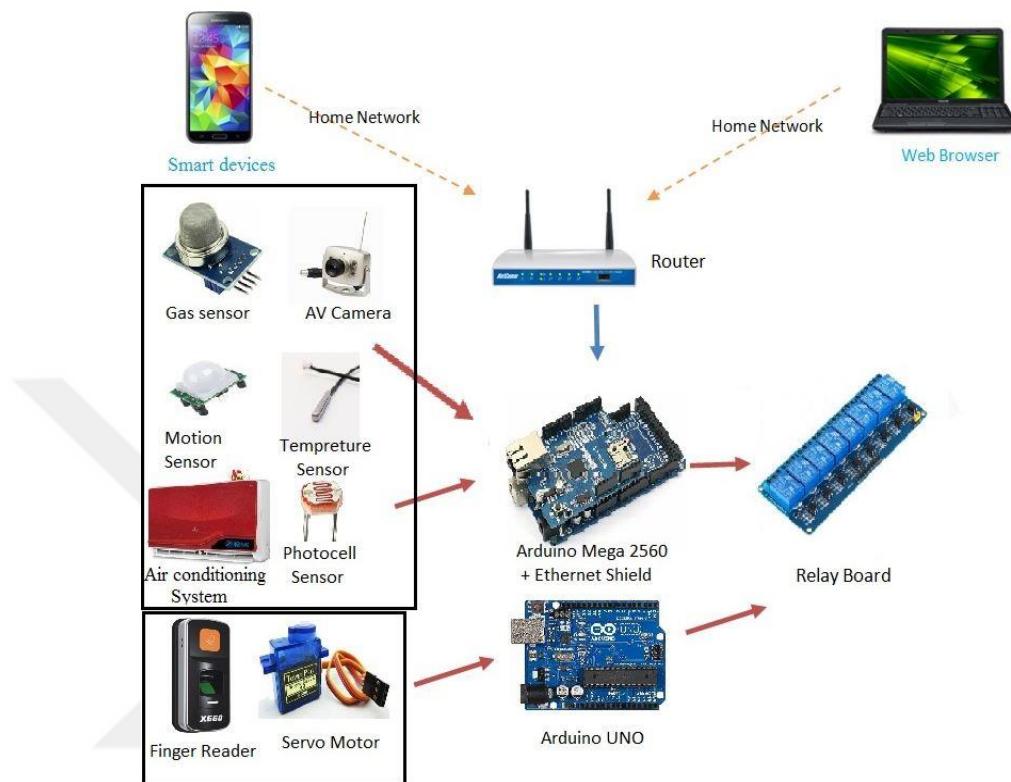
#### 3.2 Project flow chart



**Figure 3.1** Smart home system flow chart.

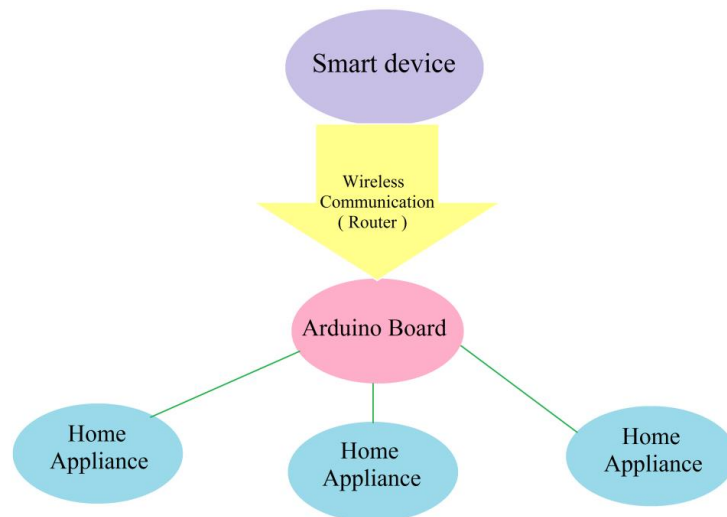
### 3.3 System design

Figure (3.2) shows the system main components and parts.



**Figure 3.2** Smart home system diagram.

In this system two types of communications are used, first is wireless connection (via Wi-Fi) and the second is wired by connecting appliances to the microcontrollers (Arduino boards). The router will enable a wireless connection for any smart device to wirelessly connect with the microcontroller through the web browser interface as shown in figure (3.3).



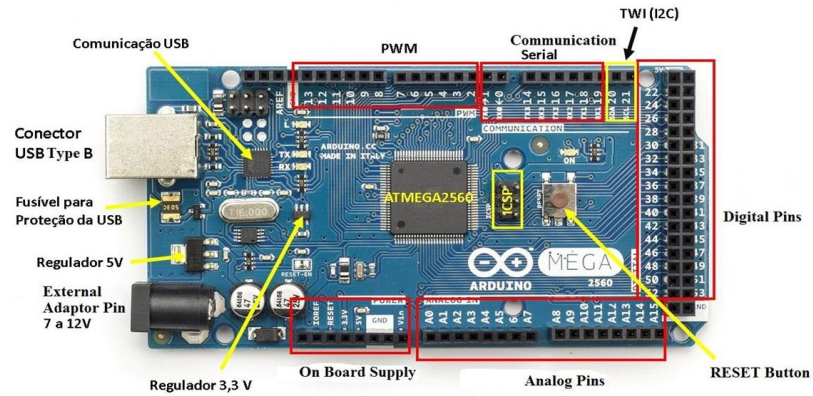
**Figure 3.3** Communication flow chart between user and system.

### **3.4 Hardware implementation and software programming**

This part shows the implementation of the hardware system and how these parts are connected, from the Arduino Mega 2560 and Arduino UNO to the appliances. This home automation system is integrated by using Arduino Mega as a backbone for the system, Arduino UNO, Arduino ethernet shield, router, relays modules, sensors and other electronic components. In this part there is the programming of each part, programming process will let each electronic part in the project interact with the microcontroller through arduino program IDE using C and C++ programming languages code.

#### **3.4.1 Arduino Mega 2560**

The Mega 2560 is the backbone of this project, it is a smart microcontroller board that depends on the ATmega2560. It has 54 digital input/output pins (of which 15 can be used as PWM outputs), 16 analog inputs, 4 UARTs (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. Arduino Mega shown in figure (3.4).



**Figure 3.4** Arduino Mega 2560 board.

This board can be easily used, it has many ports and pins that allow many devices to be connected to it. It can be supplied by electrical power either via USB cable or by AC-DC adapter. This board is programmed by using Arduino software (IDE) as illustrated in figure (3.5).



**Figure 3.5** Arduino software (IDE).

Its main advantages are as follows:

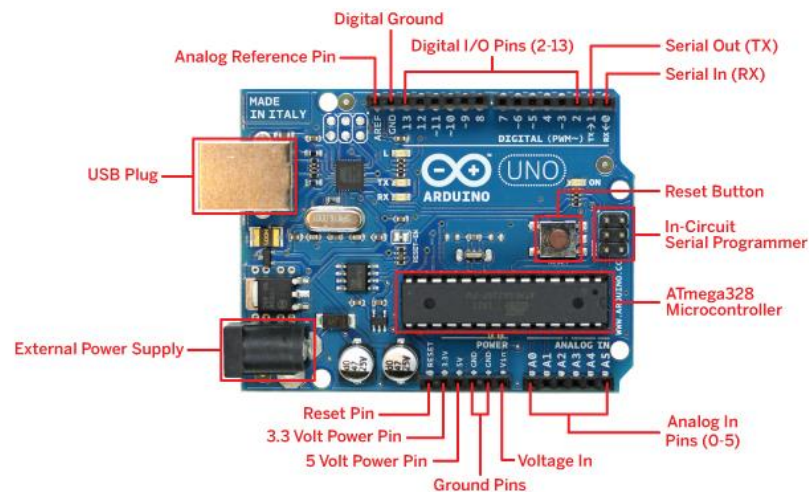
- 1) Cheap and have large libraries
- 2) High response for signal processing.
- 3) Wide range of input and output.

**Table 1** Arduino Mega 2560 specifications.

Microcontroller	ATmega2560
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	54 (of which 15 provide PWM output)
Analog Input Pins	16
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	256 KB of which 8 KB used by bootloader
SRAM	8 KB
EEPROM	4 KB
Clock Speed	16 MHz
LED_BUILTIN	13
Length	101.52 mm
Width	53.3 mm
Weight	37 g

### 3.4.2 Arduino UNO

The Arduino UNO is a smart microcontroller board that depends on the ATmega328. It has a 16 MHz ceramic resonator, 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a USB connection, a power jack, an ICSP header, and a reset button. The Arduino Uno shown in figure (3.6).



**Figure 3.6** Arduino UNO board.

This board can be easily used, it is low price made it very popular microcontroller. It can be supplied by electrical power either via USB cable or by AC-DC adapter. This board programmed by using Arduino software (IDE). Its main advantages are as follows:


- 1) Cheap and have large libraries
- 2) Open source microcontroller.
- 3) Programed in an easy way.

**Table 2** Arduino UNO specifications.

Microcontroller	ATmega328P
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
LED_BUILTIN	13
Length	68.6 mm
Width	53.4 mm
Weight	25 g

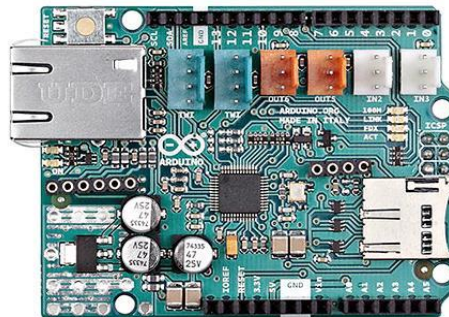
Arduino UNO and Arduino Mega from the most popular microcontrollers. Arduino Mega has more digital and analog pins than the UNO, bigger flash memory in Mega 256KB if it is compared to the 32KB in UNO, but still UNO is have price of Mega 2560. Fig. shows comparison in specifications between Arduino UNO and Arduino Mega 2560 boards.

**Table 3** Arduino UNO VS. Arduino Mega 2560.

	Arduino Mega	Arduino UNO
Voltage	5V	5V
Digital I/O	54	14
Analog Inputs	16	6
UART	4	1
Speed	16MHz	16MHz
PWM	14	6
Programming Interface	USB via ATmega16U2	USB via ATmega16U2
Preview		

### 3.4.3 Arduino Ethernet shield

The Arduino Ethernet shield is a chip that connects the Arduino to the internet or to a router. Arduino Ethernet shield shown in figure (3.7).

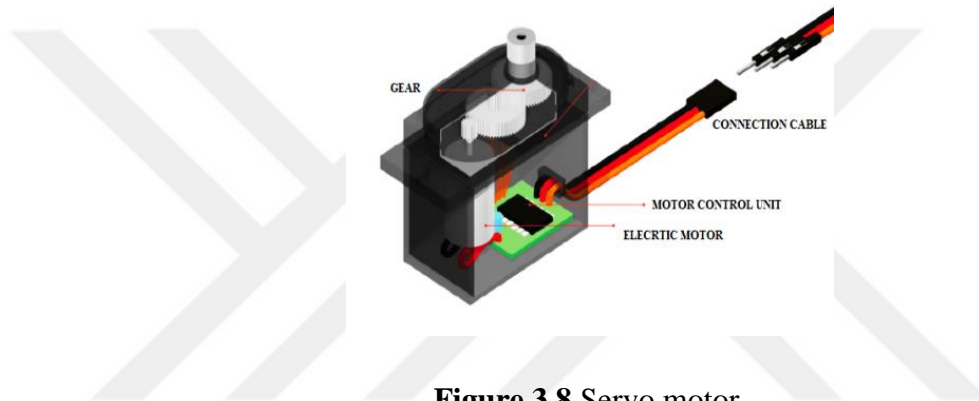


**Figure 3.7** Arduino Ethernet shield.

### 3.4.4 Servo motor

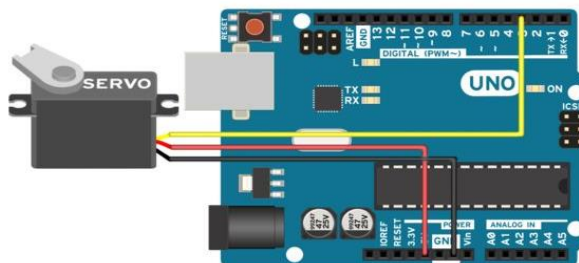
In this project servo motor was used to control the main door of the house (open / close). Biometric finger print reader modem used for house security. Because of this reason this modem installed into the house main door; the door can be open by using the legal RFID card or fingerprint otherwise the door cannot open. The servo motor consists of three main components as shown in figure (3.8). These components are:

- 1- Control circuit unit (microcontroller).
- 2- Motor take the signal from control circuit.
- 3- Gear train.



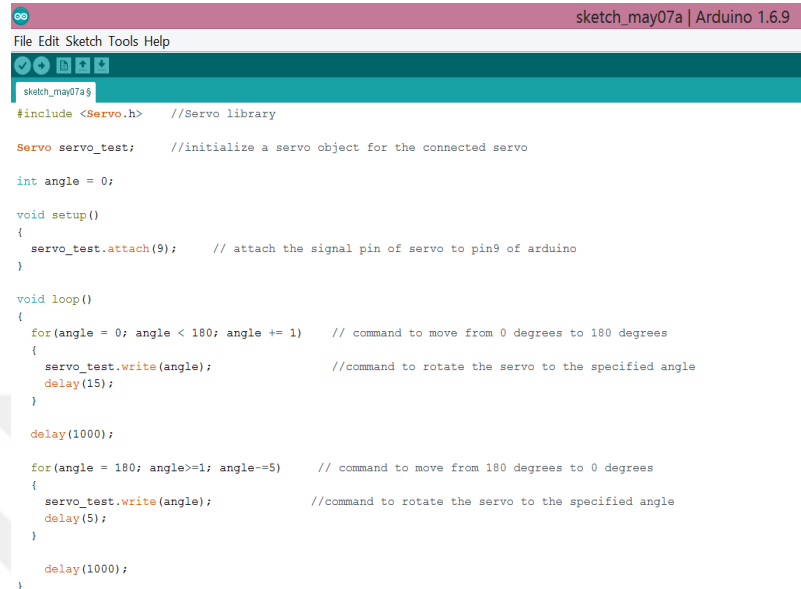
**Figure 3.8** Servo motor.

For connecting servo motor to Arduino UNO, at first VCC pin of servo motor need to be connected to the VCC port in the Arduino UNO board, secondly GND pin of servo motor need to be connected to GND port in Arduino UNO board, lastly control pin of servo motor need to be connected to one of the digital ports in Arduino UNO board, as shown in figure (3.9).



**Figure 3.9** Servo motor connected to Arduino UNO.

In order to make servo motor interact with the arduino board, C and C++ programming code was written in the Arduino IDE, as illustrated in figure (3.10).

The image shows a screenshot of the Arduino IDE interface. The title bar at the top reads "sketch\_may07a | Arduino 1.6.9". Below the title bar is a menu bar with "File", "Edit", "Sketch", "Tools", and "Help". A toolbar with various icons is visible below the menu bar. The main text area contains the following C++ code:

```
#include <Servo.h> //Servo library

Servo servo_test; //initialize a servo object for the connected servo

int angle = 0;

void setup()
{
  servo_test.attach(9); // attach the signal pin of servo to pin9 of arduino
}

void loop()
{
  for(angle = 0; angle < 180; angle += 1) // command to move from 0 degrees to 180 degrees
  {
    servo_test.write(angle); //command to rotate the servo to the specified angle
    delay(15);
  }
  delay(1000);

  for(angle = 180; angle>=1; angle--=5) // command to move from 180 degrees to 0 degrees
  {
    servo_test.write(angle); //command to rotate the servo to the specified angle
    delay(5);
  }
  delay(1000);
}
```

**Figure 3.10** Servo motor programming code in Arduino.

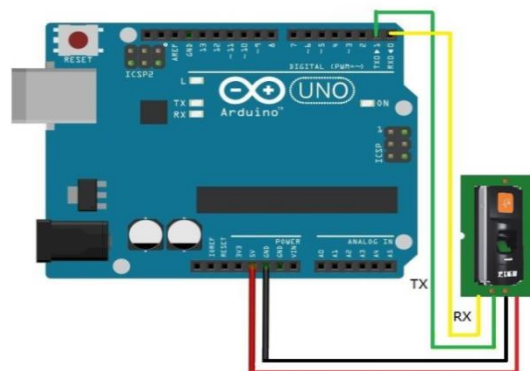
### 3.4.5 Biometric fingerprint modem and RFID reader

In this project, the Finger print RFID modem that is called (Biometric finger print reader modem) is used as a security device. This modem installed in the house main door, the door cannot be opened unless one user uses the legal RFID card or authorized fingerprint. In addition, a Biometric reader modem cannot read any other RFID card and fingerprint, except for an RFID cards and finger prints that defined in the system. As shown in figure (3.11).



**Figure 3.11** Biometric fingerprint and RFID reader module.

For connecting Biometric fingerprint and RFID reader module to Arduino UNO, at first VCC pin of Biometric fingerprint and RFID reader module need to be connected to the VCC port in the Arduino UNO board, secondly GND pin of Biometric fingerprint and RFID reader module need to be connected to GND port in Arduino UNO board, lastly control pins of Biometric fingerprint and RFID reader module need to be connected to the serial port in and serial port out in Arduino UNO board, as shown in figure (3.12).



**Figure 3.12** Biometric fingerprint and RFID reader module connected to Arduino UNO.

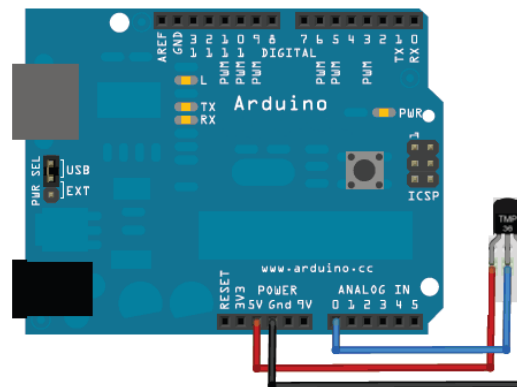
### 3.4.6 Temperature sensor

In this project, temperature sensor used for measuring the house temperature. The cooling system will start to work automatically on the desired temperature degree. The temperature sensor that used in this project shown in figure (3.13).



**Figure 3.13** Temperature sensor.

For connecting temperature sensor to Arduino Mega, at first VCC pin of temperature sensor need to be connected to the VCC port in the Arduino Mega board, secondly GND pin of temperature sensor need to be connected to GND port in Arduino Mega board, lastly data pin of temperature sensor need to be connected to one of the analog ports in Arduino Mega board, as shown in figure (3.14).



**Figure 3.14** Temperature sensor connected to Arduino board.

In order to make temperature sensor interact with the Arduino board, C and C++ programming code was written in the Arduino IDE, as illustrated in figure (3.15).

```
sketch_may07
File Edit Sketch Tools Help
sketch_may07a$
loat temp;
int tempPin = 0;

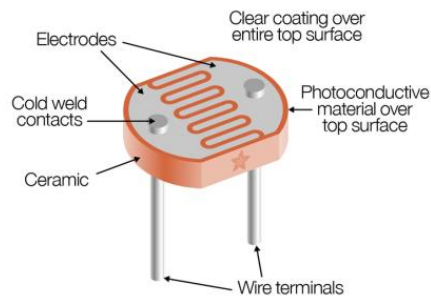
void setup()
{
  Serial.begin(9600);
}

void loop()
{
  temp = analogRead(tempPin);
  temp = temp * 0.48828125;
  Serial.print("TEMPERATURE = ");
  Serial.print(temp);
  Serial.println("*C");
}
```

**Figure 3.15** Temperature sensor programming code in Arduino.

### 3.4.7 Photocell sensor

In this project photocell sensor used for light detecting. Exterior Lights will turn on automatically when sensor detects that environment started to be dark. The photocell sensor shown in figure (3.16).



**Figure 3.16** Photocell sensor.

In order to make photocell sensor interact with the arduino board, C and C++ programming code was written in the Arduino IDE, as illustrated in figure (3.17).

```

13 int photoRPin = 0;
14 int minLight;           //Used to calibrate the readings
15 int maxLight;          //Used to calibrate the readings
16 int lightLevel;
17 int adjustedLightLevel;
18
19 void setup() {
20   Serial.begin(9600);
21
22   //Setup the starting light level limits
23   lightLevel=analogRead(photoRPin);
24   minLight=lightLevel-20;
25   maxLight=lightLevel;
26 }
27
28 void loop(){
29   //auto-adjust the minimum and maximum limits in real time
30   lightLevel=analogRead(photoRPin);
31   if(minLight>lightLevel){
32     minLight=lightLevel;
33   }
34   if(maxLight<lightLevel){
35     maxLight=lightLevel;
36   }
37
38   //Adjust the light level to produce a result between 0 and 100.
39   adjustedLightLevel = map(lightLevel, minLight, maxLight, 0, 100);
40
41   //Send the adjusted light level result to Serial port (processing)
42   Serial.println(adjustedLightLevel);
43
44   //slow down the transmission for effective Serial communication.
45   delay(50);
46 }

```

**Figure 3.17** Photocell programming code in Arduino.

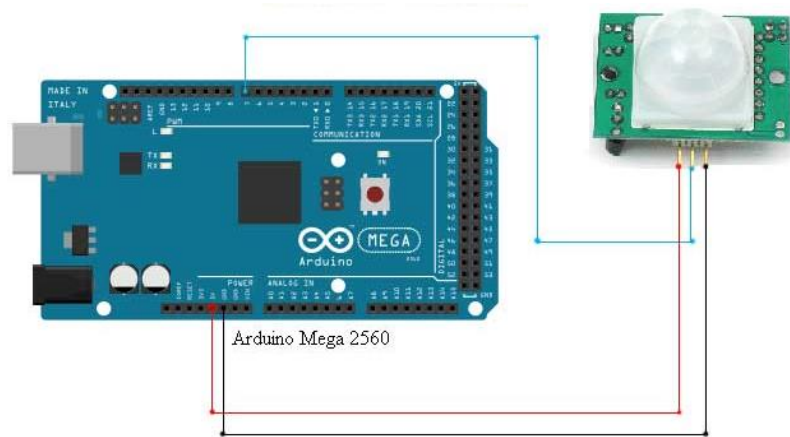
### 3.4.8 PIR motion sensor

This project used the passive infrared sensor (PIR) for detecting moving objects. Objects can be identified with this sensor range from 2 meters to 10 meters, and it is very easy to detect any objects which distance is less than 3 meters. The PIR sensor shown in figure (3.18).



**Figure 3.18** PIR sensor.

For connecting PIR sensor to Arduino Mega, at first VCC pin of PIR sensor need to be connected to the VCC port in the Arduino Mega board, secondly GND pin of PIR sensor need to be connected to GND port in Arduino Mega board, lastly data pin of PIR sensor need to be connected to one of the digital PWM ports in Arduino Mega board, as shown in figure (3.19).



**Figure 3.19** PIR sensor connected to Arduino Mega 2560.

In order to make PIR motion sensor interact with the arduino board, C and C++ programming code was written in the Arduino IDE, as illustrated in figure (3.20).

```
PIR_motion2 $
int pirPin = 2;
int count;

void setup(){
  Serial.begin(9600);
  pinMode(pirPin, INPUT);
  count = 0;
}

void loop(){
  int pirVal = digitalRead(pirPin);

  if(pirVal == LOW){
    count++;
    Serial.print("Motion Detected :");
    Serial.println(count);
    delay(2000);
  }
}
```

**Figure 3.20** PIR sensor programming code in Arduino.

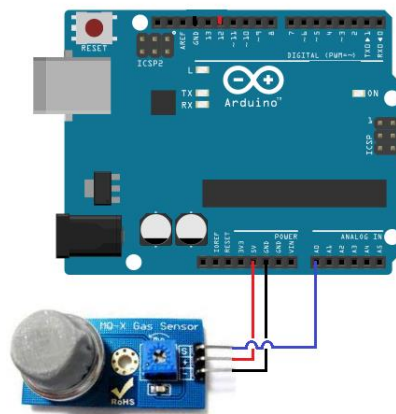
### 3.4.9 Gas sensor

The project used the gas sensor for detecting gas leakage. The alarm system will start to work when the gas begins to leak. The gas sensor shown in figure (3.21).



**Figure 3.21** Gas sensor.

For connecting gas sensor to Arduino Mega, at first VCC pin of gas sensor need to be connected to the VCC port in the Arduino Mega board, secondly GND pin of gas sensor need to be connected to GND port in Arduino Mega board, lastly data pin of gas sensor need to be connected to one of the analog ports in Arduino Mega board, as shown in figure (3.22).



**Figure 3.22** Gas sensor connected to Arduino board.

In order to make gas sensor interact with the Arduino board, C and C++ programming code was written in the Arduino IDE, as illustrated in figure (3.23).

```

File Edit Sketch Tools Help
mq_2_sensor_code$
int buzzer = 10;
int smokeA0 = A5;
// Your threshold value
int sensorThres = 400;

void setup() {
  pinMode(buzzer, OUTPUT);
  pinMode(smokeA0, INPUT);
  Serial.begin(9600);
}

void loop() {
  int analogSensor = analogRead(smokeA0);

  Serial.print("Pin A0: ");
  Serial.println(analogSensor);
  // Checks if it has reached the threshold value
  if (analogSensor > sensorThres)
  {
    digitalWrite(redLed, HIGH);
    digitalWrite(greenLed, LOW);
    tone(buzzer, 1000, 200);
  }
  else
  {
    digitalWrite(redLed, LOW);
    digitalWrite(greenLed, HIGH);
    noTone(buzzer);
  }
}

```

**Figure 3.23** Gas sensor programming code in Arduino.

### 3.4.10 Relay module

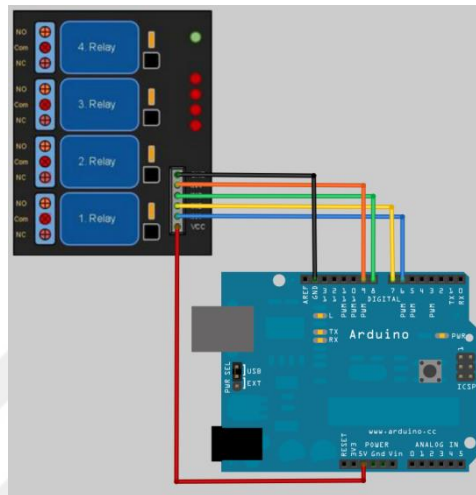
Relay is an electromagnetic device (switch) operated by a small electric current device used to turn ON/OFF a large current device. It is used to control electrical circuits automatically. Relay can be connected to a 5V Arduino board and in the other side of relay connected to a 230V appliance. In this project 8 relay module and 4 relay module were used.

A 4, 8, 16 relays boards can be connected to Arduino boards easily and it will allows to turn ON/OFF many devices in both DC and AC. 8 channels relays module illustrated in figure (3.24).



**Figure 3.24** 8 channels relay.

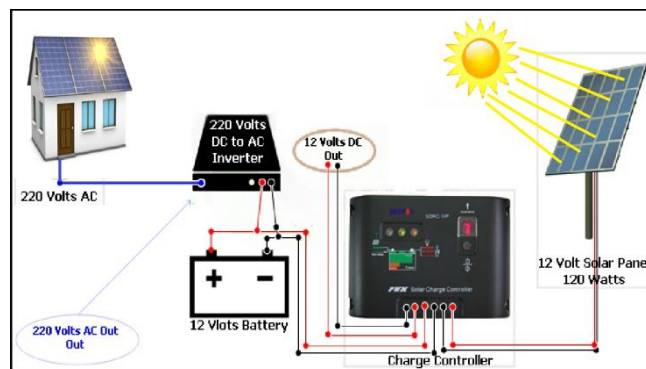
For connecting 4 relay module to Arduino board, at first VCC pin of 4 relay module need to be connected to the VCC port in the Arduino board, secondly GND pin of 4 relay module need to be connected to GND port in Arduino board, lastly each digital pin of 4 relay module need to be connected to one of the digital ports in Arduino board, as shown in figure (3.25).



**Figure 3.25** Relay module connected to Arduino board.

### 3.4.11 Solar cell system

This home automation system is supplied by electrical power through using of the green energy system as shown in figure (3.26).



**Figure 3.26** Solar cell system connected to the smart home.

This system will get light from sun converting it through the solar cell to a DC electrical energy, after that this collected power transferred to a charge controller responsible for stabilizing the collected electrical power from the solar cell in order to charge the battery with it, the next step will be inverting the power that came out from the battery convert it from low voltage DC current (6V, 12V, 24V) into high voltage AC current (220V – 240V) in order to supply the smart house system with electrical current. This solar system consists of:

- 1- Solar cell: it is an electrical device that converts light energy into electrical energy through the photovoltaic effect, it absorb the light energy directly from the sun or from any artificial light source. It consists of semiconductor materials convert the lighting energy to electrical DC energy. As shown in figure (3.27).



**Figure 3.27** Solar cell.

- 2- Charge controller, responsible for battery charging, takes electrical power that generated from solar cells.
- 3- Battery (12-24V), for saving the electrical power collected from solar cells.
- 4- DC-AC inverter, used for converting low voltage DC current (6V, 12V, 24V) into high voltage AC current (220V – 240V) in order to supply the smart house system with electrical current, as shown in figure (3.28).



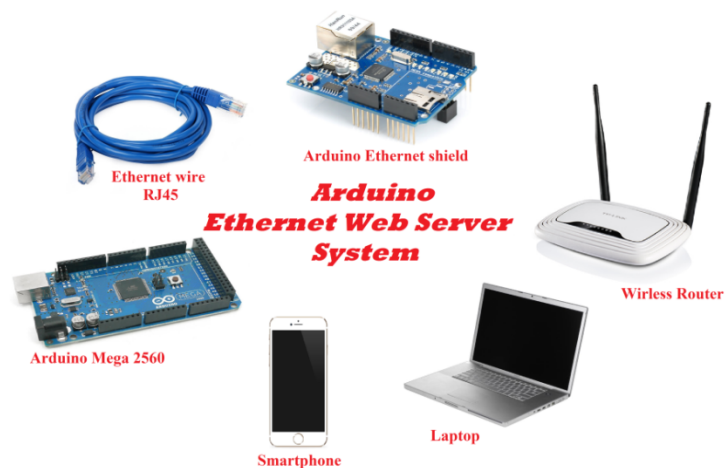
**Figure 3.28** DC-AC inverter.

### 3.5 Ethernet system

Ethernet system used in this project in order to make a small home network web server that entered through a web browser from any smartphone or computer. This Ethernet system consists of the following parts:

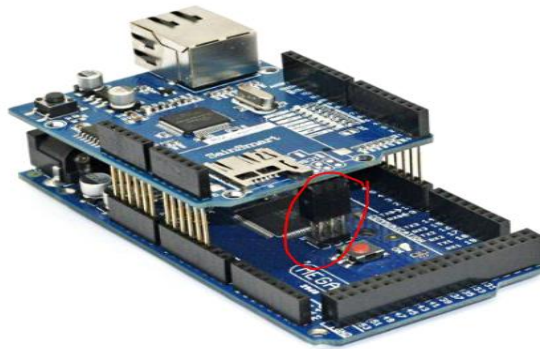
1. Arduino Ethernet shield W5100.
2. Arduino Mega 2560.
3. Wi-Fi router device.
4. Ethernet wire (RJ45)
5. Smart device.

Figure (3.29) illustrates the parts used to build this Ethernet system.



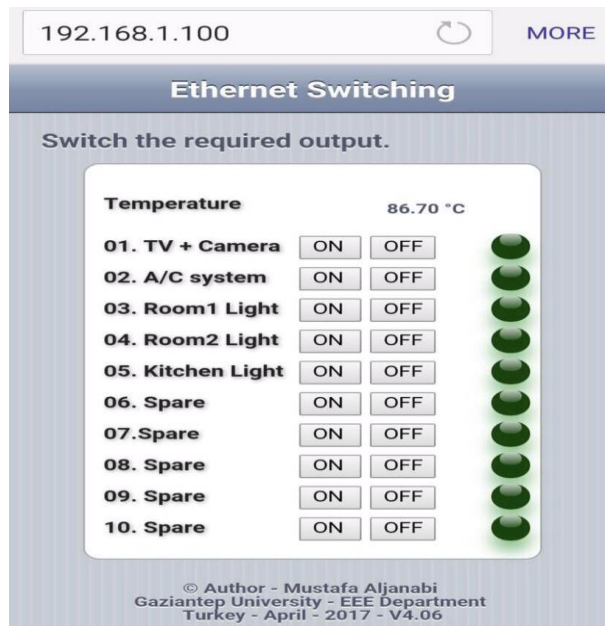
**Figure 3.29** Arduino Ethernet webserver system components.

Arduino Ethernet shield will be connected to the Arduino Mega 2560 by mounting it on the top of the Arduino board as shown in figure (3.30).



**Figure 3.30** Mounting Arduino Ethernet shield into Arduino Mega 2560.

Arduino Ethernet shield will be connected to the router using an Ethernet cable (RJ45). In this project Arduino Ethernet shield is used to create a simple web server, sensors will be controlled through this web server by opening webpage JavaScript button, values of sensors and state of switches will be read by the webpage interface. Arduino Ethernet shield connected to Arduino Mega 2560. There is an Ethernet library inside the Arduino IDE will be used to answer a HTTP request from the Ethernet shield. User can open the browser and by entering the Ethernet shield specific IP address, Arduino will respond for the HTML request from the web browser through the Ethernet shield displaying the values of the analog pins in Arduino Mega 2560. Web browser interface illustrated in figure (3.31).



**Figure 3.31** Web browser Ethernet interface.

In order to make Ethernet network interact with the arduino board, CSS3 and HTML are used for designing the Ethernet webserver webpage, C and C++ programming code was also written in the Arduino IDE, as illustrated in figure (3.32).

```

sketch_may08a | Arduino 1.6.9
File Edit Sketch Tools Help
sketch_may08a$
//ETHERNET SWITCH PROGRAM
//Intro:
//This will switch on and off outputs trough your any device using browser.
//No images or links to images. CSS3 and HTML5 use.
//Though it work with other web browser, we suggest Safari for best experiance.
//
//Version: Web Server Ethernet Switching Version 4.06
//Author: Mustafa Aljanabi - Gaziantep
//Made lot of comments for beginners.

//ARDUINO 1.0+ ONLY

#include <Ethernet.h>
#include <SPI.h>
#include <EEPROM.h>

//CONFIGURATION

//IP manual settings
byte ip[] = {192, 168, 1, 100 }; //Manual setup only
byte gateway[] = {192, 168, 1, 1 }; //Manual setup only
byte subnet[] = {255, 255, 255, 0 }; //Manual setup only

// if need to change the MAC address (Very Rare)
byte mac[] = {
  0xDE, 0xAD, 0xBE, 0xEF, 0xFE, 0xED };

//Ethernet Port
EthernetServer server = EthernetServer(80); //default html port 80

```

**Figure 3.32** Ethernet webserver programming.

## CHAPTER 4

### EXPERIMENT AND RESULTS

#### 4.1 Introduction

This chapter will talk about the project experiment and results that achieved.

#### 4.2 Results

After connecting sensors and devices that mentioned in chapter 3, the expected results were gained, a smart house system powered by solar cells achieved successfully. It was a low cost smart home system controlled by smart devices such as smartphones or computer. It is practical easy to use with high security was mainly targeted to disabled and elderly people. This smart home automation system can saves energy by reducing electricity wasting.

Servo motor was connected to Arduino UNO board, the desired results were gained, and the achieved results was opening and closing the house gate through this motor. As shown in figure (4.1).



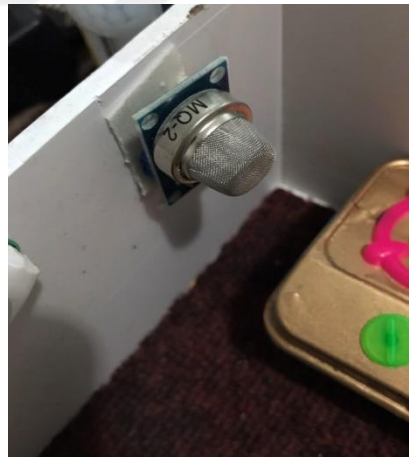
**Figure 4.1** Servo motor connected to the smart home system.

The Biometric fingerprint module and RFID card reader gave the results, and achieved the wanted goal by giving high security to the home. As shown in figure (4.2).



**Figure 4.2** Biometric fingerprint / RFID card reader connected to smart home system.

As well as the gas sensor worked successfully and gave an alarm when gas started to leak. As shown in figure (4.3).



**Figure 4.3** Gas sensor connected to the smart home system.

Further, the photocell sensor gave high response more than the expected. As shown in figure (4.4).



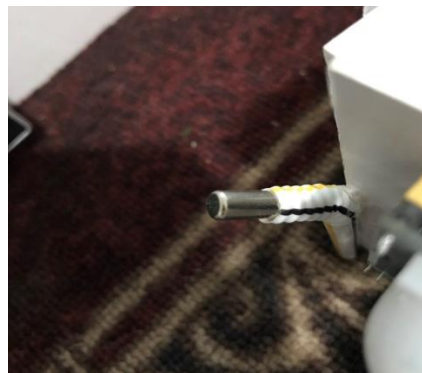
**Figure 4.4** Photocell sensor connected to the smart home system.

In addition PIR motion sensor detection was very accurate as expected. As shown in figure (4.5).



**Figure 4.5** PIR sensor connected to the smart home system.

On the other hand temperature sensor worked perfectly<sup>1</sup> and accurately. As shown in figure (4.6).



**Figure 4.6** Temperature sensor connected to the smart home system.

The Arduino boards (Mega 2560 and UNO) gave a great response and reacted with sensors and smart home appliances correctly.

These results were about the hardware part of the project. The software part of the project also gave a high response in analyzing the data received from smart home system appliances to the microcontrollers.

All results came exactly as expected. As shown in figures (4.7-4.13)



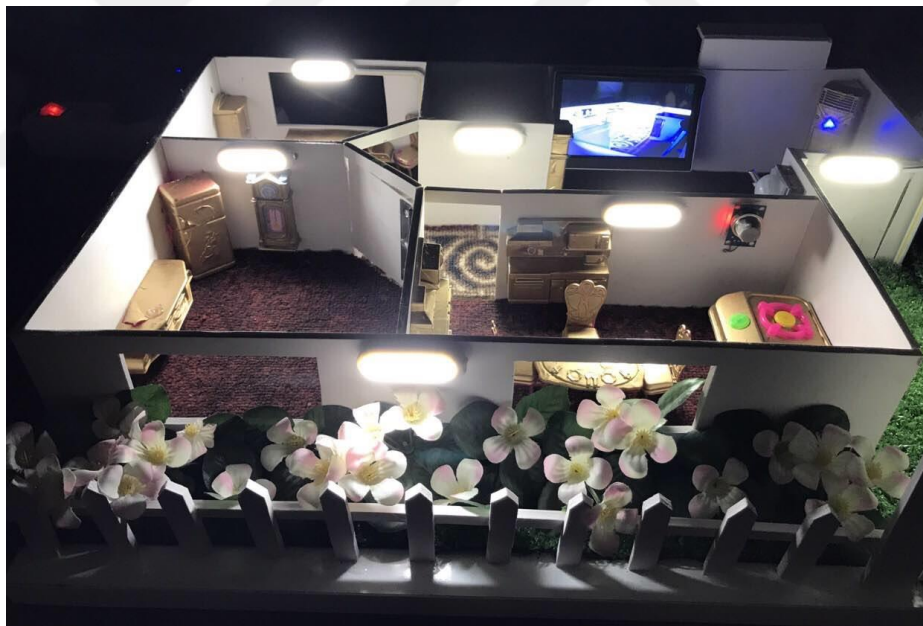
**Figure 4.7** System final result (A).



**Figure 4.8** System final result (B).



**Figure 4.9** System final result (C).



**Figure 4.10** System final result (D).



**Figure 4.11** System final result (E).



**Figure 4.12** System final result (F).



**Figure 4.13** System final result (G).

### **4.3 Discussion**

This project work with any smartphone or pc that having a Wi-Fi wireless connection and a web browser application, it can control all home appliances and sensors. Biometric fingerprint module and RFID card reader were used for security purpose. Photocell sensor used for making the house outdoor light smart system will turn ON/OFF depending on environment condition. PIR motion sensor used for detecting moving objects, indoor light system will work depending on the detection of moving objects, this sensor will save more electric power by controlling turning ON/OFF lights. Gas sensor used for gas leakage detection, it will give an alarm when gas start to leak. Ethernet webserver system used for connecting users through router wireless connection in order to control home appliances with Arduino board. Solar cell system which consists of solar cell, battery and inverter used for supplying the entire home with electrical energy which that already was collected from sunlight converted from light energy to electric energy.

## **CHAPTER 5**

### **CONCLUSION AND SUGGESTIONS FOR FUTURE WORK**

#### **5.1 Conclusion**

The purpose from this project is to create a Smart Home System powered by solar energy and control home appliances remotely through smart devices. All objectives have been achieved successfully. Users can control this smart home through sending instructions to the microcontroller (Arduino Mega 2560 and Arduino UNO), microcontroller will make analyzing and processing to this instructions, after that microcontroller will send this processed instruction to the responsible sensor. In market there is many types of smart house systems but with high cost. This project Smart Home System Powered by Solar Energy will save money because it is a low cost project and saves electrical energy due to the using of solar cell system.

#### **5.2 Future Work**

This project can be extended in future as follows:

1. Using image processing through face detection will give to system more security.
2. GSM shield can be used for sending and receiving emergency messages and alarms.

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