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AUTOMATION OF GREENHOUSES
التحكم الآلي في نظام 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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بسم الله الرحمن الرحيم

﴿ قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا

إِنَّكَ أَنتَ الْعَلِيمُ الْحَكِيمُ ﴾

سورة البقرة، الآية ﴿32﴾

DEDICATION

To our beloved mothers and fathers who supported us,

To our brothers and sisters,

To our friends and study partners

To everyone who make a positive effect on us.

ACKNOWLEDGEMENT

First of all, we praise and thank our God, and we are kindly grateful to our supervisor ***UST. Gaffar Babiker*** 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

Greenhouse is a kind of place which can change plant growth environment, create the best conditions for plant growth, and avoid influence on plant growth due to outside changing seasons and severe weather. In green houses there are a lot of parameters such as temperature, humidity, etc. and it is so hard to monitor all of these parameters by human .And any significant changes in one climate parameter could have an adverse effect on another climate parameter as well as the development process of the plants. Therefore, continuous monitoring and control of these climate factors will allow for maximum crop yield, improve quality, regulate the growth period and improve the economic efficiency.

The main objectives 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), humidity sensor (YL-38) and light sensor (LDR). Sensors input a certain voltage according to the measured factor, after that the Arduino control unit compares between the measured value and the reference one and switches on the appropriate actuator.

المستخلص

البيوت المحمية هي عبارة عن مكان يتم فيه تغيير البيئة الحيوية للنبات بتوفير البيئة المثلى لنمو النبات ولتفادي تغيرات المناخ الخارجي. في البيت المحمي يوجد الكثير من المؤشرات البيئية ومن الصعب على الانسان مراقبة كل هذه المؤشرات. ان التغيير في احد المؤشرات البيئية قد يؤثر في مؤشر بيئي اخر وبالتالي يؤثر في عملية نمو النبات. لذلك لابد من التحكم والمراقبة المستمرة لهذه المؤشرات لتحقيق انتاج أكبر، وتحسين نوعية النبات وتحسين الكفاءة الاقتصادية.

الأهداف 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 وبناءً 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 الرطوبة (YL-38) وحساس الإضاءة (LDR). تقوم الحساسات بإدخال جهد معين مكافئ للعامل البيئي المقاس، بعد ذلك تقوم وحدة تحكم أردوينو بمعالجة ومقارنة القيمة المقاسة بالقيمة المرجعية وتشغيل الخرج المناسب.

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CHAPTER ONE

Introduction

1.1 Overview

Agriculture is important to human beings because it forms the basis for food security. It helps human beings grow the most ideal food crops and raise the right animals with accordance to environmental factors. Being able to grow the right crops and keep the livestock ensures that human beings are able to eat healthy diets and form strong immune systems fight against diseases and infections.

World widely the traditional farming experienced many obstacles which reduced the quality and limited the crops productivity such as changing climate, insects, quantity of water and the inability of growing very important types of fruits and vegetables all around the year. The higher desire and the increasing human demand led to a high progress in agriculture techniques. One of these techniques is the greenhouses, it is an efficient method of agriculture which offered solutions and revealed advanced abilities.

A greenhouse is an exceptionally outlined homestead structure building to give a more controllable environment to better harvest generation, crop security, product seeding and transplanting. Also, the accessible space of area for developing yields has been altogether diminishing, following to more space of area is vigorously utilized for housing and commercial ventures as a part of this present day period. In most tropical nations, the utilization of greenhouse has been developed for cost effective farming i.e. organic products, new blossoms and vegetables generation.

The effectiveness of plant creation inside greenhouse depends fundamentally on the conformity of ideal atmosphere development conditions to attain to high return at low cost, great quality and low natural burden. To attain to these objectives a few parameters, for example, light, temperature and humidity, soil moisture must be controlled ideally given certain criteria through warming, lighting, ventilation and water creation. Persistent checking and controlling of these ecological variables gives significant data relating to the individual impacts of the different elements towards acquiring most extreme harvest creation. Greenhouse situations present remarkable difficulties to great control. Temperature changes happen quickly and fluctuate broadly relying upon sun powered radiation levels, outside temperatures and moistness levels in the greenhouse. Poor light intensity and high stickiness frequently bring about poor natural product set and quality. More exact control can decrease heating fuel and electrical expenses, expand the efficiency of laborers by empowering them to go to more important assignments, empowering directors and producers to settle on better administration choices and invest more energy dealing with the procedure.

1.2 Research Problems

Sudan is an agrarian economy. Agribusiness is the single biggest delivering area of economy since it comprises around 30% of the nation's GDP (Gross domestic product) and utilizing so many of the labor force.

Till now our agricultural systems are followed by conventional method whereas developed countries use automated system to control their agrarian economy to grow more products than before using same lands and weathers, though Moderate weather condition always helps us to grow different plants at different seasons but it does not helping us to escalate crops production without impeding crops from natural destruction. In addition, dry spells are connected with the late arrival or an early withdrawal of monsoon rains furthermore because of discontinuous droughts agreeing with cultivated phases of different harvests in the north and central areas of Sudan. Another downside of climate change is not able to produce a wide range of items like fruits and crops.

And the 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

In the greenhouse the essential elements that influence the growth and the harvest estimate of the corps, there are light, air, water, temperature, and soil. Therefore the main objective of the research is to control temperature, light, air and water for greenhouse requirement due to the crops climate.

1.4 Research Methodology

Simulation has covered by using Proteus software programming to ensure controlling the greenhouse parameters.

A model of greenhouse has been implemented by using an Arduino and sensors.

1.5 Research Outlines

The research covers an abstract and five Chapters. Chapter One deals with an introduction that provide an overview of entire research. Chapter Two concern with an explanation the greenhouses systems by an overview that covered the greenhouses history, classification, internal structure and work principles. Chapter Three consists of an overview of Arduino control unit, Arduino classification and software. Chapter Four presents an overview of the main components of the project, system operation and system code. Chapter Five gives a brief conclusion, summary to the project and recommendation for further research.

CHAPTER TWO

The System of Greenhouses

2.1 Introduction

Greenhouse technology has come a long way since the time of the ancient Romans, but the concept -an enclosed structure providing a special environment for plants- is essentially the same today. Gardeners use these structures to protect plants from heat or cold, to extend a plant's growing season or to foster non-native plants.

The Roman emperor's cucumber experiment was referenced some half a millennium later by Thomas Hill, author of the first popular gardening book in English. He gives his readers practical advice on protecting spring seedlings in a cold frame -type structure until the weather is reliably warm:

"The young plants may be defended from cold, boisterous winds, frosts, the cold air and Scorching sun rays, if Glasses made for the only purpose, be set over them, which on such wise bestowed on the beds, yielded in a manner to Tiberius Caesar (a Roman emperor from 14 AD to 37 AD), Cucumbers all the year, in which he took great delight..." (Thomas Hill, "The Gardener's Labyrinth", 1577). [1]

Before the 20th century Agriculture production inside protected structures was initiated in France and Netherlands in the 19th century. This method was applied in simple, low, glass structures, which provided climate protection, and were used mainly for the growth of ornamental plants.

By the beginning of the 20th century, mostly after the end of 2nd world war, the technology of greenhouse construction accelerated its development, especially in

Western Europe cold countries, Netherlands leading the course. Agro-technical systems, aeration solutions and accompanying accessories were gradually added to the structures, while the structure foundations improved to the known, traditional heavy steel constructions covered by rigid glass boards.

By the end of the fifties of the 20th century the greenhouses technology flowed to the north and center of Europe where a wave of experiments and research in the field had begun. The 60ties revealed a new kind of structure covering sheets. They were the flexible, low priced polyethylene sheets, which caused a conceptual revolution in the field of greenhouses. Simultaneously appeared other types of good light transition coverings, such as polycarbonate (a kind of covering made of plastic polymers) leaving behind the traditional glass covering. [2]

2.2 Types of greenhouse

The greenhouse types are represented in the forms of structure design and covering sheets.

2.2.1 Structure design

The greenhouses are available in different shapes and sizes suitable for different climatic zones prevailing in world. Each zone requires different shapes of greenhouse for providing favorable climatic condition for the growth of plants. As per the review carried out by Tiwari and Goyal (1998), it is revealed that there is need to finalize the shape of greenhouse for a given climatic condition. [3]

On the basis of shape, greenhouses are classified as single span ground-to-ground type. If the single span greenhouses are joined together, then the facility is known as multi-span greenhouse. A greenhouse is said to be of lean-to- type (solarium if its north side forms the wall of residence in northern hemisphere. On the basis of shapes greenhouses may be named as follows and these are shown in Figure (2.1):

- Spherical dome
- Hyperbolic paraboloid
- Quonset
- Modified Quonset
- Gothic arch
- Mansard roof
- Gabic even span
- Gabic uneven span

The shape Quonset type greenhouse is most economical and required minimum maintenance and energy payback time is least. [3]

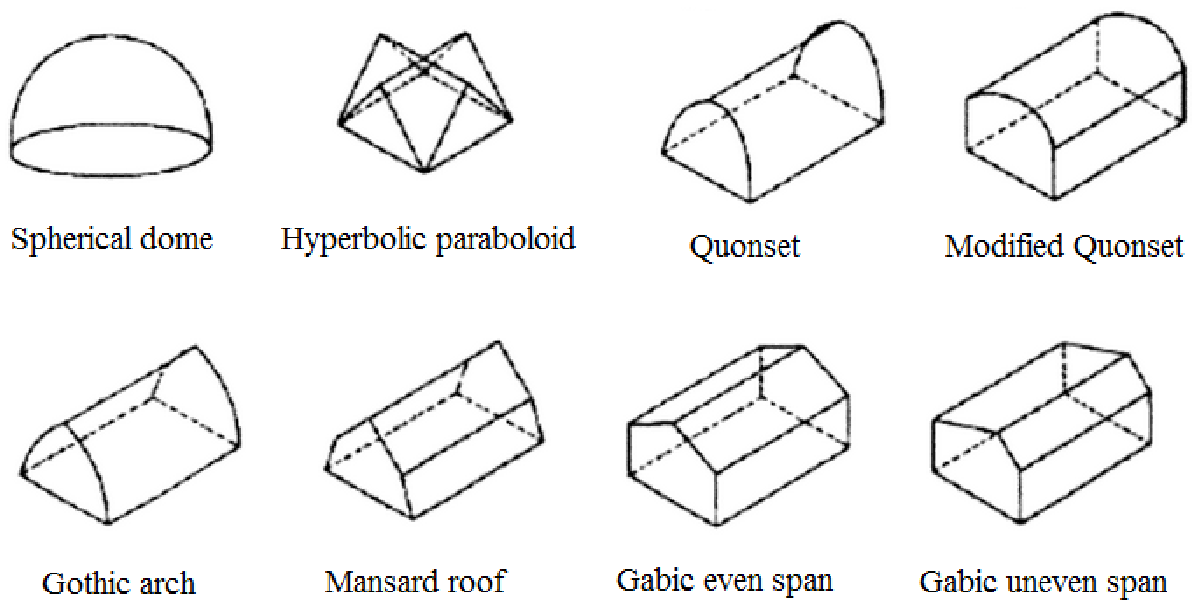


Figure 2.1: Different shapes and sizes of greenhouses.

2.2.2 Covering sheets

Lading 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: [4]

- **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.

- **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.

- **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.

- **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.

2.3 Styles of greenhouses

There are two styles of modern greenhouse: the first is often described as an English greenhouse, and the second is known as a Dutch light house. [5]

2.3.1 English greenhouse

The English greenhouse usually stands on low brick walls, its woodwork is painted white and glazed with overlapping sheets of glass set in putty and secured with sprigs. Provided it has sheets of glass 600 x 600 mm (2 ft. x 2 ft.) it has much to commend it, except the disadvantage of having to paint it inside and out every third year.

Aluminum-alloy greenhouses are constructed in the style of the English greenhouse. Their advantage of high light transmission has already been stressed but the fact that they do not require any painting makes them highly attractive. The overlapping sheets of glass usually rest on plastic cushions and are secured by stainless-steel clips or metal clamping strips. They are mass-produced and are, therefore, highly competitive in price. Figure (2.2), represents the English greenhouse style. [5]

Figure 2.2: English greenhouse.

2.3.2 Dutch light house

The second style is the Dutch light house which is of less pleasing appearance. It is usually assembled from prefabricated frames of pressure-treated timber glazed with sheets of Dutch light glass and all supplied as a kit. Precast concrete slabs are usually included and form the base on which the house stands. The sheets of glass slide into the wooden frames and are secured by wooden cleats, nailed onto the frame with galvanized nails. Putty is not required. Dutch light houses are very serviceable. The pressure-treated timber never requires painting and has a known life of thirty years. Also it is a relatively simple matter to take the house to pieces and re-assemble it on another site if the need arises.

There are then three choices: English greenhouses, pleasing in appearance, but which must be painted both inside and out at regular and frequent intervals; Dutch light houses with the advantages of relative cheapness, low maintenance and excellent light transmission; aluminum alloy houses, easily cleaned with virtually no maintenance and good light transmission. The latter two have really superseded the first, but the choice between them to some extent depends upon the purpose to which the house is to be put; the Dutch light type is highly suitable for tomatoes, cucumbers and lettuce grown as unheated crops, and the aluminum-alloy house comes into its own if it is to be heated or if it is intended to provide it with staging for plants in containers.

Both Dutch light and metal houses can be obtained in the so-called 'Gazebo style' (Fig. 2.3) which is very useful for small gardens where space is at a premium. A domed house in the metal range is of geodetic design and is again especially useful for small areas. [5]

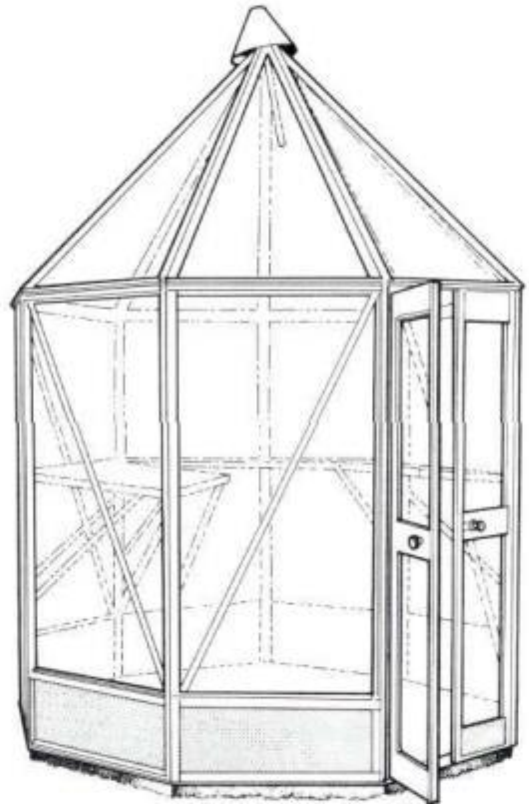


Figure 2.3: Dutch light house.

2.4 Site selection

A good building site can make a difference in the functional and environmental operation of a greenhouse. The following discussion may help in evaluating potential locations for selection as a greenhouse site.

Ground slope for drainage and building orientation are important factors. A south-facing slope is good for winter light and protection from northerly winds. It should also provide adequate drainage of surface water from the site. Swales can be built around greenhouses to direct surface water away. Subsurface drainage is also important and may require the digging of test holes to see what problems, if any, may exist or develop.

Greenhouses need a dependable supply of energy in the form of electricity and fuel for heating. An electric power distribution line adjacent to the site will reduce the investment needed to bring electricity to the greenhouse. A short access road to a public all-weather road should result in fewer problems in maintaining an adequate fuel supply and in transporting supplies to the greenhouse and plants to market. Telephone service is necessary for successful operation.

A dependable supply of high quality water is needed for greenhouse operation. Check with a local well driller or groundwater geologist, if available, to determine the potential for an adequate water source. Zoning regulations control land use in most communities. Consult the appropriate local or state agency before planning a facility and work with the officials during planning and construction to keep problems from developing. All new facilities must comply with the Americans with Disabilities Act. [6]

2.5 Effect of environmental factors

The greenhouse system is a complex system. Any significant changes in one climate parameter could have an adverse effect on another climate parameter as well as the development process of the plants. Therefore continues monitoring and control of these climate factors will allow for maximum crop yield. Temperature, humidity, light intensity and CO2 are the four most common climate variables that most growers generally pay attention to. However, looking at these four climate variables will give the growers a good picture of the operation of the greenhouse system. [7]

2.5.1 Temperature

Plant temperature is affected by radiation energy transfer, convective heat transfer, and evaporation from the plant surface. The relationship between plant growth and temperature is complex because it is a factor in the reaction rates of various metabolic processes.

Temperature is the most easily measured aerial environmental parameter. However, each plant species has its own optimum range and timetable for features such as productivity, flowering, and timing to market.

- ❖ **Air temperature**

Air temperature is best accomplished with an aspirated housing to move the air sample across the sensor and protect it from direct exposure to solar radiation. This ensures a more accurate representation of the air in the general greenhouse environment as opposed to a specific spot.

- ❖ **Soil temperature**

Soil temperature probes are typically used to control bottom heat systems. They are also used to monitor soil temperatures and the temperature within the microclimate of the plant. This information can be valuable for determining how and why the plant is responding and what measures the grower may want to take to improve performance or identify problems.

- ❖ **Pipe temperature**

Pipe temperature sensors are used to monitor the water temperature and pipe surface temperature in hot water heating systems to control mixing valves, minimum pipe temperatures for dehumidification, as well as boiler output and/or transport system temperatures. There are three methods of: sensors (1) surface mount temperature. Sensors (2) wet well sensors, and (3) dry well sensors.

- ❖ **Irrigation water temperature**

Water temperature can be monitored with a pipe temperature sensor, as above, or with a simple waterproof sensor dropped into the water.

- ❖ **Other temperatures**

Variety of purposes can be monitored by other Temperatures. For example, equipment operation can often be confirmed with a simple appropriately placed temperature sensor to confirm things like unit heater operation, an overheated irrigation or heating pump, even fan operation or open vents. Alarms can then be set in the system to alert staff when problems occur.

2.5.2 Lighting

Light is generally considered the most limiting factor in plant growth and development. Recent improvements in lamp design and lighting methods have increased the use of electric lighting for commercial production of ornamental and vegetable plants in greenhouses and growth rooms. In selecting and designing a lighting system, many factors have to be evaluated. These include:

- Plant response to light.
- Influence of other environmental factors.
- Light level, duration, and spectral requirements of the plants.
- Light sources that will give the best results.
- System layout that will give the most even light.
- Initial and operating costs of the system.

2.5.3 Humidity

Relative humidity is the ratio of actual vapor pressure of water vapor in the air to the vapor pressure that would be present if the air was saturated with moisture at the same temperature. Water vapor moves from one location to another because of vapor pressure differences, so relative humidity affects transpiration from plants by affecting the vapor pressure difference between a plant leaf and surrounding air. Normal plant growth will generally occur at relative humilities between 25–80%. A secondary effect of relative humidity is the response of pathogenic organisms. For example, most pathogenic spores will not germinate at relative humilities below 95%.

A tight greenhouse will have reduced air exchange and higher relative humidity. Thermal blankets or double glazing layers will also result in increased relative humidity. Reduced air exchange will reduce the amount of water vapor removed from the greenhouse. Additional insulation will result in higher inside surface temperatures, reducing the condensation potential. The condensation rate depends on the rate of air movement across the surface, the rate at which heat of condensation is removed from the surface, and the rate of evaporation from other surfaces in the greenhouse.

In general, the relative humidity of the inside air will be controlled by the temperature of the coldest inside surface. For example, if the inside surface temperature is 36°F and the inside temperature is 60°F, the inside relative humidity will be about 40%.

2.5.4 Soil

Rooting media provide plant support, serve as a source of water and plant nutrients, and permit diffusion of oxygen to the plant roots. During respiration, oxygen moves into roots and carbon dioxide moves out. The media should have sufficient pore size and distribution to provide adequate aeration and moisture retention necessary for acceptable crop production. Media range amended soil and amended soil mixes to soilless media such as gravel, sand, peat, or liquid films.

2.5.5 Air speed

Air speed influences many factors that affect plant growth, such as transpiration, evaporation, leaf temperature, and carbon dioxide availability. In general, air speeds of 20–50 ft./min. (fpm) across leaf surfaces facilitate carbon dioxide uptake. At an air speed of 100 fpm, carbon dioxide uptake is reduced, and at 200 fpm, growth is inhibited.

CHAPTER THREE

Arduino Control Unit

3.1 Introduction

Arduino is an open-source electronics platform based on easy-to-use hardware and software. Arduino boards are able to read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. The board receive orders by sending a set of instructions to the microcontroller on the board. To do so the Arduino use programming language (based on Wiring), and the Arduino Software IDE (Integrated Development Environment), based on Processing.

Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs.

The software, too, is open-source, and it is growing through the contributions of users worldwide. [8]

3.2 Arduino Hardware

All Arduino boards have a few key capabilities and functions. Figure (3.1) Show the Arduino Uno components and circuits. [9]

These are some key components that should be concerning with:

- ■ Atmel microcontroller.
- ■ USB programming/communication interface(s).
- ■ Voltage regulator and power connections.
- ■ Breakout I/O pins.
- ■ Debug, Power, and RX/TX LEDs.
- ■ Reset button.
- ■ In-circuit serial programmer (ICSP) connector(s).

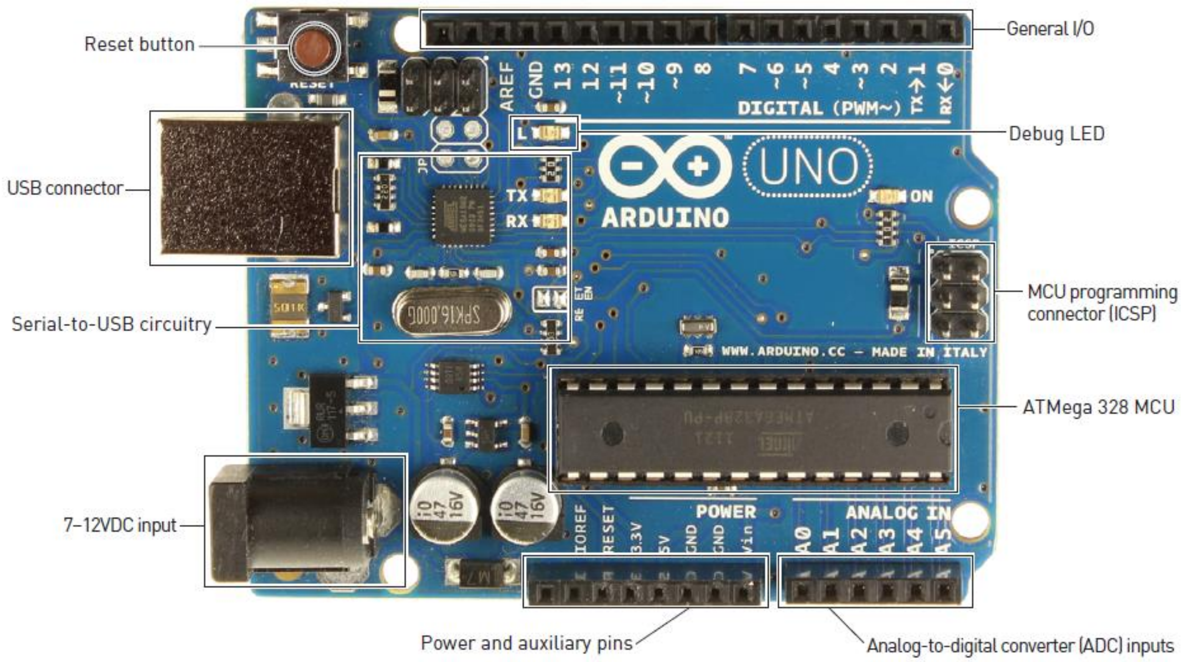


Figure 3.1: Arduino Uno components.

3.2.1 Atmel Microcontroller

At the heart of every Arduino is an Atmel microcontroller unit (MCU). Most Arduino boards, including the Arduino Uno, use an AVR ATMega microcontroller. The Arduino Uno in Figure (3.1) uses an ATMega 328p. The Due is an exception; it uses an ARM Cortex microcontroller. This microcontroller is responsible for holding all of compiled code and executing the commands has been specify. The Arduino programming language gives access to microcontroller peripherals, including analog-to-digital converters (ADCs), general-purpose input/output (I/O) pins, communication buses (including I2C and SPI), and serial interfaces. All of this useful functionality is broken out from the tiny pins on the microcontroller to accessible female headers on the Arduino that can be plug wires or shields into. A 16 MHz ceramic resonator is wired to the ATMega's clock pins, which serves as the reference by which all program commands execute. Can be use the Reset button to restart the execution of program. Most Arduino boards come with a debug LED already connected to pin 13.

3.2.2 Programming Interfaces

Ordinarily, ATMega microcontroller programs are written in C or Assembly and programmed via the ICSP interface using a dedicated programmer as shown in figure (3.2). Perhaps the most important characteristic of an Arduino is that can be programed easily via USB, without using a separate programmer. This functionality is made possible by the Arduino Bootloader. The Bootloader is loaded onto the ATMega at the factory (using the ICSP header), which allows a serial USART (Universal Synchronous/Asynchronous Receiver/Transmitter) to load program on the Arduino without using a separate programmer.

In the case of the Arduino Uno and Mega 2560, a secondary microcontroller (an ATMega 16U2 or 8U2 depending on your revision) serves as an interface between a USB cable and the serial USART pins on the main microcontroller. The Arduino Leonardo, which uses an ATMega 32U4 as the main microcontroller, has USB baked right in, so a secondary microcontroller is not needed. In older Arduino boards, an FTDI brand USB-to-serial chip was used as the interface between the ATMega's serial USART port and a USB connection.

Figure 3.2: AVR ISP MKII programmer.

3.2.3 General I/O and ADCs

The part of the Arduino that should be taking care the most about during the projects is the general-purpose I/O and ADC pins. All of these pins can be individually addressed via the programs that will be write. All of them can serve as digital inputs and outputs. The ADC pins can also act as analog inputs that can measure voltages between 0 and 5V (usually from resistive sensors). Many of these pins are also multiplexed to serve additional functions, which should be explore during the projects. These special functions include various communication interfaces, serial interfaces, pulse-width-modulated outputs, and external interrupts.

3.2.4 Power Supplies

For the majority of the projects, it will be simply use the 5V power that is provided over the USB cable. However, when it is ready to untether project from a computer, it should be an other power options. The Arduino can accept between 6V and 20V (7-12V recommend) via the direct current (DC) barrel jack connector, or into the V_{in} pin. The Arduino has built-in 5V and 3.3V regulators:

■ 5V is used for all the logic on the board. In other words, when it toggle a digital I/O pin, it will be toggling it between 5V and 0V.

■ 3.3V is broken out to a pin to accommodate 3.3V shields and external circuitry.

3.3 Arduino Classification

This review cannot possibly cover all the available Arduino boards; there are many, and manufacturers are constantly releasing new ones with various features. The following section highlights some of the features in the official Arduino boards. [9]

3.3.1 Arduino Uno

The Arduino Uno as shown in Figure (3.3) is the flagship Arduino. It uses a 16U2 USB-to-serial converter chip and an ATMega 328p as the main MCU. It is available in both DIP and SMD versions (which defines whether the MCU is re-movable).

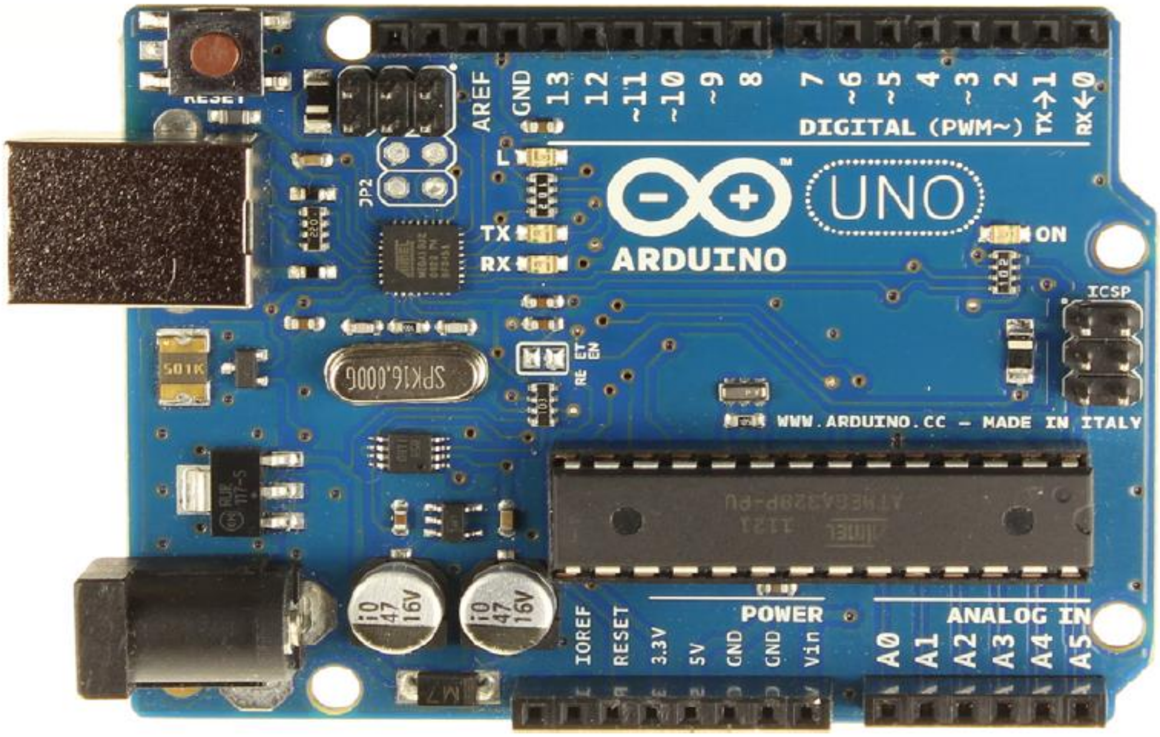


Figure 3.3: Arduino Uno.

3.3.2 Arduino Leonardo

The Arduino Leonardo as shown in Figure (3.4) uses the 32U4 as the main microcontroller, which has a USB interface built in. Therefore, it doesn't need a secondary MCU to perform the serial-to-USB conversion. This cuts down on the cost and enables to do unique things like emulate a joystick or a keyboard instead of a simple serial device.

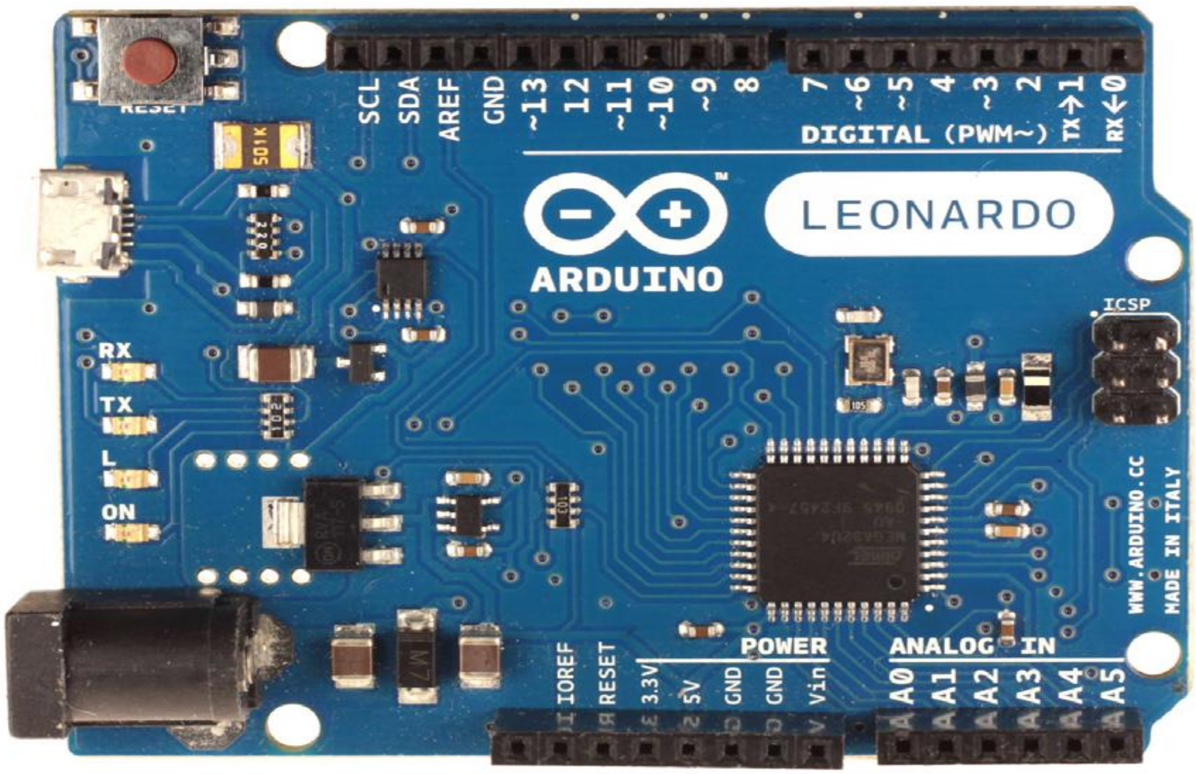


Figure 3.4: Arduino Leonardo.

3.3.3 Arduino Mega 2560

The Arduino Mega 2560 as shown in Figure (3.5), employs an ATMega 2560 as the main MCU, which has 54 general I/Os to enable you to interface with many more devices. The Mega also has more ADC channels, and has four hardware serial interfaces (unlike the one serial interface found on the Uno).

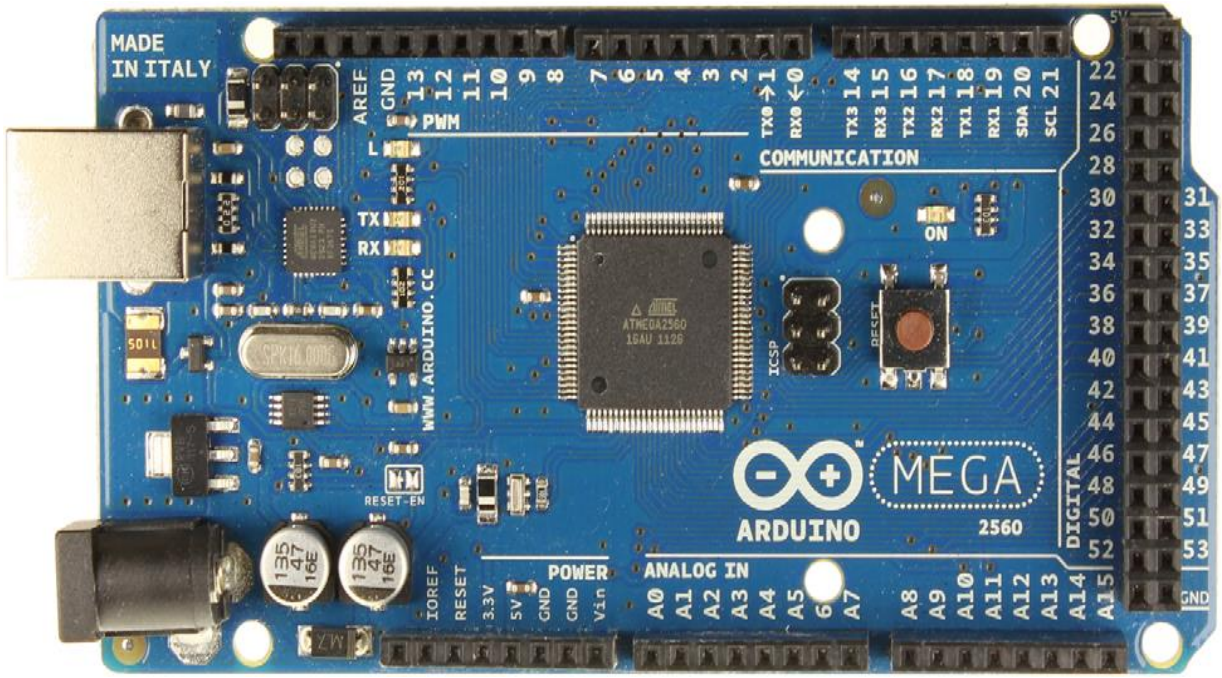


Figure 3.5: Arduino Mega 2560.

3.3.4 Arduino Due

Unlike all the other Arduino variants, which use 8-bit AVR MCUs, the Arduino Due as shown in Figure (3.6), uses a 32-bit ARM Cortex M3 SAM3X MCU. The Due offers higher-precision ADCs, selectable resolution pulse-width modulation (PWM), Digital-to-Analog Converters (DACs), a USB host connector, and an 84 MHz clock speed.

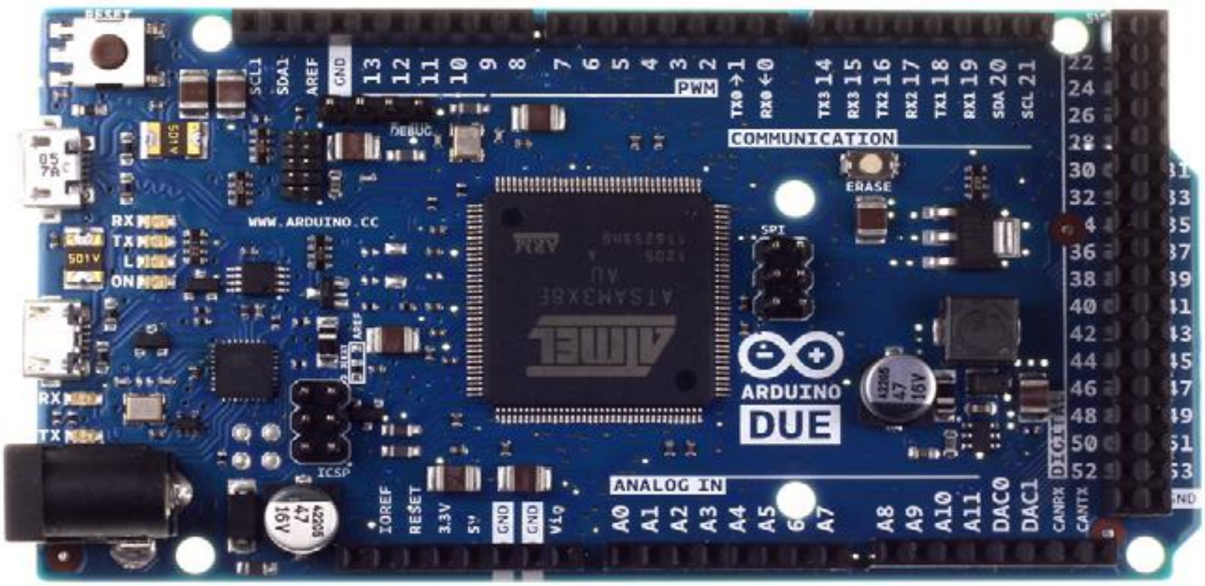


Figure 3.6: Arduino Due.

3.3.5 Arduino Nano

The Arduino Nano as shown in Figure (3.7), is designed to be mounted right into a breadboard socket. Its small form factor makes it perfect for use in more finished projects.

Figure 3.7: Arduino Nano.

3.3.6 Arduino Mega ADK

The Arduino Mega ADK as shown in Figure (3.8), is very similar to the Mega 2560, except that it has USB host functionality, allowing it to connect to an Android phone so that it can communicate with apps that have been written.

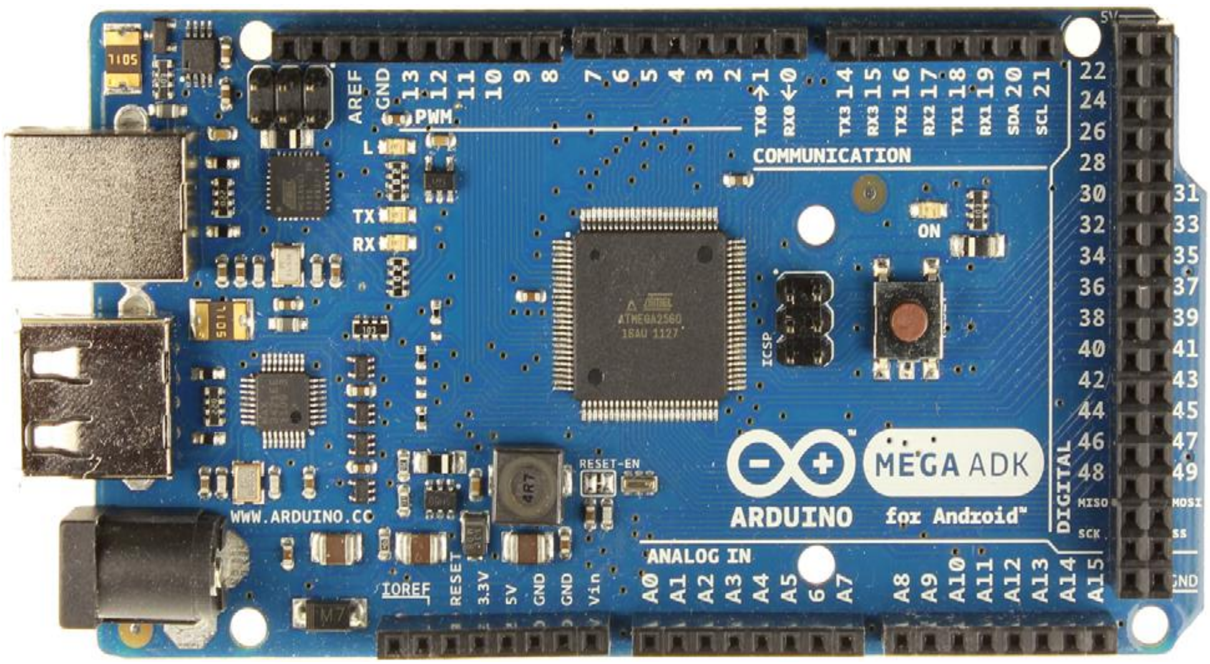


Figure 3.8: Arduino Mega ADK.

3.3.7 Arduino LilyPad

The Arduino LilyPad as shown in Figure (3.9), is unique because it is designed to be sewn into clothing. Using conductive thread, you can wire it up to sewable sensors, LEDs, and more. To keep size down, you need to program it using an FTDI cable.

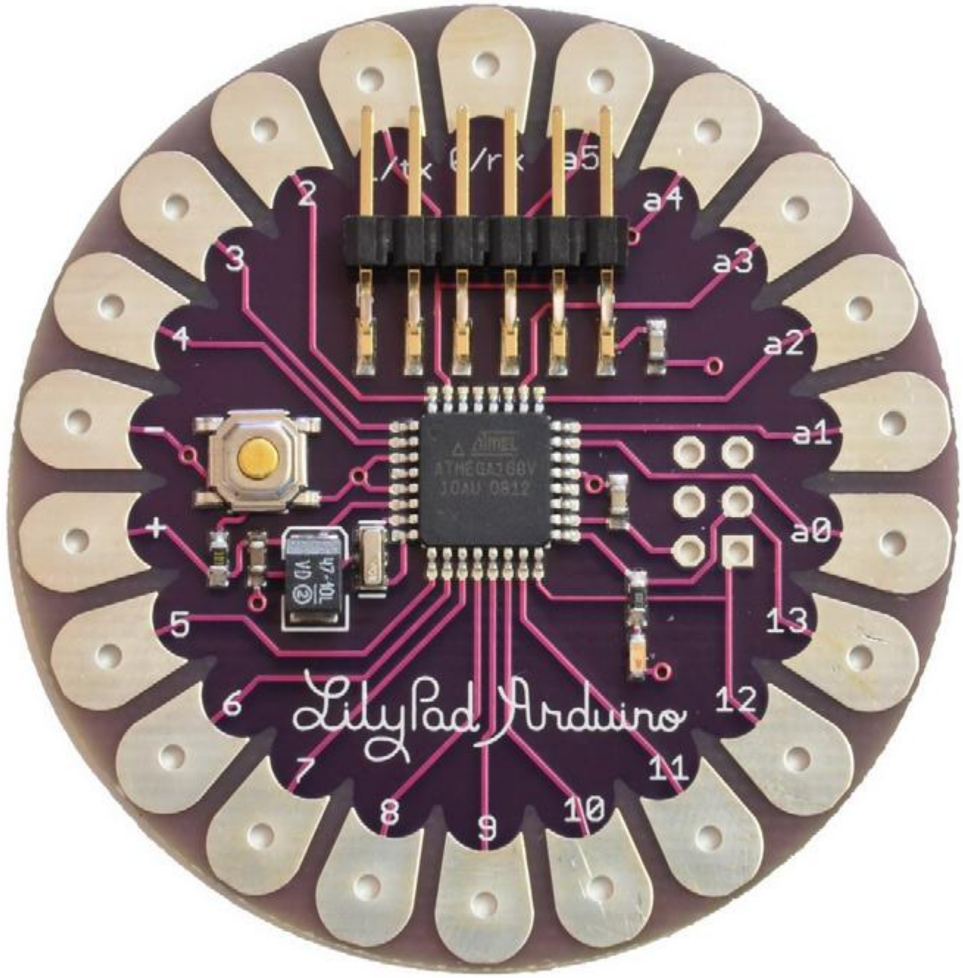


Figure 3.9: Arduino LilyPad.

3.4 Arduino Software

A program for Arduino may be written in any programming language for a compiler that produces binary machine code for the target processor. Atmel provides a development environment for their microcontrollers, AVR Studio and the newer Atmel Studio.

The Arduino project provides the Arduino integrated development environment (IDE) as shown in figure (3.9), which a cross-platform application is written in the programming language Java. It originated from the IDE for the languages Processing and Wiring. It includes a code editor with features such as text cutting and pasting, searching and replacing text, automatic indenting, brace matching, and syntax highlighting, and provides simple one-click mechanisms to compile and upload programs to an Arduino board. It also contains a message area, a text console, a toolbar with buttons for common functions and a hierarchy of operation menus.

A program written with the IDE for Arduino is called a sketch. Sketches are saved on the development computer as text files with the file extension *.ino.* Arduino Software (IDE) pre-1.0 saved sketches with the extension *.pde.*

The Arduino IDE supports the languages C and C++ using special rules of code structuring. The Arduino IDE supplies a software library from the Wiring project, which provides many common input and output procedures. User-written code only requires two basic functions, for starting the sketch and the main program loop, that are compiled and linked with a program stub *main()* into an executable cyclic executive program with the GNU toolchain, also included with the IDE distribution. The Arduino IDE employs the program avrdude to convert the executable code into a text file in hexadecimal encoding that is loaded into the Arduino board by a loader program in the board's firmware. [10]

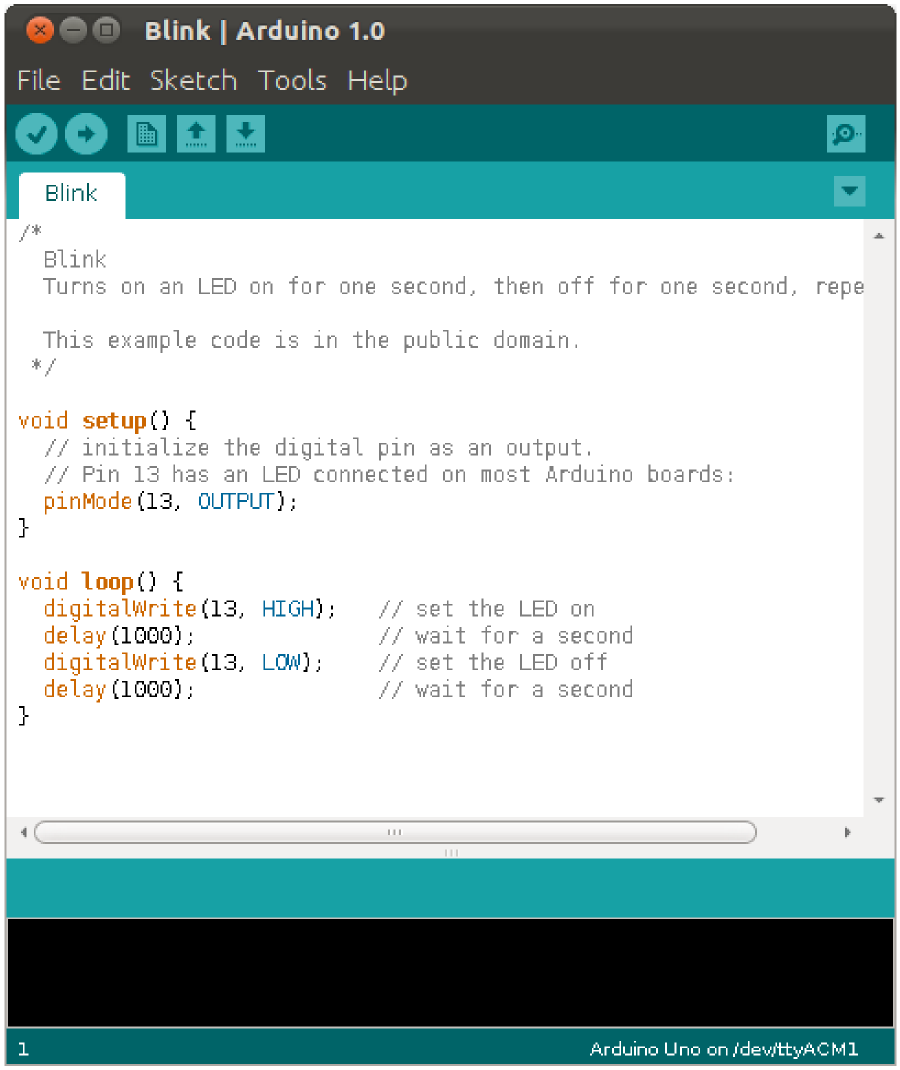


Figure 3.10: Screenshot of the Arduino IDE showing the Blink simple program.

CHAPTER FOUR

System Description and Implementation

4.1 Introduction

Greenhouse control system can be summarized in simple block diagram as shown as in figure (4.1). The block diagram contains all the operators and describes the process that is goes on.

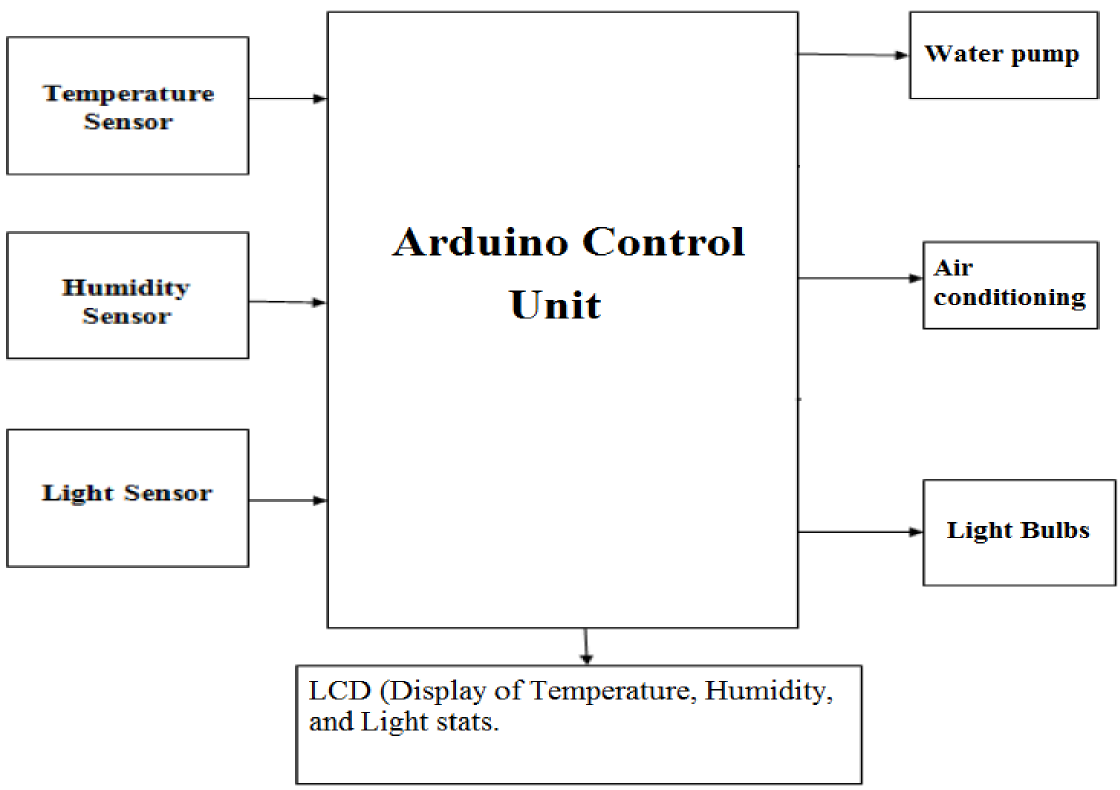


Figure 4.1: The block diagram of the greenhouse control.

In general, the temperature parameter is the primary focus of most climate control systems. This may include the air temperature surrounding the aerial portion of the plant, as well as, root zone and leaf temperatures. The changes of external climatic condition strongly influence the inside air temperature. For example, the decrease of the temperature outside the greenhouse or the increase of the wind speed will lead to the decrease of the temperature inside the greenhouse.

The entire greenhouse temperature depends on air, soil, pipe and Irrigation water Temperature. [6]

The operation of temperature control can be describe as shown in figure (4.2).

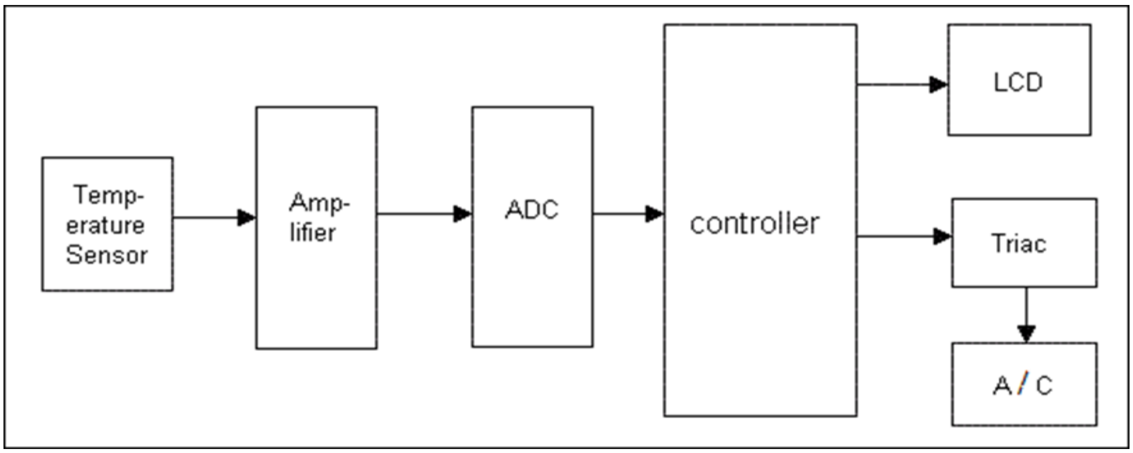


Figure 4.2: the block diagram of temperature control.

The block diagram is contains temperature sensor, amplifier, Analog to Digital Converter (ADC), controller (it can be any kind of controllers, like microcontroller, Arduino, PID controller, PLC, etc.), liquid-crystal display (LCD), Triac (triode for alternating current) and Air Condition (A/C).

Temperature control system operation is beginning by temperature sensor measuring Current temperature and send an electrical signal, but this signal is too small, that is why it need to be increase, that will done by the amplifier. After that, there is a new problem must be solved, that is the controller do not reading an analogue signal, here the role of the Analog to Digital Converter, to converting the signal from analogue to digital.

The controller will receive a digital signal contains a data that sensor was read, data will be compared to those already saved in system memory as a programing code. On the basis of these data controller will decide, if the temperature is hot and need to be cold down by the air condition or not need.

This operation is infinite, as long as the system works.

Then there is system of humidity of the soil. Soil water also affects the crop growth. Therefore, the monitor & control of soil condition has a specific interest, because good condition of a soil may produce the proper yield.

The proper irrigations and fertilizations of the crops are varies as per the type, age, phase and climate. The pH value, moisture contains, electric conductivity and the temp of a soil are some key parameters. The pH valves and other parameters will help to monitor the soil condition. The temperature and the moisture can be controlled by the irrigation techniques like drift and sprinkles system in a greenhouse.

The temperature of the soil and the inside temperature of the green house are inter related parameters, which can be, control by proper setting of ventilation. Since the temperature control is depends on direct sun radiation and the screen material used, the proper set point can adjust to control soil temperature. The temperature set-point value depends on actual temperature of the inside and outside of the greenhouse.

4.2 System description

The main concept of the designed block diagram as shown in Figure (4.3), is describe the inputs and outputs components. Then receive factor values from sensors and switches in order to activate the outputs such as conditioning units, water pump, air condition and light bulbs.

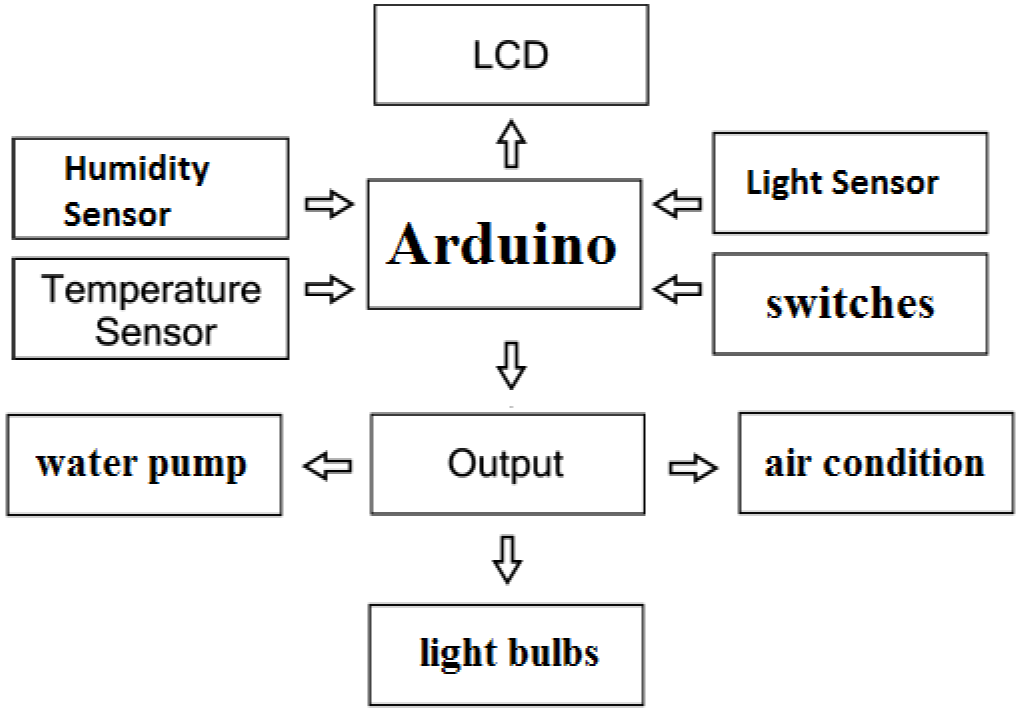


Figure 4.3: block diagram of greenhouse control system.

4.3 System components

The system components selected according to the functionality of automation greenhouse system, Arduino is required to control the greenhouse actuators according to certain values received from sensors in order to activate other components.

4.3.1 Arduino Uno unit

The Arduino Uno is a microcontroller board based on the ATmega328. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

Arduino is an open-source electronics prototyping platform based on flexible, easy-to-use hardware and software. It's intended for artists, designers, hobbyists, and anyone interested in creating interactive objects or environments.

Arduino can sense the environment by receiving input from a variety of sensors and can affect its surroundings by controlling lights, motors, and other actuators. The microcontroller on the board is programmed using the Arduino programming language (based on Wiring) and the Arduino development environment (based on Processing). Arduino projects can be stand-alone or they can communicate with software running on a computer.

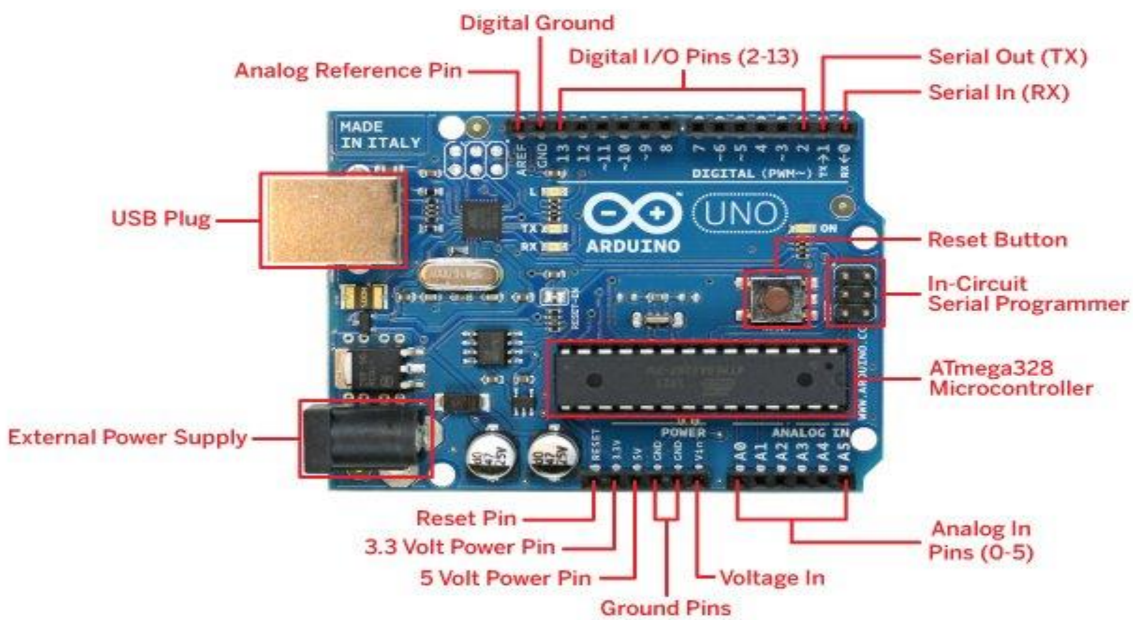


Figure 4.4: Arduino Uno.

4.3.2 Temperature sensor LM35

The LM35 as shown in Figure (4.5) 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.

Table 4.1: The technical specification of LM35:

Specification	Value
Temperature Measuring Range	-55 to 150°C
Output Voltage	+6V to -1.0V
Output Current	10mA

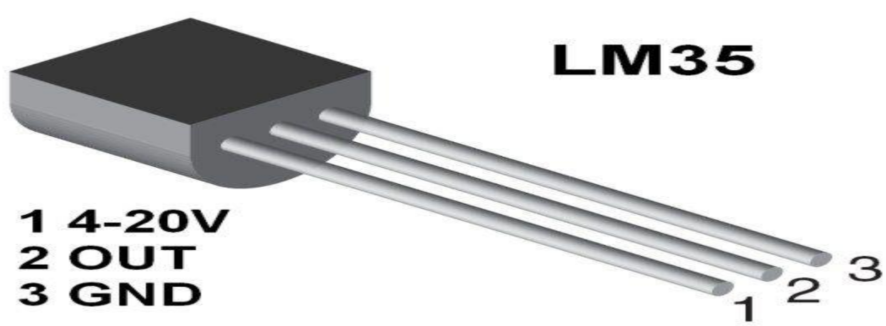


Figure 4.5: Temperature sensor LM35.

4.3.3 Humidity sensor YL-38

YL-38 Soil Moisture Sensor as shown in Figure (4.6) is used to measure the moisture level in soil. It is widely used for performing experiments in courses like soil science, environmental science and botany. It can also evaluate the optimum soil moisture contents for various species of plants. We can place the prongs of the sensor into soil and check the moisture level, but the position of the prongs should be correct. For example the prongs of the sensor should be oriented horizontally and rotated onto their side, like the position of knife while cutting something. That is why, because the soil moisture often varies by depth.

Usually dry soil is made up of solid material and air pockets called pores or spaces. Approximately, their ratio would be 55% solid material and 45% pores. If we add some water to the soil, the pores begin to fill with that water, then the ratio would be 55% of minerals, 35% of pore spaces and 10% of water. This would be an example of 10% volumetric water content. So, this is the main mechanism of YL-38 soil moisture sensor potential meter

The YL-38 ranges from 0 to 45% volumetric water content in soil. It operates on 3mA at 5v DC. Its operating temperature is from -400C to +600C.

The sensor has 4 pins at one side that are Vcc, GND, V0 and A0, and 2 pins on the other side to connect the prongs that are to be insert into the soil. The V0 pin is used for digital output and A0 pin is used for analog output. The sensor also has a potential Meter to celebrate the sensitivity of the sensor.

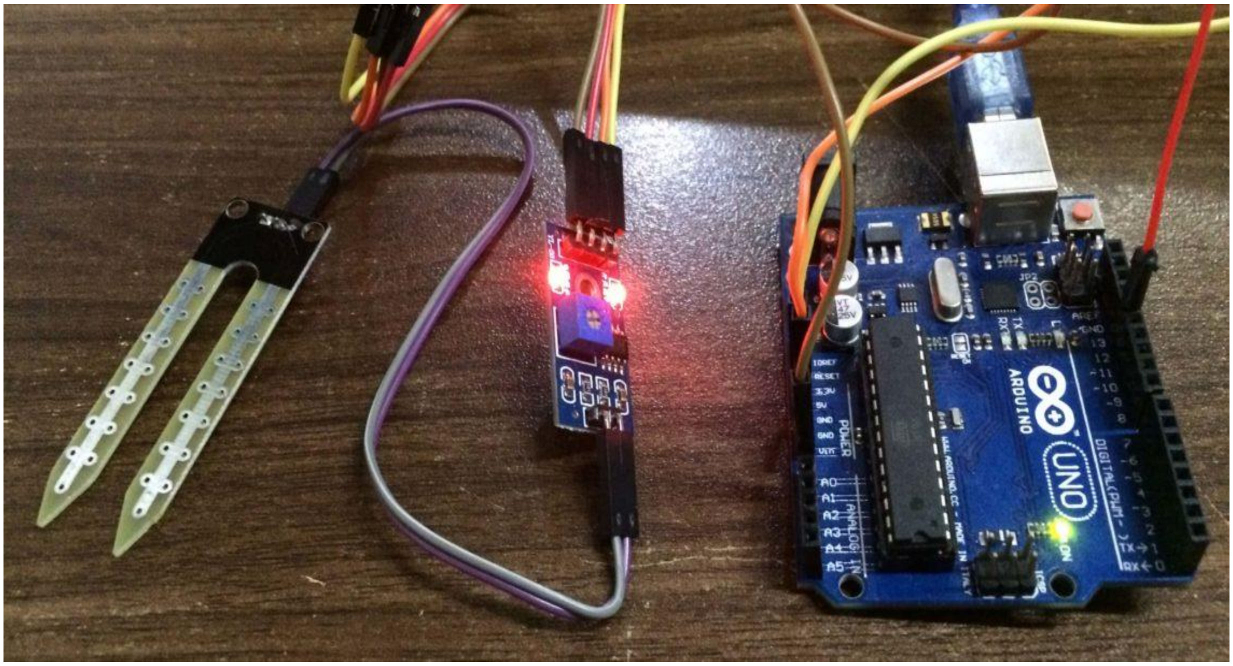


Figure 4.6: Humidity sensor YL-38.

4.3.4 Light sensor LDR

A light dependent resistor as shown in Figure (4.7) also known as a LDR is photo-resistor, photoconductor or photocell, is a resistor whose resistance increases or decreases depending on the amount of light intensity. LDRs (Light Dependent Re-sistors) 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.

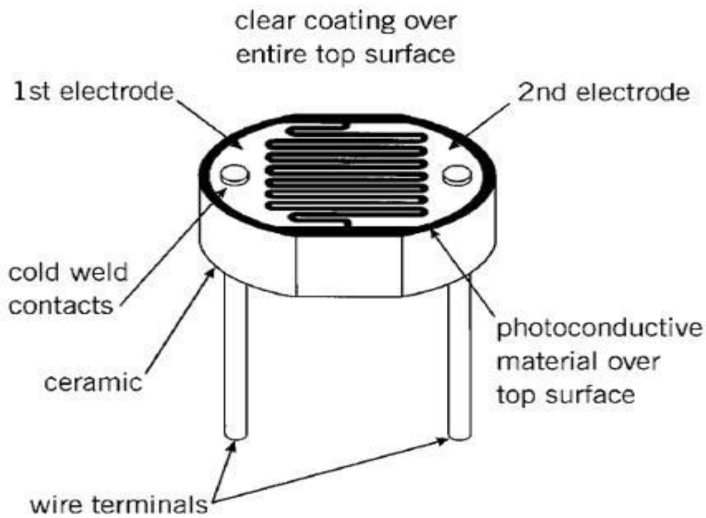


Figure 4.7: LDR Construction.

A light ward resistor deals with the guideline of photo conductivity. Photo conductivity is an optical perception in which the materials conductivity (Hence resistivity) decreases when light is consumed by the material.

At the point when light falls i.e. at the point when the photons fall on the gadget, the electrons in the valence band of the semiconductor material are eager to the conduction band. These photons in the episode light should to have energy more prominent than the band hole of the semiconductor material to make the electrons hop from the valence band to the conduction band. Consequently when light sufficiently having vitality is episode on the gadget more & more electrons are eager to the conduction band which brings about expansive number of charge bearers. The aftereffect of this methodology is more present begins streaming and thus it is said that the resistance of the gadget has diminished. This is the most well-known working standard of LDR.

LDR's are light subordinate devices whose resistance diminishes when light falls on them and increments oblivious. At the point when a light ward resistor is kept in dull, its resistance is high. This resistance is called as dull resistance. It can be as high as 1012 Ω. What's more, if the implement is permitted to retain light its resistance will diminish radically. In the event that a consistent voltage is connected to it and force of light is expanded the current begins expanding.

Figure (4.8) below shows resistance vs. illumination curve for a particular LDR.

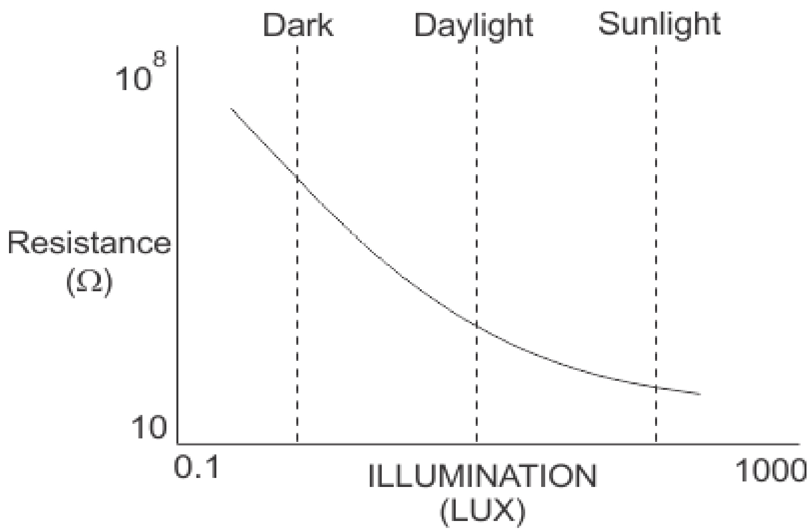


Figure 4.8: Resistance VS Illumination

LDR's have minimal effort and straightforward structure. They are frequently utilized as light sensors. They are utilized when there is a need to recognize absences or habitations of light like in a cam light meter. Used in street lamps, alarm clock, burglar alarm circuits, light intensity meters, for counting the packages moving on a conveyor belt, etc.

4.3.5 LCD display

A liquid-crystal display (LCD) as shown in Figure (4.9) 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 (4.5).

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)

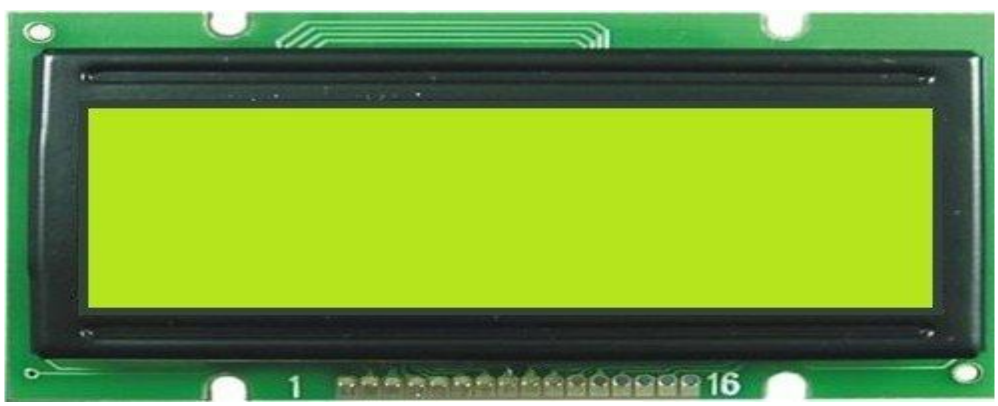


Figure 4.9: LCD Display.

4.3.6 LED

A light-emitting diode (LED) as shown in Figure (4.10) is a two-lead semiconductor light source. It is a p–n junction diode that emits light when activated. When a suitable voltage is applied to the leads, electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence.

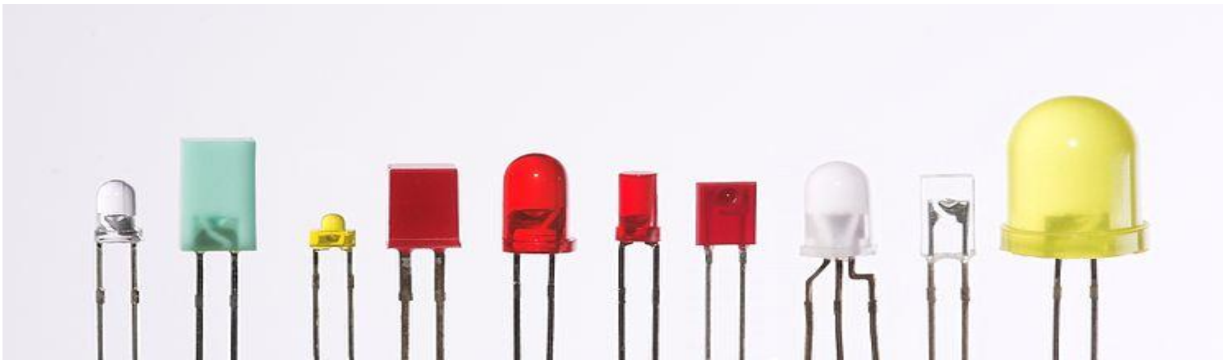


Figure 4.10: LEDs.

4.3.7 Fan

To maintain plant health during warm summer months, fans should be used. It will be used in our project for cool climate inside the greenhouse. So we will use the fan that use in pc computer for mini model, Fans are available in many sizes and capacities. Typically square 120mm and this fan cool very well and there many size for example (140mm) and may we use it. Air pressure is most important for cooling.

Figure 4.11: Fan.

4.4 System simulation

The simulation methodology that be chosen 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. The application control system is executed in connecting as shown in figure (4.12) below:

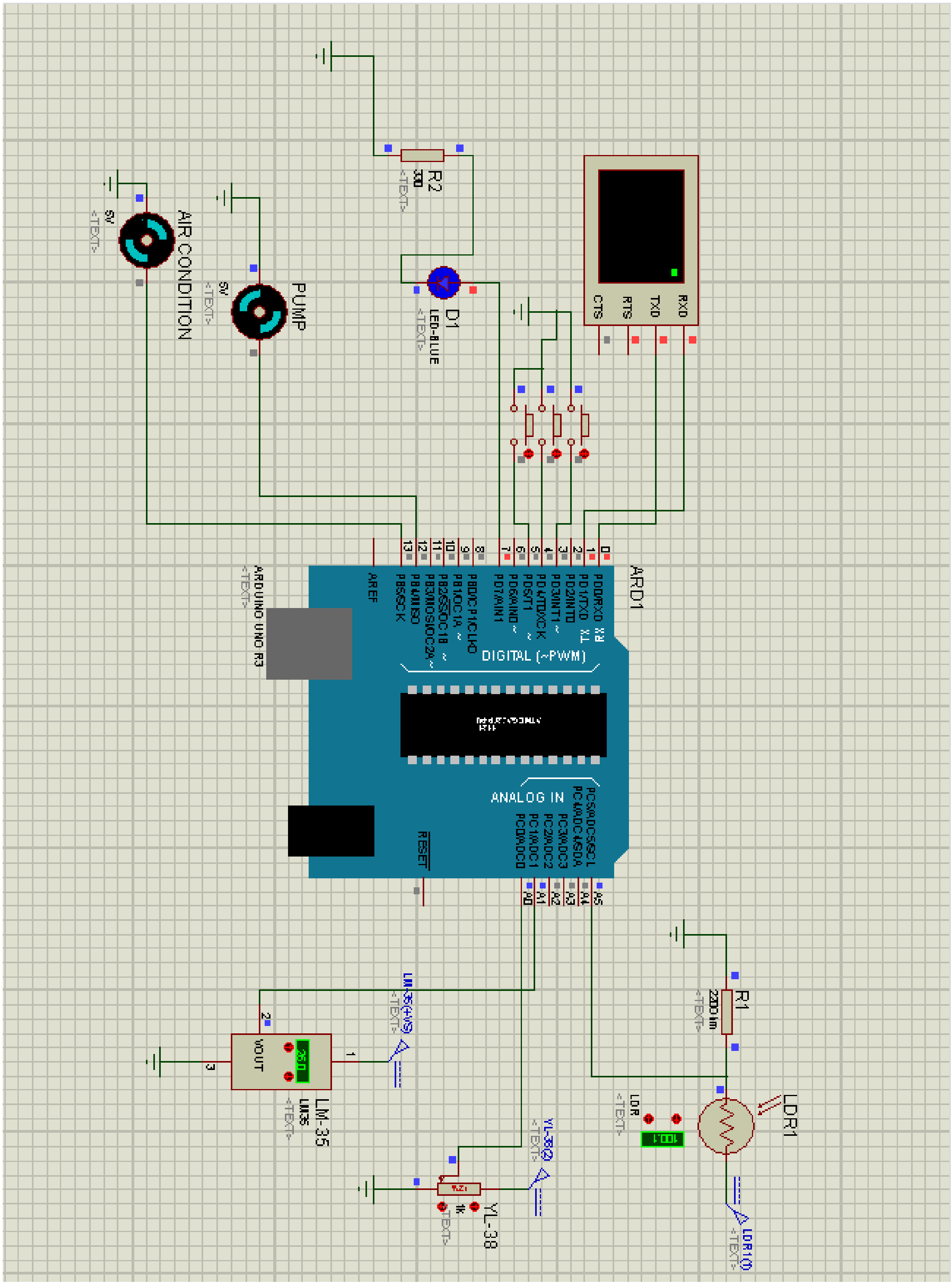


Figure 4.12: The simulation of control system.

4.5 System operation

The system is providing a multi choices modes options as shown in figure (4.13), for the user according to temperature degree, Humidity and light needed by the plant to grow.

Table 4.2: Data of multi choices modes options in system:

Case No.	Temperature value (to make the air condition work)	Humidity value (to make the Pump work)	Light value (to make the LED work)
Case One	More than 24°C	Less than 20%	Less than 100 Lux
Case Two	More than 29°C	Less than 30%	Less than 200 Lux
Case three	More than 40°C	Less than 35%	Less than 300 Lux

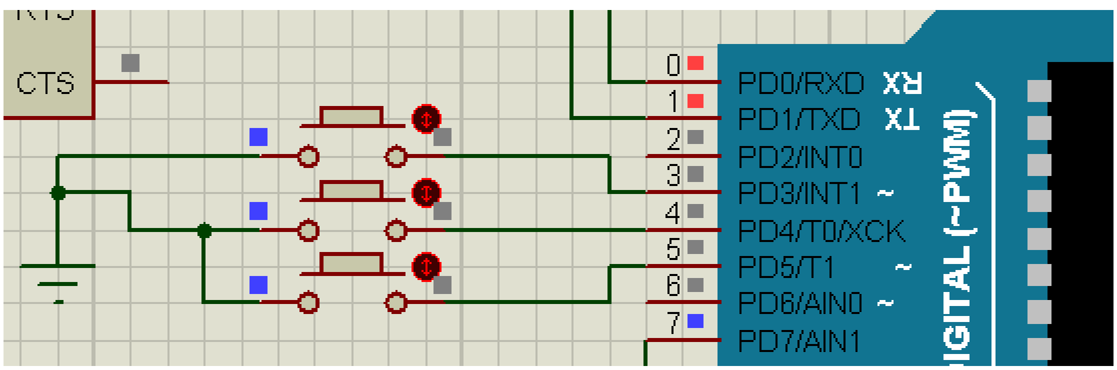


Figure 4.13: Multi choices modes options.

The Temperature sensor (LM35) that shown in figure (4.14) is used to senses the heat, whenever the sensed temperature is more than set point the sensor will send a signal to Arduino which will open the fan to cool the area.

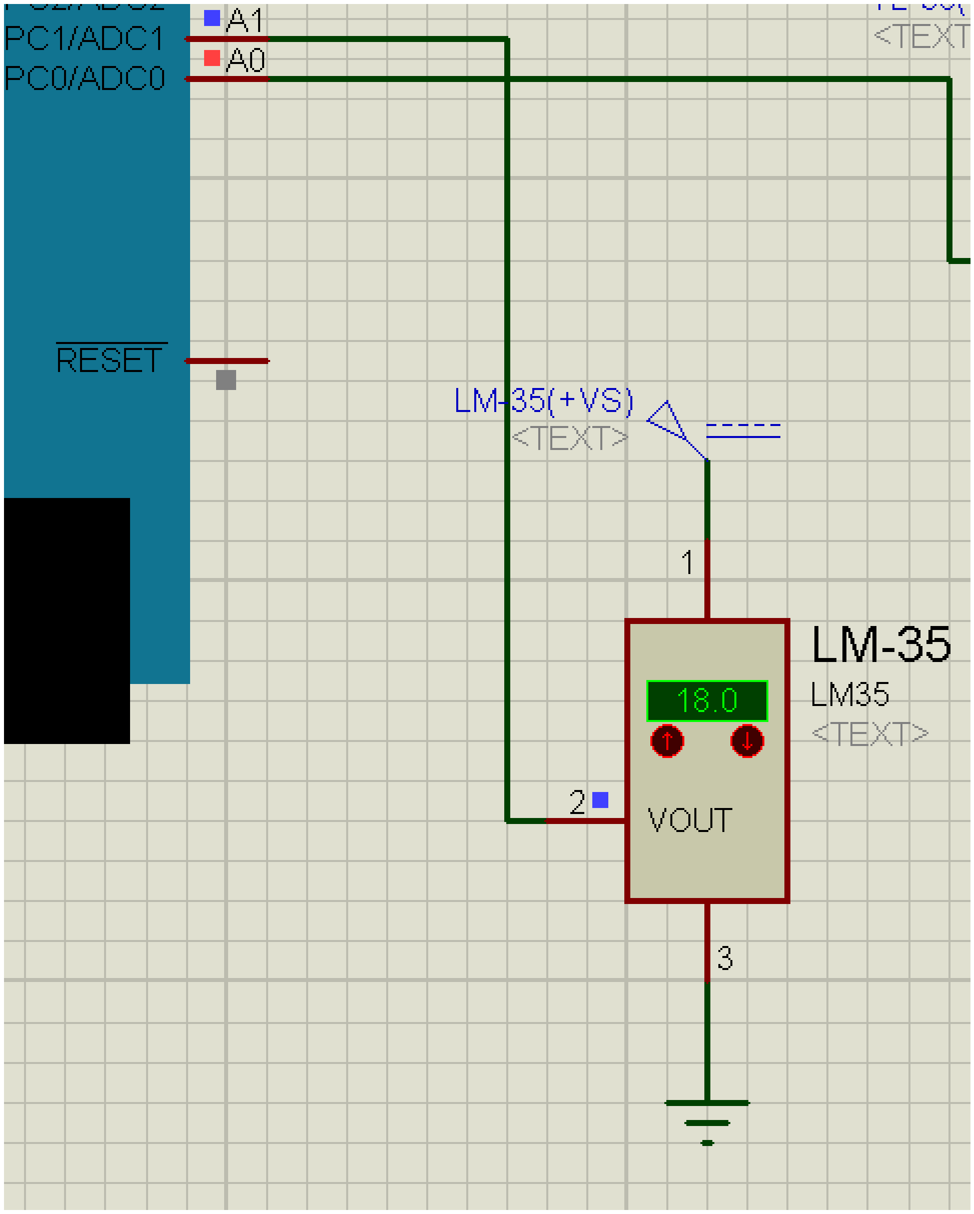


Figure 4.14: Temperature sensor LM35 in simulation.

The Humidity can be controlled by senses the humidity with (YL-38) Humidity sensor as shown in figure (4.15) which will send signal to the Arduino and the pump will operate in response to Arduino signal.

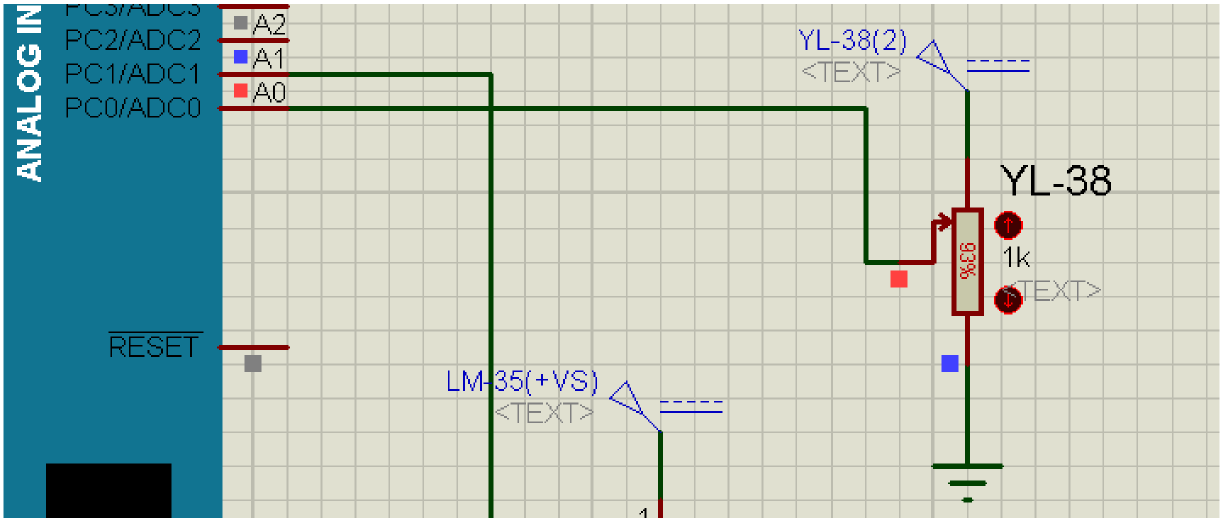


Figure 4.15: Humidity sensor YL-38 in simulation.

In the Normal day time the sun light is covering the need of light for the plants and no need for additional light sources; but on nights or when the light density which sensed by the light sensor LDR as shown in figure (4.16) is very low the LED will be on in response to a signal in Arduino.

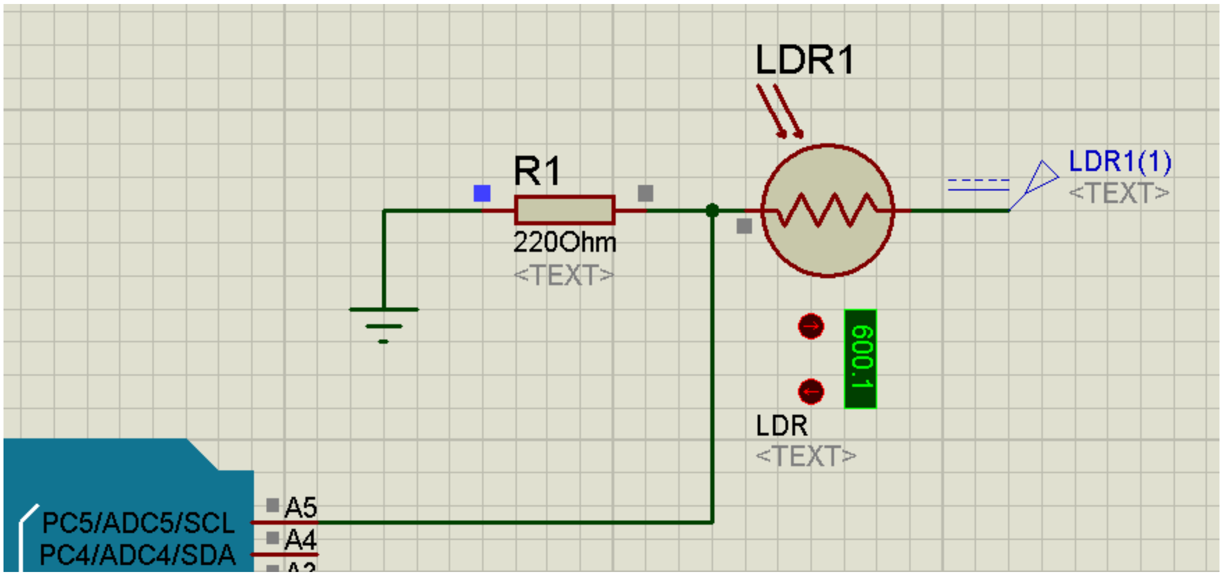


Figure 4.16: LDR sensor in simulation.

For the greenhouse the system must be shut down so the selected mode can be changed.

4.6 Code structure

The first thing in the programming code is to identify the devices connected to the Arduino control unit 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 Arduino receives the reference values from the sensors and detectors send signals for lunching conditional units depending on factors values in greenhouse, so the system can choose if this value of temperature, soil humidity or lighting needs to initiate another unit or not in order any instructions and display that on Liquid crystal display (LCD).

4.7 System code

The Arduino control unit code was written in C++ programming language and compiled with the Proteus software application:

```
int hum;

int temp;

int humidity_sensor = A0;

int lm35 = A1;

int m1 = 12;

int m2 = 13;

int s1 = 3;

int s2 = 4;

int s3 = 5;

int ldr = A5;
```

```
int brightness;

int brightness1;

int led = 7;

int x;

int y;

int z;

void setup()

{

  Serial.begin(9600);

  Serial.println("Starting  up");

  pinMode(m1, OUTPUT);

  pinMode(m2, OUTPUT);

  pinMode(s1, INPUT);

  pinMode(s2, INPUT);

  pinMode(s3, INPUT);

}


void loop()

{

  if (digitalRead(s1)  == HIGH)

  {
```

```
  x = 20;
  y = 25;
  z = 100;
}
else if (digitalRead(s2) == HIGH)
{
  x = 30;
  y = 30;
  z = 200;
}
else if (digitalRead(s3) == HIGH)
{
  x = 40;
  y = 35;
  z = 300;
}
if (x > 0 && y > 0 && z > 0)
{
  hum = analogRead(humidity_sensor);
  hum = map(hum, 0, 1023, 0, 100);
  Serial.print("HUMIDITY  = ");
```

```
Serial.print(hum);
Serial.print("%    ");
if (hum < x)
{
  digitalWrite(m1,  HIGH);
}
else {
  digitalWrite(m1,  LOW);
}
temp = analogRead(lm35);
float mv = ( temp / 1024.0) * 5000;
float cel = mv / 10;
Serial.print("TEMPRATURE = ");
Serial.print(cel);
Serial.print("C");
Serial.print("  ");
Serial.print(y);
Serial.print("   ");
if (cel > y)
{
  digitalWrite(m2,  HIGH);
```

```
    }
    else {
      digitalWrite(m2,  LOW);
    }
    brightness = analogRead(ldr);
    Serial.print("BRIGHTNESS  = ");
    Serial.println(brightness);
    if (brightness < z)
    {
      digitalWrite(led,  HIGH);
    }
    else {
      digitalWrite(led,  LOW);
    }
    delay(500);
  }
}
```

CHAPTER FIVE

Conclusion and Recommendations

5.1 Conclusion

- This research represent an application that include an Arduino Control unit and group of sensors in circuit have been designed, tested, simulated and modeled to control a greenhouse facility in order to create the atmosphere that gives the crops best conditions to growth. The main feature is the application make the operator's rule much easier, because the circuit that have been designed to control the greenhouse will do all the work inside the facility, include plants irrigation, configure the appropriate temperature and monitor lighting continuously, in other word, the circuit will control all the factors that directly effect on plant growth.
- In this research Arduino control unit was chosen to be as a heart of the application after has been discovered it is the best controller can be used in such case because it is easy and ready to use, it comes in a complete package form which includes the 5V regulator, a burner, an oscillator, a micro-controller, serial communication interface, LED and headers for the connections.

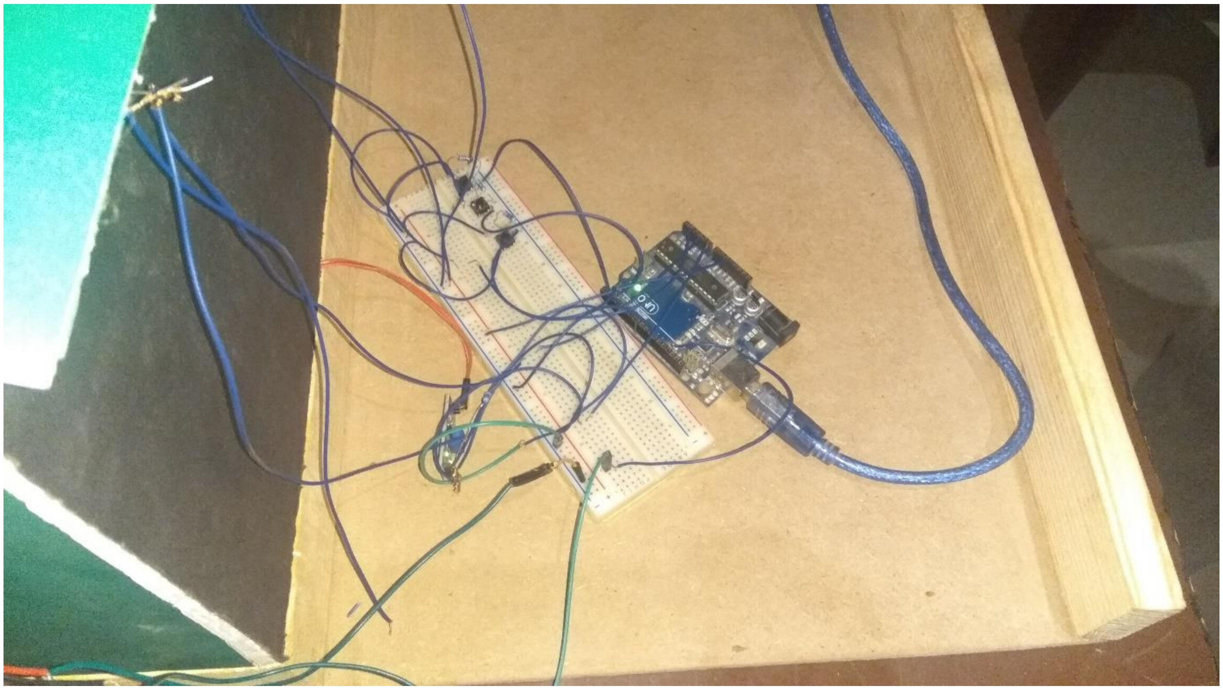
5.2 Recommendations

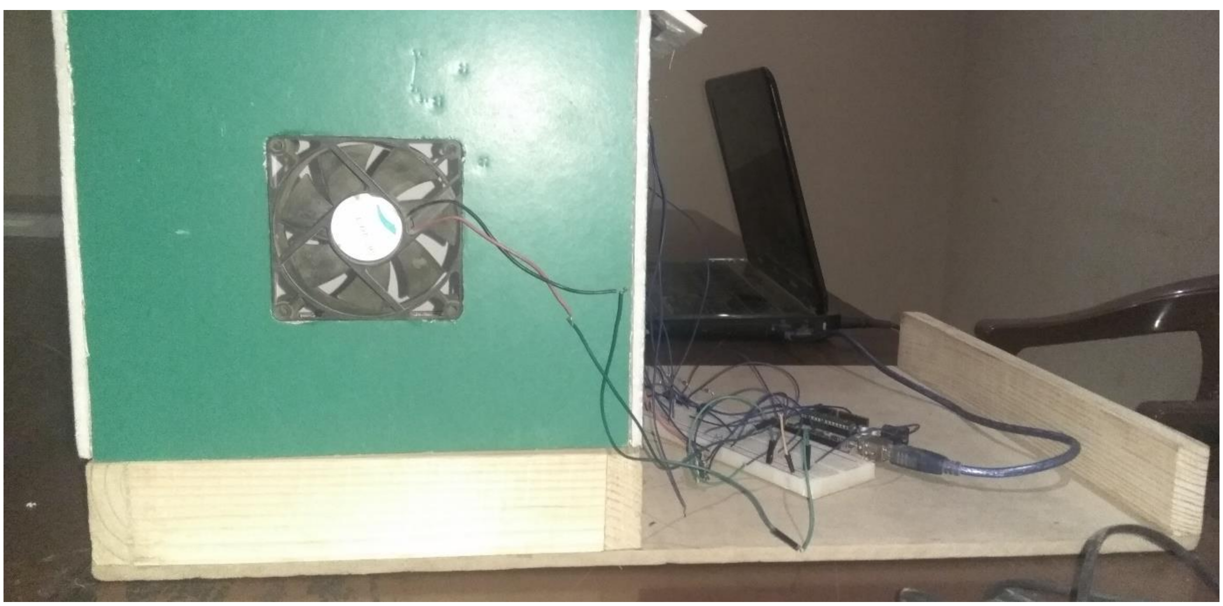
- The usage of electricity for Greenhouse can be reduced by using solar system specially the agricultural area are far from supply.
- More parameters can be detected such as air flow, Carbon monoxide (CO2) and Oxygen (O2) level.

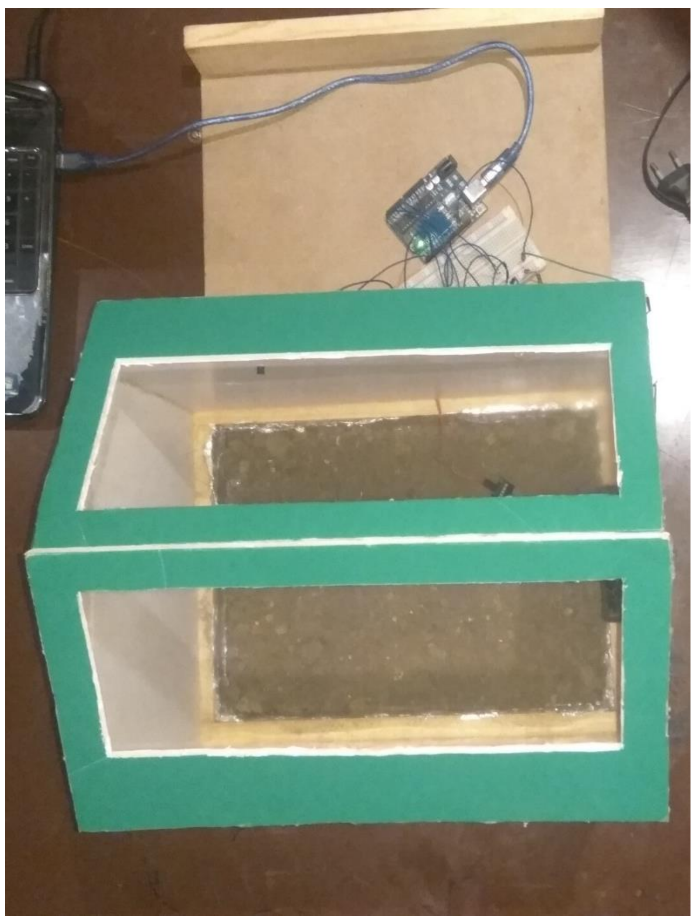
- More data of Greenhouse crops can be added to the system.
- The system provide the user with a daily report about greenhouse system conditions.
- In case of abnormal conditions warning messaged send to mobile phone, email through GSM, and relies alarm in side greenhouse facility.

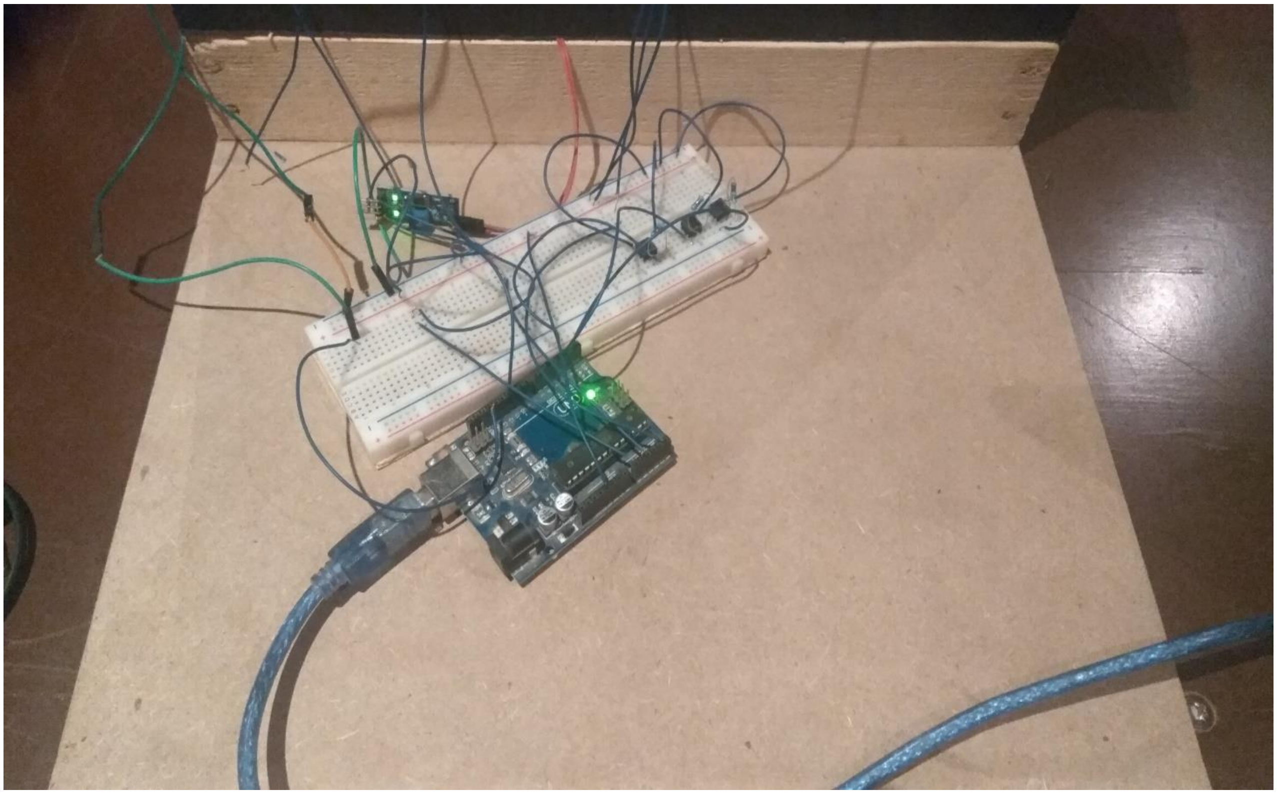
Appendix

- **System model:**









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