# Sudan University of Science and Technology
## College of Graduate Studies


# AUTOMATION OF GREENHOUSES BY USING MICROCONTROLLER

# تطويع البيوت المحمية باستخدام المتحكم الدقيق

Thesis submitted in partial fulfillment to the Requirements for The award of the degree of Master in Electrical Engineering (Microprocessor and Electronic Control)


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# الآيـه

بسم الله الرحمن الرحيم

قال تعالي:( قلْ لَوْ كَانَ الْبَحْرُ مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْرُ قَبْلَ أَنْ تَنْفَدَ كَلِمَاتُ رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا )

صدق الله العظيم

( سوره الكهف الآية 109)

# DEDICATION

**We dedicate to those who have been there for us when were in need, to those who never get tired of helping and supporting us all through the way, especially to our parents.**

# ACKNOWLEDGMENTS

I would like to thank my supervisor Dr. Abd alrasoul Jaber Alzubidi for his unlimited support, guidance, continuous encouragement and also for giving the facilities needed in completion of this thesis. My precious family for moral support through my entire studies which shaped me and made me who I am today. I fully thank all the persons who have been involved in this thesis.

# ABSTRACT

In this thesis, microcontroller(Atmega32) based system to monitor and control greenhouse temperature, humidity, and intensity of light is designed.

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 system comprises of microcontroller(Atmega32), temperature sensor (LM35), humidity sensor (HS1101),light sensor(LDR), LCD(2*16) and actuators(water pumps , heater, fans and lights).

When any change in temperature ,humidity or light cross a safety threshold which has to be maintained to protect the crops, the sensors sense the change and the microcontroller read this from the data at its input ports after being converted to a digital form by the analog to digital converter to control the temperature, humidity and intensity of light by actuating water pumps , heater, fans and lights respectively according to the necessary condition of the crops . Parameters level sensed from the sensor will be displayed in the LCD.

The result that obtained show that the system performance is quite reliable and has successfully overcome quite a few shortcomings of the existing

systems by reducing the power consumption, maintenance and complexity, at the same time providing a flexible and precise form of maintaining the environment.


# المستخلص

الأطروحه تحتوي على تصميم دائرة مبرمجه لتتحكم وتراقب درجة الحرارة ، والرطوبة النسبية وشدة الضوء داخل البيت المحمي حيث يمثل فيها المتحكم ( Atmega32) المتحكم الرئيسي .

البيت المحمي عبارة عن مكان يتم فيه تغيير بيئة نمو النبات وتوفير البيئة المثلى لنمو النبات وتفادي تغيرات المناخ الخارجي . في البيت المحمي يوجد الكثير من المؤشرات البيئية ومن الصعب على الانسان مراقبه كل هذه المؤشرات. ان التغيير في احد المؤشرات البيئيه قد يؤثر في مؤشر بيئي اخر وبالتالي يؤثر في عملية نمو النبات. لذلك لابد من التحكم والمراقبه المستمره لهذه المؤشرات لتحقيق انتاج اكبر، وتحسين نوعية النبات وتحسين الكفاءة الاقتصادية .

النظام يتكون من متحكم دقيق(Atmega32 ) ،متحسس حرارة(LM35 )،متحسس رطوبة(HS1101)،متحسس للضوء(LDR)،شاشة عرض(2*16) واجهزة استجابة( مضخات المياه ،السخان الكهربائي، مراوح ومصادر للإضاءة) .

عند حدوث اي تغير في درجة الحرارة ،او الرطوبة او الضوء عن القيمه المناسبه التي تم تحديدها لحمايه نمو النبات اجهزه الاستشعار تقوم بمعرفه هذا التغير والمتحكم الدقيق يقرا هذا التغير ويتحكم في درجة الحراره والرطوبة وشدة الضوء بتشغيل اجهزة الاستجابة على حسب حوجة النبات.

نتيجة لإستخدام هذا النظام تم حل عديد من مشكلات الأنظمة السابقة حيث تم تقليل الطاقه المستهلكة واصبحت الانظمه أقل تعقيد ويعتمد عليها للحفاظ على بيئة مناسبه لنمو النبات .

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| LCD | Liquid Crystal Display |
| RH | Relative Humidity |
| ◦ F | Fahrenheit |
| T-S | Takagi-Sugeno |
| PDC | Parallel Distributed Compensation |
| LMIs | Linear Matrix Inequalities |
| PGHS | Paprika Greenhouse System |
| GUI | Graphical User Interface |
| AVR | Advanced Virtual Risc |
| ADC | Analog to Digital Converter |
| PC | Personal Computer |
| PH | Potential of Hydrogen |
| MIPS | Million Instructions Per Second |
| MHz | Mega Hertz |
| EEPROM | Electrical Erasable Programmable Read Only Memory |
| SRAM | Static Random Access Memory |
| USART | Universal Synchronous/Asynchronous Receiver Transmitter |
| TQFP | Thin Quad Flat Pack |
| SPI | Serial Peripheral Interface |

| | |
|---|---|
| CPU | Central processing Unit |
| °C | Degree Celsius |
| CHS | Capacitive Humidity Sensor |
| LDR | Light Dependent Resistor |
| BASCOM | Basic Compiler |
| EPROMs | Erasable Programmable Read Only Memories |
| PLDs | Programmable Logic Devices |
| ID | Identification |
| IDE | Integrated Development Environment |
| ISP | in-system programmable |

# 1.1Background:

The concept of greenhouses is Protected agriculture known as crop production to non-conventional means in particular facilities  to protect from inappropriate weather conditions, such as agriculture in tunnels or plastic greenhouses with controlled internal climate control and control (glass or glass Viper) to ensure heating or cooling in summer and winter as well as the appropriate moisture control and plant protection from hot and cold air currents, precipitation and agricultural pests, and which is a sophisticated agricultural and factor in increasing agricultural productivity and quantity of crops.

Early greenhouse control was as simple as pulling a chain to open or close a vent, turning a valve to control heat or irrigation, or throwing a switch to activate a pump or fan. Over the years this evolved as greenhouse systems themselves became more complex and more reliable. Early automated control consisted of independent thermostats, humidistat, and timers. Even these simple devices allowed major advances in efficiency and product quality and made grower's lives simpler. However, many of these control devices and methods cannot deliver the level of automation and efficiency needed in today's dynamic, competitive environment.

A typical greenhouse zone may require 3 or more individual thermostats to control heating and cooling functions, plus timers for irrigation and lighting control. Additional relays are often necessary to interconnect fans and louvers and other devices that must work together.

The advantages: Does not require sensors to carry out programming, these simple devices are low cost.

The disadvantages: Requires extensive knowledge of crops and weather conditions (which are not totally predictable) to operate efficiently, and provide limited control , Lacks feedback from the crop and could damage the crop if programmed incorrectly, poor accuracy Require continuous supervision by the grower in order to maintain acceptable conditions for crop growth and health , and poor energy efficiency.

The common problems experienced with using several independent thermostats and timers to control a greenhouse led to the development of early electronic analogue controls, also known as “step” controls. These devices made a major contribution to improving the growing environment and increasing efficiency by combining the functions of several thermostats into a single unit with a single temperature sensor.

# 1.2 Research Problem:

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. Temperature, humidity and light intensity are the three most common climate variables that most growers generally pay attention to. The solution for all that thing and other in use a microcontroller to monitor and control the greenhouse environment.

# 1.3 Research Objective :

The main objective of the research is to develop a control system to monitor and control the environment of a greenhouse using microcontroller.

# 1.4 Methodology:

The system comprises of sensors, Analog to digital converter, microcontroller and actuators. When any of the above parameters cross a safety threshold which has to be maintained to protect the crops, the sensors sense the change and the microcontroller read this from the data at its input ports after being converted to a digital form by the analog to digital converter. Parameters level sensed from the sensor will be displayed in the LCD Display.

# 1.5 Research out line:

This research is divided into six chapters. Chapter1 is about the introduction and background of greenhouses. It also presents the problem statement, objective and methodology. Chapter2 includes the literature review & control technology and control of some parameters .Chapter3 illustrates the electronic circuit design of greenhouse controlled by microcontroller. Chapter4 illustrate the software of the electronic circuit. Chapter 5 presents results and discussions and finally Chapter 6 Conclusion and recommendations summarizing the work done in the research and highlight several recommendation for future work.

## 2.1 Introduction:

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 [1, 2]. For greenhouse measurement and control system, in order to increase crop yield, improve quality, regulate the growth period and improve the economic efficiency, the optimum condition of crop growth is obtained on the basis of taking full use of natural resources by changing greenhouse environment factors such as temperature, humidity, light, and CO2 concentration.The development of greenhouse measurement and control system has made considerable progress in the developed countries, and reached the multi factors comprehensive control level, but if the foreign existing systems is introduced, the price is very expensive and maintenance is not convenient.

## 2.2 Temperature 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.[3]

Temperature is raised by heating, generally by hot water circulated in ground level pipes, and lowered by opening roof ventilators. [4]

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.[5]

TO measure the temperature the sensor tip must not be exposed to radiant energy, such as from direct sunlight or a heating system radiator, as this will increase the sensor tip temperature. In that case, the measurement taken would not be representative of the surrounding air temperature. Accurate measurement of the air temperature is best accomplished using an aspirated housing to move an air sample across the sensor and protect the sensor from direct exposure to solar radiation. This ensures a more representative measurement of the greenhouse air temperature.

Two temperatures are important when dealing with evaporative cooling systems; dry bulb temperature and wet bulb temperature.

Dry bulb temperature is the temperature that is usually thought of as air temperature. It is the temperature measured by a regular thermometer exposed to the air stream.

The wet-bulb temperature is the temperature at which air is fully saturated (100% RH). Wet bulb temperature is an indication of the amount of moisture in the air. Wet bulb temperatures can be determined by checking with local weather station or by investing in an aspirated psychrometer, a sling psychrometer, or an electronic humidity meter. The best time to measure wet bulb temperature to calculate the potential cooling performance of the evaporative cooling system is in the afternoon. This is when dry bulb temperature is at its peak because solar radiation and outside temperatures are highest.

## 2.3 Humidity Control:

There are several terms that describe humidity and several ways to measure humidity. Relative Humidity indicates the “relative” fraction of water vapor in a volume of air to how much water vapor that air would contain at saturation at the same temperature and pressure. [6]

Controlling the humidity in the greenhouse can yield powerful benefits in disease reduction, improved water and nutrient uptake, and improved plant growth. It is too often underutilized and not well understood. Humidity control is a standard function of nearly all greenhouse control systems. Accurate humidity sensing can be a challenge, even with the most expensive sensors, which are typically not suitable or practical for the commercial greenhouse industry.

Humidity can generally be lowered by ventilation (which may also necessitate heating) and raised by the evaporation of water supplied from fogging nozzles. Wet and dry bulb thermometers, usually resistance elements, are used to determine the air temperature and humidity.

To measure the humidity there are two ways:

- **The traditional way to measure relative humidity:**

This is a two-step process: both wet bulb and dry bulb temperatures are obtained, and then converted to relative humidity using a psychrometric chart. The dry bulb temperature is commonly measured with a standard thermometer. The wet bulb temperature is determined from a standard thermometer modified with a wetted fabric wick covering the sensor bulb. Sufficient airflow is provided over the wick material so that as water evaporates from the wet wick, the temperature falls and the thermometer reading reflects the wet bulb temperature. A clean bulb wick (e.g., a hollow, white shoelace from a sneaker) soaked with distilled water (to prevent salt buildup on the wick) provides the best accuracy. The wick will have to be wet continuously if continuous measurements are required. With a wet wick, measured temperatures must be above freezing. Air movement can be provided through an aspirated box (with a fan) or by whirling the dry bulb/wet bulb thermometer through the air. The traditional relative humidity instrument, called a sling psychrometer, contains both dry bulb and wet bulb thermometers. The sling around swiftly (creating an airspeed of approximately 900 feet per minute [fpm] around the thermometer bulbs) on a jointed handle for about three minutes to obtain sufficient air movement needed to extract an accurate wet bulb temperature.

- **Hygrometer:**

Hygrometer is an instrument for directly measuring of relative Humidity (rather than being determined from two temperatures and the psychrometric chart). The sensor is a matrix material in which electrical properties change as water molecules diffuse into or out of the matrix material in response to air moisture content. Other hygrometers use materials, which indicate electrical changes as water molecules adhere to their surface. Sensor material changes are interpreted and displayed by the hygrometer. Careful calibration is essential. The sensor materials may not tolerate conditions near saturation. So reliability of many relative humidity sensors is questionable when the relative humidity rises above 95%. Condensation on the hygrometer surface coats the matrix material so that water molecules no longer diffuse in or out. Until the condensation is evaporated, the hygrometer will often display inaccurate humidity readings or there may be a permanent change in electrical properties.

# 2.4 Greenhouse Cooling:

Techniques of cooling can be organized into several categories; each utilizes the evaporative cooling process to reduce air temperature, as well as fan ventilation for exchanging the moist air with dry outside air. Greenhouse cooling reduces plant stress caused by high leaf and air temperatures. The root and stem system may not be able to supply adequate water to the leaves, thereby limiting transpiration, the plant cooling mechanism. Also, hot and humid air around the leaves will reduce the effectiveness of transpiration at the leaf surface. [7]

# 2.5 Greenhouse Heating :

The purpose of the heating system is to replace energy lost from the greenhouse when outside temperatures are lower than desired in the greenhouse growing area. Heat is transferred by conduction, convection, and radiation. Radiation heat loss can represent 25% or more of the total heat loss for a double-layer polyethylene greenhouse on clear nights.

The heat loss from a greenhouse depends upon three parameters:

(1) The surface area of the greenhouse.

(2) The location of the greenhouse and crop to be grown.

(3) The greenhouse heat loss rate which is largely dependent upon the glazing material.

Two of these are readily determined, and the third is an approximation depending upon the glazing and its condition and whether or not thermal screens are in place. Heat losses down to the ground are usually negligible relative to losses to the atmosphere. These are usually not included because the temperature difference between the greenhouse and soil is small and the heat transfer coefficient is relatively small. [8]

# 2.6 Light Control :

Plants respond to the relative lengths to light and dark periods as well as to the intensity and quality of light. Artificial light has been used extensively to control plant growth processes under various conditions. Plants differ in the need for light; some thrive on sunshine, others grow best in the shade. Most plants will grow in either natural or artificial light. Artificial light can be used in the following ways

•To provide high intensity light when increased plant growth is desired.

•To extend the hours of natural daylight or to provide a night interruption to maintain the plants on long-day conditions.

Proper lighting not only extends the gardening day by enabling the gardener to work in the greenhouse during the dark evenings of winter and early spring, but it aids plant growth.

## 2.7 Previous Work

The idea of growing plants in environmentally controlled areas has been around for a long time. Doctors for the Roman emperor Tiberius prescribed a cucumber a day for him. The Roman gardeners used artificial methods (similar to the greenhouse system) of growing to have it available for his table every day of the year. Cucumbers were planted in wheeled carts which were put in the sun daily, and then taken inside to keep them warm at night. The cucumbers were stored under frames or in cucumber houses glazed with either oiled cloth known as "specularia" or with sheets of mica. (Pliny the Elder and Columella). [9]

The first modern greenhouses were built in Italy in the Sixteenth Century to house the exotic plants that explorers were bringing back from the tropics. They were originally called giardini botanici (botanical gardens). The concept of greenhouses soon spread to Holland and then England, along with the plants. Some of these early attempts required enormous work to close up at night, or to winterize. There were serious problems with providing adequate and balanced heat in these early greenhouses.

Jules Charles, a French botanist, is often credited with building the first practical modern greenhouse in Leiden, Holland to grow medicinal tropical plants. In the Eighteenth Century the largest greenhouses were built. The conservatory at Kew Gardens in England is a prime example of the Victorian greenhouse. Although intended for both horticultural and non-horticultural exhibition these included London's Crystal Palace, the New York Crystal Palace and Munich’s Glaspalast. Joseph Paxton, who had experimented with glass and iron in the creation of large greenhouses as the head gardener at Chatsworth, in Derbyshire, working for the Duke of Devonshire.

In Japan, the first greenhouse was built in 1880 by Samuel Cocking, a British merchant who exported herbs. In the Twentieth Century the geodesic dome was added to the many types of greenhouses.

The success of greenhouse production depends on the efficient delivery of nutrients and water to the plants while maintaining an ideal climate within the greenhouse. Recently, research projects have been initiated to grow plants within controlled environment for purposes other than providing plant materials to meet market requirements. Plants are an important resource for sustaining and enhancing human lives and the environment. Forms of protected cultivation of plants range from growing under simple covers to production within highly integrated controlled environments.

Dusyant Pande et al [10] have discussed about The Real Time Hardware Design to Automatically Monitor Light and Temperature. In this paper, temperature and light monitoring is done with the help of two sensors and displayed on an LCD screen and the desired values of temperature and light are set with the help of provided keypad. They have used PIC microcontroller and an ADC 0809 .

A. Goswami et al [11] have proposed an Embedded System for Monitoring and Controlling Temperature and Light. In this system microcontroller AT 89S52 is used which is a 40 pin IC. The temperature measurement and light intensity from the channels of ADC 0809 are taken. The performances of the channels are distinguished on the basis of its accuracy. The accuracy indicates how accurately the sensor can measure the actual and the real world parameter. In our system we have used a 28 pin IC ATMega 328.

R. A. Eigenberg et al [12] have development a system for Rugged Environmental Monitoring Units for Temperature and Humidity. This system has additional complexity of construction and calibration for certain applications that involve harsh environment. The system also doesnot have any hardware control unit to meet specific conditions.

I. G. Saidu et al [13] have designed a Temperature Monitoring and Logging System suitable for use in Hospitals, incorporating GSM Text Messaging. Their system design using ATMega16 helps to manage the temperature of a patient that is possibly critically ill in the hospital or to monitor the operations of other hospital operations such as preservation of food, drugs, etc. Here, they have discussed the implementation of intelligent sensors that finds application in distributed measurement and monitoring
systems like meteorological stations .

Nachidi *et al* [14] have proposed system to control of air temperature and humidity concentration in greenhouses is described by means of simultaneous ventilation and heating systems by using Takagi-Sugeno (T-S) fuzzy models and the Parallel Distributed Compensation (PDC) concept**.** And showed that the robust fuzzy controller effectively achieves the desired climate conditions in a greenhouse, using this T-S fuzzy model, the stability analysis and control design problems can be reduced to sufficient conditions expressed as Linear Matrix Inequalities (LMIs) .

Palaniappan *et al* [15] have proposed an embedded greenhouse monitoring and control system to provide a highly detailed micro-climate data for plants within a greenhouse environment with an innovative method of growing temperate crops in a tropical environment using microclimatic conditions. The greenhouse was equipped with conventional wired sensors that provide readings of the air temperature, light intensity and nutrient solution temperature in the mixing tank. The acidity and concentration of the nutrient solution were manually measured, and adjusted accordingly, and high resolution data, collected with the deployment of a network of wireless sensors to provide sufficient data to develop a model for the growth of these crops under aeroponic conditions. The researcher claimed that the reliability of the star network was relatively high, with many nodes performing with a data transmission rate above 90%, where the minimum data transmission rate for all the nodes was 70% .

Lee *et al* [16] have suggested the 'Paprika Greenhouse System' (PGHS) which collects paprika growth information and greenhouse information to control the paprika growth at optimum condition. Also controls ventilators, humidifiers, lightings and video-processing through Graphical User Interface (GUI) Application by analyzing the measured data. The system provides with the 'growth environment monitoring service', which is monitoring the paprika growth environment data using sensors measuring temperature, humidity, illuminance, leaf wetness and fruit condition, the 'artificial light-source control service', which is installed to improve the energy efficiency inside greenhouse, and 'growth environment control service', controlling the greenhouse by analyzing and processing of collected data.

Song *et al* [17] have proposed system based on AVR Single Chip Microcontroller and wireless sensor networks. The monitoring and management center can control the temperature and humidity of the greenhouse, measure the carbon dioxide content, and collect the information about intensity of illumination. In addition, the system adopts multilevel energy memory. It combines energy management with energy transfer, which makes the energy collected by solar energy batteries be used reasonably. Therefore, the self managing energy supply system is established. The system has advantages of low power consumption, low cost, good robustness, extended flexible as well as an effective tool for monitoring and analysis decision-making of the greenhouse**.**

Mittal *et al* [18] have designed hardware for green house monitoring various sensors are used to control the environment. The parameters *e.g.* temperature, humidity, light intensity for green house and soil wetness for crop growth. The system comprises of sensor, ADC, microcontroller and actuators. When any of the above mentioned climatic parameters cross a safety threshold which has to be maintained to protect the crops, the sensors sense the change and the microcontroller reads this from the data at its input ports after being converted to a digital form by the ADC. The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity, at the same time providing a flexible and precise form of maintaining the environment. The continuously decreasing costs of hardware and software, the wider acceptance of electronic systems in agriculture, and an emerging agricultural control system industry in several areas of agricultural production, will result in reliable control systems that will address several aspects of quality and quantity of production.

Sahu and Mazumdar [19] have designed a simple, easy to install, microcontroller-based (Atmel) circuit to monitor and record the values of temperature, humidity, soil moisture and sunlight of the natural environment that are continuously modified and controlled in order optimize them to achieve maximum plant growth and yield. The microcontroller communicates with the various sensor modules in real-time in order to control the light, aeration and drainage process efficiently inside a greenhouse by actuating a cooler, fogger, dripper and lights respectively according to the necessary condition of the crops. An integrated Liquid Crystal Display (LCD) is also used for real time display of data acquired from the various sensors and the status of the various devices .

Alausa Dele and Kolawole [20] have proposed microcontroller based greenhouse control device is used in the automatic control and monitoring of Equipments and quantities such as screening installations, heating, cooling, lighting, temperature, soil Moisture level and other quantities/conditions in a greenhouse, with effective monitoring of all quantities therein, hence eliminating need for Human monitoring. With an enhance able feature it integrates and automates by turning ON or OFF all monitoring devices in the house as well as provides suggestions for remedies when the need arises. The system has successfully overcome quite a few short comings of the existing systems by reducing the power consumption, maintenance and complexity, at a reduced cost and at the same time providing a flexible and precise form of maintaining the environment .

## 2.8 About Automation Control System For Greenhouse Environment:

Automation in its modern usage can be defined as a technology that uses programmed commands to operate a given process, combined with feedback of information to determine that the command have been properly executed. When automated, the process can operate without human assistance. In fact, most automated systems are capable of performing their function with greater accuracy & precision and in less time that humans are able to.

The purpose of automation is to equip engineering systems with human-like capabilities of perception, reasoning/learning, communication, and task planning/execution. Two major categories of automation are fixed automation and flexible automation.

### 2.8.1 Systems :

System analysis and integration is a methodology that starts with the definition of a system and its goals, and leads to the conclusion regarding the system’s workability, productivity, reliability, and other performance indicators. Two key resources in systems analysis are: (1) information about individual system components as well as their interrelationships and (2) methods of information gathering and processing for creating value added information.

### 2.8.2 Environment :

Environment encompasses the surroundings of plants, which consist of climatic and nutritional, as well as structural/mechanical conditions. Environmental control has been perceived as a major engineering challenge in controlled environment plant production research in recent years. The climatic conditions that plants experience have been major topics of research. The degree of complexity in controlling this climate is heavily dependent on the physical structure that separates the controlled environment from its surrounding “external” environment. The interaction of the environment on both sides of the structure and the desired level of maintainability dictate the extensiveness of the control system hardware, software, and actuators.

The specific challenges faced by greenhouse automation: are as follows: making return on investment attractive; optimizing systems by properly integration of automation; culture, and environment (i.e. the ACESYS concept); balancing fixed automation and flexible automation (i.e. identifying appropriate level of necessary machine intelligence); considering multiple use of machine or parts of machine; dealing with the limited market demand and acceptance; and continuously improving research and development capabilities.

## 2.9 Greenhouse Control Technology :

Precise control of the greenhouse environment is critical in achieving the best and most efficient growing environment and efficiency. Early greenhouse control was as simple as pulling a chain to open or close a vent, turning a valve to control heat or irrigation, or throwing a switch to activate a pump or fan. Over the years this evolved as greenhouse systems themselves became more complex and more reliable. Early automated control consisted of independent thermostats, humidistat, and timers. Even these simple devices allowed major advances in efficiency and product quality and made grower's lives simpler. However, many of these control devices and methods cannot deliver the level of automation and efficiency needed in today's dynamic, competitive environment. In nature, plants do not experience a closely controlled environment and there is little evidence to suggest ever closer set point control will give an economic benefit.

Some benefits of Integrated control system in greenhouse:

- Higher Energy Efficiency
- Better Labor Efficiency
- Improved Management Effectiveness
- Reduced Water Use
- Reduced Fertilizer Use
- Reduced Chemical Use
- Improved Plant Quality & Uniformity
- Reduced Equipment Wear & Tear
- Less Plant Loss from Failures

# 2.10 Levels Of Control :

There are three levels of control requirements and equipment that need to be addressed in every zone.

### 2.10.1 Equipment Level (Control of individual equipment) :

This refers to devices that control or interface with a single type of equipment. Examples include motor controllers to control vent operation, contactors and motor starters for pumps, fans, etc. Any control system must be able to manage the equipment based on its specific and unique operational requirements.

### 2.10.2 Function Level :

This refers to control of all equipment for a particular function, such as temperature management, irrigation, fertilization, etc. Individual controllers may be electronic (analog step controllers) or microprocessor based controls. For example, temperature controllers generally provide 5-12 control outputs, depending on manufacturer and model, which allow for 2 or 3 stages of heating, and 3-5 stages of cooling. Some models will control cooling vents and heat mixing valves.

### 2.10.3 System Level (Control of all equipment, functions, and systems):

The operation of each piece of equipment in the greenhouse is affected by the operation of other equipment and changes in climate conditions. A single piece of equipment or system often performs more than one task (i.e. heaters both heat and dehumidify) and these requirements can occur simultaneously, or overlap due to time lags between an equipment operation and its ultimate effect. Fully integrated, system level control is designed to bring all of the systems in the greenhouse facility together into a single well-orchestrated and coordinated system. These integrated systems can only be effectively managed by computers which can monitor and control every aspect of the climate simultaneously.

There are two types of Integrated Computer Control systems:

- **Single Processor Centralized Control :**

These systems have a single computer processor that controls all zones from a single unit. Sensors and outputs can be wired back to the central unit or connected to local stations that then communicate with the central processor unit. A dedicated terminal or PC generally accesses these units. This architecture was common in early systems and is still used in some systems, particularly European systems. Installation of this type of system generally requires more wiring and can be more complex. If the single control unit fails, the entire facility is without automated control until it can be repaired. The overall capability of these systems is comparable to multiple processor controls.

- **Multiple Processor Distributed Control :**

These systems are comprised of multiple control units, each with its own processor, connected together to share information and integrate the control of common or global systems such as water mains and boilers. Sensors and control outputs are wired locally to the control units at or close to each zone rather than running back to a central unit. The individual control units in the system are usually accessed through one or more computer terminals, which are usually a standard PC. In some systems the access is available through a screen and keypad mounted on the individual control panels, although most companies offer a central PC interface as an option or standard to provide centralized full-featured operator access.

Integrated Control Systems provide more than control. They also deliver substantial management information to managers and growers. Data recording programs capture sensor readings and trends, and record the computer’s functions, automatically saving this data for analysis. Growers can identify unacceptable environment trends in the greenhouse, such as insufficient temperatures or excessive humidity, or equipment malfunctions, before the plants are negatively affected. Previous successes can be more easily repeated by capturing and duplicating conditions that worked well. Light levels and quality, soil moisture levels, CO2 levels, water application rates and quantities, nutrient and pH levels, and a host of other factors and conditions can be monitored and archived.

## 3.1An Overview Of The Greenhouse Design:

In this research a digital circuit is designed, assembled and implemented by using several components and devices as shown in figure 3.1 . The proposed system is an embedded system which will closely monitor and control the microclimatic parameters of a greenhouse on a regular basis round the clock for cultivation of crops or specific plant species which could maximize their production over the whole crop growth season and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent.

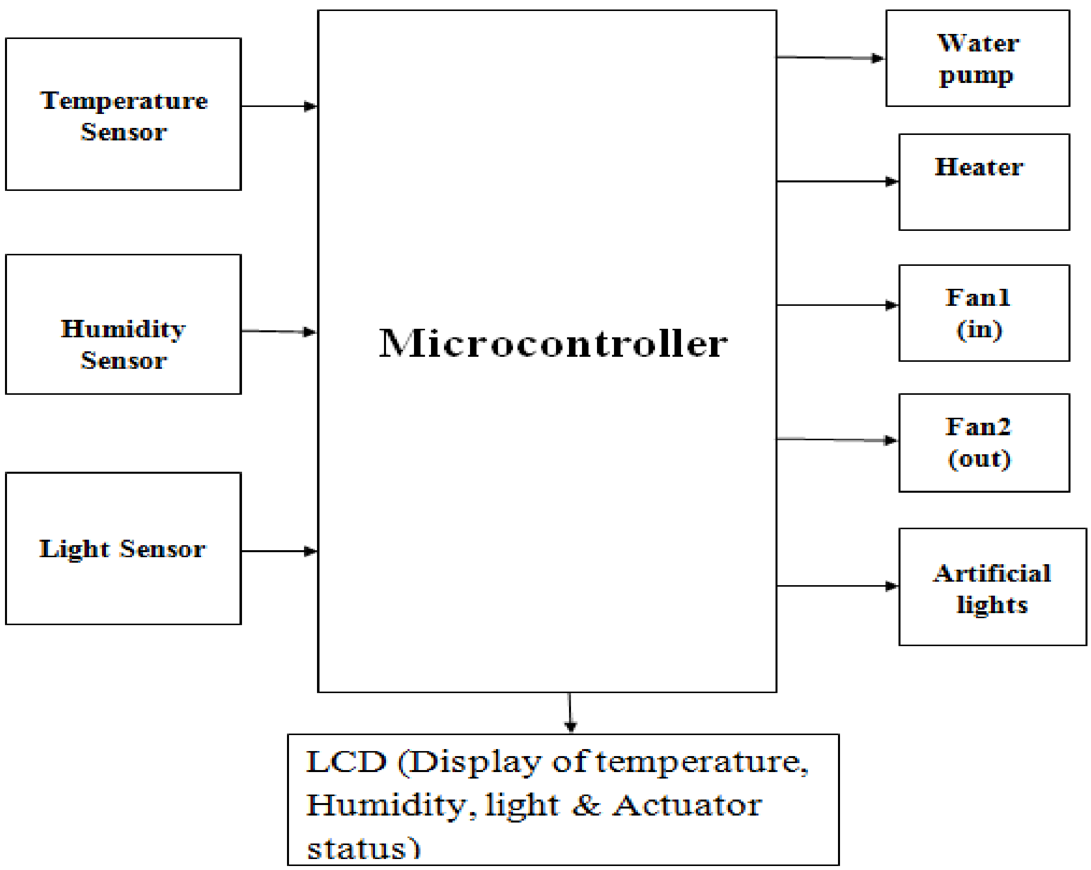


Figure 3.1: Block diagram of the system

# 3.2 Parts Of The System:

• Microcontroller (atmega32)

• Sensors (Data acquisition system):

-Temperature sensor (LM35)

-Humidity sensor( HS1101)

-Light sensor (LDR)

• Analog to Digital Converter

• Liquid Crystal Display

• Actuators – Relays

• Devices controlled:

- Water pump
- Two fans (Fan1(in)&Fan2(out))
- Heater
- Artificial Lights

## 3.2.1 Microcontroller (Atmega32):

ATmega32 is a low-power CMOS 8-bit microcontroller based on the AVRenhanced RISC architecture. By executing powerful instructions in a single clock cycle, the Atmega32 achieves throughputs approaching 1 MIPS per MHz allowing the system designer to optimize power consumption versus processing speed

The Atmega32 provides the following features:

- 32Kbytes of In-System Programmable Flash Program memory with Read-While-Write capabilities
- 1024bytes EEPROM, 2Kbyte SRAM,
- 32general purpose I/O lines

- 32 general purpose working registers
- a JTAG interface for Boundaryscan
- On-chip Debugging support and programming,
- three flexible Timer/Counters with compare modes,
- Internal and External Interrupts
- a serial programmable USART
- a byte oriented Two-wire Serial Interface
- an 8-channel
- 10-bit ADC with optional differential input stage with programmable gain (TQFP package only)
- a programmable Watchdog Timer with Internal Oscillator
- an SPI serial port and six software selectable power saving modes.

The Idle mode stops the CPU while allowing the USART,Two-wire interface, A/D Converter, SRAM, Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator,disabling all other chip functions until the next External Interrupt or Hardware Reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping. The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode,both the main Oscillator and the Asynchronous Timer continue to run. Figure 3.2 shows Pin out Atmega32.(Appendix B)

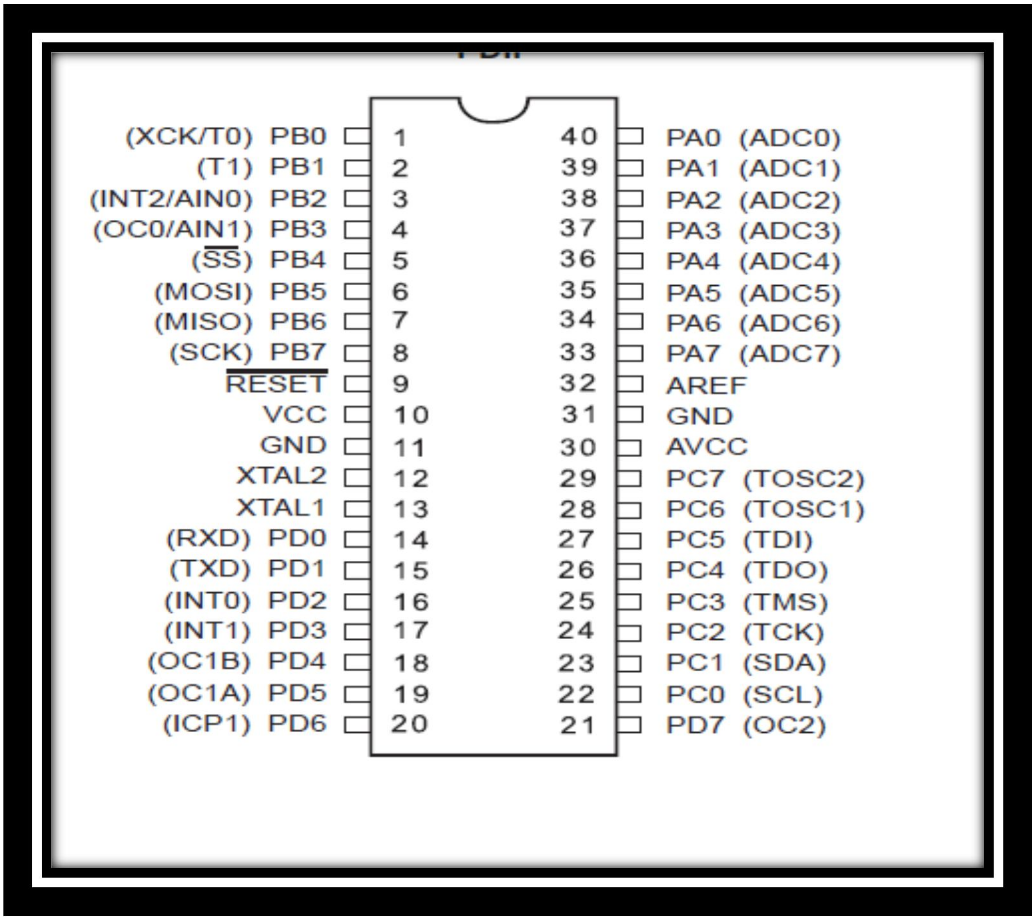


**Figure3.2:** Pin out Atmega32

### 3.2.1.1 Port A (PA7..PA0):

Port A serves as the analog inputs to the A/D Converter. Port A also serves as an 8-bit bi-directional I/O port, if the A/D Converter is not used. Port pins can provide internal pull-up resistors (selected for each bit). The Port A output buffers have symmetrical drive characteristics with both high sink and source capability. When pins PA0 to PA7 are used as inputs and are externally pulled low, they will source current if the internal pull-up resistors are activated. The Port A pins are tri-stated when a reset condition becomes active, even if the clock is not running.

#### 3.2.1.2 Port B (PB7..PB0):

Port B is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port B output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port B pins that are externally pulled low will source current if the pull-up resistors are activated. The Port B pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port B also serves the functions of various special features of the Atmega32.

#### 3.2.1.3 Port C (PC7..PC0):

Port C is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port C output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port C pins that are externally pulled low will source current if the pull-up resistors are activated. The Port C pins are tri-stated when a reset condition becomes active, even if the clock is not running. If the JTAG interface is enabled, the pull-up resistors on pins PC5 (TDI), PC3 (TMS) and PC2 (TCK) will be activated even if a reset occurs. The TD0 pin is tri-stated unless TAP states that shift out data are entered. Port C also serves the functions of the JTAG interface and other special features of the Atmega32.

#### 3.2.1.4 Port D (PD7..PD0):

Port D is an 8-bit bi-directional I/O port with internal pull-up resistors (selected for each bit). The Port D output buffers have symmetrical drive characteristics with both high sink and source capability. As inputs, Port D pins that are externally pulled low will source current if the pull-up resistors are activated. The Port D pins are tri-stated when a reset condition becomes active, even if the clock is not running. Port D also serves the functions of various special features of the Atmega32.

### 3.2.2 Temperature Sensor (LM 35):

Temperature sensing technology is one of the most widely used sensing technologies in the modern world. It allows for the detection of temperature in various applications and provides protection from excessive temperature excursions. The LM35 shown in Figure 3.3 was selected in this application. The LM35 is a precision integrated circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature, thus it 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 water level.

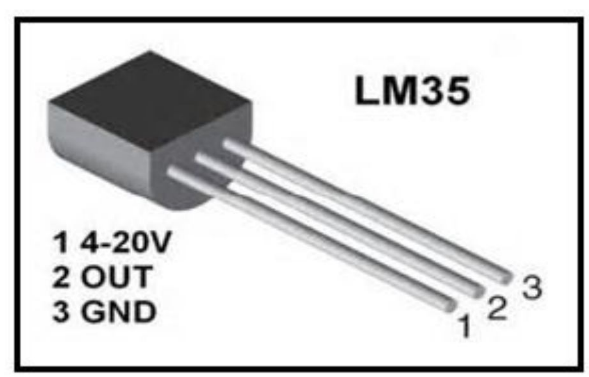


Figure3.3: The LM35 temperature sensor

Table 3.1 shows the technical specification of LM35. (Appendix C).

| Specification | Value |
|---|---|
| Power Supply: | 4 to 20 voltages |
| Temperature Measuring Range | -55 to 150°C |
| Output Voltage | +6V to −1.0V |
| Output Current | 10mA |

### 3.2.3 Humidity Sensor (HS1101):

A humidity sensor measures and regularly reports the humidity in the air. When it comes to humidity sensing technology, there are three types of humidity sensors: capacitive, resistive and thermal conductivity humidity sensors. The sensor that used in this thesis is the relative humidity sensor HS1101 as shown in Figure 3.4. This HS1101 is based on a unique capacitive cell; therefore, by using simple RC circuit wiring it is easy to interface with any microcontroller, which is widely used in industrial, home and office automation, and weather telemetry applications.

Figure 3.4: Humidity sensor

The changes in the dielectric constant of a Capacitive Humidity Sensor (CHS) are nearly directly proportional to the relative humidity of the surrounding environment. HS1101 have analog output of varying capacitance in response to change in relative humidity.

Table 3.2 shows technical Specification of HS1101 sensor. (Appendix D).

| Specification | Value |
| --- | --- |
| Power Supply: | 5 to 10 V |
| Humidity Measuring Range | 1 to 99% RH |
| Operating Temperature | 40 to 100 °C |

### 3.2.4 Light Dependent Resistor (LDR):

Light dependent resistor (LDR) also know as photoconductor or photocell. Plants use light in the range of 400 to 700 nanometers which is most commonly referred to as PAR (Photo-synthetically Active Radiation). Monitoring PAR is important to ensure their plants are receiving adequate light for photosynthesis. Light Dependent Resistors (LDR) shown in Figure 3.5 was selected in this application. LDR is basically a resistor that has internal resistance increases or decreases dependent on the level of light intensity impinging on the surface of the sensor where it measures visible light as seen by the human eye with fast response, and small in size. Table 3.3 shows technical specification of LDR.

Feature:

-Quick response.

-Reliable performance.

-Epoxy or hermetical package.

-Good characteristic of spectrum.

Figure 3.5: light dependent resistor

Table 3.3 shows technical specification of LDR. (Appendix E).

| Specification | Value |
|---|---|
| Voltage ,AC or DC peak | 320V |
| Current | 75mA |
| Power Dissipation at 30°C | 250mW |
| Operating temperature range | -60°C to 75°C |

### 3.2.5 Analog To Digital Converter :

In physical world parameters such as temperature, pressure, humidity, and velocity are analog signals. A physical quantity is converted into electrical signals. We need an analog to digital converter (ADC), which is an electronic circuit that converts continuous signals into discrete form so that the microcontroller can read the data. Analog to digital converters are the most widely used devices for data acquisition.[21]

Table 3.4 shows Getting data from the analog world

| | | | | |
|---|---|---|---|---|
| Analog world | Transducer | Signal Conditioning | Analog to Digital Converter | Micro-controller |

### 3.2.6 Liquid Crystal Display:

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector. It is often utilized in battery-powered electronic devices because it uses very small amounts of electric power. For this purpose an LCD 2×16 shown in Figure 3.7 .

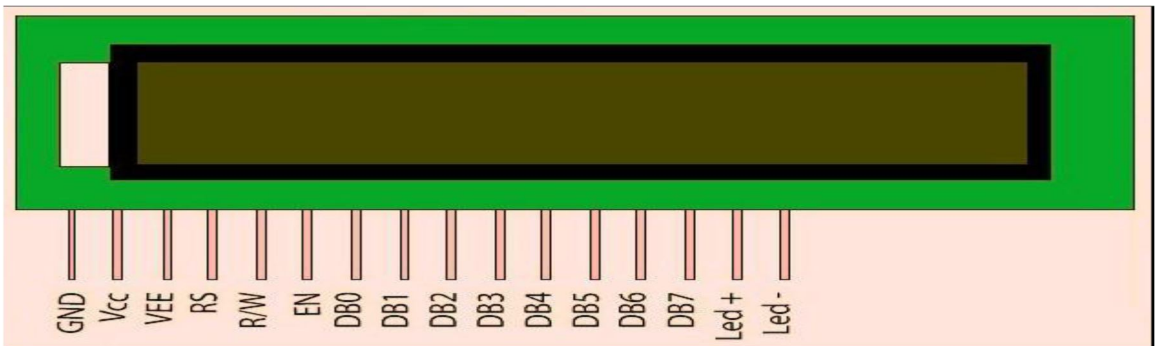


Figure 3.6: LCD and its pin out

Table 3.5 show Technical specifications of the JHD 162A LCD

| Specification | Value |
| --- | --- |
| Number of characters | 16 characters*2 lines. |
| Module dimension | 80.0mm*36.0mm*9.7mm. |
| Area | 66.0mm*16.0mm. |
| Active area | 56.2mm*11.5mm. |
| Dot size | 0.55mm*0.65mm. |
| Dot pitch | 0.60mm*0.70mm. |
| Character size | 2.95mm*5.55mm. |
| Character pitch | 3.55mm*5.95mm. |
| LCD Type | Positive, Reflective, Yellow Green. |

### 3.2.7 Relay:

The relay driver is used to isolate both the controlling and the controlled device. The relay is an electromagnetic device, which consists of solenoid, moving contacts (switch) and restoring spring and consumes comparatively large amount of power. Hence it is possible for the interface IC to drive the relay satisfactorily. To enable this, a driver circuitry, which will act as a buffer circuit, is to be incorporated between them. The driver circuitry senses the presence of a "high" level at the input and drives the relay from another voltage source.

### 3.2.8 Fans:

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 .

### 3.2.9 Heater:

Each plant species has an optimum temperature range. Heating devices will maintain the temperature within that range during periods of cold weather. Important do not undersize the heating capacity. You may not need all your heaters much of the year, but if you undersize your system you may lose your entire crop during the coldest nights of winter.

### 3.2.10 Water Pump:

Pumps provide the means for moving water through the system at usable working pressures. The operation and maintenance of these pumps are some of the most important duties for many water utility operators. There are two basic types of pumps used in water and wastewater systems. The most common type of pump is the centrifugal pump. The other type is the positive displacement pump. And the pump we use it here to run an Overhead Spray Kit.

### 3.2.11 Artificial lights:

Outdoor lighting can be used to provide us with more time in the greenhouse or it can be used to affect the growth of our plants. Greenhouse lighting is designed to provide good general illumination allowing us to work in our greenhouse when it's dark outside. Also known as supplementary lighting, greenhouse lighting can also be used to increase day length during those parts of the year when it starts to get dark earlier - the winter and spring months. Grow lighting is designed specifically to help the growth of your plants and is often used to 'force' plants to flower out of season.

## 3.3 The Circuit Diagram:

- Port A is used as fallow: PA0 is used as connected to the LM35, PA1 is used as connected to the LDR with resistor and PA2 is used as connected to the HS1101 replaced as variable resistor.
- Port B is used as fallow: PB0,PB1,PB2,PB3,PB4 respectively are used as connected to driver with FAN1,FAN2,LAMP,PUMP and heater.
- Port C is used as fallow : PC0,PC1,PC2,PC3,PC4,PC5 respectively are used as connected to reset, enable,D4,D5,D6,D7 of the 2×16 LCD.

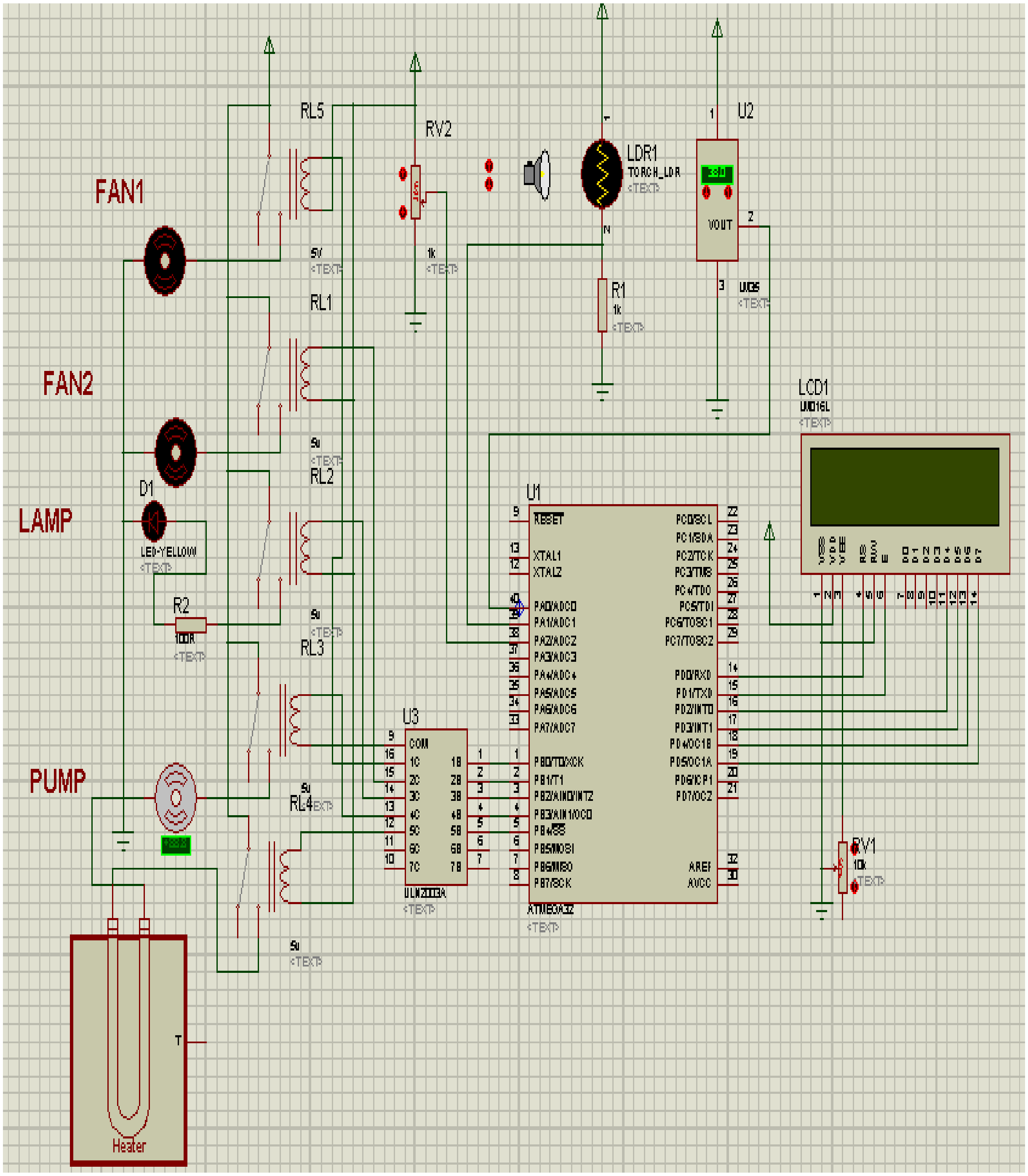


Figure 3.7 shows the simulation circuit diagram

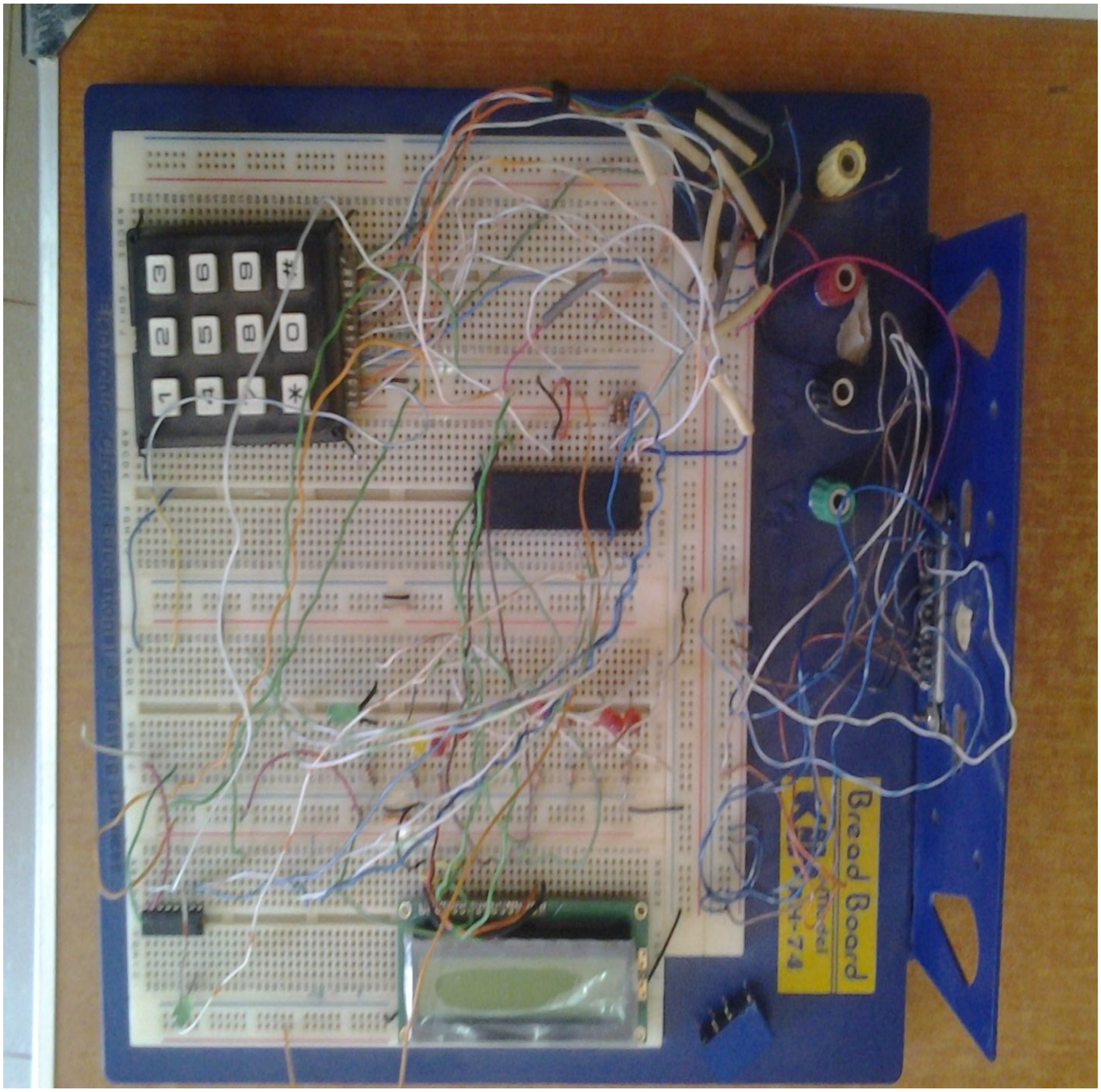


Figure 3.8 shows the practical circuit diagram

## 4.1 Microcontroller Programming:

Programming of microcontrollers means writing its software and stores it inside its internal EPROM or flash memory. Since the user writes the program in the buffer of the PC, some kind of interfacing tools are required to load these programs inside the microcontroller memory. These interfacing tools often called programmers. Each microcontroller family has its own programmer.

Programmers must have the ability to read, erase, program and sometimes verify the program that loaded inside the memory. Modern programmers have their software that enables to perform these operations simply and easily, and more advanced families have in-circuit programmers. Each programmer has its connection with the PC and it can be either serial or parallel.

Some programmers such as Galep-32 are called universal programmers for it can program a wide range of microcontroller families and other devices such as EPROMs, EEPROMs, flash memories, PLDs and other devices.

Programming the microcontroller using Galep-32 can be achieved through these steps:

- Choose the ID of the microcontroller in the programmer’s software.
- Check the memory if it is blank or not.
- Erase the memory if it is not blank.
- Load the program to the programmer’s buffer from where it stored.
- Transfer the program to the microcontroller memory.

# 4.2 Microcontroller’s Software:

When writing a program for the microcontroller using a high level language, the code of the language is known for the user. But for the microcontroller’s processor, two programs must be available to translate this code to one that can be understood by the microcontroller’s processor. These programs are compiler and assembler.

## 4.2.1 Compiler:

A compiler is a computer program (or set of programs) that transform source code written in a computer language (the source code) into another computer language (the target code) often having a binary form. The most common reason for wanting to transform source code is to create an executable file. So, compilers are primarily used for programs that translate source code from a high level language to a lower level language (assembly language) or machine code.

One classification of compilers is by plat form on which their generated source executes. This is known as the target plat form. A native or host compiler is the one whose output is intended to directly runs on the same type of computer and operating system that the compiler itself is runs on. The cross compiler is designed to run on a different plat form, and its often used when developing software for embedded systems that are not intended to support a software developing environment.

## 4.2.2 Assembler:

An assembler is a program that translates programs from assembly language to machine language. It takes the basic computer instructions and converts them into a pattern of bits that the processor can use to perform its basic operations. A program written in assembly language consists of a series of instructions mnemonics that correspond to a stream of executable instructions, when translated by an assembler that can be loaded into memory and executed.

So, when decided to choose software for microcontroller’s programming, the software must contain the compiler and assembler for the desired processor. The software always came in packages of compilers and assemblers for specific microcontroller’s family. These packages has an editor operates under specific language/languages and most of them have simulation technique.

**Requirement for programming learning:**

**1- Get to know the hardware you are using**

▪ Get a copy of the datasheet

▪ Learn about the power supply required

▪ Learn how to configure and connect to input and outputs

▪ Find out about the different types of memory and amount of each

▪ Find out about the speed of processing

**2- Get to know the language and the IDE you are using**

▪ Learn to access the help file (e.g. highlight a word and press F1)

▪ The language has syntax, specific grammar/word rules you must use correctly

▪ The IDE (Integrated Development Environment) has special commands and built in functions you must know and use: $crystal, $regfile, config, alias, const, port, pin

▪ Learn common I/O functions: set, reset, debounce, locate, LCD, GetADC

▪. Understand the limitations of and use variables: byte, word, long, single, double)

▪ Use constants instead of numbers in the code (e.g. waitms timedelay)

g. Get to know the control functions: Do-Loop (Until), For-Next, While-Wend, If-Then (Else). Get to know about text and math functions (read help file, write a few simple programs using the simulator)

**3- Develop Algorithms (written plans for the process the program must carry out)**

▪. Have a goal in mind for the program – use specifications from the brief

▪. Plan your i/o by drawing a system block diagram

▪. Determine variables and constants required in the program

▪ Determine the state of all the I/O when the program begins

▪. Write the algorithm - Identify and describe the major processes the micro must do.

**4-Draw Flowcharts or Statecharts (visual diagram for the process the program must carry out)**

▪. Identify the blocks/states that will be used

▪. Use arrows to link the blocks and visualise control processes and program flow

**5-. Develop code from the flowcharts**

▪. The outer looping line is replaced with a do-loop

▪. Backwards loops are replaced with do-loop do-loop-until, for-next, while-wend

▪. Forward loops are generally replaced with If-Then-End If

▪. Replace the blocks with actual commands

▪. Layout the code with correct indentations(tabs)

▪. Develop an understanding of subroutines and when to use them

▪. Experiment by purposely putting in errors and seeing their effects

# 4.3 BASCOM Software Package:

BASCOM is an Integrated Development Environment (IDE) that supports the 8051 family of microcontrollers and some derivatives as well as Atmel's AVR microcontrollers. Two products are available for the various microcontrollers - BASCOM-8051 and BASCOM-AVR.

### 4.3.1 BASCOM-AVR:

BASCOM-AVR is not only a BASIC Compiler, but also a comfortable Integrated Development Environment (IDE) running under Windows and Windows NT. Such a development environment supports the whole process from coding and testing a program to programming the used microcontroller.

### 4.3.2 Atmel's AVR Microcontrollers:

Atmel's AVR microcontrollers use a new RISC architecture which has been developed to take advantage of the semiconductor integration and software capabilities of the 1990's. The resulting microcontrollers offer the highest MIPS/mW capability available in the 8-bit microcontrollers market today.

The architecture of the AVR microcontrollers was designed together with C-language experts to ensure that the hardware and software work hand-in-hand to develop a highly efficient, high-performance code. To optimize the code size, performance and power consumption, AVR microcontrollers have big register files and fast one-cycle instructions.

The family of AVR microcontrollers includes differently equipped controllers - from a simple 8-pin microcontroller up to a high-end microcontroller with a large internal memory. The Harvard architecture addresses memories up to 8 MB directly. The register file is "dual mapped" and can be addressed as part of the on-chip SRAM, whereby fast context switches are possible.

All AVR microcontrollers are based on Atmel's low-power nonvolatile CMOS technology. The on-chip in-system programmable (ISP), downloadable flash memory permits devices on the user's circuit board to be reprogrammed via SPI or with the help of a conventional programming device.

By combining the efficient architecture with the downloadable flash memory on the same chip, the AVR microcontrollers represent an efficient approach to applications in the "Embedded Controller" market.

# 4.4 System Operation Flow Chart:

The system algorithm for the operation of the greenhouse will be represented in the figure 4.1 below:

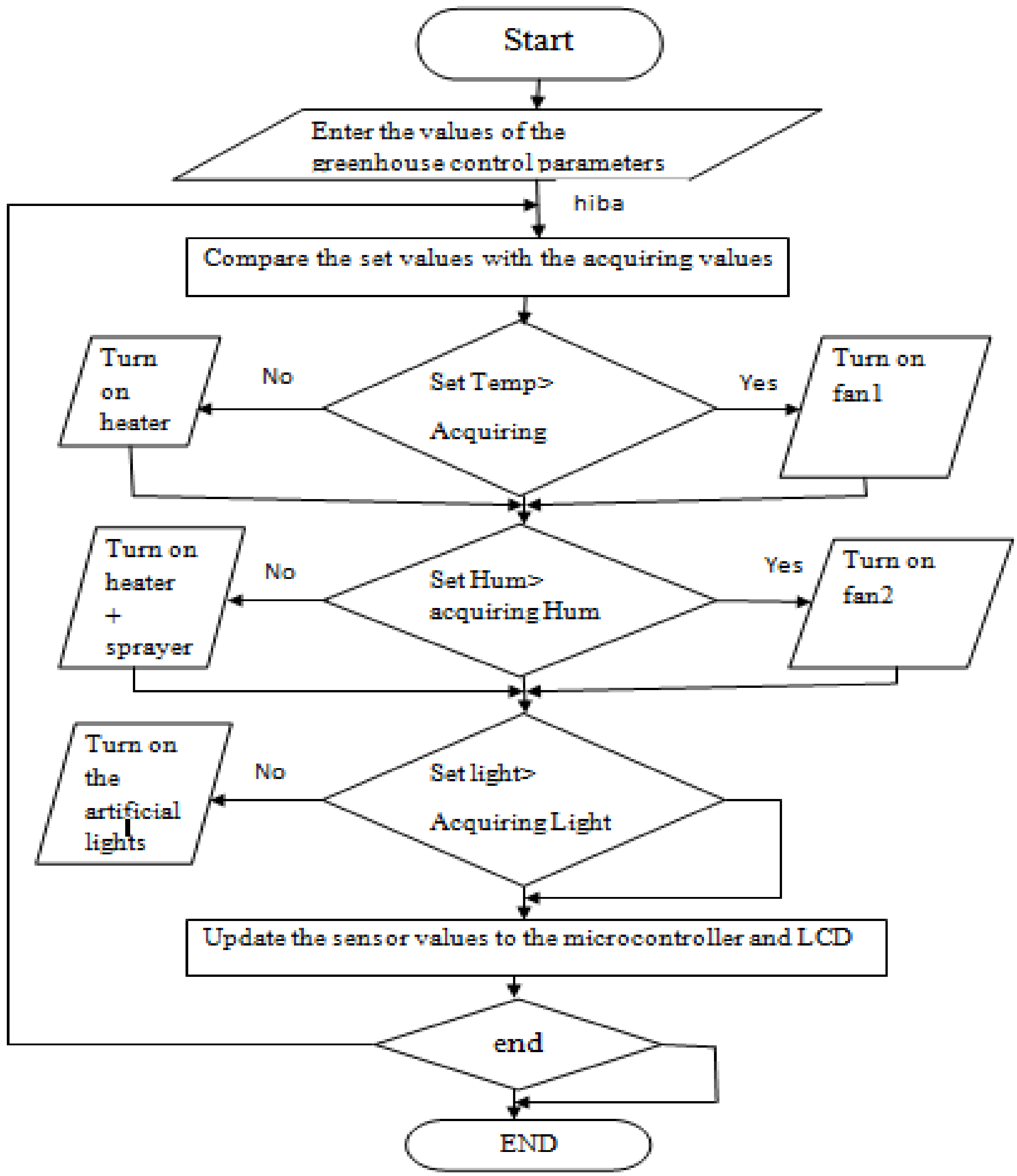


Figure 4:1 System operation flow chart

# 5.1 Results:

Based on implementing the hardware circuit model, the following results are obtained:

**-Temperature control:**

Once the temperature becomes higher than the set limit the system responds by operating the fan1 in blower mode and the heater is switch off as shown in figure 5.1. A continuous tracking to the temperature can be achieved. In addition, while the acquired temperature in the green house was decreasing comparable to the set one the system responds by operating the heater and fan1 will switch off as shown in figure 5.2.

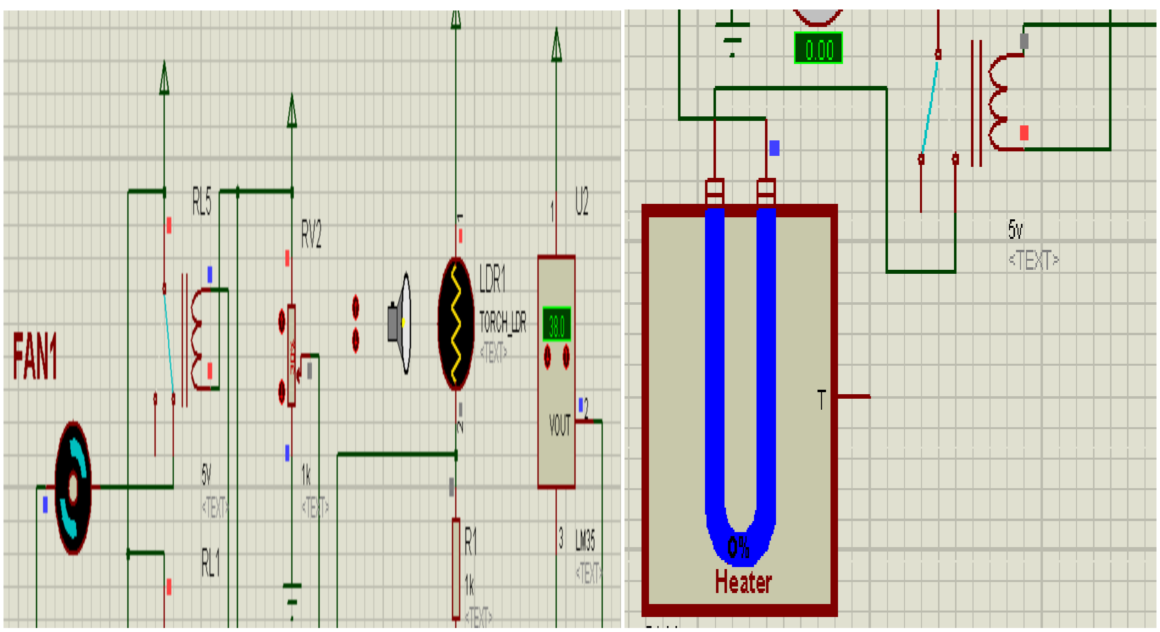


Figure 5.1 The increasing of temperature

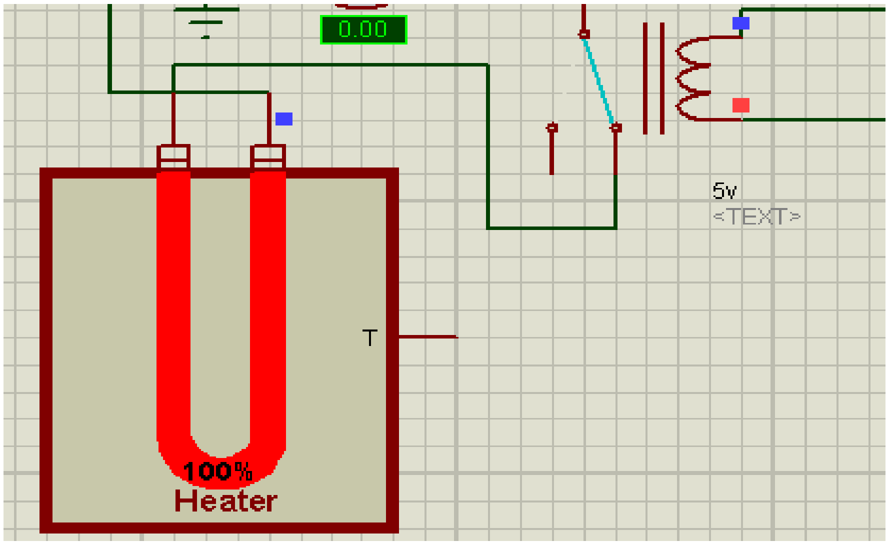


Figure 5.2 The decreasing of temperature

**- Humidity control:**

Once the humidity percentage becomes lower than the set point the system responds by operating the water pump and heater to inject vapor water to the environment of the green house and fan2 switch off as shown in figure 5.3, while the acquiring humidity percentage increasing comparable to the set one the system responds by operating fan2 in sucking mode to reduce the vapor water from the environment and both water pump and heater switch off as shown in figure5.4.

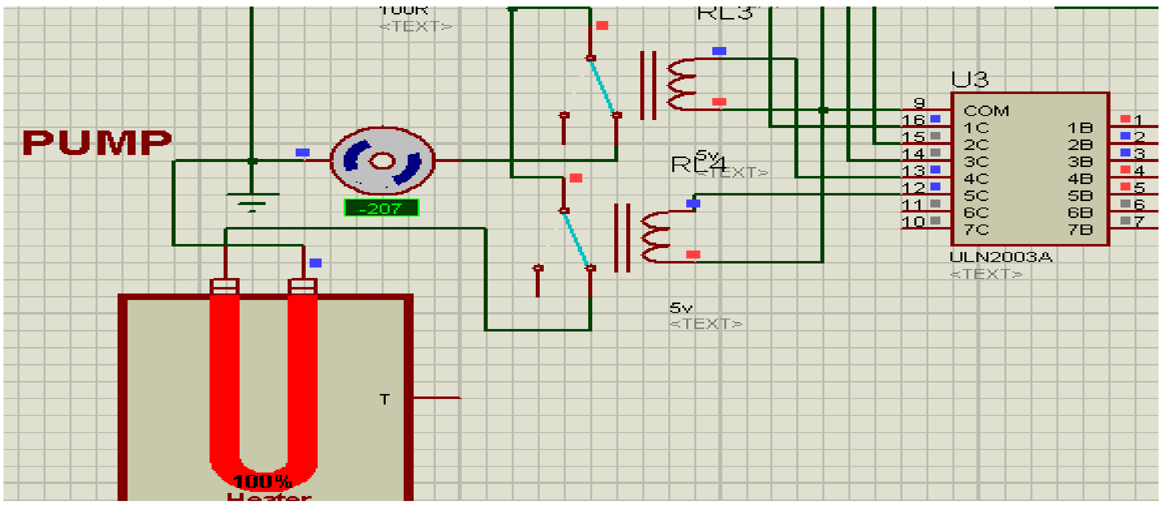


Figure 5.3:The decreasing of humidity

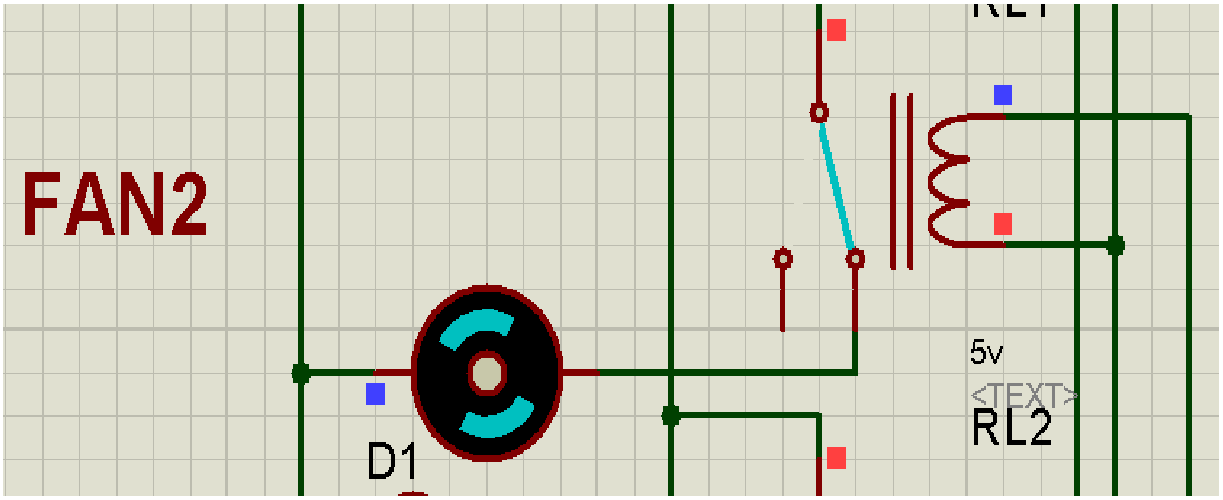


Figure 5.4:The increasing of humidity

**- Light control:**

Once the intensity of light becomes lower than the set limit the system will responds by operating the artificial lights as shown in figure 5.5 and once it reaches the set limit it will switch off the artificial lights as shown in figure 5.6.

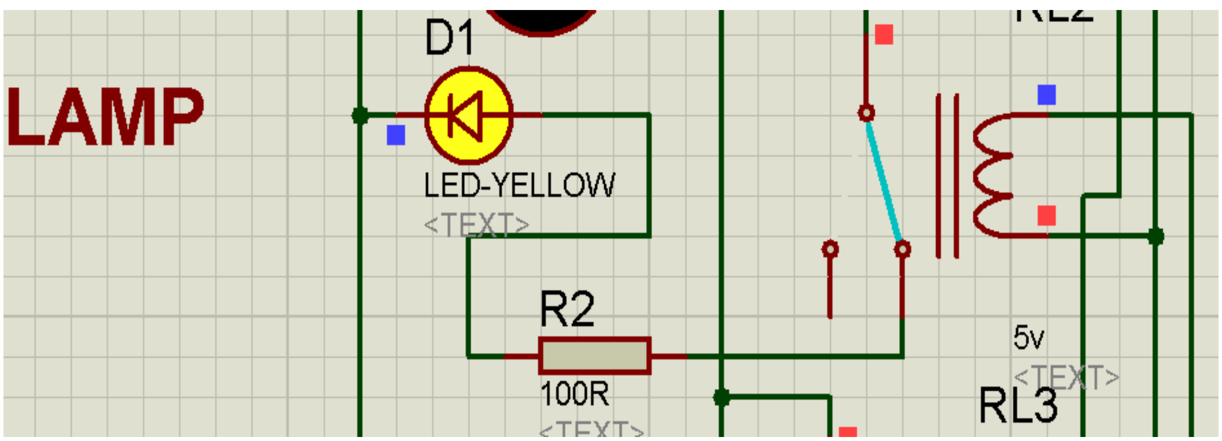


Figure 5.5:The decreasing of light

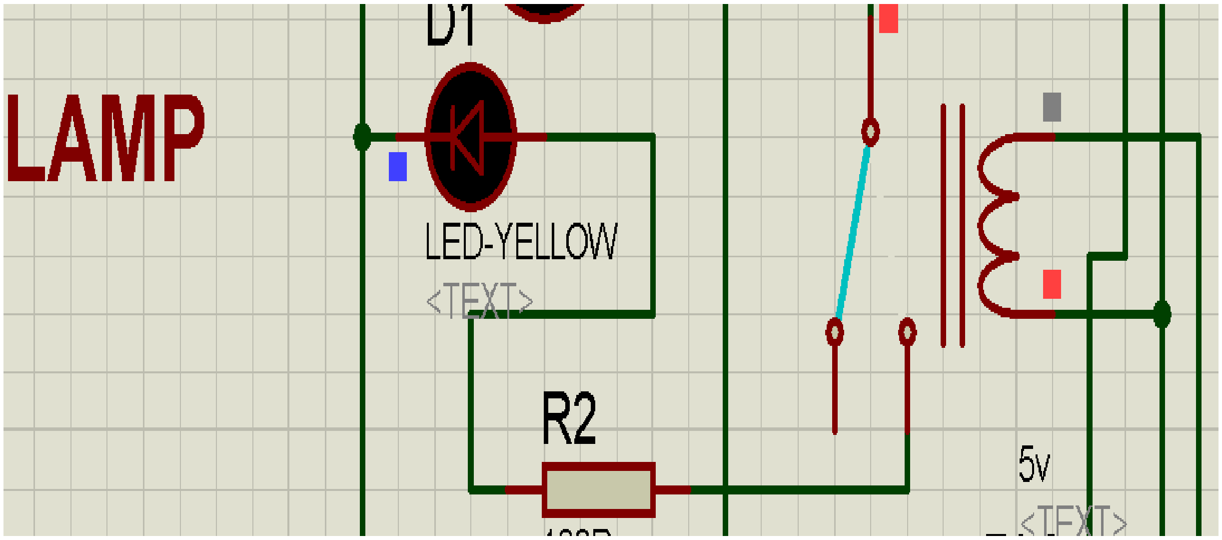


Figure 5.6:The increasing of light

Table 5.1: The obtained results

| Parameters | The set value>the acquiring value | The set value<the acquiring value |
|---|---|---|
| Temperature | Turn on fan1 | Turn on the heater |
| Humidity | Turn on fan2 | Turn on the sprayers+ the heater |
| light | Turn on the LEDS | ------------------ |

## 5.2 Discussion:

It is important to understand that the sensors always have a degree of inaccuracy with them and they may affected by other parameters besides the “sensed “ variable. And another important factor is related to the sensor time response ,the sensor must deliver a signal that reflects the state of the system within the frame of time required by the application. Thus proper selection of the sensors and understanding the principle of operation is critical to the success of the system.

# 6.1 Conclusion:

A step-by-step approach in designing the microcontroller based system for measurement and control of the three essential parameters for plant growth, i.e. temperature, humidity, and light intensity, has been followed. The results obtained from the measurement have shown that the system performance is quite reliable and accurate.

The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity, at the same time providing a flexible and precise form of maintaining the environment.

The continuously decreasing costs of hardware and software, the wider acceptance of electronic systems in agriculture, and an emerging agricultural control system industry in several areas of agricultural production, will result in reliable control systems that will address several aspects of quality and quantity of production. Further improvements will be made as less expensive and more reliable sensors are developed for use in agricultural production.

# 6.2 Recommendations:

The following improvements can be recommended for possible future work:

- more parameters can be detected such as soil moisture and co2 level as well other conditions may included such as shade and fire detection.
- using different devices to monitor and control greenhouse environment such as plcs.
- To use solar system to reduce electricity usage.
- Global System for Mobile Communication (GSM) and Short Message Service (SMS) can also be integrated into the system. These extra features will allow the system to directly alert the user of any abnormal changes in the greenhouse environment through the transmission of a simple short text message.

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# A. Appendix

# Bascom code

```
' This program is written by engineer Hiba Mohammed Osman
' The function of the program is "Control of green house"
' Sudan univ. of sc. & tech. - college of engg.
' Specialisation - Control engineering
' Batch

$regfile = "m32def.dat"                    ' we use the M32
$crystal = 8000000
$baud = 9600

'LCD CONFIGURATION
'-------------------------------------------------------------------------------
 * 216Config Lcd =
Config Lcdpin = Pin , Db4 = Portd.4 , Db5 = Portd.5 , Db6 = Portd.6 , Db7 =
Portd.7 , E = Portd.3 , Rs = Portd.2
Cls
Cursor Off
Dim Count As Integer
' Initialization of PORTB
Config Pinb.0 = Input
Config Pinb.1 = Input
Config Pinb.2 = Input
Config Pinb.3 = Input
```

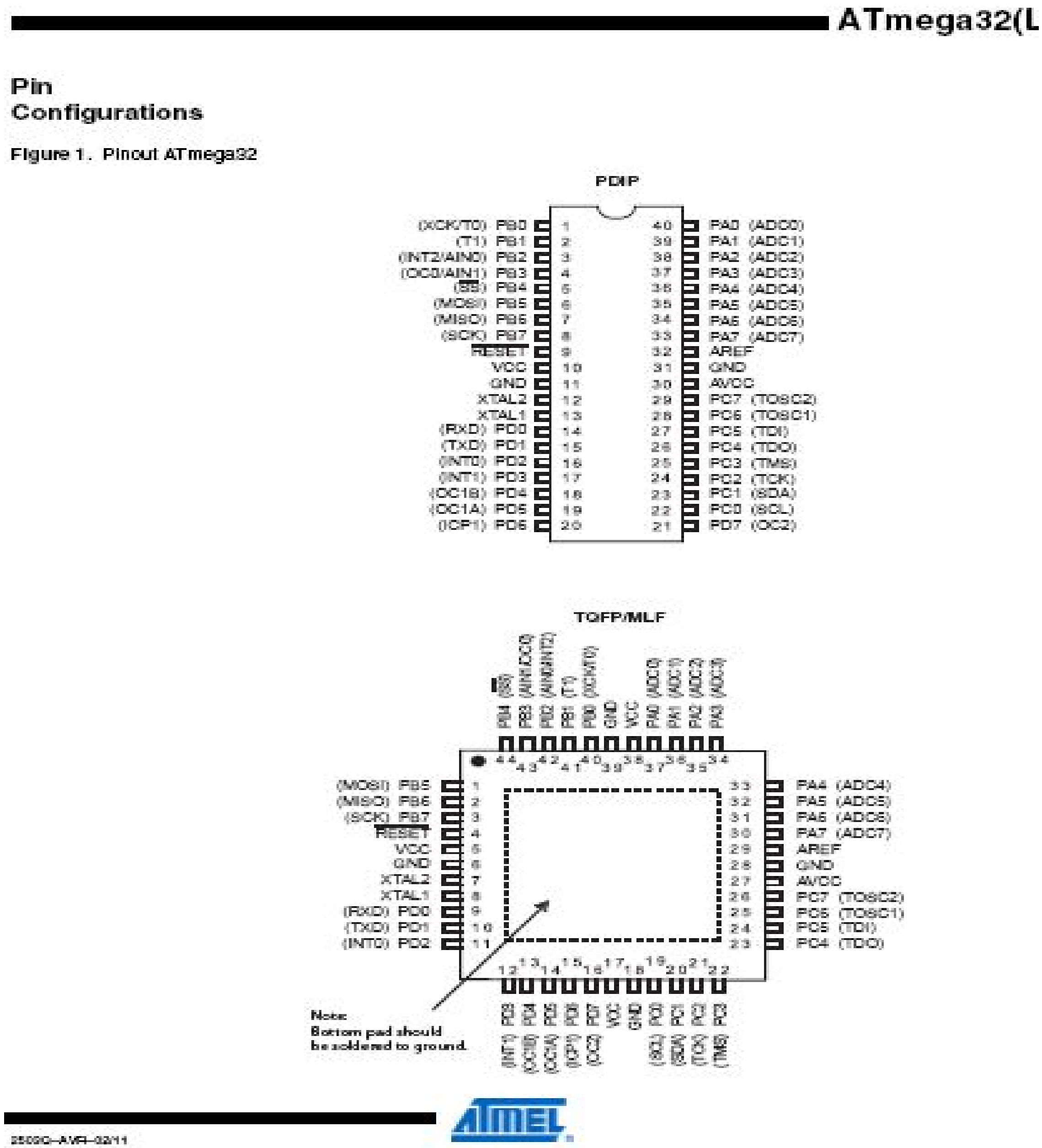
```
'Disply a message
Count = 0
Lcd "WELCOME" ; Count
Waitms 5000
' Initialization of PORTA
Config Porta.0 = Output
Config Porta.1 = Output
Config Porta.2 = Output
Config Porta.3 = Output
Waitms 5000
Greenhouse:
Do
'Activation of the water pump
       If Pinb.0 = 1 Then
            Porta.0 = 1
            Waitms 5000
   Cls
   Locate 2 , 1
  Lcd "PUMPING WATER" ; Count
  Waitms 5000
   Count = Count + 1
      Else
         Porta.0 = 0
         Count = Count
   End If
'Activation of the heater
'Activation of the lighting
   If Pinb.1 = 1 Then
```

```
            Porta.1 = 1
Waitms 5000
 Cls
   Locate 2 , 1
  Lcd "LIGHTING" ; Count
  Waitms 5000
   Count = Count + 1
   Else
         Porta.1 = 0
         Count = Count
   End If
'Activation of fan1
   If Pinb.2 = 1 Then
            Porta.2 = 1
            Waitms 5000
   Cls
   Locate 2 , 1
  Lcd "FAN 1" ; Count
  Waitms 5000
   Count = Count + 1
 Else
         Porta.2 = 0
         Count = Count
   End If
'Activation of the fan2
   If Pinb.3 = 1 Then
            Porta.3 = 1
            Waitms 5000
```

```
  Cls
   Locate 2 , 1
  Lcd "FAN 2" ; Count
  Waitms 5000
   Count = Count + 1
  Else
        Porta.3 = 0
        Count = Count
   End If
Loop
End
```

# B. Appendix B

# ATMEGA32 Microcontroller Data Sheet


ATmega32(L

**Pin Configurations**

**Figure 1.** Pinout ATmega32



A full data sheet can be downloading available:

www.atmel.com/images/doc2503.pdf.

# C. Appendix C

# LM35 Precision Centigrade Temperature Sensors Data Sheet

National Semiconductor

November 2000



## LM35
## Precision Centigrade Temperature Sensors

### General Description

The LM35 series 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 ±¼°C at room temperature and ±¾°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.

### Features

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guaranteeable (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 μA current drain
- Low self-heating, 0.08°C in still air
- Nonlinearity only ±¼°C typical
- Low impedance output, 0.1 Ω for 1 mA load

### Typical Applications

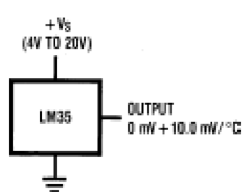
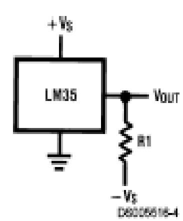



FIGURE 1. Basic Centigrade Temperature Sensor (+2°C to +150°C)




Choose $R_1 = -V_S/50\ \mu A$

$V_{OUT}$ = +1,500 mV at +150°C
= +250 mV at +25°C
= −550 mV at −55°C

FIGURE 2. Full-Range Centigrade Temperature Sensor

A full data sheet can be downloading available:

http://www.ece.usu.edu/ece_store/spec/lm35dt-3p.pdf

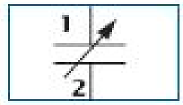
# D. Appendix D

# HS1101 Relative Humidity Sensor Data Sheet

## RELATIVE HUMIDITY SENSOR

**HS 1100 / HS 1101**

*Based on a unique capacitive cell, these relative humidity sensors are designed for high volume, cost sensitive applications such as* ***office automation, automotive cabin air control, home appliances, and industrial process control systems.*** *They are also useful in all applications where humidity compensation is needed.*




HS 1100
Top opening

HS 1101
Side opening

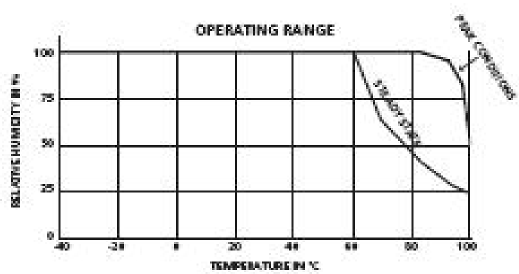
### FEATURES

- **Full interchangeability** with no calibration required in standard conditions
- **Instantaneous desaturation** after long periods in saturation phase
- Compatible with automatized assembly processes, **including wave soldering, reflow and water immersion** (1)
- High reliability and long term stability
- Patented solid polymer structure
- Suitable for linear voltage or frequency output circuitry
- Fast response time
- Individual marking for compliance to stringent traceability requirements

(1) soldering temperature profiles available on request

### MAXIMUM RATINGS (Ta= 25°C unless otherwise noted)

| Ratings | Symbol | Value | Unit |
|---|---|---|---|
| Operating Temperature | Ta | -40 to 100 | °C |
| Storage Temperature | Tstg | -40 to 125 | °C |
| Supply Voltage | Vs | 10 | Vac |
| Humidity Operating Range | RH | 0 to 100 | % RH |
| Soldering @ T = 260°C | t | 10 | s |



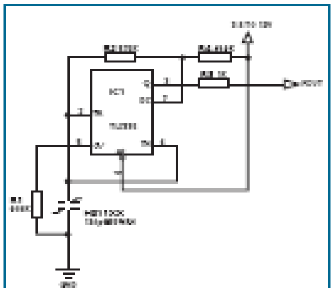

### CHARACTERISTICS

(Ta = 25°C, measurement frequency @ 10kHz unless otherwise noted)

| Characteristics | Symbol | Min. | Typ. | Max. | Unit. |
|---|---|---|---|---|---|
| Humidity measuring range | RH | 1 | | 99 | % |
| Supply voltage | Vs | | 5 | 10 | V |
| Nominal capacitance @ 55% RH* | C | 177 | 180 | 183 | pF |
| Temperature coefficient | Tcc | | 0.04 | | pF/°C |
| Averaged Sensitivity from 33% to 75% RH | ΔC/%RH | | 0.34 | | pF/%RH |
| Leakage current (Vcc = 5 Volts) | Ix | | 1 | | nA |
| Recovery time after 150 hours of condensation | tr | | 10 | | s |
| Humidity Hysteresis | | | +/-1.5 | | % |
| Long term stability | | | 0.5 | | %RH/yr |
| Response time (33 to 76 % RH, still air @ 63%) | ta | | 5 | | s |
| Deviation to typical response curve (10% to 90% RH) | | | +/-2 | | % RH |

* *Tighter specification available on request*

# FREQUENCY OUTPUT CIRCUITS



*BILL OF MATERIAL AVAILABLE ON REQUEST*

## COMMENTS

This circuit is the typical astable design for 555. The HS1100/HS1101, used as variable capacitor, is connected to the TRIG and THRES pin. Pin 7 is used as a short circuit pin for resistor R4.
The HS1100/HS1101 equivalent capacitor is charged through R2 and R4 to the threshold voltage (approximately 0.67Vcc) and discharged through R2 only to the trigger level (approximately 0.33Vcc) since R4 is shorten to ground by pin 7.
Since the charge and discharge of the sensor run through different resistors, R2 and R4, the duty cycle is determined by :

$$t_{high} = C@\%RH*(R2+R4)*\ln 2$$

$$t_{low} = C@\%RH*R2*\ln 2$$

$$F = 1/(t_{high}+t_{low}) = 1/(C@\%RH*(R4+2*R2)*\ln 2)$$

$$Output\ duty\ cycle = t_{high}*F = R2/(R4+2*R2)$$

To provide an output duty cycle close to 50%, R4 should be very low compared to R2 but never under a minimum value.
Resistor R3 is a short circuit protection. 555 must be a CMOS version.

## REMARK

R1 unbalances the internal temperature compensation scheme of the 555 in order to introduce a temperature coefficient that matches the HS1100/HS1101 temperature coefficient. In all cases, R1 should be a 1% resistor with a maximum of 100ppm coefficient temperature like all other R-C timer resistors. Since 555 internal temperature compensation changes from one trademark to one other, R1 value should be adapted to the specific chip. To keep the nominal frequency of 6660Hz at 55%RH, R2 also needs slight adjustment as shown in the table.

| 555 Type | R1 | R2 |
|---|---|---|
| TLC555 (Texas) | 909kΩ | 576kΩ |
| TS555 (STM) | 100nF capacitor | 523kΩ |
| 7555 (Harris) | 1732kΩ | 549kΩ |
| LMC555 (National) | 1238kΩ | 562kΩ |

*For a frequency of 6660Hz at 55%RH*

### *Typical Characteristics for Frequency Output Circuits*

REFERENCE POINT AT 6660Hz FOR 55%RH / 25°C

| RH | 0 | 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Frequency | 7351 | 7224 | 7100 | 6976 | 6853 | 6728 | 6600 | 6468 | 6330 | 6186 | 6033 |

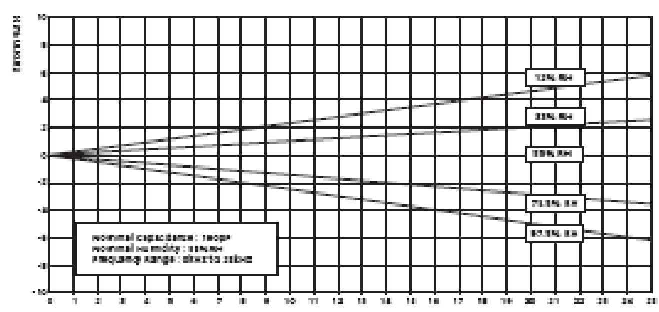
Typical for a 555 Cmos type. TLC555 (RH : Relative Humidity in %, F : Frequency in Hz)

**Polynomial response :**

$$F_{mes}(Hz) = F_{55}(Hz)(1.1038-1.9368\,10^{-3}*RH+3.0114\,10^{-6}*RH^2-3.4403\,10^{-8}*RH^3)$$

### *Measurement Error vs Stray Capacitance*

A special attention is required in order to minimize stray capacitance in the layout. The added capacitance will act as a parallel capacitance with the sensor and create a measurement error.



HPC001 Rev. 7 June 2002

All data sheet downloading available:

www.jameco.com/jameco/products/prodds/2082901.pdf

# E. Appendix E

# LDR Light Dependent Resistors Data Sheet

*Data pack F* *Issued March 1997* **232-3816**

**Data Sheet**

## Light dependent resistors

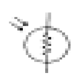
**NORP12 RS stock number 651-507**
**NSL19-M51 RS stock number 596-141**

Two cadmium sulphide (cdS) photoconductive cells with spectral responses similar to that of the human eye. The cell resistance falls with increasing light intensity. Applications include smoke detection, automatic lighting control, batch counting and burglar alarm systems.

### Guide to source illuminations

| Light source | Illumination (Lux) |
|---|---|
| Moonlight | 0.1 |
| 60W bulb at 1m | 50 |
| 1W MES bulb at 0.1m | 100 |
| Fluorescent lighting | 500 |
| Bright sunlight | 30,000 |

Circuit symbol



### Light memory characteristics

Light dependent resistors have a particular property in that they remember the lighting conditions in which they have been stored. This memory effect can be minimised by storing the LDRs in light prior to use. Light storage reduces equilibrium time to reach steady resistance values.

### NORP12 (RS stock no. 651-507)

**Absolute maximum ratings**

| | |
|---|---|
| Voltage, ac or dc peak | 320V |
| Current | 75mA |
| Power dissipation at 30°C | 250mW |
| Operating temperature range | -60°C to +75°C |

### Electrical characteristics

$T_A$ = 25°C. 2854°K tungsten light source

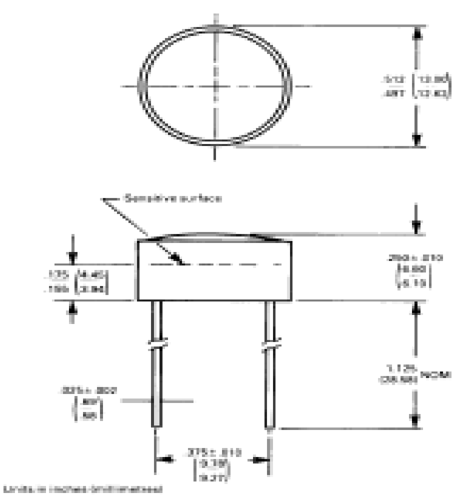
| Parameter | Conditions | Min. | Typ. | Max. | Units |
|---|---|---|---|---|---|
| Cell resistance | 1000 lux<br>10 lux | -<br>- | 400<br>9 | -<br>- | Ω<br>kΩ |
| Dark resistance | - | 1.0 | - | - | MΩ |
| Dark capacitance | - | - | 3.5 | - | pF |
| Rise time 1 | 1000 lux<br>10 lux | -<br>- | 2.8<br>18 | -<br>- | ms<br>ms |
| Fall time 2 | 1000 lux<br>10 lux | -<br>- | 48<br>120 | -<br>- | ms<br>ms |

1. Dark to 110% $R_L$
2. To $10 \times R_L$
$R_L$ = photocell resistance under given illumination.

**Features**

- Wide spectral response
- Low cost
- Wide ambient temperature range.

Dimensions




All data sheet downloading available:

www.biltek.tubitak.gov.tr/.../40/LDR_NSL19_M51.pdf