Sudan University of Science and Technology
Collage of Engineering
School of Electrical and Nuclear Engineering

MONITORING AND CONTROLLING OF GREENHOUSE

المراقبة والتحكم في البيوت المحمية

A Project Submitted in Partial Fulfilment for the Requirements of the Degree of B.Sc. (Honor) in Electrical Engineering (Control)

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الآيـة

قال الله تعالى:

{قَالُواْ سُبْحَانَكَ لاَ عِلْمَ لَنَا إِلاَّ مَا عَلَّمْتَنَا إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيم}

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سورة البقرة , الآية ٣٢

DEDICATION

To my beloved mother and father who supported me,

To my brothers and sisters,

To my friends and study partners

To everyone who make a positive effect on me.

ACKNOWLEDGEMENT

First of all, we praise and thank our God, and we are kindly grateful to our supervisor **Dr. Awadallah Taifour Ali** who was extremely generous to us with his time, effort and concern, and who was such a big help and supporter through this project. We also we would like to thank anyone who helped us.

ABSTRACT

The main idea of this project is to control the temperature, light, and irrigation system inside the greenhouse to provide an appropriate growing environment to plants. The environmental factors inside the greenhouse are studied, and appropriate circuit to control those factors is designed and implemented using suitable components. To control these environmental factors suitable sensors are used such as temperature sensor (LM35) and light sensor (LDR). Sensors input a certain voltage according to the measured factor, after that the microcontroller compares between the measured value and the reference one and switches on the appropriate actuator.

المستخلص

الفكرة الاساسية من هذا المشروع هي التحكم في درجة الحرارة والاضاءة ونظام الري داخل البيوت المحمية لكي تهيئ مناخ نباتي مناسب للبناتات. تم دراسة العوامل البيئية داخل البيوت المحمية وبناءا على ذلك تم تصميم دائرة مناسبة للتحكم في هذة العوامل و تطبيقها بإستخدام مكونات مناسبة. للتحكم في هذة العوامل البيئية تم إستخدام حساسات مثل حساس درجة الحرارة (LM35) وحساس الإضاءة (LDR) . تقوم الحساسات بإدخال جهد معين مكافئ للعامل البيئي المقاس , بعد ذلك يقوم المتحكم الدقيق بمعالجة ومقارنة القيمة المقاسة بالقيمة المرجعية وتشغيل الخرج المناسب.

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LIST OF ABBREVIATIONS

PE	Low density polyethylene
PVC	Polyvinyl chloride
HID	High-intensity discharge
VLSI	Very large scale integrator
CPU	Central processing unit
MCU	Microcontroller unit
IC	Integrated circuit
LCD	Liquid crystal display
LDR	Light dependent resistor
IRR	Irrigation

CHAPTER ONE

INTRODUCTION

1.1 Background

Greenhouses are a special type of growing structure used to provide a suitable growing environment to the plants and the flowers inside. Demand is increasing day after day on food, as a natural result of the increase in population on the one hand and increase the diversity of consumption on the other hand, since the nature of the climate in Sudan and the Arab countries are not appropriate overall length to produce enough fruits and vegetables to meet the needs of the population and achieve food security, so protected Agriculture earn particular importance in view of what can be done to fill the shortage of agricultural production and achieve self-sufficiency.

1.2 Problem Statement

Climate in Sudan and Arab countries is not suitable to grow all kind of plants all over the year, and even the plants that are grown sometimes they are not in their high quality. This disability of growing all kind of plants makes a shortage in vegetables and fruits.

1.3 Research Objectives

The main objectives of the research are:

- Design of control circuit for greenhouse system using microcontroller.
- Simulation of greenhouse control circuit.
- Implementation and testing of proposed control circuit.

1.4 Methodology

- The system is modelled using microcontroller type PIC18f46K20.
- The system simulation has been carried out by using Mikro C as a programming language.
- Proteus software is used as a simulator and compiler.
- The proposed circuit is implemented in bred board

1.5 Research layout

The research contains an abstract and five chapters. Chapter One consists of general introduction, background of the greenhouse, problem statement that the project deal with, objectives, methodology and research layout. Chapter Two covers a theoretical background of greenhouse, sensors and the microcontroller.

In Chapter three the system is described and components are introduced. Chapter Four is about system simulation and implementation. Chapter Five consists of the conclusion, recommendations, references and the programming code as appendix.

CHAPTER TWO

THEORETICAL BACKGROUND

2.1 Introduction

The scientific progress of the human enabled him to innovate and develop many of the tools and methods used to increase production and improve the quality in different areas of life, including the impact on the surrounding circumstances where the advantage of that is positive for him, and could sometimes create artificial conditions mimic the best conditions for the exercise of activity in difficult environmental conditions. Protected agriculture one of the modern scientific methods to overcome the environmental non-suitable for agricultural production, which succeeded already in the desert regions, hot and harsh conditions of water scarcity, lack of soil fertility and increase the proportion of salts and as a result, the field of agriculture open (exposed) face numerous difficulties. Thanks to research and experience, it has shown that the best way for the production of vegetables and fruits is the method of protection from risk of high temperatures in summer and winter frost, as well as protection from sandstorms, which provides the opportunity to increase the yield and the quality of the production throughout the year [1].

The greenhouse industry as we know it today probably originated in Holland during its “Golden Age’’, the 1600s and it became an essential part of the garden from the latter part of the eighteenth century onwards. Such structures had long been in the mind of gardeners but their development had had to await the invention and production of cheap sheet glass. This in its turn had to wait upon the industrial revolution and the development of the necessary techniques [2].

2.2 Types of Greenhouses

Greenhouses can be varied depending on a lot of characters but mainly it can be varied into:

- structure design
- covering sheets

2.2.1 Structure design

Greenhouses are available in different shapes and sizes suitable for different climatic zones prevailing in the world. Each zone requires different shapes for providing favorable climatic conditions for the growth of plants. The greatest amount of insulation possible, covering of maximum ground area for the least cost and a structurally sound facility are some of the criteria for development of several types of greenhouse as seen in figure (2.1) and figure (2.2) [2]. Greenhouse structures design such as:

- Mansard
- Maw tooth
- Ridge and furrow
- Vinery house
- Arch
- Standard peak
- Venlo house Quonset

2.2.2 Covering sheets

Cladding cover will drastically affect the amount of sunlight reaching the crops; the cladding will also determine heat loss of the structure. The most common materials are:

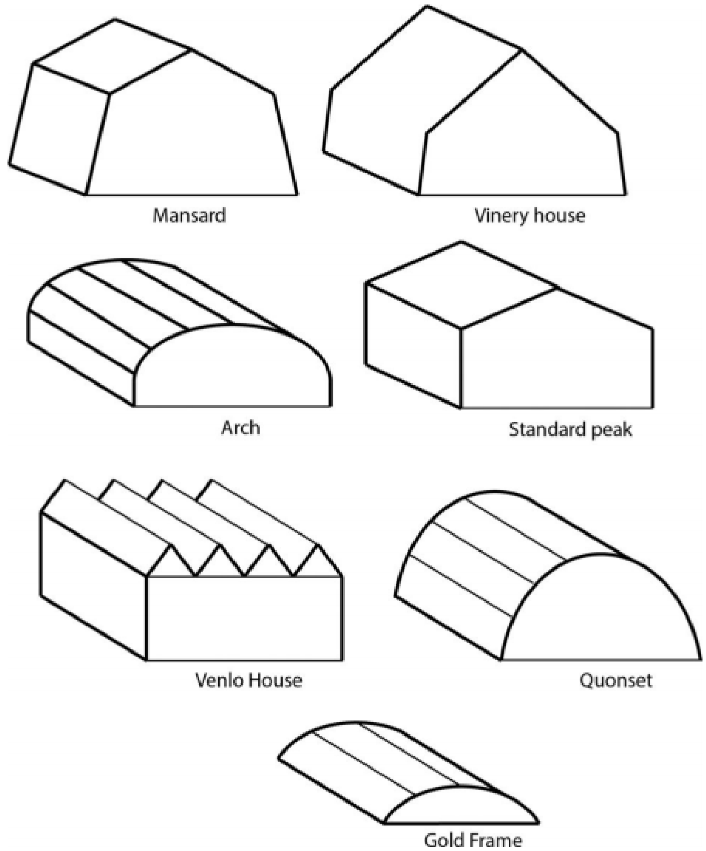

Figure (2.1) Basic shapes of Greenhouse

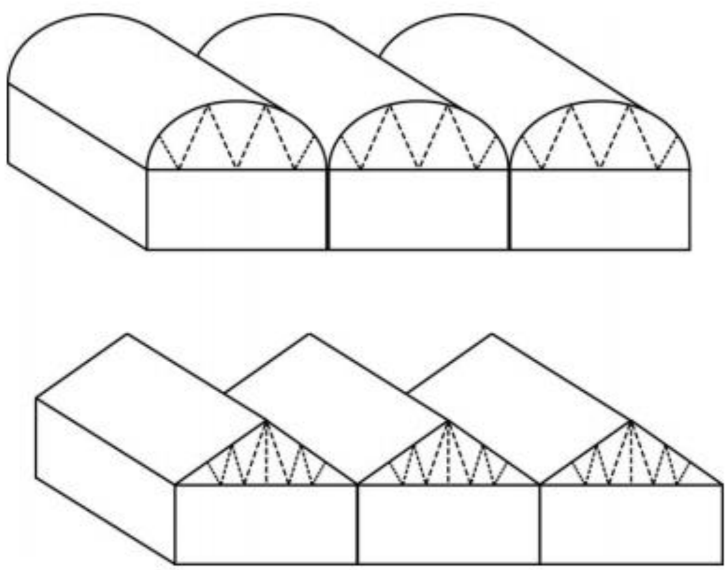

Figure (2.2) Ridges and Furrow shapes

2.2.2.1 Low density polyethylene (PE)

Low cost. Resistant to extreme weather conditions, molding ability and it is light hence it does not cause large loads on the structure. Not readily degradable so its use must be measured [2].

2.2.2.2 Glass

The traditional greenhouse covering against which all others are judged. Good quality glass is an attractive, very transparent, and formal (in appearance) covering material [2].

2.2.2.3 Polyvinyl chloride PVC

Polyvinyl Chloride is the most economical and used choice widely used due to its versatility, malleability and mechanical properties. It is lightweight so it does not generate large stresses in the structure [2].

2.2.2.4 Fiberglass reinforced panels FRPs

Rigid plastic panels made from acrylic or polycarbonate that comes in large corrugated or flat sheets. They are durable, retain heat better than glass does, and are lightweight [2].

2.3 Styles of Greenhouses

There are two styles of modern greenhouses, the English greenhouse and the Dutch light house.

2.3.1 English greenhouse

English greenhouse as shown in Figure (2.3) is usually stands on a low bricks wall, and its woodwork painted white and glazed with overlapping sheets of glass [1].

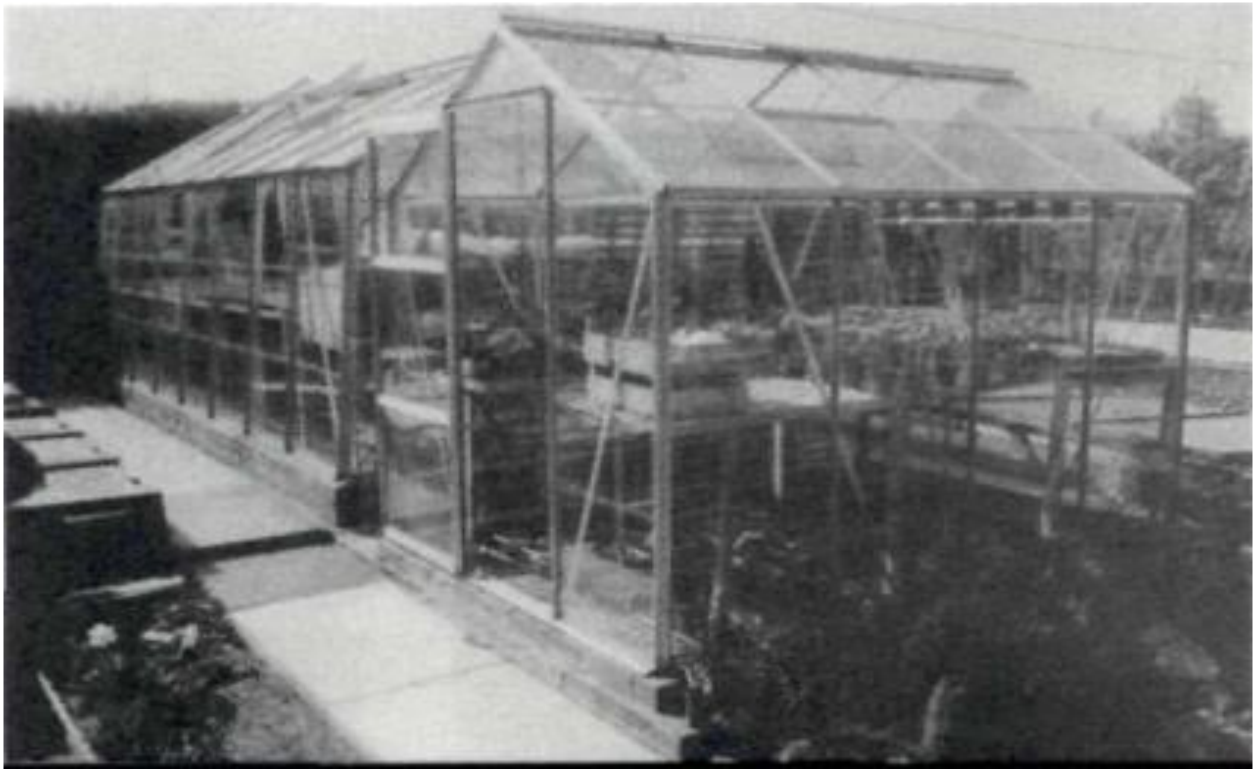

Figure (2.3) English greenhouse style

2.3.2 Dutch Light House

Dutch Light House as shown in figure (2.4), its less pleasing appearance, it is usually assembled from prefabricated frame of pressure-treated timber glazed with sheets of Dutch light glass and all supplied as a kit [1].

2.4 Site selection

A greenhouse complex should be located in such a way that it is well connected with markets, both for its supply and sale of its produce. The proposed greenhouse site should have adequate communication means i.e. telephone, fax, etc. There should be sufficient availability of good quality water and electricity [2].

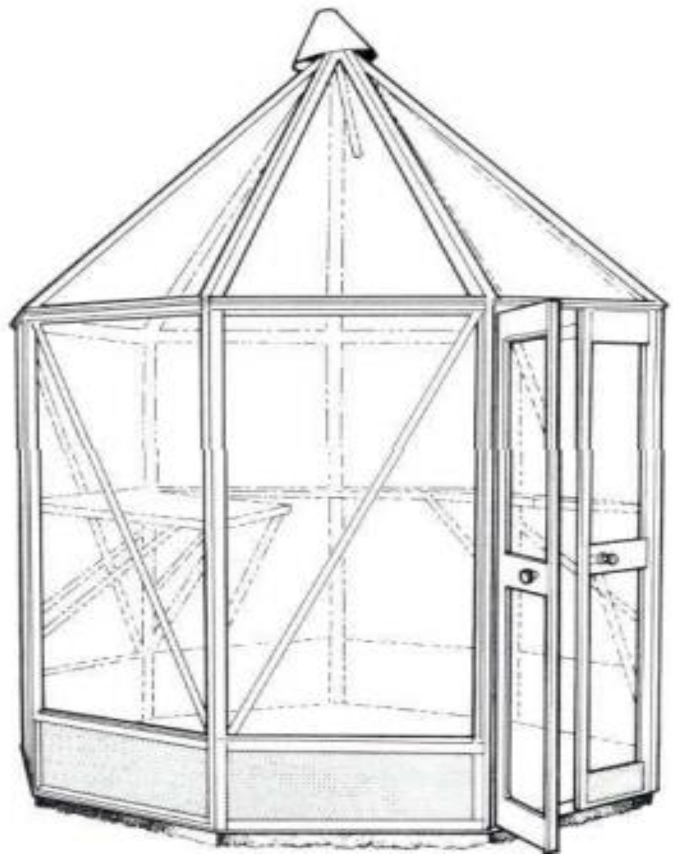

Figure (2.4) Dutch light house style

2.5 Environmental Factors Inside a Greenhouse

In order to provide a suitable growing environment to the plants these are the factor to be controlled:

2.5.1 Heating

Each type of plants has its own heating environmental conditions, some plants grows better in cold weather, others grows better in worm weather and others give you the best growing income in hot weather. Once you understand your greenhouse heating requirements, you'll need to determine what type of heater to use and whether you'll need to run a gas line and power to the greenhouse. The two main types of greenhouse heaters are electric and fuel-fired (gas, propane, kerosene, or oil) as shown in figure (2.5). Also heat sink system can be used to get use of the solar heat [3].

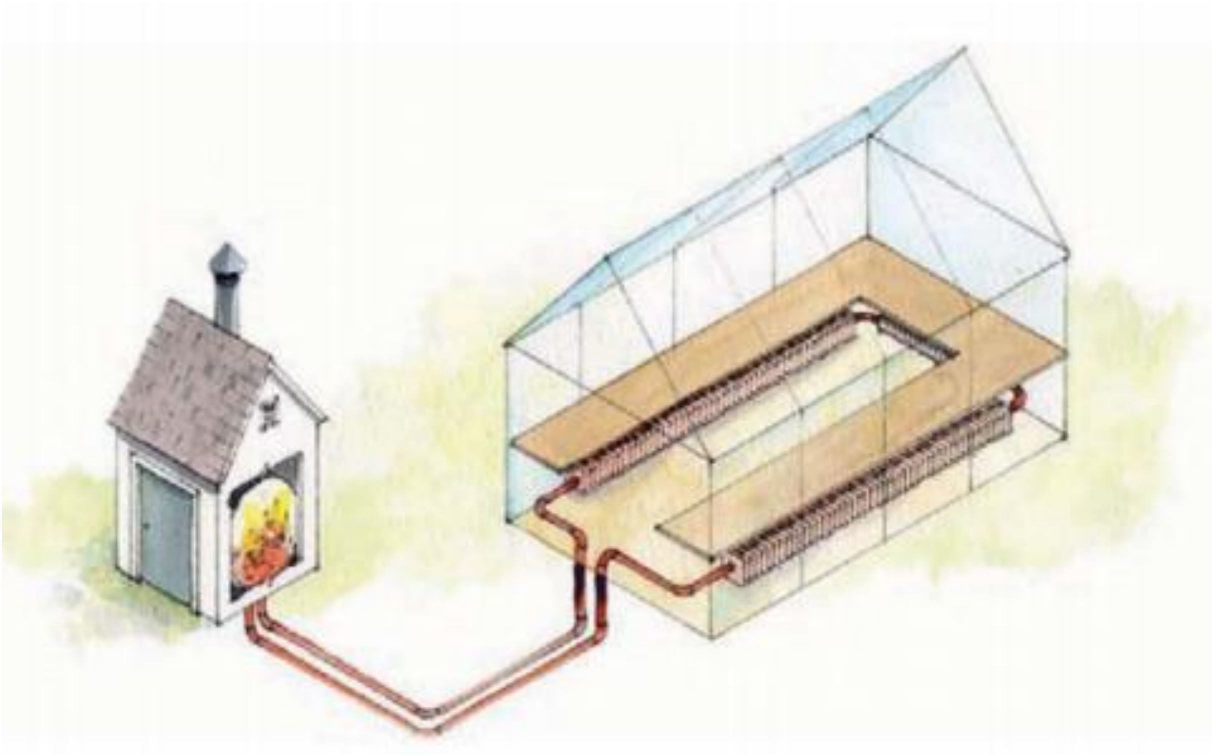

Figure (2.5) fuel-fired heating system

2.5.2 Ventilation

Whether your plants thrive depends on how well you control their environment. Adequate sunlight is a good start, but ventilation is just as important: It expels hot air, reduces humidity, and provides air circulation, which is essential even during winter to move cold, stagnant air around, keep diseases at bay, and avoid condensation problems. There are two main options for greenhouse ventilation: vents and fans. Because hot air rises, roof vents are the most common choice. They should be staggered on both sides of the ridgeline, even exchange of air and proper circulation [3].

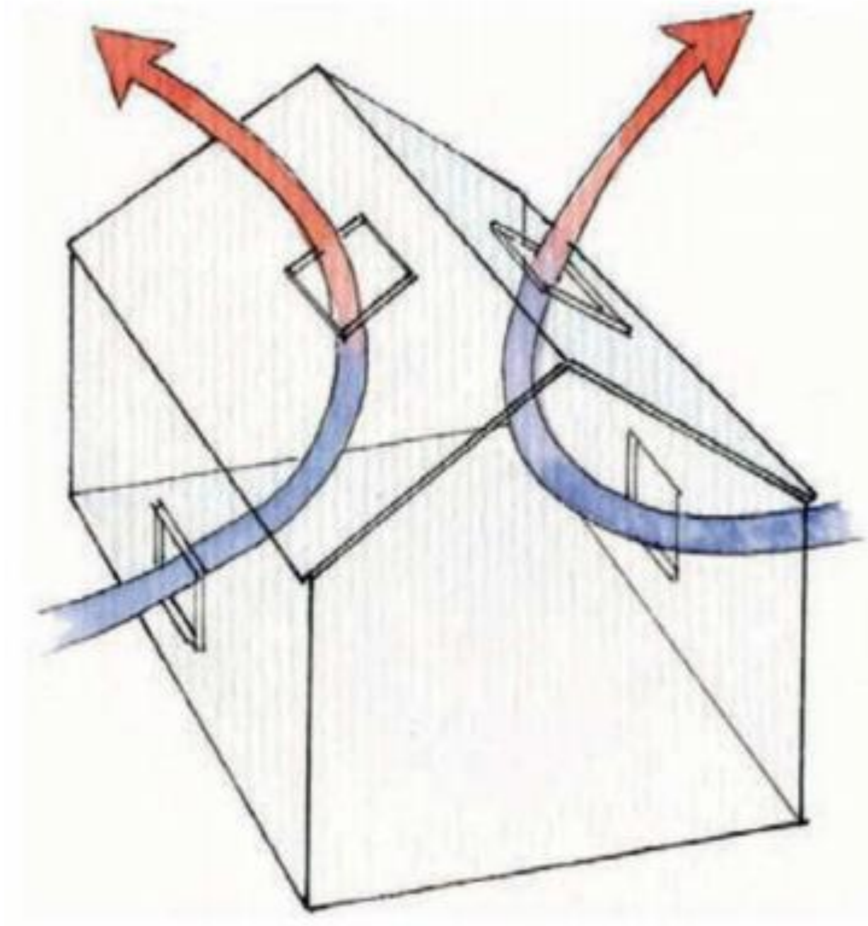

Figure (2.6) roof vents

2.5.3 Humidity

Humidity of the greenhouse can be an air humidity or soil humidity and both depends on the percentage of water in the soil or in the air, so all greenhouses need some kind of water supply system, such as watering systems which can be as simple as a hose connected to the nearest outdoor spigot or as complex as a frost-proof underground line extending from your basement to a special hydrant in the greenhouse. Water supply system can be a misting system, when the temperature inside the greenhouse rises and the vents open, they release humidity. Misting increases humidity, which most plants love- levels of about 50 percent to 65 percent are ideal- and dramatically decreases the temperature by as much as 20° F [3].

2.5.4 Cooling

Although vents and fans arc the first line of defense when the temperature inside the greenhouse starts to climb, other cooling methods such as misting, humidifying, evaporative cooling, and shading can also help to maintain the idea l growing environment. Cooling is crucial during summer, but it can be just as important on a sunny winter day [3].

2.5.5 Lighting

All the plants need sunlight to complete the progress of photosynthesis, so sunlight is a major factor during the day. Plants may need additional light. And no matter where the greenhouse is located, you'll likely need to rely on supplemental lighting during night. Supplementing natural light with artificial light can be tricky. Natural light is made up of a spectrum of colors that you can see (colors of the rainbow) and those you can't see. Plants absorb light from the red and blue ends of the spectrum so its important to choose bulbs that provide those spectrums, taking in mind the intensity and the distance between plants and the artificial lighting system because Lights that are set too far away or that don't provide enough brightness (measured in lumens or foot-candles) will produce weak, spindly plants. There are three basic types of lights are available; incandescent bulbs, fluorescent tubes, and high-intensity discharge (HID) lights. Each has advantages and disadvantages, which is why greenhouse gardeners often use a combination of two or more types to achieve light that is as close to natural as possible [3].

2.6 Sensors

A sensor is a device that detects events or changes in quantities and provides a corresponding output, generally as an electrical or optical signal; for example, a thermocouple converts temperature to an output voltage. But a mercury-in-glass thermometer is also a sensor; it converts the measured temperature into expansion and contraction of a liquid which can be read on a calibrated glass tube. Sensors are used in everyday objects such as; touch sensitive elevator buttons (tactile sensor) and lamps which dim or brighten by touching the base, besides innumerable applications of which most people are never aware. With advances in micro machinery and easy-to use microcontroller platforms, the uses of sensors have expanded beyond the more traditional fields of temperature, pressure or flow measurement, for example into MARG sensors. Moreover, analog sensors such as potentiometers and force-sensing resistors are still widely used. Applications include manufacturing and machinery, airplanes and an aerospace, cars, medicine and robotics. A sensor's sensitivity indicates how much the sensor's output changes when the input quantity being measured changes. For instance, if the mercury in a thermometer moves1cm when the temperature changes by 1°C, the sensitivity is 1cm/°C (it is basically the slope Dy/Dx as summing a linear characteristic). Some sensors can also have an impact on what they measure; for instance, a room temperature thermometer inserted into a hot cup of liquid cools the liquid while the liquid heats the thermometer. Sensors need to be designed to have a small effect on what is measured; making the sensor smaller often improves this and may introduce other advantages. Technological progress allows more and more sensors to be manufactured on a microscopic scale as micro sensors using MEMS technology. In most cases, a micro sensor reaches a significantly higher speed and sensitivity compared with macroscopic approaches [4].

2.7 Microcontroller

Microcontroller is a programmable single-chip integrated circuit (IC) that controls the operation of the system. Also we can say microcontroller is a microcomputer with few other application-specific devices on a single-chip of

VLSI (very large scale integrator). It has the specified computational capabilities as well as the enhanced IO operation and control capability, so it's a integrated part in the real time control or communication system [6]. Often the system to be controlled is a machine. One of the most common applications is automotive control. This includes engine fuel injection control, transmission control, suspension and ride control [6]. The microcontroller unit uses the sensors inputs to control thingnition timing of maximum fuel efficiency [5].

2.7.1 Technical view

A microcontroller is a single-chip device that contains memory for program information and data. It has logic for programmed control reading inputs, manipulating data, and sending outputs. In the other hand it has built-in interfaces for input/outputs as well as a central processing unit (CPU). we often refer to the device (the chip) as a microcontroller unit (MCU). The built-in interface capability is used for sensors, actuators, and communication. In practical, a microcontroller has other parts. Also, many applications require other chips in addition to the MC chip; those are called support chips [5].

2.7.2 Types of Microcontrollers

The microcontrollers are classified in terms of, internal bus width, embedded microcontroller embedded instruction set, memory architecture, IC chip or VLSI core and family. For the same family there may be various versions with various sources [6].

CHAPTER THREE

SYSTEM DESCRIPTION AND COMPONENTS

3.1 System Description

The main concept of the designed block diagram shown in figure (3.1) is to receive reference values from the keypad .Then receive environmental factors from sensors and compare them with the reference values and take the appropriate action to modify the greenhouse environment as desired.

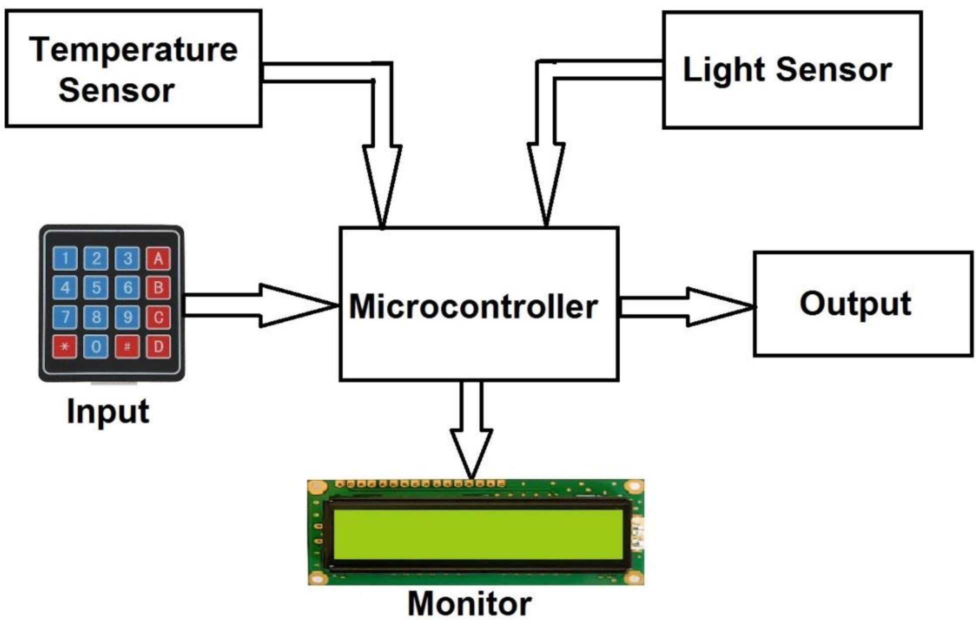

Figure (3.1) block diagram of the Greenhouse Controlling and Monitoring system

3.2 Greenhouse System Components

The system components selected according to the functionality of greenhouse system, microcontroller PIC is required to control greenhouse actuators according to certain values received from sensors. These values will be compared with reference values inserted by user using keypad. To monitor the system characteristics we used LCD display.

3.2.1 Pic 18f46k20 microcontroller

The PIC18F46K20 microcontroller shown in Figure (3.2) is one of the latest products from *Microchip*. It features all the components which modern microcontrollers normally have. For its low price, wide range of application, high quality and easy availability, it is an ideal solution in applications such as the control of different processes in industry, machine control devices, measurement of different values etc. Some of its main features are listed below. The selection has been done due to their Small instruction set to learn, Inexpensive microcontrollers; built in oscillator with selectable speeds, Wide range of interfaces.

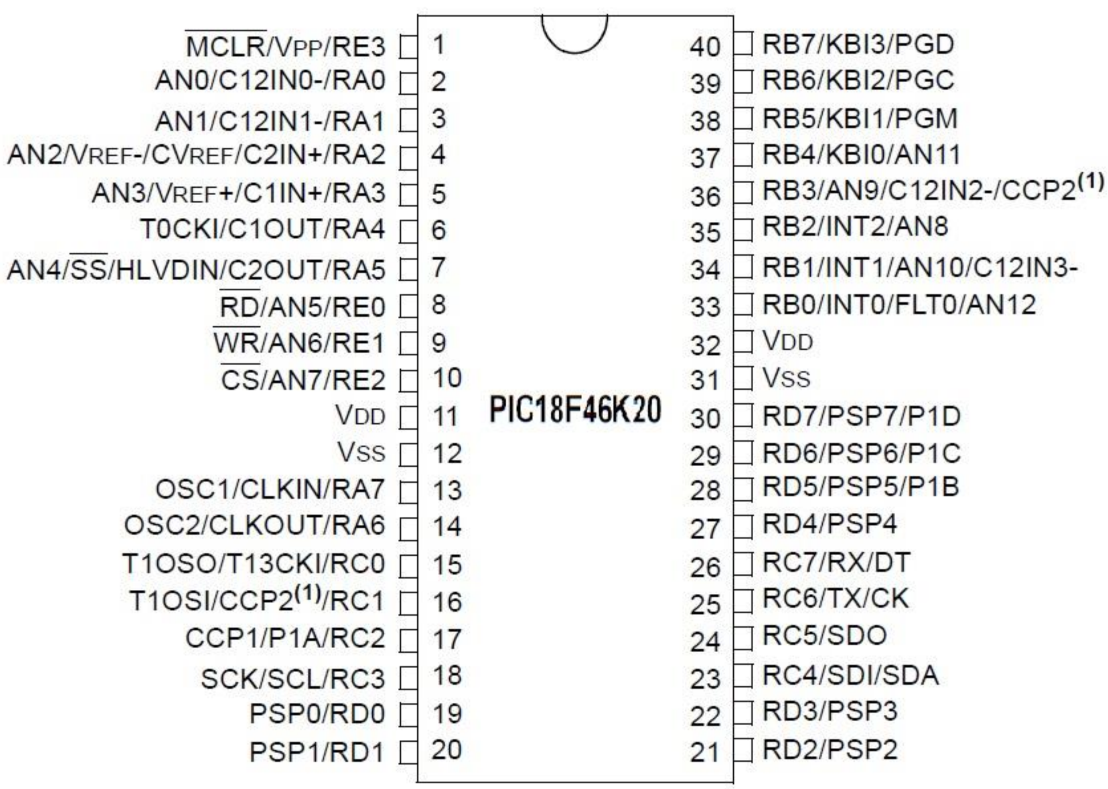

Figure (3.2) pic18F46K20, Top view

3.2.2 Light dependent resistor LDR

A light dependent resistor also known as a LDR is shown in figure (3.3), photo-resistor, photoconductor or photocell, is a resistor whose resistance increases or decreases depending on the amount of light intensity. LDRs (Light Dependent Resistors) are a very useful tool in a light/dark circuits. A LDR can have a variety of resistance and functions. For example it can be used to turn on a light when the LDR is in darkness or to turn off a light when the LDR is in light. It can also work the other way around so when the LDR is in light it turns on the circuit and when it's in darkness the resistance increase and disrupts the circuit.

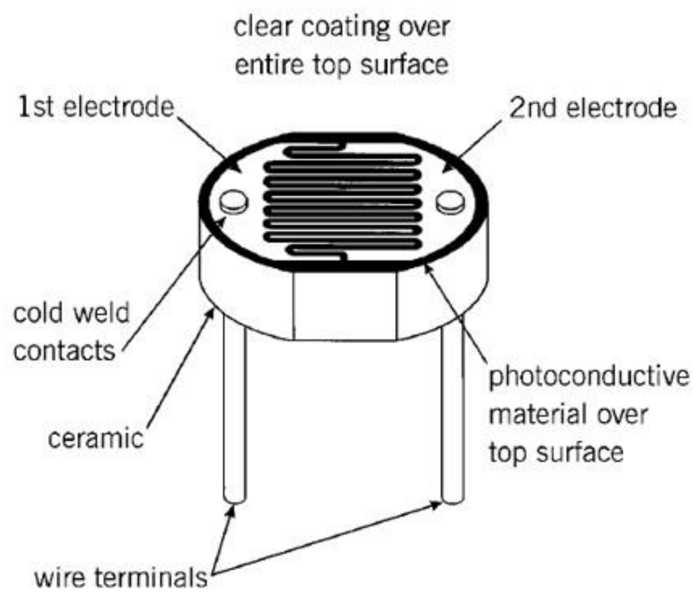

Figure (3.3) LDR Construction

3.2.3 Temperature sensor LM35

The LM35 as shown in figure (3.4) are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling.

The LM35 does not require any external calibration or trimming to provide typical accuracies of ±1⁄4°C at room temperature and ±3⁄4°C over a full −55 to +150°C temperature range. Low cost is assured by trimming and calibration at the wafer level. The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies. As it draws only 60 μA from its supply, it has very low self-heating, less than 0.1°C in still air. The LM35 is rated to operate over a −55° to +150°C temperature range, while the LM35C is rated for a −40° to +110°C range (−10° with improved accuracy). The LM35 series is available packaged in hermetic TO-46 transistor packages, while the LM35C, LM35CA, and LM35D are also available in the plastic TO-92 transistor package. The LM35D is also available in an 8-lead surface mount small outline package and a plastic TO-220 package.

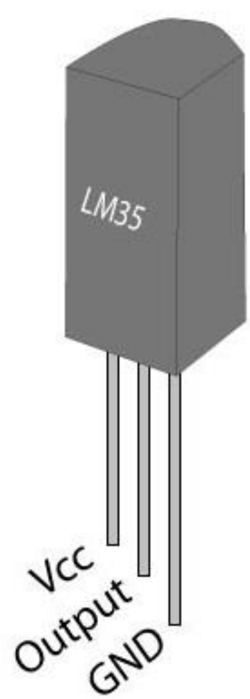

Figure (3.4) Temperature Sensor LM35

3.2.4 LCD display

A liquid-crystal display (LCD) shown in figure (3.5) is a flat panel display, electronic visual display, or video display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary images (as in a general-purpose computer display) or fixed images with low information content which can be displayed or hidden, such as preset words, digits, and 7-segment displays as in a digital clock. They use the same basic technology, They come in many sizes 8x1 , 8x2 , 10x2 , 16x1 , 16x2 , 16x4 , 20x2 , 20x4 ,24x2 , 30x2 , 32x2 , 40x2 etc. Many multinational companies like Philips Hitachi Panasonic make their own special kind of LCD's to be used in their products. All the LCD's performs the same functions (display characters numbers special characters ASCII characters etc.). Their programming is also same and they all have same 14 pins (0-13) or 16 pins (0 to 15) as shown in figure (3.6).

All LCDs have:

- 8 Data pins.
- VCC (Apply 5v here).
- GND (Ground this pin).
- RS (Register select).
- RW (read - write).
- EN (Enable).
- V0 (Set LCD contrast).

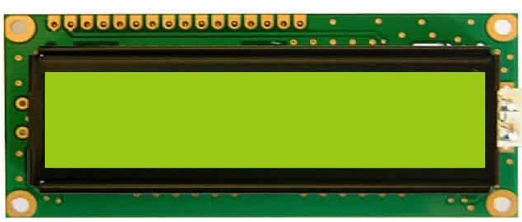

Figure (3.5) LCD LM016L Display

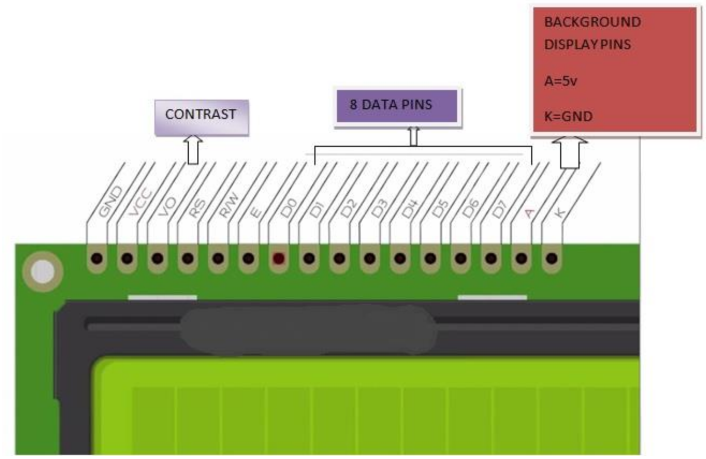

Figure (3.6) LCD Pins Description

3.2.5 Keypad 4x4

A 16-button keypad shown in figure (3.7) provides a useful human interface component for the most applications in daily life. Convenient adhesive backing provides a simple way to mount the keypad in a variety of applications.

Figure (3.7) Keypad 4x4 with Connector

3.2.6 ULN 2803A

The ULN2803A shown in figure (3.8) is a high-voltage, high-current Darlington transistor array. The device consists of eight NPN Darlington pairs that feature high-voltage outputs with common-cathode clamp diodes for switching inductive loads. The collector-current rating of each Darlington pair is 500 mA. The Darlington pairs may be connected in parallel for higher current capability. Applications include relay drivers, hammer drivers, lamp drivers, display drivers (LED and gas discharge), line drivers, and logic buffers. The ULN2803A has a 2.7-kΩ series base resistor for each Darlington pair for operation directly with TTL or 5-V CMOS devices.

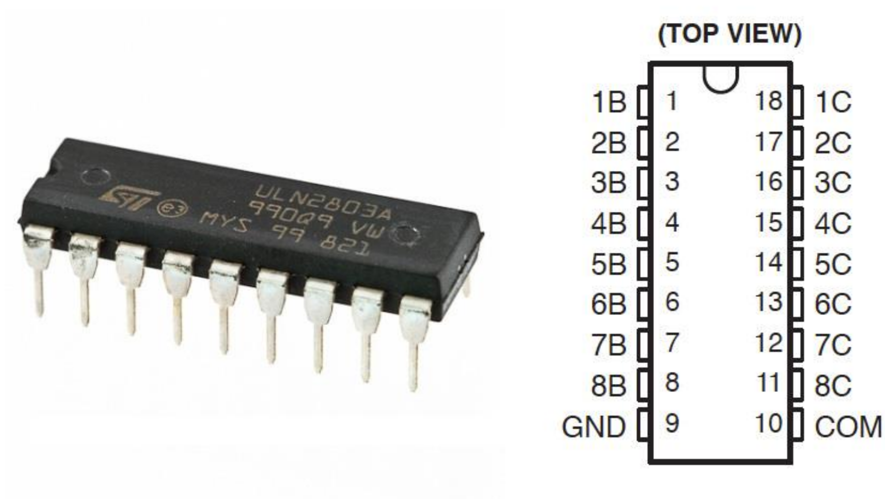

Figure (3.8) ULN2803A

3.2.7 Resistors

Resistors (R) are the most fundamental and commonly used of all the electronic components, to the point where they are almost taken for granted. There are many different Types of Resistor available for the electronics constructor to choose from, from very small surface mount chip resistors up to large wire wound power resistors.

3.2.7.1 Film Type Resistors

The generic term Film Resistor as shown in figure (3.9) consists of *Metal Film, Carbon Film* and *Metal Oxide Film* resistor types, which are generally made by depositing pure metals, such as nickel, or an oxide film, such as tin-oxide, onto an insulating ceramic rod or substrate.

Figure (3.9) A Typical Resistor

3.2.7.2 Potentiometer

Potentiometers (also called *pots*) shown in figure (3.10) are variable resistors, used as voltage or current regulators in electronic circuits. By means of construction, they can be divided into 2 groups: coated and wire-wound. With coated potentiometers, (figure 1.6a), insulator body is coated with a resistive material. There is a conductive slider moving across the resistive layer, increasing the resistance between slider and one end of pot, while decreasing the resistance between slider and the other end of pot.

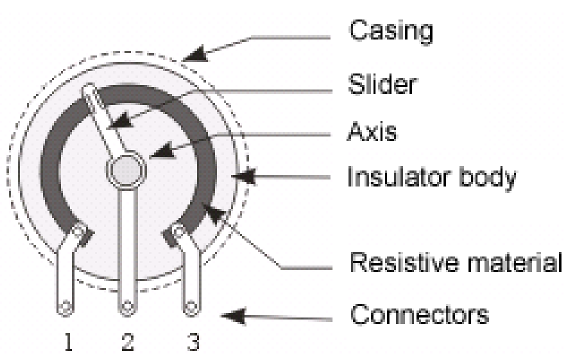

Figure (3.10) Coated potentiometer

CHAPTER FOUR

SYSTEM SIMULATION AND IMPLEMENTATION

4.1 System Software Considerations

In this project we decided to choose Mikroc language to program the microcontroller and mikroc software from microchip as a compiler, and Proteus as a simulator for the control circuit.

4.1.1 Code

The microcontroller code was written in mikroc language and compiled with the mikroc PRO application.

4.1.1.1 Mikro C

The MikroC PRO is a powerful, feature-rich development tool for PIC microcontrollers. It is designed to provide the programmer with the easiest possible solution to developing applications for embedded systems, without compromising performance or control, MikroC PRO for PIC is a complete IDE for coding, simulating, programming, and debugging your PICs. Writing your code in C brings advantages over writing it in assembler. This code will be converted from binary to hex to be burned inside the microcontroller chip. The code attached in the appendix.

4.1.1.2 Code structure

The first thing in the programming code is to identify the devices connected to the microcontroller and specify which pins connected to every device. Then each pin is identified as an input or output pin and each variable are identified. After that the microcontroller receives the reference values from the keypad and displays them on the LCD. Then it receives the environmental factors from the sensors and compares them and takes action to modify the environment as desired whether it's cooling or heating or increasing light intensity. There is a counter designed to calculate the execution time and turn the irrigation on and off according to the inserted time.

4.1.2 System simulation

The simulation methodology that we chose is Proteus software simulation. The proteus schematic capture module lies at the heart of the system. It combines the design environment with the ability to define most aspects of the drawing appearance. Proteus provides a full real life simulation. From the tools components library we added pic 18f46k20 to schematic capture (workspace) as shown in figure (4.1).

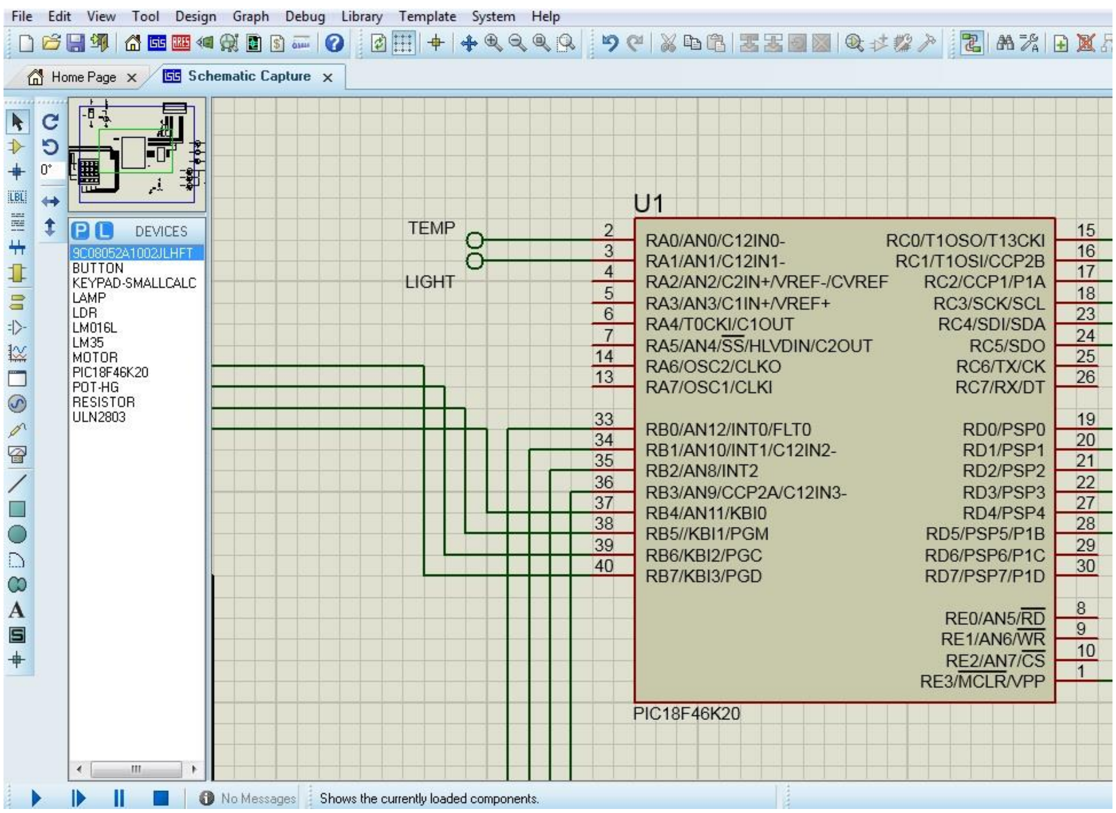

Figure (4.1) Implementing pic18f46k20 in workspace

Then Keypad is added in circuit and connected to port B at the pic by considering the keypad array and resistors location as shown figure (4.2).

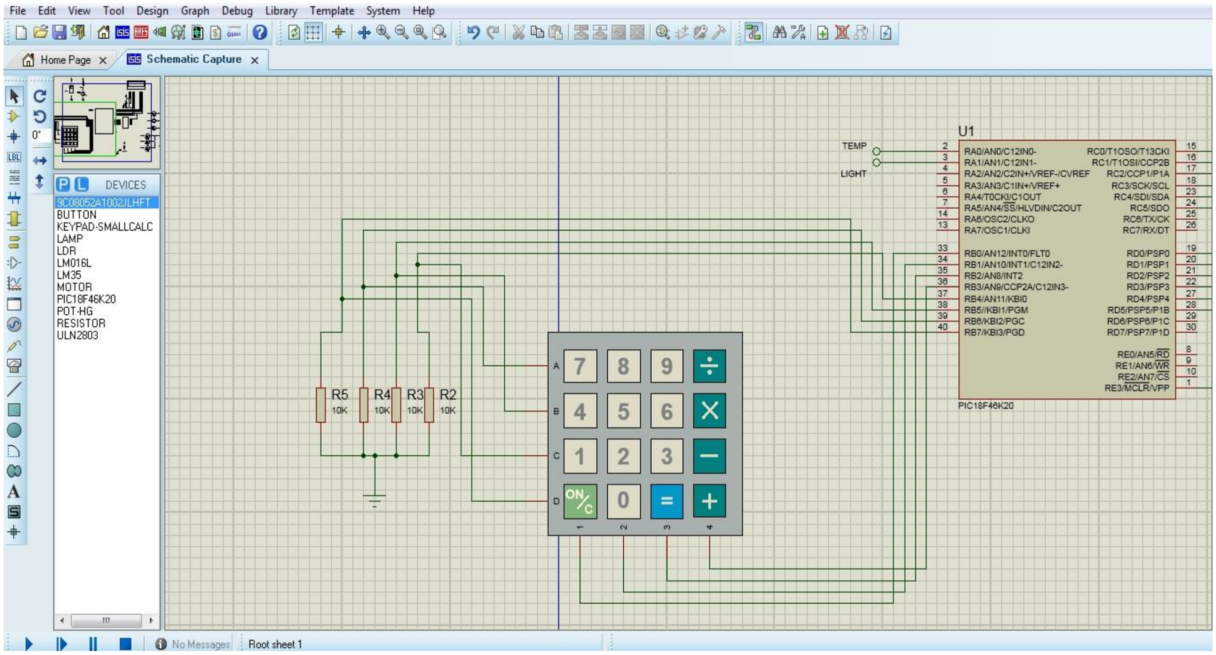

Figure (4.2) Keypad connections

LM016L LCD display attached with port C on the pic considering the potentiometer connection for word light intensity which is obvious in real implementation as shown in figure (4.3).

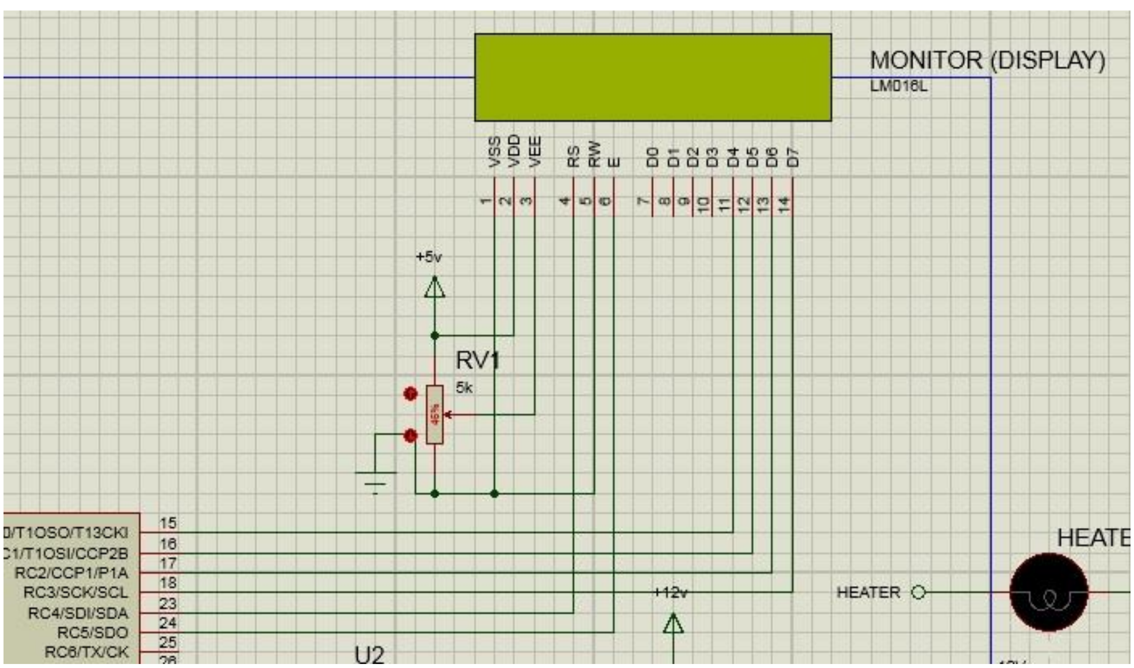

Figure (4.3) LCD display connection

Then temperature sensor LM35 and light sensor LDR are added and connected to PIC with analog pins A0 and A1 respectively as shown in figure (4.4).

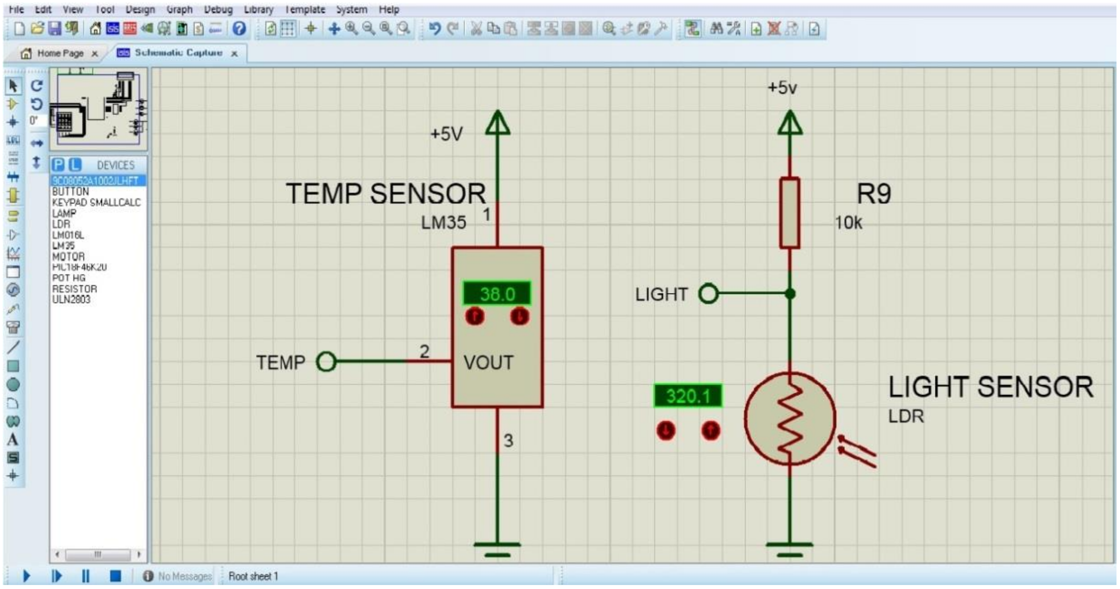

Figure (4.4) Sensors connection

The output devices are connected to port D in the PIC through the ULN2803 chip giving a specific functionality which is more like switches as shown in figure (4.5).

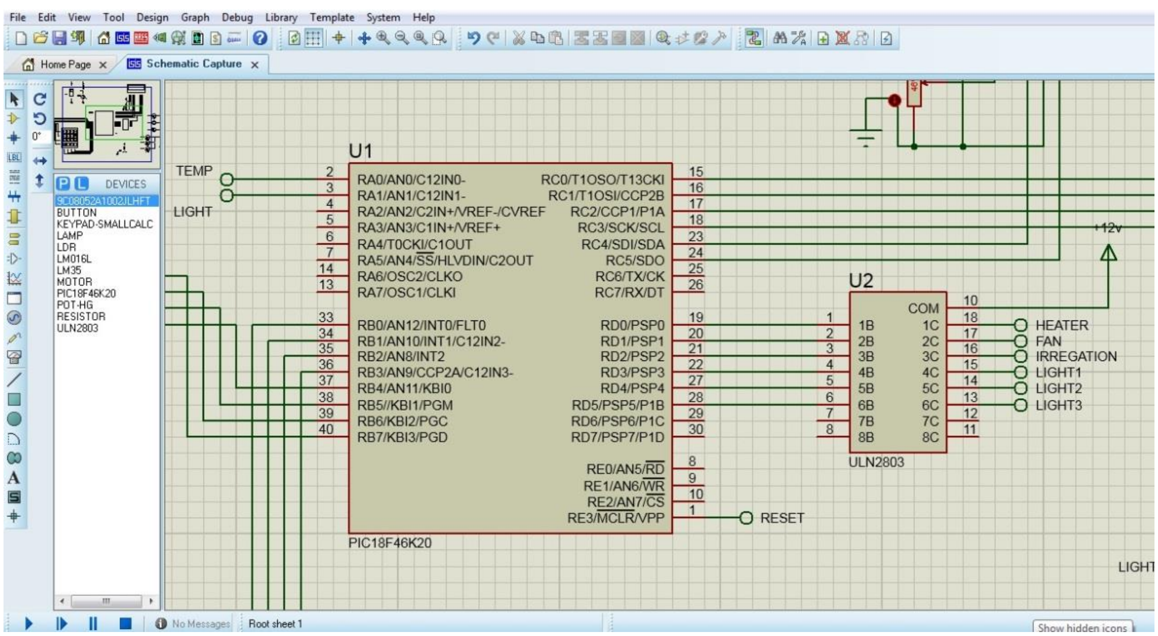

Figure (4.5) ULN2803A connection

The completed simulation circuit is shown in figure (4.6) below.

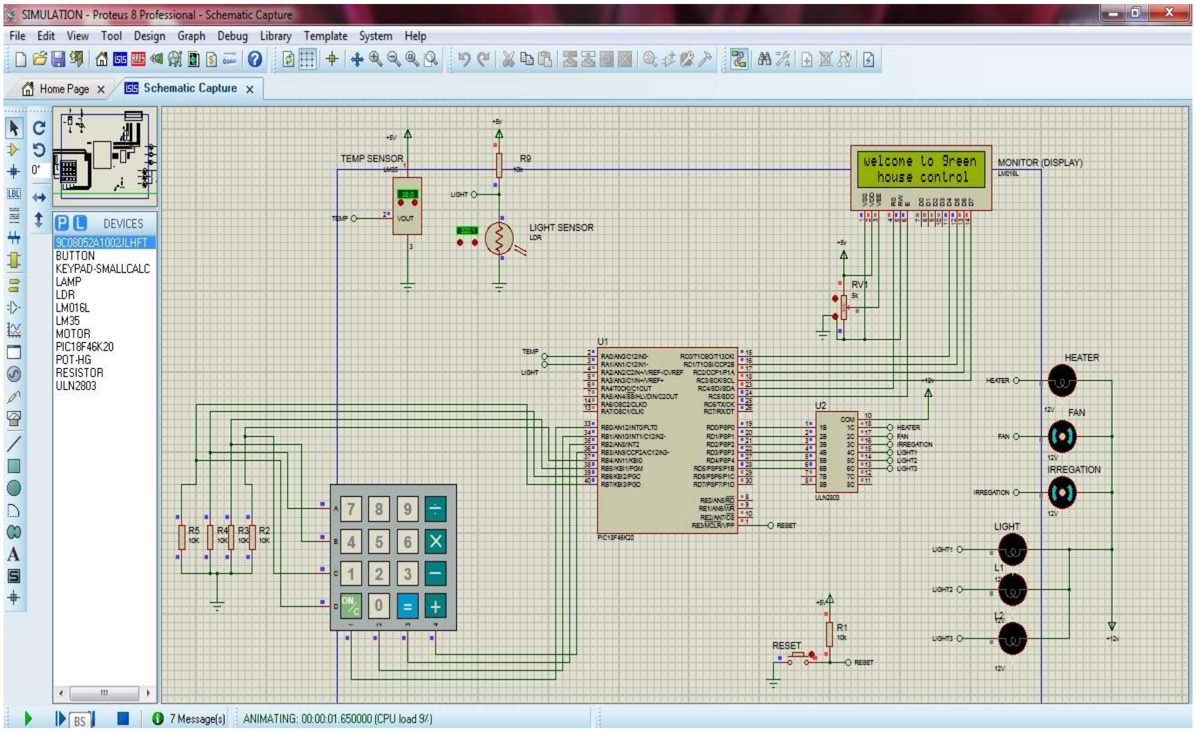

Figure (4.6) Full view of Simulation

4.2 System Implementation and Testing

After introducing all the components at the previous chapter, at this chapter we progress all the implementation of the electronic circuit of the project. Figure (4.7) shows that components are placed at the board starting with the Microcontroller chip, which is the brain of the whole project, and the program is on it, It just needs an input and output device to implement the program within. The LCD is connected to show the progressed and the reference data. Each sensor has a reference data input from the user to compare it with the measured data from the same sensor, in order to decide the progress that the microcontroller should do.

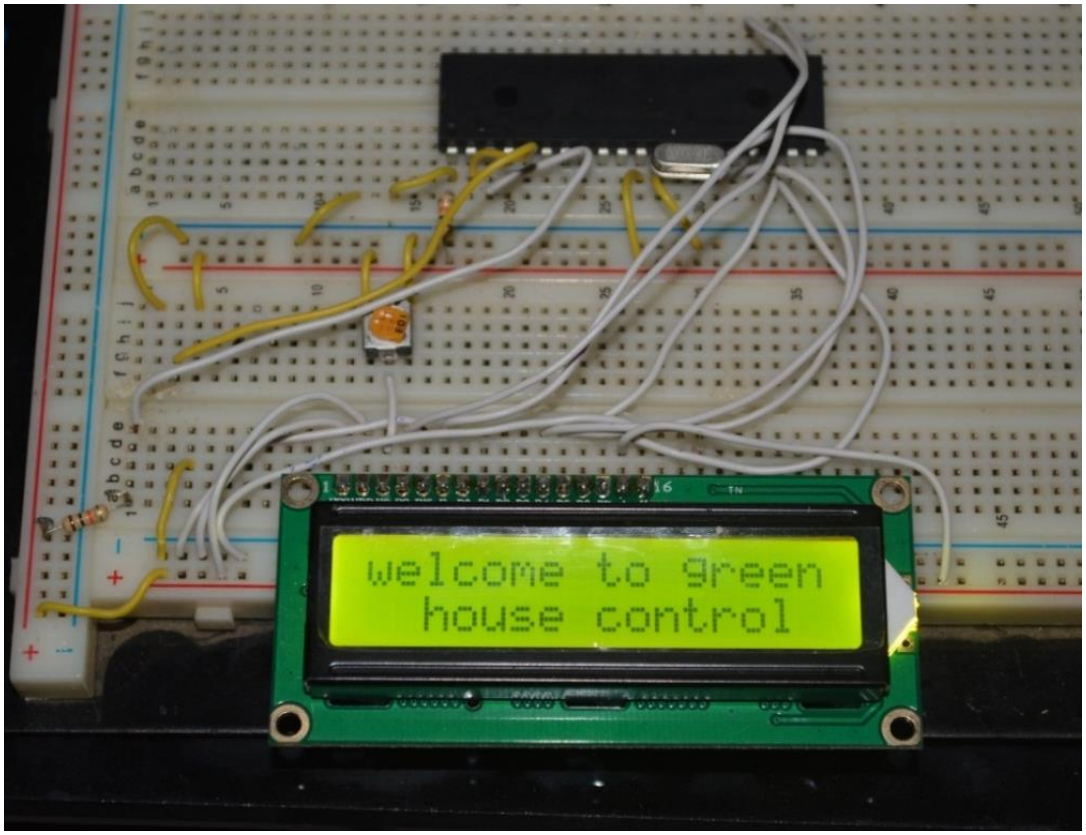

Figure (4.7) Connecting Microcontroller chip and LCD

After that the input sensors and the keypad are placed on the board starting with the temperature sensor (LM35), this sensor input a certain voltage to the microcontroller as shown in figure (4.9) in its analogue input pin. The input voltage control two output, one is the cooling fan in case the weather temperature is higher that the required temperature inside the greenhouse, and the other output is the heater when the weather temperature is lower than the required. The required temperature will be inserted by the user at the beginning of the program project. The relationship between the measured temperature from the sensor (LM35) and the measured voltage from the voltmeter according to that temperature is a positive relationship as shown in table (4.1), the voltage increase when the temperature increases.

Here is a table of the temperatures from the sensor and the measured voltage:

Temperature (C^{o})	**Voltage (mV)**
10	252
15	305
20	358
25	411
30	464
35	517
40	570

Table (4.1) measured voltage according to the temperature sensor input

Also the relationship between the sensor and the measured voltage can be described by a line chart as shown in figure (4.8), and obviously it is a linear relationship.

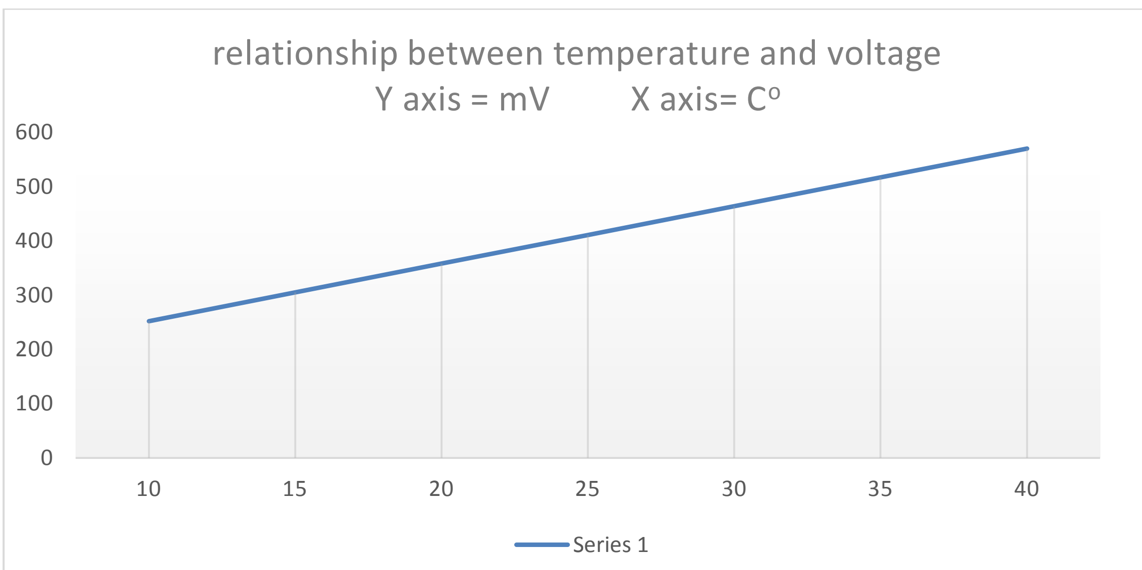

Figure (4.8) line chart of the relationship between the voltage and the temperature

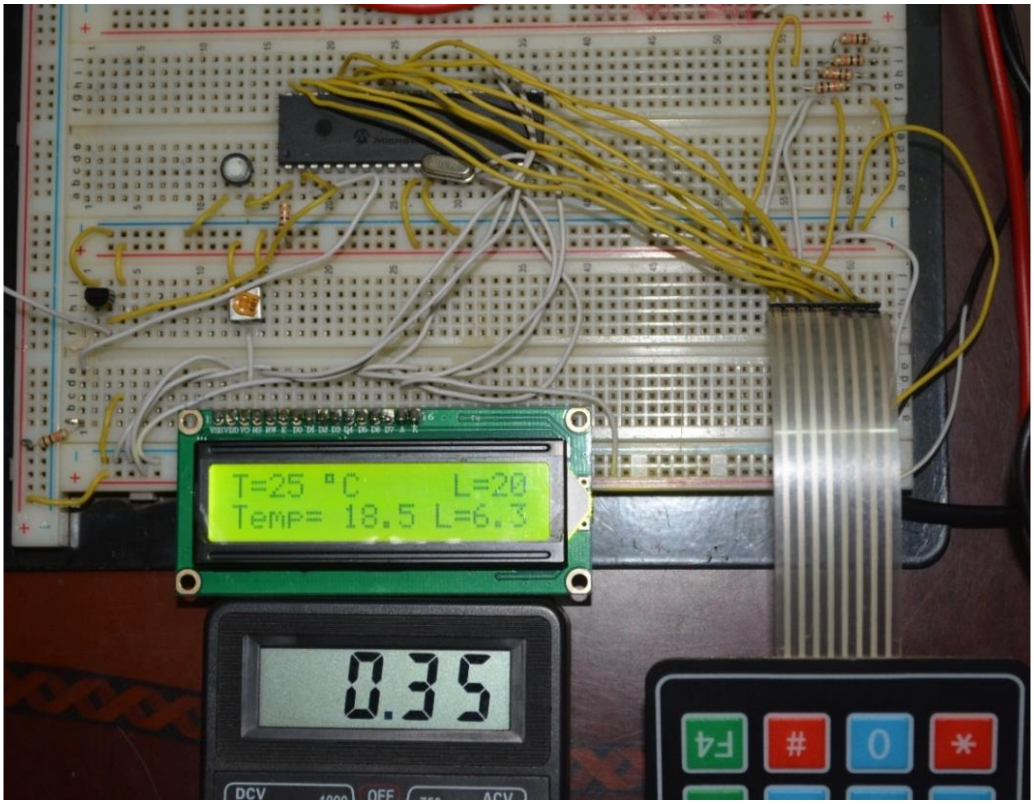

Figure (4.9) measuring temperature sensor’s voltage (mV)

Secondly, the light sensor (LDR) is connected and with it a (10k) resistor to make a voltage share between it and the LDR sensor, the voltage (5v) will be shared between them according to the change of the LDR resistor, The LDR resistor change in the range of (0.1k to 200k). This sensor inputs voltage according to the measured light from the sensor. It controls the lighting system of the greenhouse, it open three levels of light, high light, medium light and low light. Those levels will be decided according to the difference between the required light and the measured one. Also the required light will be inserted in the beginning of the program. The input voltage to the microcontroller has an inverse relationship with the measured light as shown in table (4.2), when the light increases the input voltage decrease and vice versa.

Here is a table of the measured voltages according to the light from the sensor:

Light (%)	Voltage (v)
2.5	4.45
5	4.21
10	1.2
20	0.73
30	0.56
40	0.45
50	0.39
60	0.32
70	0.30
80	0.29

Table (4.2): measured voltage according to the light intensity

According the measured voltages which taken by using voltmeter as shown in figure (4.10), it can be noticed that the relationship is almost an exponential relationship, because when the measured light from the sensor reaches a certain limit the input voltage become almost the same. For the humidity and the irrigation system it will be controlled by a timing system, irrigation and mist pump will be opened for a certain time, and it will be closed for another certain time, those times will be inserted by the user as (Irr on and Irr off) at the beginning of the program. The outputs pins of the microcontroller are connected to the input pins of a chip called ULN2803A. This chip is a set of high voltage, high current transistors. At the end the overall circuit contains two analogue input sensor (temperature sensor (LM35) and light sensor (LDR)) and an internal programmed timer, to control four outputs (heater, cooling fans, lighting system and mist and irrigation system), each output is connected to voltage source (12v) and the ground wire is connected to the output pin of ULN2803A to complete the circuit and switch on the certain output according to its Input.

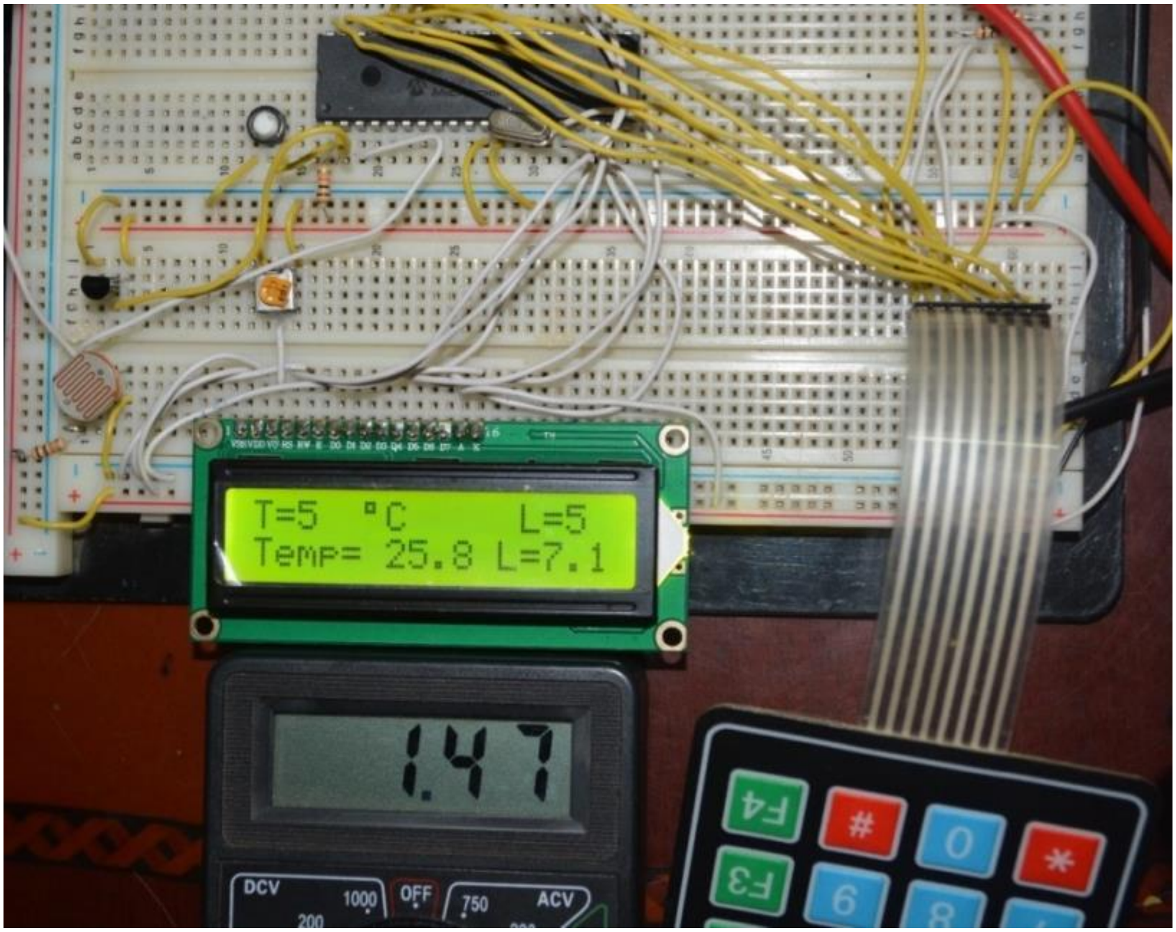

Figure (4.10) measuring voltage from light sensor

The completed circuit is shown in figure (4.11). Those are the factors that we control electronically, and there is the ventilation factor which it is controlled structurally by making some ventilation roof vents.

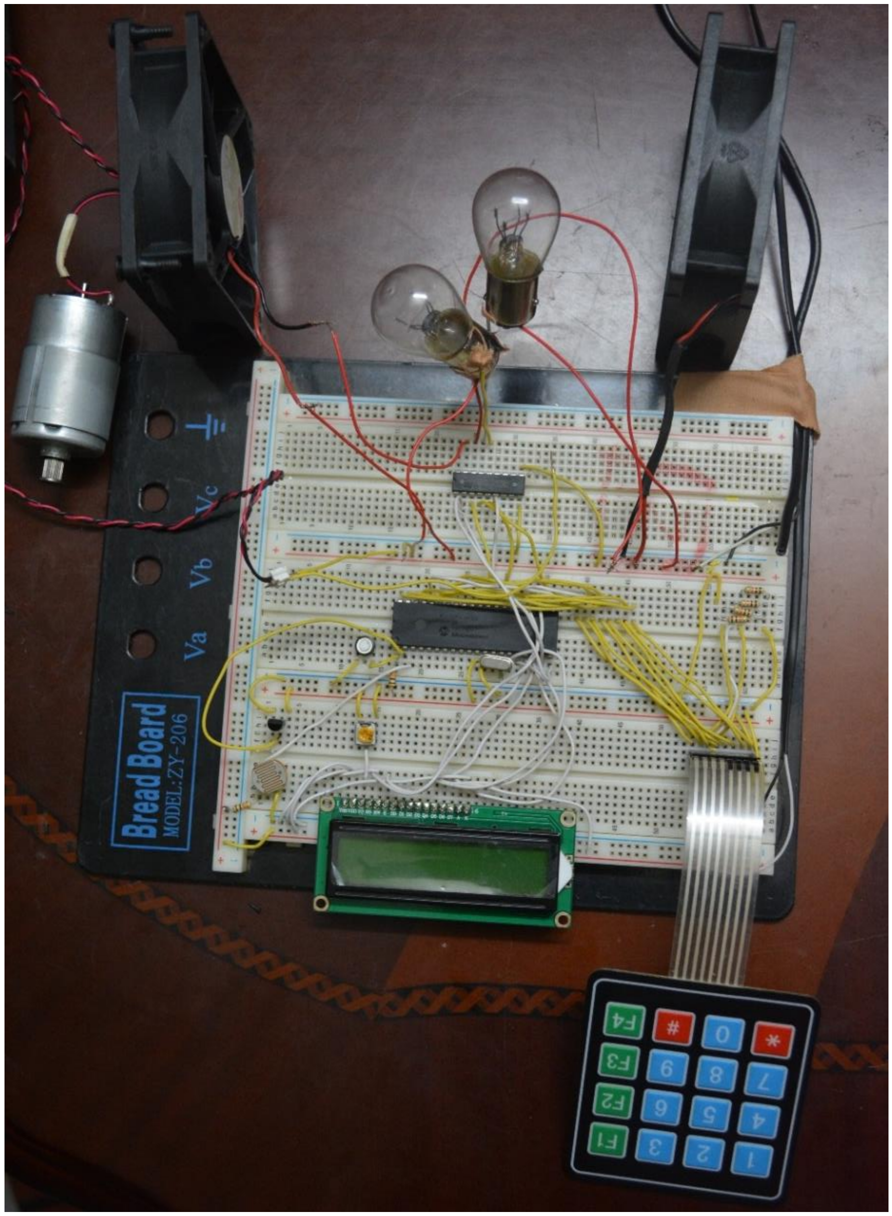

Figure (4.11) circuit of the greenhouse

CHAPTER FIVE

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

In this project the control circuit that controlling light, temperature and irrigation of greenhouse is designed, simulated, implemented and tested successfully. The temperature system and the light system are capable to maintain the required temperature and light intensity after comparing it with the measured values from the sensors. The irrigation system is capable to provide plants with water for a certain time and stop doing that for another certain time.

5.2 Recommendations

To improve the performance of the project it recommended that:

- The lighting system become full analogue or works on a big number of lighting levels to provide the plants with the exact amount of light it needs.
- The irrigation works by using humidity sensor.
- Use of intelligent control algorithm for the microcontroller.

Appendix

- **Program code:**

```
// Keypad module connections
char  keypadPort at PORTB;
// End Keypad module connections
// LCD module connections
sbit LCD_RS at LATC4_bit;
sbit LCD_EN at LATC5_bit;
sbit LCD_D4 at LATC0_bit;
sbit LCD_D5 at LATC1_bit;
sbit LCD_D6 at LATC2_bit;
sbit LCD_D7 at LATC3_bit;

sbit LCD_RS_Direction at TRISC4_bit;
sbit LCD_EN_Direction at TRISC5_bit;
sbit LCD_D4_Direction at TRISC0_bit;
sbit LCD_D5_Direction at TRISC1_bit;
sbit LCD_D6_Direction at TRISC2_bit;
sbit LCD_D7_Direction at TRISC3_bit;
// End LCD module connections
#define LIGHT1 PORTD.RD3
#define LIGHT2 PORTD.RD4
#define LIGHT3 PORTD.RD5
#define IRR PORTD.RD2
#define HEATER PORTD.RD0
#define FAN PORTD.RD1
#define ENTER 15
```

```
#define CLEAR 13
#define ON 1
#define OFF 0
void main() {
unsigned short kp,kl,Txt[14],Tnt[14],Tet[14];
unsigned short Temp_Ref, Light_Ref ;      //  Reference Temperature
unsigned char inTemp,inLight;
unsigned int temp,irr_on,irr_off,x=1,y=0;
float mV, ActualTemp,mv1,Actuallight,light,z,r;
Keypad_Init();                          // Initialize Keypad
ADCON1=7;                               // Configure PORTD as digital I/O
ANSEL  = 0;                         // Configure AN pins as digital I/O
ANSELH = 0;
TRISA0_bit = 1;                         //Configure AN0 (RA0) as input
TRISC = 0;                              //PORTC are outputs (LCD)
TRISD0_bit=0;                           //RD0 is output (Heater)
TRISD1_bit=0;                           //RD1 is output (Fan)
TRISD2_bit=0;
TRISD3_bit=0;
TRISD4_bit=0;
TRISD5_bit=0;
Lcd_Init();                             // Initialize LCD
Lcd_Cmd(_LCD_CLEAR);                    // Clear display
Lcd_Cmd(_LCD_CURSOR_OFF);               // Cursor off
Lcd_Out(1, 1, "welcome to green");
Lcd_Out(2, 3, "house control");
delay_ms(2000);                         //3s delay
```

```
HEATER = OFF;
FAN = OFF;
IRR=OFF;
LIGHT1=OFF;
LIGHT2=OFF;
LIGHT3=OFF;
//ON startup, read the Referance Temperature from the Keypad
    START:
    Lcd_Cmd(_LCD_CLEAR);                    // Clear display
    Lcd_Out(1, 1, "Enter Temp Ref");
    Temp_Ref=0;
     Lcd_Out(2, 1, "Temp Ref: ");
     while(1)
     {
      do
      kp = Keypad_Key_Click();             // Store key code in kp variable
      while (!kp);
      if ( kp == ENTER )break;
      if (kp > 3 && kp < 8) kp = kp-1;
      if (kp > 8 && kp < 12) kp = kp-2;
      if (kp ==14)kp = 0;
      if ( kp == CLEAR )goto START;
      Lcd_Chr_Cp(kp + '0');
      Temp_Ref =(10*Temp_Ref) + kp;
    }
   Lcd_Cmd(_LCD_CLEAR);                    // Clear display
   Lcd_Out(1, 1, "Temp Ref: ");
```

```
intToStr( Temp_Ref,Txt);        //Convert to String
inTemp=Ltrim(Txt);
 Lcd_Out_CP(inTemp);                 //Display Ref Temp
//Wait until # is pressed
kp =0;
 Lcd_Cmd(_LCD_CLEAR);                    // Clear display
 Lcd_Out(1, 1, "Enter LIGHT Ref");
 Light_Ref=0;
  Lcd_Out(2, 1, "LIGHT Ref: ");
  while(1)
  {
   do
   kl = Keypad_Key_Click();             // Store key code in kp variable
   while (!kl);
   if ( kl == ENTER )break;
   if (kl > 3 && kl < 8) kl = kl-1;
   if (kl > 8 && kl < 12) kl = kl-2;
   if (kl ==14)kl = 0;
   if ( kl == CLEAR )goto START;
   Lcd_Chr_Cp(kl + '0');
   Light_Ref =(10*Light_Ref) + kl;
 }
  //entering the irregation on time
 Lcd_Cmd(_LCD_CLEAR);                    // Clear display
 Lcd_Out(1, 1, "Enter irr on");
 irr_on=0;
 Lcd_Out(2, 1, "irr on: ");
```

```
while(1)
 {
  do
  kp = Keypad_Key_Click();            // Store key code in kp variable
  while (!kp);
  if ( kp == ENTER )break;
  if (kp > 3 && kp < 8) kp = kp-1;
  if (kp > 8 && kp < 12) kp = kp-2;
  if (kp ==14)kp = 0;
  if ( kp == CLEAR )goto START;
  Lcd_Chr_Cp(kp + '0');
  irr_on =(10*irr_on)+kp;
  }
 //entering irregation off time
Lcd_Cmd(_LCD_CLEAR);                   // Clear display
Lcd_Out(1, 1, "Enter irr off");
irr_off=0;
Lcd_Out(2, 1, "irr off: ");
while(1)
 {
  do
  kp = Keypad_Key_Click();            // Store key code in kp variable
  while (!kp);
  if ( kp == ENTER )break;
  if (kp > 3 && kp < 8) kp = kp-1;
  if (kp > 8 && kp < 12) kp = kp-2;
  if (kp ==14)kp = 0;
```

```
        if ( kp == CLEAR )goto START;
        Lcd_Chr_Cp(kp + '0');
        irr_off =(10*irr_off)+kp;
        }
       Lcd_Cmd(_LCD_CLEAR);            // Clear display
       Lcd_Out(1, 1, "Light Ref= ");
       intToStr( Light_Ref,Tnt);       //Convert to String
       inLight=Ltrim(Tnt);
       Lcd_Out_CP(inLight);                //Display Ref Light
   Lcd_Cmd(_LCD_CLEAR);            // Clear display
   Lcd_Out(1, 1, "T=");
   Lcd_Chr(1,6,223);                // Different LCD displays have different
   Lcd_Chr(1,7,'C');                // Display "C" for Celsius
   Lcd_Out(1, 13, "L=");
   Lcd_Out(1, 15, inLight);

//Program loop
 while(1) {
    //Display Referance Temperature and Actual Temperature
    temp = ADC_Read(0);             //Read temperature from AN0
    mV = temp * 5000.0/1024.0;       //Convert to mV
    ActualTemp = mV/10.0 ;           // Convert to degrees Celcius
    intToStr( Temp_Ref,Txt);        //Convert to String
    inTemp=Ltrim(Txt);
    light = ADC_Read(1);             //Read light from AN1
   Actuallight=34410/(light)-33;
    r=Actuallight/10;
```

```
floattostr(r,Tet);
lcd_out(2,12,"L=");
lcd_out(2,14,Tet);

//Lcd_Out(1, 1, "Temp Ref: ");
Lcd_Out(1, 3, inTemp);        //Display Ref Temp
Lcd_Out(2, 1, "Temp= ");
FloatToStr(ActualTemp,Txt);        //Convert to string
Txt[4] = 0;
Lcd_Out(2,7,Txt);

 //Compare ref temp with actual emp
 if (Temp_Ref >  ActualTemp)  //If Temp Ref is less than actual Temp, Switch ON Heater
 {
 HEATER = ON,
 FAN = OFF;
 }
  if (Temp_Ref <  ActualTemp)  //If Temp Ref is greater than actual Temp, Switch ON Fan
 {
 HEATER = OFF,
 FAN = ON;
 }
 if (Temp_Ref ==  ActualTemp)  //If Temp Ref is equal to actual Temp, Switch OFF Fan and Heater
 {
 HEATER = OFF,
 FAN = OFF;
```

```
}
Delay_ms(1000);        //Wait 10 s
z=Light_Ref-r;
if(z>0)
{
if(z<20)
{
LIGHT1=ON;
LIGHT2=OFF;
LIGHT3=OFF;
}
if(z>20&&z<50)
{
LIGHT2=ON;
LIGHT1=OFF;
LIGHT3=OFF;
}
if(z>50)
{
LIGHT3=ON;
LIGHT1=OFF;
LIGHT2=OFF;
}
}
if(x>0)
{
y=0;
```

```
x=x+1;
if(x==irr_off+1)
{
x=0;
y=1;
IRR=ON;
}
}
if(y>0)
{
x=0;
y=y+1;
if(y==irr_on+1)
{
y=0;
x=1;
IRR=OFF;
}
}
 }
}
```

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