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School of Electronics Engineering

Green house Monitoring and Controlling Using Wireless Sensor Network through ZigBee technology

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A Research Submitted In Partial fulfillment for the Requirements of the Degree of B.Sc. (Honors) in Electronics Engineering

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SEP 2015

الإستهلال

بسم الله الرحمن الرحيم

قال تعالى:

(قُلْ لَوْ كَانَ الْبَحْر مِدَادًا لِكَلِمَاتِ رَبِّي لَنَفِدَ الْبَحْر قَبْل أَنْ تَنْفَد كَلِمَات رَبِّي وَلَوْ جِئْنَا بِمِثْلِهِ مَدَدًا)

صدق الله العظيم

(سورة الكهف الايه 109)

DEDICATION

**To our parents, who directed my first step in the right way…

**To our brothers and sisters…

** To our friends who are always ready to help…

**To our colleges…

We dedicate this work….

ACKNOWLEDGMENTS

Our grateful thanks firstly to Our God who guided us to the strait way in our life. Then many thanks and appreciations are extended to our supervisor **Dr.Fadul Ahmed** for his valuable advice and endless effort to make this work come into reality. We would like to thank **Dr. Omer Abdel Razag** for his support. We would like to express my sincere thanks to the Industrial Research and Consultancy Center (IRCC) Sudan for providing the right place to complete this work. A lot of thanks for electronic engineering school for its dedication laboratories to graduation projects.

ABSTRACT

In this research, an embedded system which is closely monitored and controlled the climate parameters such as humidity, temperature, and light of a greenhouses based on wireless sensor network on a regular basis round the clock for cultivation of crops or specific plant species which could maximize their production was presented. The designed system comprises beside the sensors from microcontroller, monitor, and wireless communication based on XBee and respondents such as fan, heater and pump. This a low cost and flexible system can be empowered by a reliable management scenario in order to maintain the greenhouses environmental conditions. The designed system shows the importance of using the wireless sensor network in such application, where the installation, power and running cost were minimized. The obtained results show a good management performance to the greenhouse environment where the wireless sensor network can be utilized to form a network from several greenhouses.

المستخلص

هذا البحث يحتوي على تصميم نظام مضمن (مدمج) لرصد ومراقبة بعض المؤشرات البيئية مثل الرطوبه النسبية، ودرجه الحرارة، وكثافة الضوء داخل البيت المحمي بواسطة شبكة الإستشعار اللاسلكية على أساس منتظم على مدار الساعه لتوفير بيئة مناسبة لزراعة المحاصيل أو الأنواع النباتية المحددة لزيادة الإنتاج والإنتاجية. ويتألف النظام المصمم بجانب أجهزة الأستشعار من : المتحكم الدقيق، وشاشة للعرض، وسيط إتصال لاسلكي متوافق مع نظام شبكة الإستشعار اللاسلكية وأجهزة الإستجابة كالمروحة، والسخان الكهربائي، ومضخه المياه .هذا النظام قليل التكلفة والمرونة تم تزويده بإجرائية لإدارته بغرض المحافظة على الشروط المناخية بالبيت المحمي .النتائج المتحصل عليها برهنت على جودة إستخدام تقنية شبكة الإستشعار اللاسلكي في إدارة البيوت المحمية حيث يمكن إستخدام شبكة الإستشعار اللاسلكية لتشكيل شبكة من عدة بيوت محمية.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADC	Analog to Digital Converter
API	Application Programming Interface
AVR	Advanced Virtual Risk
BASCOM	BASic COMpiler
CPU	Central Processing Unit
DC	Direct Current
DHT	Digital Humidity and Temperature
EEPROM	Electrical Erasable Programmable Read Only Memory
GND	Ground
GSM	Global System Mobile
GUI	Graphical User Interface
ISM	Industrial, Scientific & Medical
IT	Information Technology
LCD	Liquid Crystal Display
LDR	Light Dependent Resistor
LMI	Linear Matrix Inequalities
MEMS	Micro Electro Mechanical System
NEST	Network Embedded System Technology
PC	Personnel Computer
PDA	Personal Digital Assistant
PDC	Parallel Distributed Compensation
PGHS	Paprika Green House System
PID	Proportional Integral Derivative
RAM	Random Access Memory
ROM	Read Only Memory
RF	Radio Frequency
RX	Receiver
SMS	Short Message Service

SIM	Subscriber Identification Module
T-S	Takagi – Sugeno
TX	Transmit
USB	Universal Serial Bus
WSAN	Wireless Sensor Actor Networks
WSN	Wireless Sensor Network

LIST OF ABBREVIATIONS

A	Ampere
°C	Degree Celsius
GHz	Gaga Hertz
V	Voltage
W	Watt

Chapter one

INTRODUCTION

CHAPTER ONE
INTRODUCTION

1.1 Background

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.

Greenhouse measurement and control system is complex system it needs various parameters in greenhouse automatic monitoring, information processing, real-time control and online optimization. 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.

In recent years, Sudan has launched many projects based on greenhouse. The measurement and control system used in these greenhouses is mostly based on cable, so it is not only wiring complex, but also unfavorable to improve the system efficiency. With the rapid development of the low cost, low power sensor and wireless communication technology, the conditions that construct wireless greenhouse measurement and control system becomes mature, and it is important to realize agricultural modernization [3, 4].

1.2 Problem Statement

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. Greenhouse installations require a large amount of wires and cables to distribute sensors and actuators. Agriculture fields are most likely far away from central controlling station in which a suitable link between field and central station has to be in place in order to effectively monitor and operate remote field station without physical attendance of human guard.

1.3 Proposed solution

The propose design is to use a wireless sensor network based on ZigBee technology for monitoring and controlling greenhouses climate. The system consists of a number of field stations connected to the central station. Local stations are used to measure the environmental parameters, send those measures to central station to be displayed and to be controlled accordingly, this operation of controlling actuators is to maintain climate parameters at predefine set points . Each local station microcontroller is used to store the instant values of the environment parameters, send them to the central station and receive the control signals that required for the operation of the actuators. The communication between the local station and central station is achieved via ZigBee wireless modules.

1.4 Objectives

The objectives of this research are to implement, design and realize a low cost wireless sensor network based technology for monitoring and controlling greenhouse climate, and implement prototype hardware in a real time environment.

1.5 Methodology

In the effort to achieve the objectives of this project, there is several scopes need. The project needs to accomplish the right way to achieve its intended objectives.

The system consists of local stations and a central station, where the local stations are used to measure the environmental parameters and to control the operation of controlled actuators such as fan, heater, water pump and LEDs to maintain climate parameters at set points for the temperature، humidity, water level in soil and light intensity. The central station is used to set and monitor the environmental parameters. Therefore, a suitable selection for the sensors and their compensation circuit can be achieved.The ATmega16 microcontroller is selected to be the processing module for both the local and central unit and the programming is done in BASCOME language. And communication between them is achieved via XBee WSN modules in each. Test and evaluate the system and its components can be achieved using ISIS Proteus environment.

1.6 Research Outline

This thesis is organized as follow: Chapter two introduces the greenhouse and wireless sensor technology. In addition, some of the previous greenhouse designs were reviewed. In chapter three, the design and implementation of the proposed greenhouse monitoring and controlling was demonstrated. In chapter four the results were showed and discussed. In chapter five, the conclusion and recommendations were drawn and presented, respectively.

Chapter two

Literature Review

CHAPTER TWO

Literature Review

2.1 Introduction

Today agriculture is changing in response to the requirements of modern society, where ensuring food supply through practices such as water conservation, reduction of agrochemicals and the required planted surface, which guarantees high quality crops are in demand.

As it is well known that greenhouse is a building or complex in which plants are grown. These structures range in size from small sheds to industrial-sized buildings. Greenhouses are often used for growing flowers, vegetables and fruits. Greenhouses are very useful for they provide an optimal temperature around plants, protect them from weather extremes, extends the growing season, allowing you to sow plants earlier and harvest plants later and allows economic crops such as tomatoes, cucumbers, melons and aborigines to crop more successfully [5]. Basic factors affecting plant growth such as sunlight, water Content in soil, air humidity, temperature, CO2 concentration. These physical factors are hard to control manually inside a greenhouse and there is a need for automated designarises.

i. Temperature effects

One of the benefits of growing crops in a greenhouse is the ability to control all aspects of the production environment temperature is one of the most important factors to be monitored because it is directly related to the growth and development of plants. Different crop species have different optimum growing temperatures and these optimum temperatures can be different for the root and the shoot environment and for the different growth stages during the life of the crop. Since we are usually interested in rapid crop growth and development, we need to provide these optimum temperatures throughout the entire cropping cycle. If a greenhouse were like a residential or commercial building, controlling the temperature would be much easier since these buildings are insulated so that the impact of outside conditions is significantly reduced [6].

ii. Humidity effects

Water vapour inside the greenhouse is one of the most significant variables affecting the crop growth.Humidity is important to plants because it partly controls the moisture loss from the plant. The leaves of plants have tiny pores, CO2 enters the plants through these pores, and oxygen and water leave through them. Transpiration rates decrease proportionally to the amount of humidity in the air. This is because water diffuses from areas of higher concentration to areas of lower concentration [7]. Due to this phenomenon, plants growing in a dry room will most likely lose its moisture overtime. The damage can be even more severs when the difference in humidity is large.

The humidity control is complex because if temperature changes then relative humidity changes inversely. Temperature and humidity are controlled by the same actuators. The main priority is for temperature control because it is the primary factor in the crop growth .Based on the inside relative humidity value the temperature set-point can be adjusted to control the humidity within a determined range. Hence to control the required humidity is very complex task. For proper control of humidity internal air can be exchange with outside air by properly controlling ventilations of the green house [5].

iii. Light effect

All things need energy to grow, human and animals get energy from food. Plants, on the other hand, get energy from the sun light through a process called photosynthesis. This is how light affects the growth of a plant. Without light, a plant would not be able to produce the energy it needs to grow. Aside from its effect through photosynthesis, light influences the growth

of individual organs or of the entire plant in less direct ways. The most striking effect can be seen between a plant grown in normal light and the same kind of plant grown in total darkness. The plant grown in the dark will have a tall and spindling stem, small leaves, and both leaves and stem, lacking chlorophyll, are pale yellow. Plants grown in shade instead of darkness show a different response. Moderate shading tends to reduce transpiration more than it does photosynthesis. Hence, shaded plants may be taller and have larger leaves because the water supply within the growing tissues is better. With heavier shading, photosynthesis is reduced to an ever greater degree and, weak plants result [7].

iv. water level in soil effects

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 values 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 interrelated 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 [8].

2.2 Previous Works

There are many previous studies in this area which should be reviewed for helping in proposing a system with solvable problem in greenhouses.

Stipanicev and Marasovic [9] have proposed system is an embedded Web server unit system based on TINI board, by collecting data from distributed sensors and activating connected actuators using simple 1-wire local network. On the other side Web server is connected to the Internet through Ethernet or dial-up network [9]. They have claimed that the developed system shows all advantages of Network Embedded System Technology (NEST), like the possibility of changing physical topology and low dimensions and cost in comparison with PC based system, preserving the full functionality at the same time [9].

Nachidiet al [10] has 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) [10].

Qianet al [11] have compared the advantages of ZigBee with other two similar wireless networking protocols, Wi-Fi and Bluetooth, and proposed a wireless solution for greenhouse monitoring and control system based on ZigBee technology. As an explorative application of ZigBee technology in Chinese greenhouse, it may promote Chinese protected agriculture. With the capabilities of self-organizing, self-configuring, self-diagnosing and self-healing, the ZigBee based monitoring and control system provides nearly unlimited installation. Flexibility for transducers, increases network robustness, and consider ably reduces costs. Therefore, they concluded that the ZigBee-based monitoring and control system can be a good solution for greenhouse monitoring and control [11].

Elmusratiet al [12] have suggested a different approach for implementing WSN in greenhouse environment by making use of a commercial wireless sensing platform provided by Sensinode Inc. The hardware design of the system consists of Sensinode's Micro 2420U100 operates as basic measuring node, with four commercial sensors (e.g. humidity, temperature, light and CO_2). The idea behind this development is to test the reliability and feasibility of a prototype wireless environment monitoring system in commercial greenhouse. The experimental result showed that the network can detect local difference in the greenhouse climate caused by various disturbances in the environment [12].

Palaniappanet al [13] 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 pa 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% [13].

Abdul Aziz et al [14] have proposed system has a measurement which capable of detecting the level of temperature to developed a remote temperature monitoring system using wireless sensor and Short Message Service (SMS) technology. This system also has a mechanism to alert farmers regarding the temperature changes in the greenhouse so that early precaution steps can take and testing several types. This extended to include more environmental variables to be monitored in the agricultural greenhouse which relate to the increment of fruits and vegetables productivity. For example, other than temperature, the soil and water acidity level in the greenhouse also play important role to the quality of fruits, enhanced to produce a system that can trigger automatic actions of related components such as the sprinkler, lighting and air ventilators, rather than just send alert notification message, the proposed system is enhance by implementing artificial intelligent components to enable advanced implementations such as self-learning, predicting, and define ambiguous situation which provide preventive measures [14].

Lee et al [15] 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 [15].

Song et al [16] 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 environment is provided [16].

Chiung, Guan and Jwu [17] have utilized Field Point of National Instrument to build the greenhouse environment control system, and LABVIEW as programming language for compiling. They have used smart mobile (or PDA) to control the Personnel Computer (PC) server through the wireless network where the Field Point will adjust environment of greenhouse through controlling the device. Moreover, user can master the status of the greenhouse through web cam, and which use the smart mobile to control greenhouse environment system on anywhere. The result of this proposed system showed that the designed system could be more effective in manpower savings and raising the economic value of products i.e. Phalaenopsis [17].

Rahaliet al [18] has designed and development of an electronic system based on a microcontroller that integrates remote control functions rooted in the GSM network. The system allows the acquisition of different climatic parameters in an agricultural greenhouse. In addition, this electronic system achieves the control and remote monitoring of greenhouse solutions, in particular drip irrigation stations, by sending SMS messages. The system, also, includes a serial cable, a GSM, conditional sensors card, power interfaces and microcontroller. An active SIM card is required to receive and send messages. A graphical user interface using LABVIEW software for the acquisition, monitoring with PC and storage of all data through the PCL812PG card have been developed. This interface encompasses at the same time reliability, flexibility of use, interactivity and processing capability in real-time of the whole data. The proposed system presented several advantages: user friendly, easily implemented, focus main parameters, use GSM phones because of theirs availability, low cost of SMS in Morocco, and network coverage [18].

Zagade and Kawitkar [19] designed and implemented of a WSN that can monitor the air temperature, humidity and ambient light intensity in greenhouse. This can help farmers to understand the environmental conditions and they can adopt different methods to increase the crop production. The system is integrated with small size application specific sensors and radio frequency modules. All monitored parameters are transmitted through a wireless link to cellular device for analysis. A cell phone is used instead of computer terminal keeping mind that system will be used by farmers and considering power management [19].

Deore and Umale [20] have given an emphasis on WSN approach for greenhouse monitoring and control. A control system is developed and tested using recent ATmega microcontroller. The farmers in the developing countries can easily use designed for maximizing yield. ATmega microcontrollers are preferred over other microcontrollers due to some important features including10bit ADC, sleep mode, wide input voltage range and higher memory capacity. The design system considered optimization and functional improvement of the system. The system has several advantages in term of its compact size, low cost and high accuracy [20].

Sagar [21] has developed the monitoring and GSM systems for using in greenhouse applications, where real time data of climate conditions and other environmental properties are sensed and control decisions are taken by monitoring system and they are modified by the automation system and sends SMS that what operation is performed by them to user. The architecture of a greenhouse monitoring system comprises of a set of sensor nodes and a control unit that communicate with each sensor node and collects local information to make necessary decisions about the physical environment. The system is little cost with wireless sensors but it works with more effectively [21].

Song et al [22] have proposed system scheme based on wireless sensor network, where they adopted an Atmega128L chip and a low power RF chip from TI i.e. CC2530 to design the sink node and sensor nodes in the WSN. 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, and so on. And 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. In addition, the nodes deployment method and time synchronization problem are analyzed in detail. The system can solve the problem of complex cabling with the advantages of low power consumption, low cost, good robustness, extended flexible and high reliability. An effective tool is provided for monitoring and analysis decision-making of the greenhouse environment [22].

Othman and Shazali [23] have discussed and reviewed wireless sensor network applications for environmental monitoring. Development in the technology of sensor such as Micro Electro Mechanical Systems (MEMS), wireless communications, embedded systems, distributed processing and wireless sensor applications have contributed a large transformation in WSN recently. It assists and improves work performance both in the field of industry and our daily life Wireless sensor network has been widely used in many areas especially for surveillance and monitoring in agriculture and habitat monitoring. Environment monitoring has become an important field of control and protection, providing real-time system and control communication with the physical world. An intelligent and smart Wireless Sensor Network system can gather and process a large amount of data from the beginning of the monitoring and manage air quality, the conditions of traffic, to weather situations in the monitoring system [23].

Mittal et al [24] have designed hardware for green house monitoring various sensors are used to control the environment parameters such as temperature, humidity, and 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 [24].

Berezowski [25] has reviewed the landscape of the application of wireless sensor networking in greenhouse management to make computer engineer more aware about this specific application domain and the space it offers for applying IT and communication infrastructure, as well as to make horticulture researchers more aware of what wireless technologies have to offer and how to optimize their usage in the greenhouse. Also identified, formulated and discussed the design space of a few in opinion most important problems in developing efficient and cost effective WSN deployments for greenhouses. The reasons to propose such an analysis have come from the gap have observed between the results observations coming from preliminary field experimentation in the greenhouse [25].

Hwang and Yu [26] have proposed design and implementation of a remote monitoring and controlling system using ZigBee networks. This system is targeting the home network. Web service and a smart phone are used for the client system to monitor and control the home. This system can be applied in many areas such as elderly protecting systems, cultural heritage or forest fire monitoring systems, managing systems for agricultural cultivation and so on [26].

Sahu and Mazumdar [27] 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 [27].

Alausa Dele and Kolawole [28] 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 enhanceable 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 [28].

Mohanty and Patil [29] have proposed some important parameters that should be monitored at a greenhouse in order to achieve good results at the end of the agricultural production such as temperature, light and humidity. And have presented a wireless sensor network having several sensor nodes with these commercial sensors to measure the above parameters. The system can efficiently capture greenhouse environmental parameters and it shows normal communication between source and sink node and fine network stability. It also obtains strong adaptability, good confidentiality and high reliability. So will developed greenhouse wireless sensor network monitoring system design based on solar energy. The sensor nodes receive the solar energy and supply it to the wireless sensor network. The design will consume less energy and cost effective [29].

Nikhade and Nalbalwar [30] have summarized an idea that can carry out to provide an efficient control mechanism of microclimate into greenhouses through the implementation of an infrastructure of wireless sensors network to control environmental parameters. This enables a real time action process that aims to atomise the network tasks. Based on the advantage gained from the small size of the network, low cost distributed sensing network that can be employed anywhere and even with harsh environments greenhouse crops are in essential neediness for WSAN system which achieve better monitoring-controlling and hence avoiding damage of the crops due to unstable inside parameters like temperature, humidity, soil moisture, leaf temperature and many other parameters which affects crops growth and may cause of diseases. The design is more focusing on automation jobs, optimizing the response time, and providing instant solution [30].

Gaoet al [31] have designed a wireless greenhouse monitoring system based on ZigBee and GSM technology to resolve the problems of complicated cabling and costly wired network in the current system. The system consists of two parts: a wireless sensor network and remote control terminal. According to parameter distribution in the monitoring regional, a wireless transmission network was formed, all of the nodes in the network using solar power. In the remote control terminal, the study developed a simplified expert decision system, in which the part of greenhouse control decision adopts the fuzzy decoupling control algorithm to realize the temperature and humidity decoupling control and increase the accuracy of decision-making according to the experimental test. It can realize real-time, accurate monitoring and collecting of parameters data in the greenhouse environment; the remote control terminal can give effective decision management solutions. The system achieves automatic real-time monitoring of environmental parameters and gives correct decision plans, which is of a broad application prospect [31].

Jianjunet al [32] has presented system that consists of a data acquisition controller and greenhouse remote monitoring and control software. The system, monitor temperature ,humidity, soil water content and concentration of carbon dioxide inside the greenhouse which then saved to a database. According to the current indoor temperature, the target temperature and the offset temperature, Proportional Integral and Derivative (PID) control method is used to control temperature control in greenhouse. The system is implemented using low power wireless components, and easy to be installed [32].

In addition, Lambebo and Haghani [33] provided a detailed study and implementation of a WSN for real time and continuous environmental monitoring of green house gases. A tree-topology WSN consisting of two sensor nodes and a base station was successfully built and tested using open source and inexpensive hardware to measure the concentration level of several greenhouse gases. The captured data is made available to the user through a graphing Application Programming Interface (API). The network works within the range of 100 meters for optimum performance [33].

2.3 Wireless Sensor Network in Greenhouse Management

Monitoring and control of the greenhouse environment play a decisive role in Greenhouse production processes. There are many techniques applied in greenhouse to Control the climate such as: proportional, integral and derivative (PID) controllers, artificial intelligence (AI) such as fuzzy logic systems (FLS), artificial neural networks (ANNs), genetic algorithms (GAs) and Wireless Sensors Network (WSN).

In recent years, environmental monitoring using wireless sensors technology has become more important. Especially in the agriculture industry, wireless sensor technology is very suitable for distributed data collecting and monitoring in tough environments [37]. A wireless sensor network (WSN) is a computer network consisting of spatially distributed autonomous devices using sensors to cooperatively monitor physical or environmental conditions, such as temperature, sound, vibration, pressure, motion or pollutants, at different locations. During the last decade wireless sensor networks are utilized in many civilian applications, including environment and habitat monitoring, health care applications, home automation, and traffic control .Several standards are currently either ratified or under development by organizations. Standards are used far less in WSNs than in other computing systems which make most systems incapable of direct communication between different systems. The principal standards commonly used in WSN communications are: Wi-Fi, Bluetooth and ZigBee. All these mentioned technologies work at similar RF frequencies, and their applications sometimes over lap. In addition, a survey conducted by [38] of the advance in wireless sensor network applications has reviewed a wide range of applications and identified the agriculture industry as a potential area of deployment, together with a review of the factors influencing the design of sensor networks for this application. IntelCorp was found as one of the main players in the early implementation of wireless sensor networks in the agriculture industry [39].

Research and implementation of WSN in greenhouse climate management was carried out all over the world over the last few years. One of such applications was the use of a web based WSN platform for greenhouse climate monitoring and control.WSN can form a useful part of the automation system architecture in modern greenhouses. Compared to the wired systems, the installation of WSN is fast, cheap and easy. Moreover, it is easy to relocate the measurement points when needed by just moving sensor nodes from one location to another within a communication range of the coordinator device where a greater level of flexibility and mobility at low cost and low power consumption is provided. If the greenhouse's plant is high and dense, the small and light weight nodes can even be hanged up to the plants branches.

The sensor nodes In Wireless communication collect data and communicate over a network environment to a computer system, which is called, a base station. Based on the information collected, the base station takes decisions and then the actuator nodes perform appropriate actions upon the environment.

In conclusions regarding which wireless technology is more superior, since the suitability of wireless technology is solely dependent on the application. For example, ZigBee wireless technology cannot be applied to high data implementations applications such as audio/video streaming and graphic web browsing because of their high bandwidth requirements. Bluetooth and Wi-Fi on the other hand are not suitable for battery powered applications of their high power consumption characteristics. For this particular thesis ZigBee wireless technology was chosen for a number of reasons: ZigBee has very low power consumption, Low network complexity, it is designed for remote monitoring and control applications, and ZigBee networks can scale to hundreds and thousands of devices.

Table 2.1 specifies important differences between ZigBee, WI-Fi and Bluetooth.

	ZigBee	Wi-Fi	Bluetooth
Range	10-100meters	50-100meters	10-100mters
Networking topology	Ad hoc, peer to peer, star or mesh	Point to hub	Ad-hoc , very small networks
Operating frequency	868MHZ(Europe) 900-928MHZ(NA),2.4 GHZ(worldwide)	2.4 and 5 GHZ	2.4 GHZ
Complexity	Low	High	High
Power consumption	Very low	High	Medium
Security	128 AES plus application layer security	64 and 128 bit encryption	64 and 128 bit encryption
Typical application	Industrial control and monitoring, sensor networks, building automation, home control and automation, toys, games.	Wireless LAN connectivity, broadband internet access.	Wireless connectivity between devices such as phones, PDA, laptops, headset

2.4 ZigBee Technology

ZigBee is new short range wireless communication technology, representing a wireless sensor network which is highly reliable, secure, low data rate, low power consumption, low cost and fast reaction with a Radio Frequency (RF) communications standard based on IEEE 802.15.4. There are three kinds of device types in ZigBee. Every ZigBee network will have a single coordinator device. You cannot call anything a network until you have at least two things connected. So every ZigBee network will also have at least one other device, either a router device or an end device. Many networks will have both, and most will be much larger than just two or three radios:

i. ZigBee coordinator

Every ZigBee network is permitted only one coordinator. This node initializes the network, selects the appropriate channel, and permits other devices to connect to it is network. It is also responsible for routing traffic in a ZigBee network. In a star topology, the coordinator is at the center of the star and all traffic from any end device must travel to this node. End devices can talk to another end device but the message must be routed through the coordinator. The coordinator is at the top of the tree in a tree topology, and it is the root node of the mesh in a mesh network. A ZigBee coordinator also has the capability to provide security services.

ii. ZigBee router

A router can relay message in a network and is able to have child nodes connected to it through any router or end device. Router functions only work within a tree or mesh topology since all traffic is routed through the center node (coordinator) in a star topology. Routers can substitute and take place of end devices but the routing function would be of no use in that case. A router can sleep when inactive if the network supports beaconing but it will periodically wake up to notify it is presence to the network.

iii. ZigBee end device

End device can be mainly credited for the power saving features of a ZigBee network. They can be sleeping for the majority of the time and expanding battery life of a device since these nodes are not used for routing traffic. These nodes carry enough function to talk to their parent nodes which is either a coordinator or a router. An end device does not possess the ability to have other nodes connect to it is network through the end device since it must be connected to the network through either a router or directly to the coordinator. ZigBee standard uses default distributed address allocation mechanism, which is used to allocate unique network addresses to each node. Which have been associated to cluster tree network. It provides a set of the addresses to each potential parent when PAN coordinator establishes a network. Parent the assigns the addresses to it is children. There are four major ZigBee topologies: point to point, mesh, star, and mixed (cluster tree) as in Figure 2.1. Each has its own advantage and disadvantages. Mostly star and mesh topologies are used frequently.

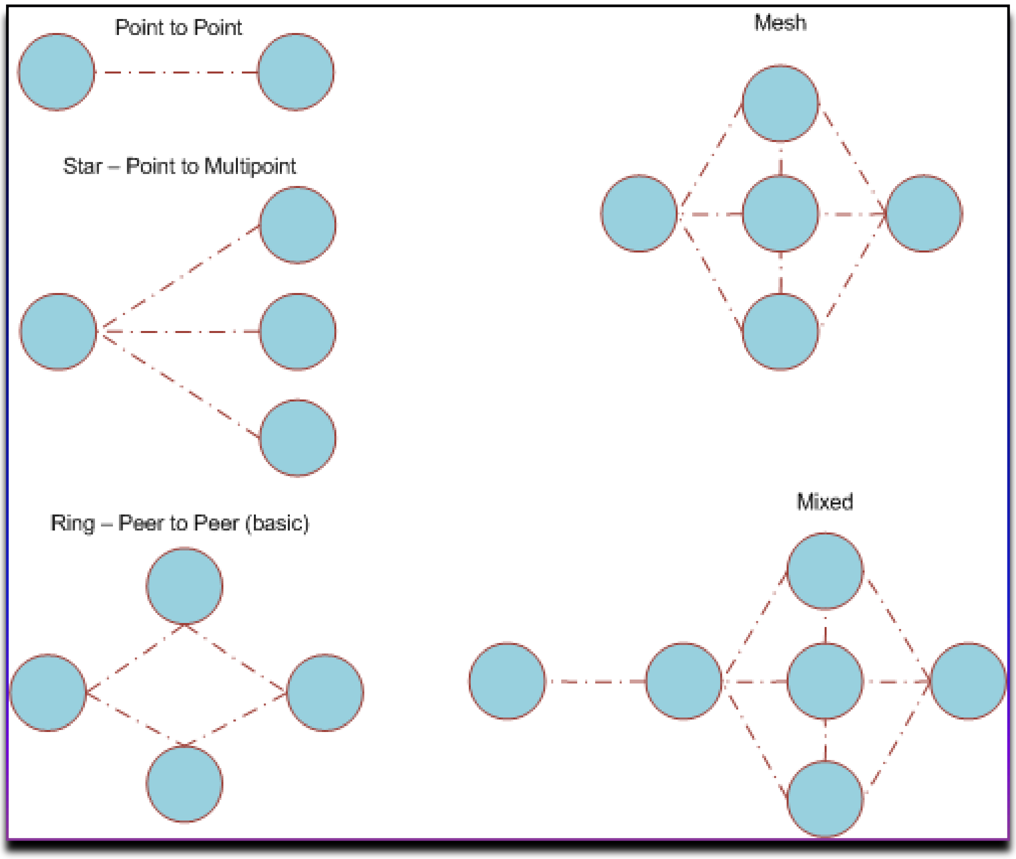

Figure 2.1: ZigBee point to point, star, mesh, and mixed topologies

Chapter three

Circuit Design

CHAPTER THREE

Circuit Design

3.1 An Overview Of The Greenhouse Design

The proposed green house system is presented in Figure 3.1. As can be grasped, the system has the following units: sensing unit, processing unit, displaying and power supply unit, communication unit, and derivers and actuators unit. In the following, the units of the proposed greenhouse system were designed, simulated, implemented, tuned and integrated. A Proteus ISIS environment simulator was utilized to simulate the proposed system as shown in Figure 3.2, where the implemented system was achieved by using the breadboard.

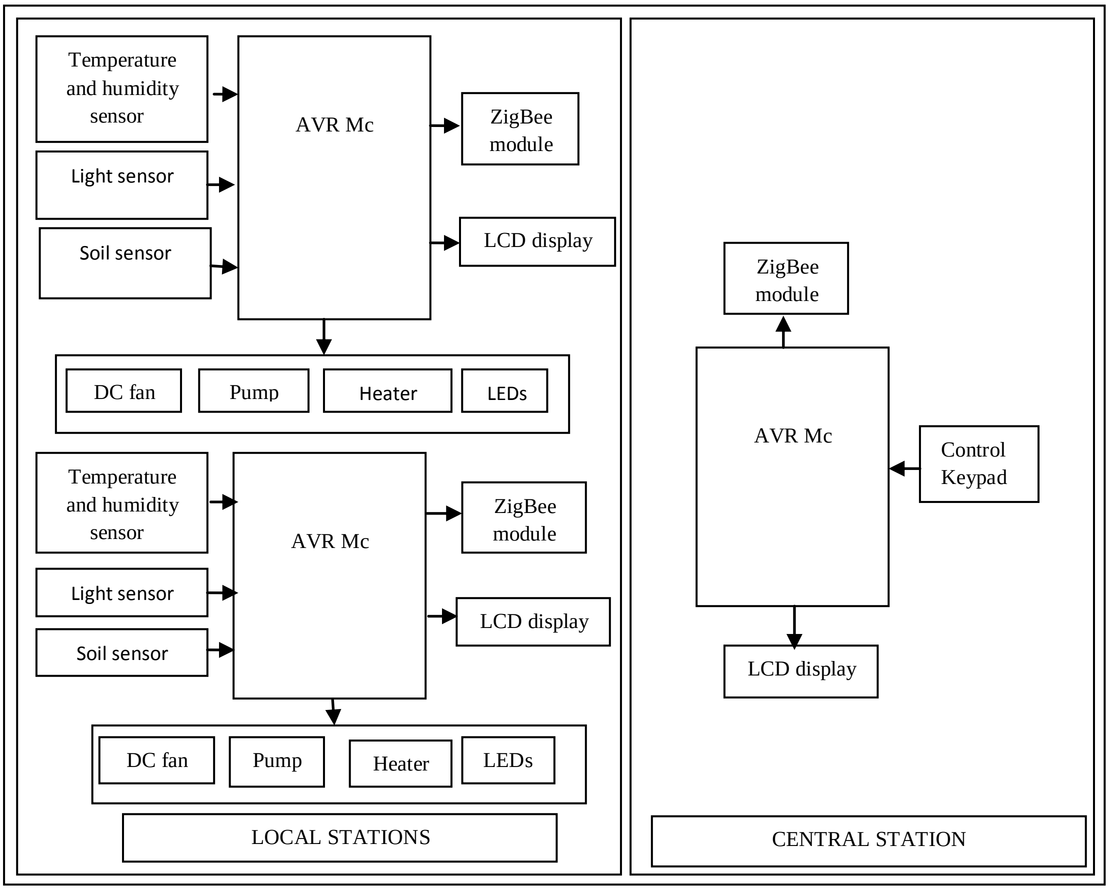

Figure 3.1: The Proposed Greenhouse Block Diagram

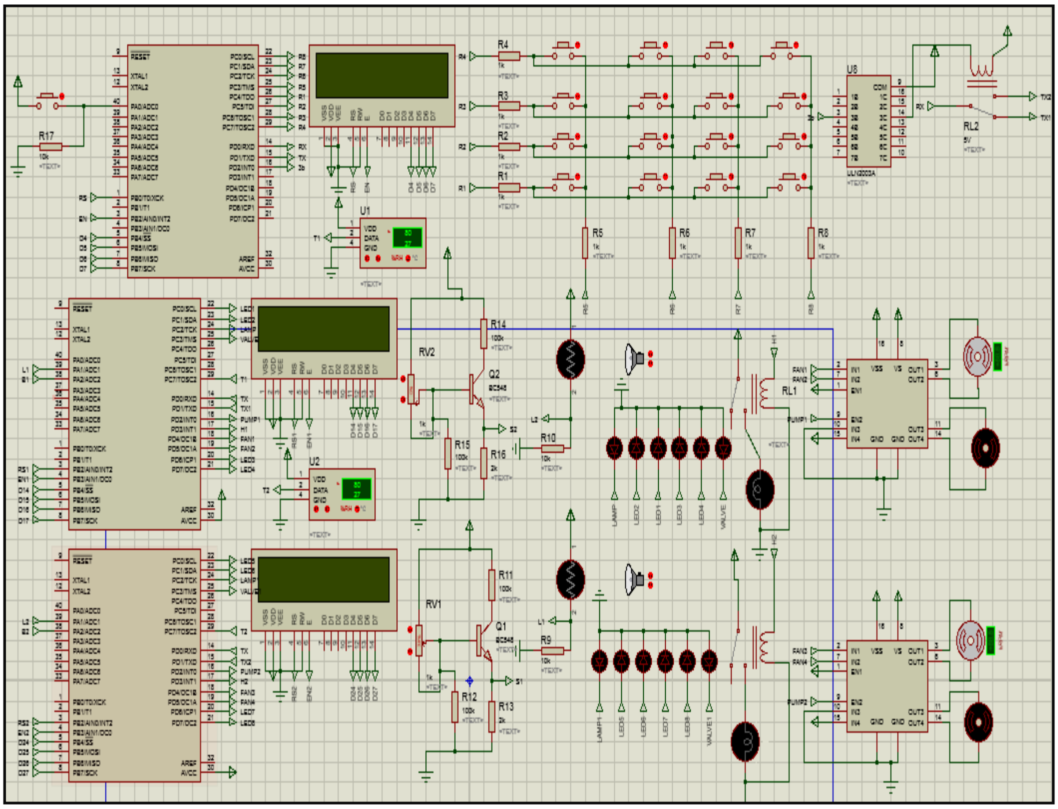

Figure 3.2: The Complete Schematic Diagram of The Proposed Greenhouse System

3.2 Sensing Unit

Transducer is a device which transforms energy from one type to another, even if both energy types are in the same domain. Typical energy domains are mechanical, electrical, chemical, magnetic, optical and thermal. Transducer can be further divided into sensors –which monitors a system– and actuators –which impose an action on the system.

Sensor is a device for sensing a physical variable of a physical system or an environment. It senses the environmental phenomena and output an electrical signal. An actuator may be described as opposite to a sensor it converts electrical signal into generally nonelectrical energy. For example, an electric motor is an actuator it converts electric energy into mechanical action.

The following factors must be considered when choosing sensor:

- Rang and span: This represent the range a limits heater which the input can vary. The span is the maximum value of the input minus the minimum value.
- Errors: Is the different between the result of the measurement and the free value of the quantity being measured where (Error = measured value – free value)
- Accuracy: is the extent to which the value indicated by measurement system might be varying. It is the summation all possible error that to accuracy.
- Sensitivity: it is relationship indicating how much output you get per unit input.
- Stability: it is the ability to give the same output when used to measure a constant input over a period of time.
- Resolution: when input varies continuously over the range the output signals for the some seasons may change in serial steps.

In this thesis the sensors used to measure environmental parameters are: Temperature and Humidity sensor (i.e.DHT11), light sensor (i.e. LDR), and Soil Moisture Sensor (i.eYL-69).

3.2.1 Temperature And Humidity Sensor

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 DHT11 shown in Figure 3.3 was selected in this application. DHT11 is a basic, low-cost digital temperature and humidity sensor. It uses a capacitive humidity sensor and a thermistor to measure the surrounding air, and spits out a digital signal on the data pin (no analog input pins needed). It's fairly simple to use, but requires careful timing to grab data. The only real down side of this sensor is you can only get new data from it once every 2 seconds. Table 3.1 shows technical specification of DHT 11. (Appendix C).

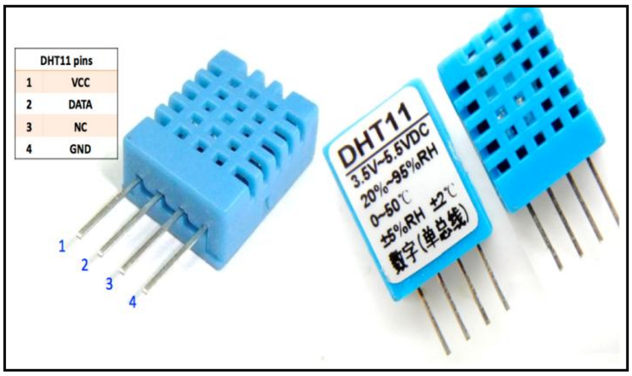

Figure 3.3: The DHT11 Sensor

Table 3.1: Technical Specification Of DHT11

Specification	Value
Resolution	1
Response time Temperature /Humidity	30 S /10 S
Accuracy Temperature /Humidity	±2℃/±5%RH
Range Temperature/ Humidity	0-50 ℃/ 20-90%RH
Power supply	DC 3.5～5.5V
Sampling period	more than 2 seconds

3.2.1.1 Single bus to transfer data defined

Data for communication and synchronization between the microprocessor and DHT11, single-bus data format, a transmission of 40 data, the high first-out.

3.2.1.2 Data format

The 8bit humidity integer data + 8bit the Humidity decimal data +8 bit temperature integer data + 8bit fractional temperature data +8 bit parity bit.

3.2.1.3 Parity bit data definition

8bit humidity integer data + 8bit humidity decimal data +8 bit temperature integer data + 8bit temperature fractional data” 8bit checksum is equal to the results of the last eight. Figure 3.4 show the data timing diagram.

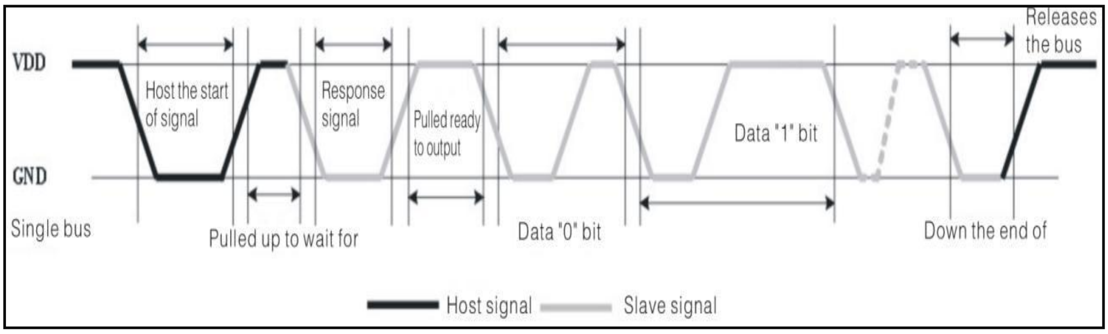

Figure 3.4 Data Timing Diagram

3.2.2 Light Sensor

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 3.2 shows technical specification of LDR. (Appendix D).

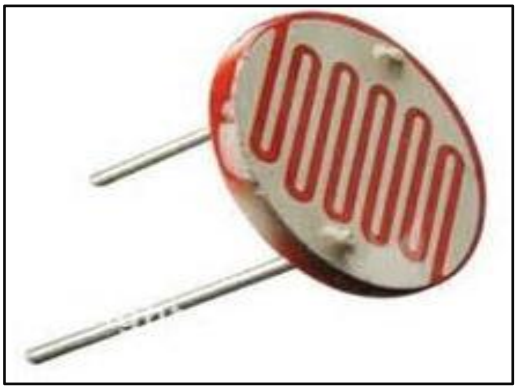

Figure 3.5: The Light Dependent Resistor

Table 3.2: Technical Specification of LDR

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

Because LDR give variable resistor it must connected to voltage divider circuit as shown in Figure 3.6, where the equation of Vout from the voltage divider is:

$$\mathrm{Vout} = \frac{\mathrm{LDR} \times \mathrm{Vin}}{\mathrm{LDR} + \mathrm{R1}} \qquad (3.1)$$

Then,

$$\mathrm{LDR} = \frac{\mathrm{Vout} \times \mathrm{R1}}{\mathrm{Vin} - \mathrm{Vovt}} \qquad (3.2)$$

To calculate the intensity of light uses this equation:

$$\mathrm{R1} = \frac{500}{\mathrm{LUX}} \qquad (3.3)$$

$$\mathrm{LUX} = 500/\mathrm{R1} \qquad (3.4)$$

Vout=Output voltage

Vin=Input voltage

R1=Resistor of voltage divider

LUX =Light intensity

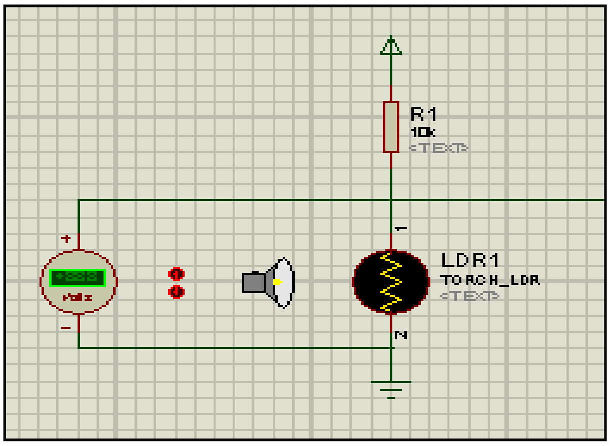

Figure 3.6: Schematic of Signal Conditioning Circuit For LDR Sensor

3.2.3 Soil Moisture Sensor

The Soil Moisture Sensor is used to measure the volumetric water content based on the dielectric constant of soil. The sensor is inserted in the soil to sense the existence of water. An electric current can easily pass through if there is moisture and due to the fact that the level of moisture is hard to determine and to make sure that the moisture sensor is very accurate and efficient. Figure 3.7 shows the Soil Moisture Sensor YL-69, and Figure 3.8 show the Equivalent Circuit of Soil Moisture Sensor.

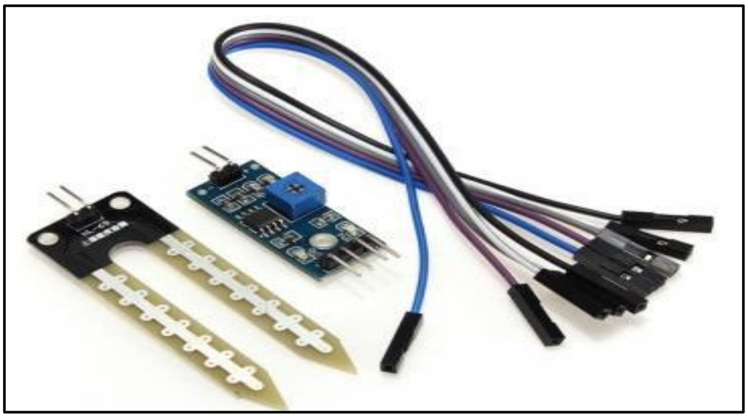

Figure 3.7: Soil Moisture Sensor YL-69

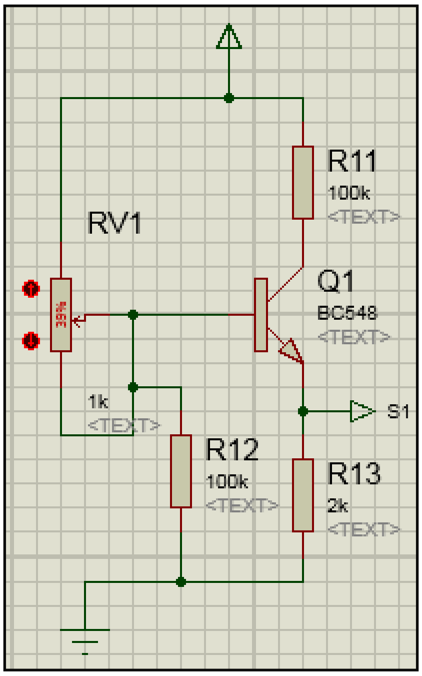

Figure 3.8: Equivalent Circuit of Soil Moisture Sensor

3.3 Processing Unit

(CPU) in order to perform various tasks as data acquisition, and data processing. Therefore a microcontroller was integrated into each transmit and receive stations. It is an integrated chip that has a CPU, Random Access Memory (RAM), Read Only Memory (ROM), on chip timers, Digital to Analog Converter (DAC) and many other components that are also presented on a computer. There are a large number of commercially available microcontrollers on the market today. Depending on the type application, each microcontroller has its advantages and disadvantages. The AVR ATmega16 microcontroller Shown in Figure 3.9 was selected. This particular microcontroller was chosen for several reasons, including its ease of programming, reliability, low power , high performance, CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. (Appendix E).

Features:

- 32 x 8 General Purpose Working Registers
- 512 Bytes EEPROM
- 1 Kbyte Internal SRAM
- 32 Programmable I/O Lines
- 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- 2.7V - 5.5V for ATmega16L
- 0 - 8 MHz for ATmega16L

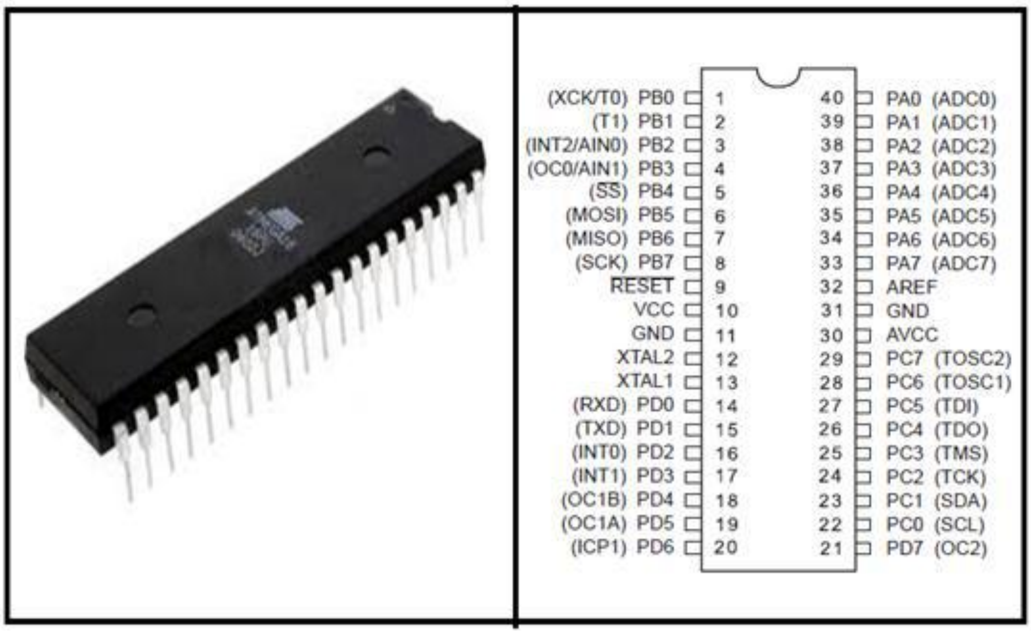

Figure 3.9: AVR ATmega16 Microcontroller

The BASCOM language was selected to programming the ATmaga16 Microcontroller for its simplicity. The BASCOM was invented in 1995 for personal usage only. Since that time, a lot of options and extensions were added. Without the help and patience of the many users, BASCOM would not be what it is today: "the best and most affordable tool for fast proto typing".

3.4 Wireless communication unit

To collect data from sensing unit and are monitored in the control unit to provide the appropriate conditions for the plant is a wireless communication where XBee ZigBee wireless modules were selected. The XBee as shown in Figure 3.10 is a device used to send and receive data wirelessly base on ZigBee/IEEE 802.15.4 network standard and support the unique needs of low-cost, low-power wireless sensor networks. The XBee module requires minimal power and provides reliable delivery of critical data between devices where some of its specifications were presented in Table 3.3. There are several types of XBee module, the very popular XBee type is series 1 and series 2. (See Appendix F)

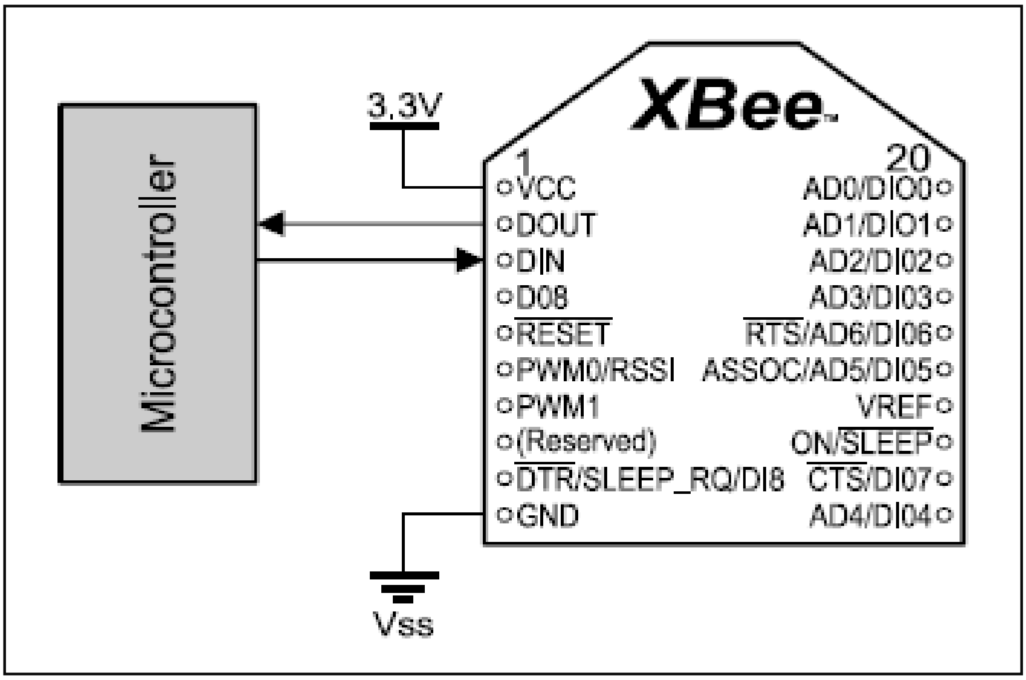

Figure 3.10: The XBee Module and Its Pin Description

Table 3.3: Technical Specifications of The XBee Module

Specification	**Value**
Radio Frequency Band	ISM 2.4GHz
RF Data Rate	250,000 bps
Indoor/Urban	up to 100ft/30 m
Outdoor Line-of-Sight	up to 300ft(100 m)
Transmit Power	1 mW (0 dBm)
Receiver Sensitivity	-92 dBm
TX Current/RX Current	45 mA (3.3 V)/ 50 mA (3.3 V)
Power-Down Current	< 10 Ma

3.5 Display Unit

The collected and processed data may need to be displayed. A 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 3.11 and Table 3.4 was used for simplicity and cost efficient.

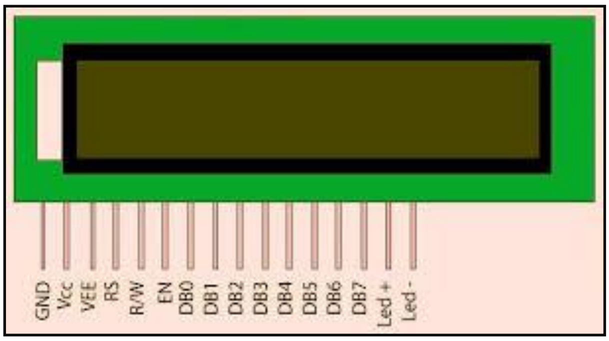

Figure 3.11: LCD And Its Pin Out

Table 3.4: Technical Specifications Of the 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.

3.6 Actuation Unit

An actuator is a piece of equipment which will produce a movement when signal is given. Actuators are used in the computer control of an environment, industrial automation and in robotics or, more generally, actuators are the machines used for output in control applications. For the situation in a computer controlled greenhouse, the actuators receive their control signal from the microcontroller to control the inside climate variables of the greenhouse. The designed unit includes the following actuators:

i. A ventilation fan: its speed determines the exchange between inside and outside air, thus causing natural ventilation.
ii. Heating system: consists of heater is distributed in the greenhouse.

- DC Fan: have developed for applications with demanding environmental requirements, signal speed, alarm with limit speed, external temperature sensor, analogue control input, and moisture protection.
- 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.

3.7 Power Supply Unit

The limitation of the wireless sensor unit can be discussed in term of the power, which is to be considered as crucial in the deployment of the sensor section. The sensor section needs to have low power consumption, and be portable and flexible. To meet these requirements a portable source of power is proposed. Monitoring of the environmental behavior should be done for duration of complete season. Power supply to sensor node is provided with 3.3VDC/220mA. After determine the output voltage and current of all components of the system that supported by the electrical characteristics for them to make a simple linear power supply in Figure 3.12, use a transformer to step down the 120V AC to a lower voltage needed. Next, send the low voltage AC through a bridge rectifier to make it DC and use filter capacitors that limit the rectifier ripple to a reasonable value. Finally, add a linear regulator with that can handle the required current to regulate the output voltage.

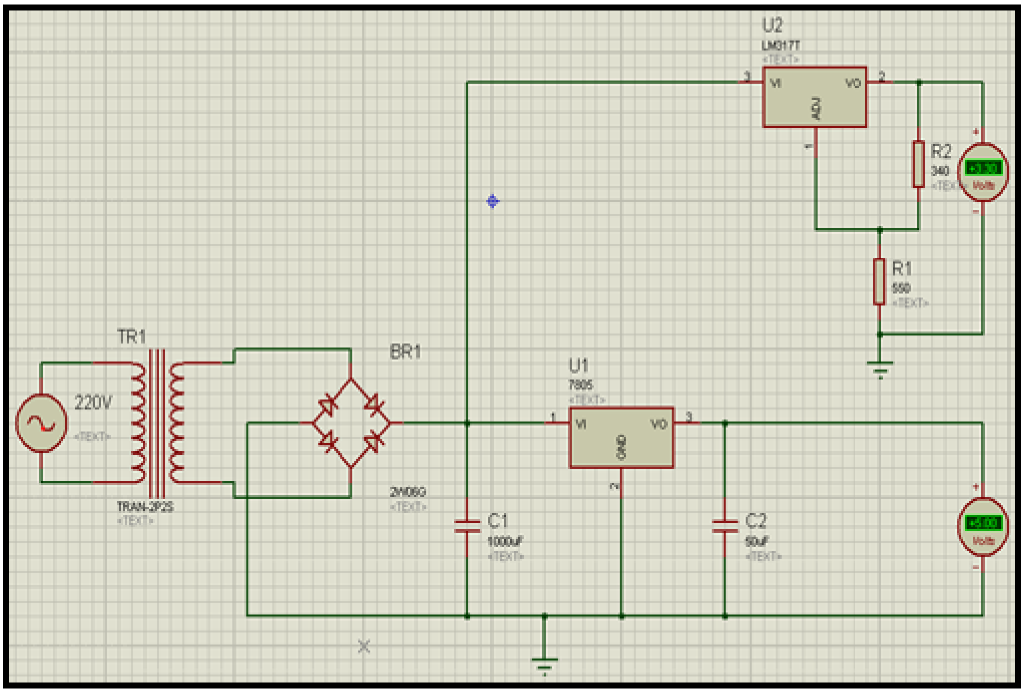

Figure 3.12: Design of Power Supply Unit

3.8 Monitoring And Control Unit

The transmission unit connected as shown in Figure 3.13. It contains several electronic elements: microcontroller (Atmega16), LCD for display, keypad for entering the data of set the system and ZigBee module for receive or transmit which replaced by wire communication. The proposed microcontroller was utilized as follow:

- Port B is used to interface the LCD.
- Port C is used to interface the keypad
- Port D is used as follow: PD 0 to receive data and PD1to transmit data.

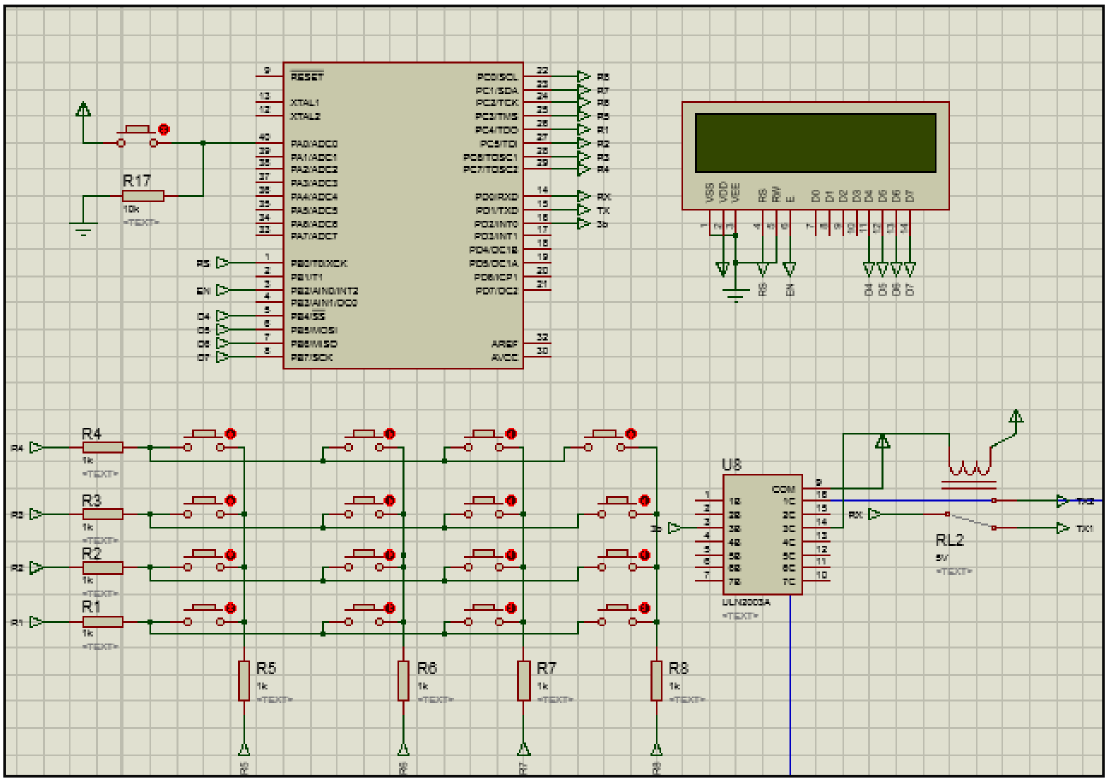

Figure 3.13: Monitoring and Control Unit

3.9 Sensing And Response Unit

The receiving unit connected as shown in Figure 3.14. It contains several electronic elements as follows:

- Microcontroller (Atmega16), DHT11 temperature and humidity sensor, YL-69 soil measure sensor, LDR light sensor, DC fan, DC motor, heater ,valve and lamp (which replaced by LEDs and four LEDs to show stutes of them two to each one), and ZigBee module for receive or transmit .
- DHT11 sensor: Have needed for reading the temperature and humidity in the Greenhouse.

- LDR sensor: Have needed for reading the light density in the Greenhouse.
- YL-69 sensor: Have needed for reading water level in soil.
- DC fan: Have needed for ventilation in greenhouse if the temperature is increase above and humidity is increase the needed of the plant.
- Water pump: Have needed for pumping water (which replaced by DC motor) in Greenhouse if the relative humidity is decrease the needed of the plant
- Heater: Have needed for heating in greenhouse if the temperature decreasing and humidity decreasing the needed of the plant.
- Relay: The relay driver is used to isolate both the controlling and the controlled device. The relay is an electromagnetic device, which consist 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. Hence the relay is used to switch the electrical supply to the appliances (Appendix H).
- L293D Driver: The L293D is quadruple high-current half-H driver. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. The device is designed to drive inductive loads such as relays,

solenoids, DC and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications (Appendix I).

- ULN2003 Driver: ULN2003 are high-voltage, high-current darling on drivers comprised of seven NPN Darlington pairs. All units feature integral clamp diodes for switching inductive loads. Applications include relay, hammer, lamp and display (LED) drivers. (Appendix J).
- The LM317 Regulator: is an adjustable 3 terminal positive voltage regulator capable of supplying in excess of 1.5 A over an output voltage range of 1.2 V to 37 V. This voltage regulator is exceptionally easy to use and requires only two external resistors to set the output voltage. Further, it employs internal current limiting, thermal shutdown and safe area compensation, making it essentially blow out proof. The LM317 serves a wide variety of applications including local, on card regulation. This device can also be used to make a programmable output regulator, or by connecting a fixed resistor between the adjustment and output, the LM317 can be used as a precision current regulator. (Appendix G).
- Port A is used as follow: PA1 connected to the LDR with resistor 10KΩ, PA2 connected with soil measure sensor.
- Port B is used to interface the LCD.
- Port C is used as follow: PC0, PC1 is used to show the stutes of light, PC2 connected to lamp, PC3 connected to valve and PC7 connected to DHT11 sensor.
- Port D is used as follow: PD0 is used to receive data, PD1 is used to transmit data, PD2 connected to motor, PD3 connected to heater, PD4 and PD5 connected to fan and PD6, and PD7 show the statues of water level in soil.

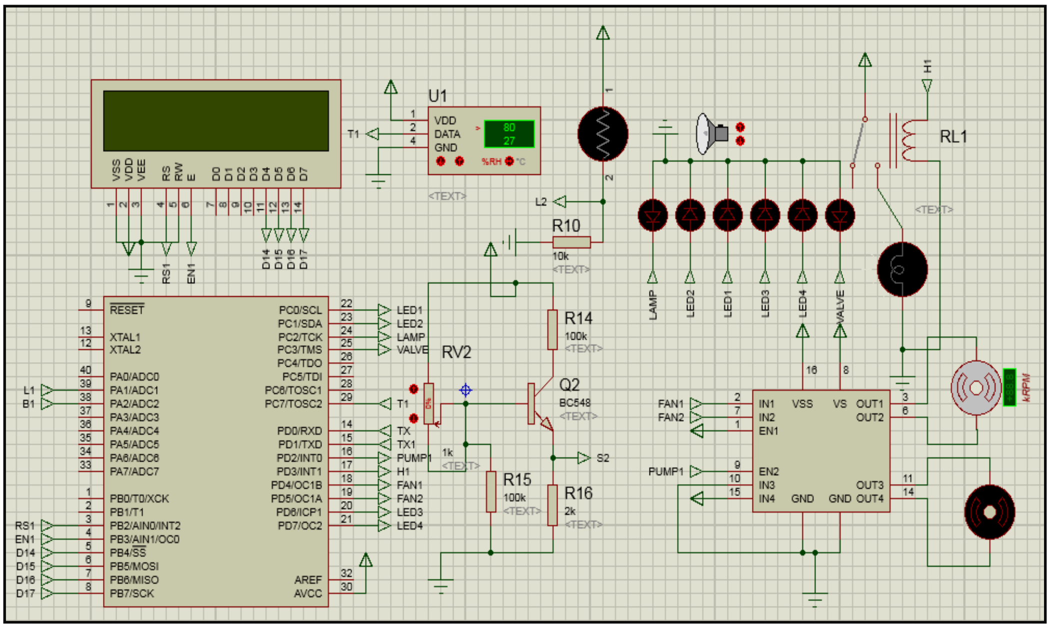

Figure 3.14: Sensing and Response Unit

3.10 System Operation Flow Chart

The system is clarified using the flowchart; it is illustrate comparing the set values with the acquiring values as shown in Figure 3.15.

Firstly enter the values of the greenhouse parameters and upload these values into sensing and response unit to comparing with acquiring values. If the set temperature greater than the acquired temperature the microcontroller send signal to run the fan and the heater, else run the fan. If the set humidity greater than the acquired humidity the microcontroller send signal to run the pump, heater and fan, else run the fan. If the set light greater than the acquired light the microcontroller send signal to ON the lamp, else OFF the lamp. If the set of soil measure greater than the acquired soil measure the microcontroller send signal to open the valve, else close the valve.

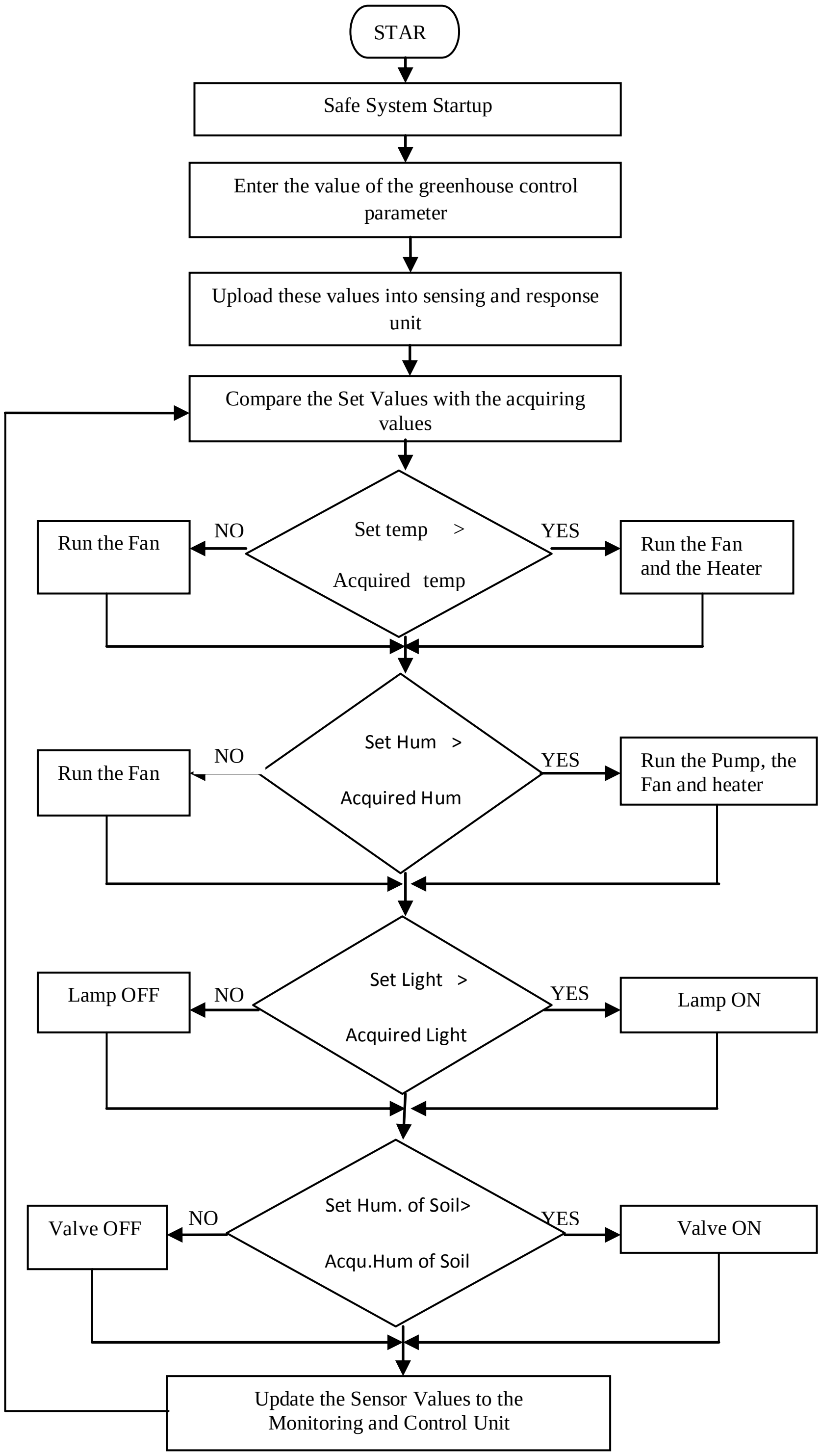

Figure 3.15: The Flow Chart

Chapter four

Simulation Results

Chapter four

Simulation Results

4.1 Introduction

As mentioned in chapter three, the monitoring and controlling unit and sensing and response unit based on wireless sensor network can be there got different result based on effective management of greenhouse environment. In this chapter, these different responses were discussed based on the greenhouse management.

4.2 The Monitoring and Control Unit

After safe system booting, the set sensors value entered via keypad (maximum & minimum temperature, etc) as shown in Figure 4.1.

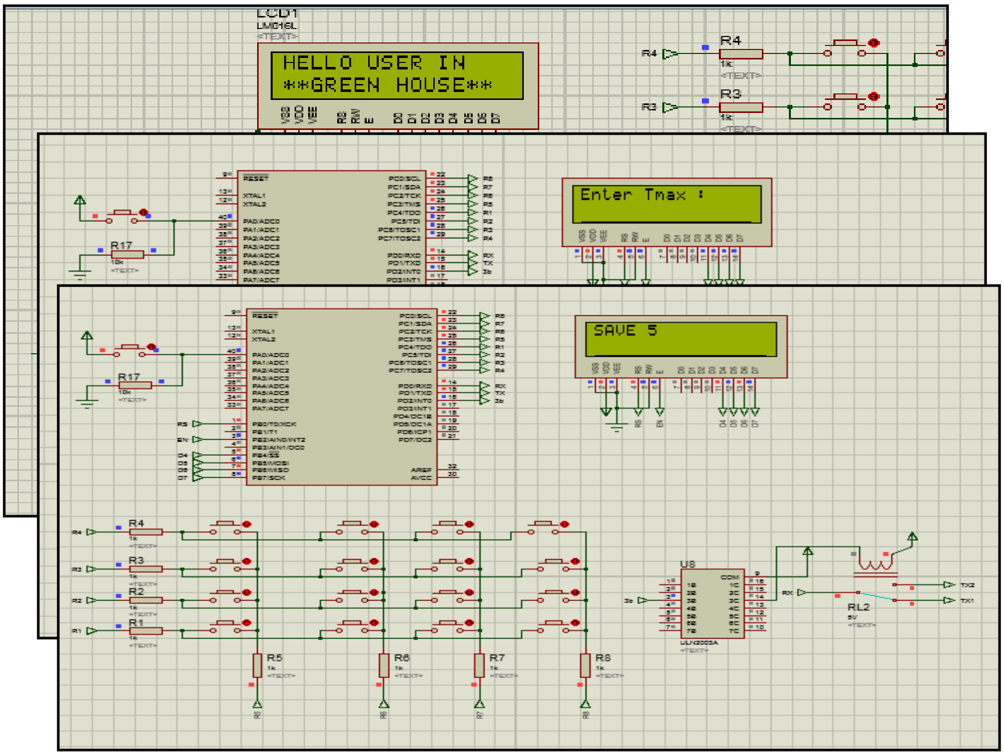

Figure 4.1: Entering and Saving Data

The set sensors values at the monitor and control unit were uploaded through the XBee module to the sensing and response unit. After set sensors values were sent to local station and it compare them with sensor value the statues of the parameter were sent via XBee module to Monitoring and Control Unit as shown in Figure 4.2.

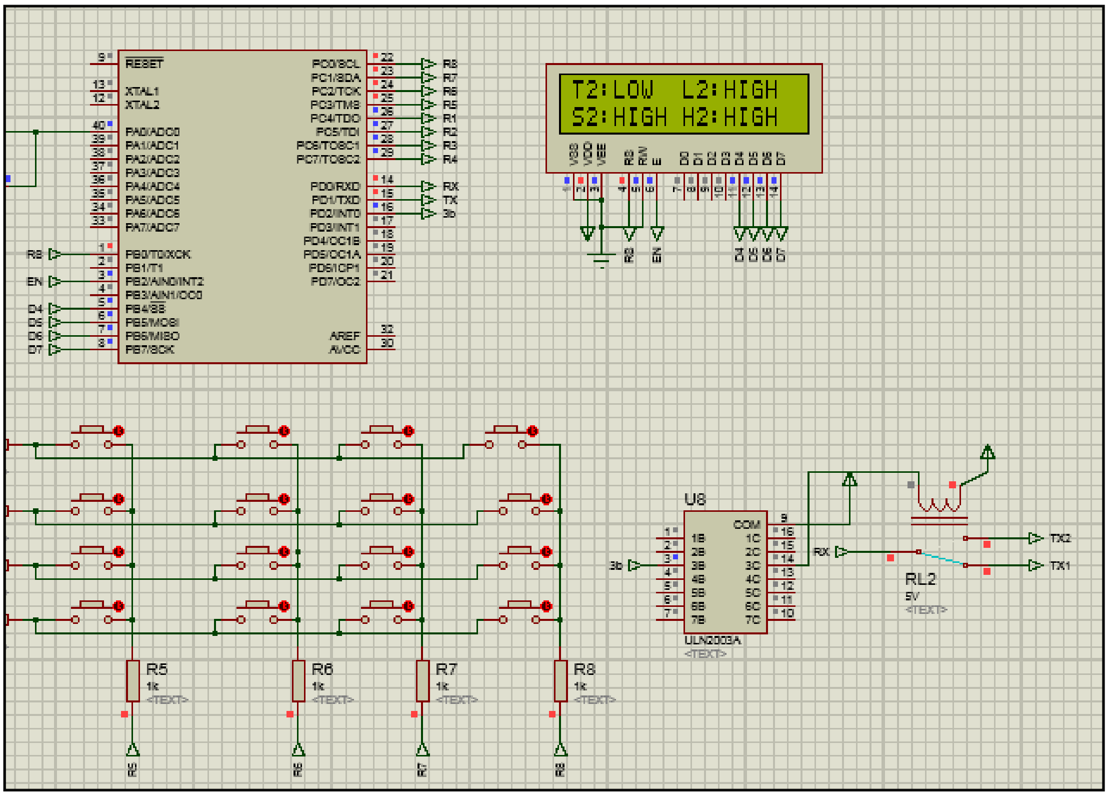

Figure 4.2: Receive The Statues Of The Parameter

4.3 The Sensing and Response Unit

The sensing and response unit receives the preset sensor values at the monitoring and control unit through its associated XBee module. Then these values were stored at the microcontroller memory to maintain the environmental conditions of the greenhouse accordingly. Four environmental conditions can be maintained: temperature, humidity, light, and level of water in the soil. In the following, the associated response to the change of each parameter can be explored.

4.3.1 Temperature Control

To decrease the acquired temperature in the green house to meet the required one, a ventilating fan can be turned on as in Figure 4.3. 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, a heater with the circulation fan can be turned on as shown in Figure 4.4.

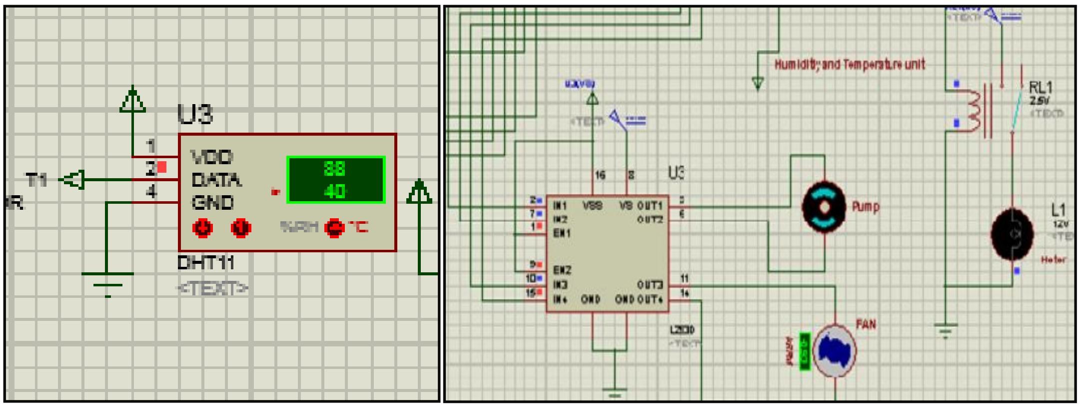

Figure 4.3: The Decreasing Temperature

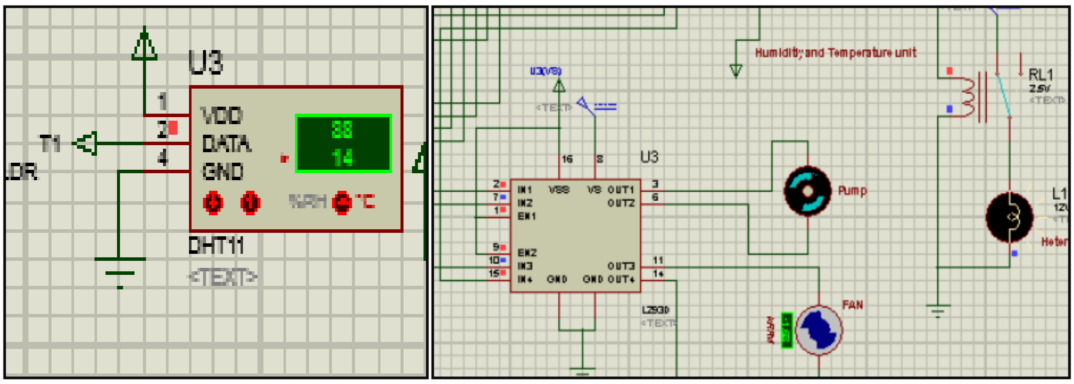

Figure 4.4: The Increasing Temperature

4.3.2 Humidity Control

The DHT 11 humidity sensor can track the percentage of the humidity at the green house atmosphere. While the humidity shows decrement percentage, the water pump, heater and circulation fan can be turned on to inject vapored water to the environment of the green house as can be shown in Figure 4.5. In contrast, when the humidity recorded a higher percentage than the set one, the sucker fan can be turned on to evacuate the excessive percentage of humidity as shown in Figure 4.6.

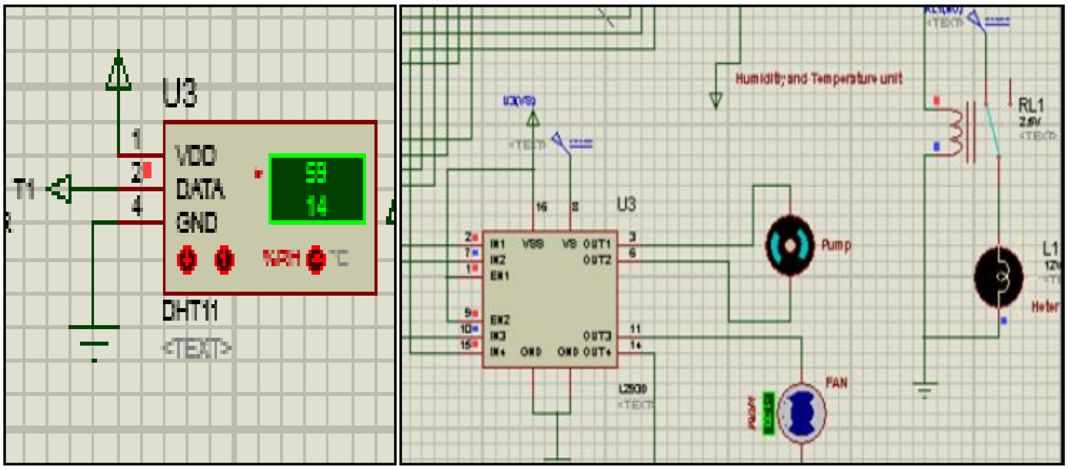

Figure 4.5: The Decreasing Humidity

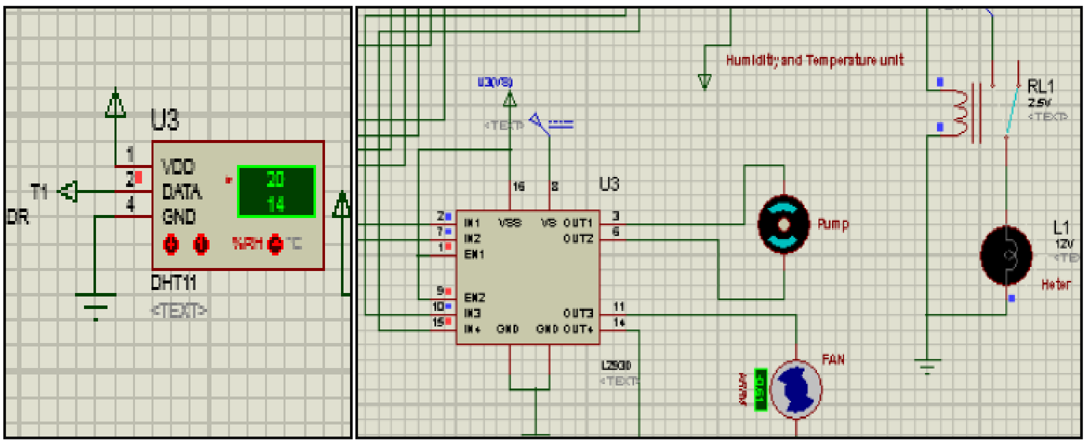

Figure 4.6: The Increasing Humidity

4.3.3 Light Control

Most of the crop needs a natural sun light to grow. The green house can provide this direct sun light through its transparent roof. After while this transparent roof become darker by the accumulated dust, therefore the light intensity sensor can be used to monitor and note when the received light is less than the required amount. A lamp can be recognized to indicate the low light intensity inside the greenhouse as shown in Figure 4.7, Figure 4.8 and Figure 4.9 to show the statues of light.

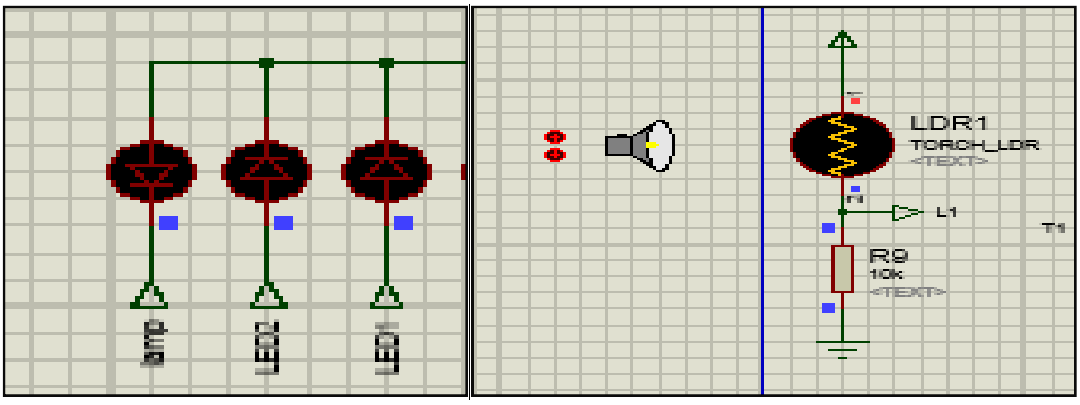

Figure 4.7: The Normal Range of Light

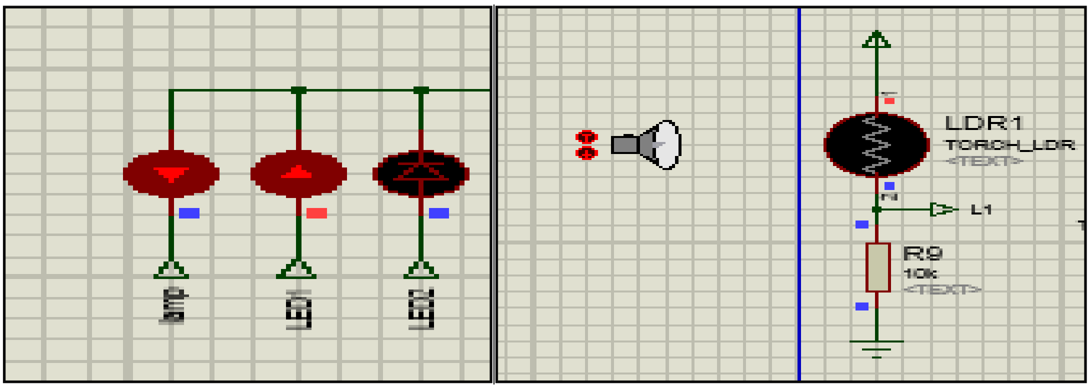

Figure 4.8: The Increasing Light

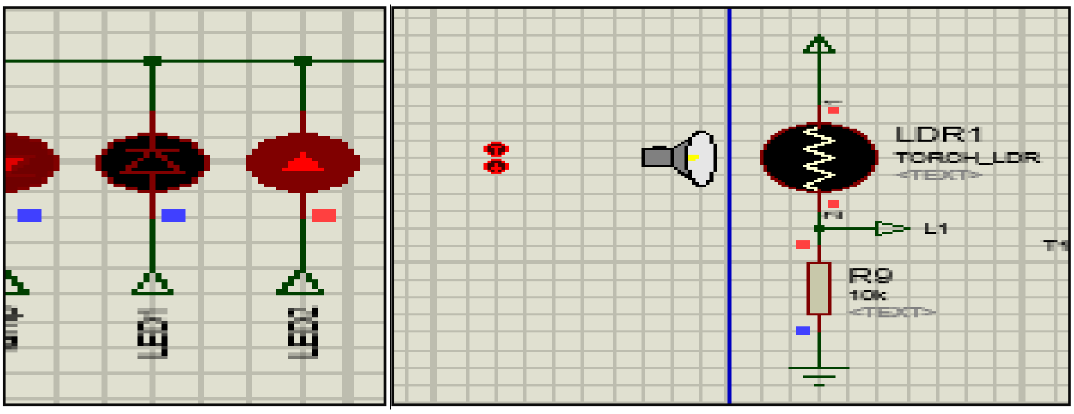

Figure 4.9: The Decreasing Light

4.3.4 Soil Control

The YL-69 sensor track the level of water in soil. While the level of water shows decrement percentage, the valve open as can be shown in Figure 4.11 and Figure 4.10 show the normal range . In contrast, when the water level recorded a higher percentage than the set one, the valve closed as shown in Figure 4.12.

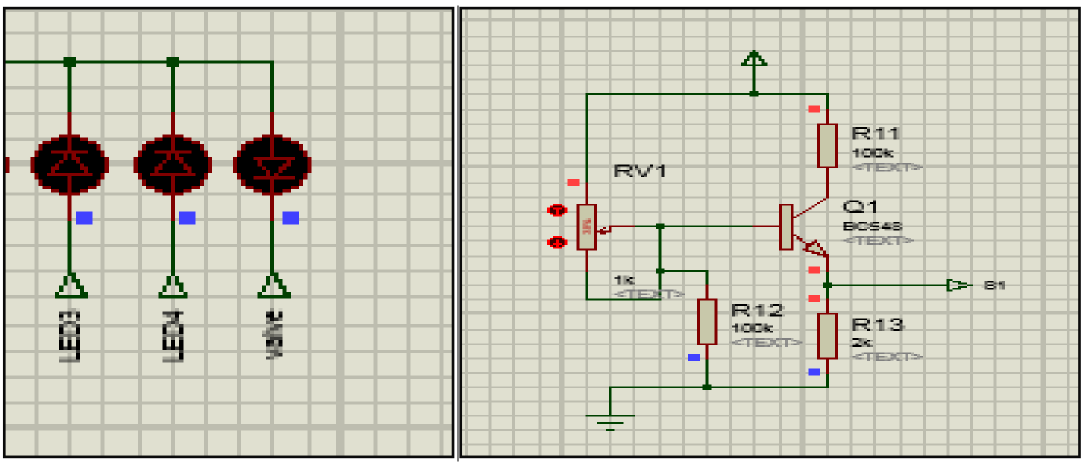

Figure 4.10: The Normal Range of Water

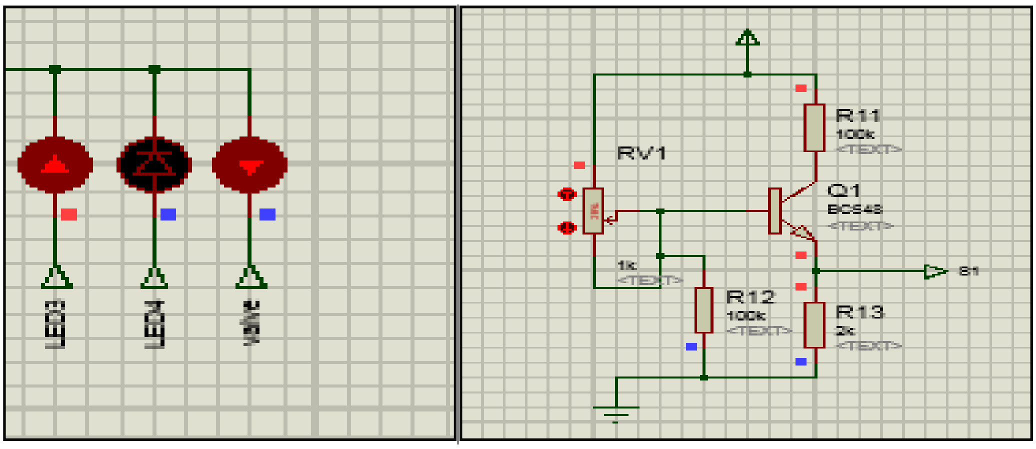

Figure 4.11: The Increasing water

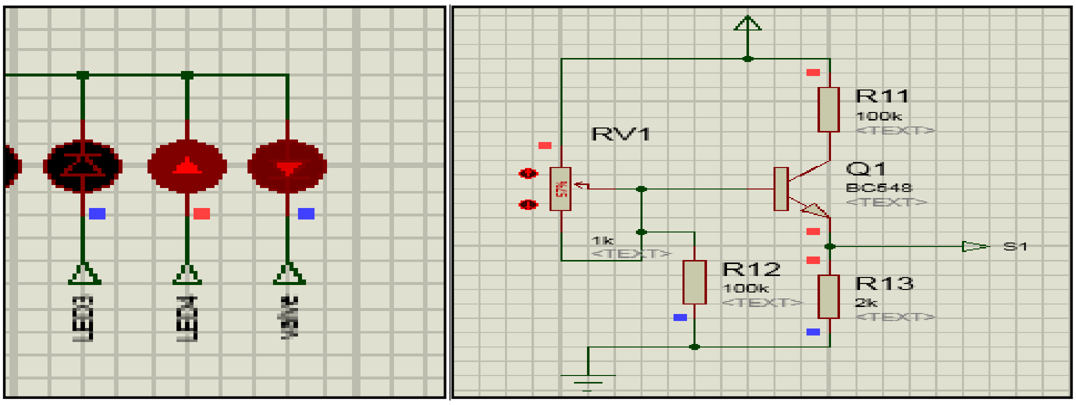

Figure 4.12: The Decreasing water

Chapter five

Conclusion And Recommendations

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This thesis presents a design of a simple and low cost monitoring and control greenhouse system based on a ZigBee technology. A temperature, humidity and light sensors were integrated with fan, heater and pump to figure out the sensing and responding unit. The microcontroller and XBee module were utilized to be the processing and communication units respectively.

The proposed WSN i.e. XBee is one of the promising solution lower installation and running costs, and increase flexibility and reliability in a greenhouse management system. Compatibility, compactness, portability and low power consumption is some of important key elements in the design of wireless system. Therefore a carefully selection of sensing devices and circuitry components is also very important especially when interfaced to the microcontroller. The management scenario of the entire environment of the greenhouse has a crucial importance in utilizing the attached responding elements, where the logical relation between them should be studies firstly. In conclusion, greenhouse climate monitoring and controlling is one attractive application field to create a wireless automation system.

5.1 Recommendations

This research has provided a comprehensive report on the design process and implementation of a ZigBee based wireless greenhouse management system. Certainly, there is a need for further study to improve the system reliability and capability. The following improvements can be recommended for possible future work:

- More sensors can be added to the sensing unit to monitor other environmental parameters such as soil pH level, air flow, carbon monoxide and oxygen level.
- Using MAX232 circuit with GUI in controlling unit.
- Add GBS module for locate the local station and predict the parameter depending on region.
- Global system for mobile communication and 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 green house environment through the transmission of a simple short texts message.

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APPENDIX

A.APPENDIX A

CODE OF CENTRAL STATION

```
$regfile = "m16def.dat"

$crystal = 8000000

$baud = 9600

'*****************************LCD configuration*********************

ConfigLcd = 16 * 2

ConfigLcdpin = Pin , Db4 = Portb.4 , Db5 = Portb.5 , Db6 = Portb.6 , Db7 = Portb.7
, E = Portb.2 , Rs = Portb.0

Cursor Off

Cls

Config Com1 = Dummy ,Synchrone = 0 , Parity = None , Stopbits = 1 , Databits = 8
, Clockpol = 0

Enable Urxc

Config Pina.0 = Input

Config Portd.2 = Output

ConfigKbd = Portc                    'KEYBAD CONFIGURATION

Dim Bt As Byte

Dim S As String * 64

Dim K As Byte

Dim C As Byte

C = 0
```

```
Dim Tmax1 As Byte                    'MAXMUM TEMPRETURE
Dim Tmax2 As Byte
Dim TmaxAs Word
Dim Tmin1 As Byte                    'MINMUM TEMPRETURE
Dim Tmin2 As Byte
Dim TminAs Word
Dim Lmax1 As Byte                    'MAXMUM LIHGT
Dim Lmax2 As Byte
Dim LmaxAs Word
Dim Lmin1 As Byte                    'MINMUM LIHGT
Dim Lmin2 As Byte
Dim LminAs Word
Dim Hmax1 As Byte                    'MAXMUM HUMIDUTIY
Dim Hmax2 As Byte
Dim Hmax As Word
Dim Hmin1 As Byte                    'MINMUM HUMIDUTIY
Dim Hmin2 As Byte
Dim Hmin As Word
Dim Smax1 As Byte                    'MAXMUM LEVEL OF WATER IN SOIL
Dim Smax2 As Byte
```

```
Dim SmaxAs Word
Dim Smin1 As Byte                    'MINMUM LEVEL OF WATER IN SOIL
Dim Smin2 As Byte
Dim SminAs Word
Dim F As Byte                         'keypad value
Dim Q As Byte
'*********WELLCOM IN GREENHOUSE MONTIRING SYSTEM************
Cls
Locate 1 , 1
Lcd "Enter Tmax : "
'***********CALCAULATE & SEND MAXMUM TEMPERTURE*****
Do
K = Getkbd()                          'GET FROM KEYBAD
If K <> 16 Then Gosub Key1
Waitms 100
Locate 2 , C
Lcd F
If C = 1 Then
Waitms 200
Cls
Locate 1 , 1
Lcd "SAVE " ; Tmax
```

```
Print Tmax
C = 0
Wait 2
Exit Do
End If
Loop
Cls
Locate 1 , 1
Lcd "Enter Tmin : "

'***********CALCAULATE & SEND MINMUM TEMPERTURE************
Do
K = Getkbd()                              'GET FROM KEYBAD
If K <> 16 Then Gosub Key2
Waitms 100
Locate 2 , C
Lcd F
If C = 1 Then
Waitms 200
Cls
```

```
Locate 1 , 1

Lcd "SAVE " ; Tmin

Print Tmin

C = 0

Wait 2

Exit Do

End If

Loop

Cls

Locate 1 , 1

Lcd "Enter Lmax"


'*********CALCAULATE & SEND MAXMUM LIGH*********************

Do                                'GET FROM KEYBAD

K = Getkbd()

If K <> 16 Then Gosub Key3

Waitms 100

Locate 2 , C

Lcd F

If C = 1 Then

Waitms 200

Cls
```

```
Locate 1 , 1

Lcd "SAVE " ; Lmax

Print Lmax

C = 0

Wait 2

Exit Do

End If

Loop

Cls

Locate 1 , 1

Lcd "Enter Lmin:"

*********CALCAULATE & SEND MINMUMLIGH**********************

Do

K = Getkbd()                                'GET FROM KEYBAD

If K <> 16 Then Gosub Key4

Waitms 100

Locate 2 , C

Lcd F

If C = 1 Then

Waitms 200

Cls

Locate 1 , 1
```

```
Lcd "SAVE " ; Lmin

Print Lmin                          'SEND THE VALUE TO LOCAL
STATION

C = 0

Wait 2

Exit Do

End If

Loop

Cls

Locate 1 , 1

Lcd "Enter Hmax"


'****************CALCAULATE & SEND MAXMUM HUMIDITY**********

Do

K = Getkbd()                                'GET FROM KEYBAD

If K <> 16 Then Gosub Key5

Waitms 100

Locate 2 , C

Lcd F

If C = 1 Then

Waitms 200

Cls
```

```
Locate 1 , 1
Lcd "SAVE " ; Hmax
Print Hmax   'SEND THE VALUE TO LOCAL STATION
C = 0
Wait 2
Exit Do
End If
Loop
Cls
Locate 1 , 1
Lcd "Enter Hmin:"
'****************CALCAULATE & SEND MINMUM HUMIDITY***********
Do
K = Getkbd()                                'GET FROM KEYBAD
If K <> 16 Then Gosub Key6
Waitms 100
Locate 2 , C
Lcd F
If C = 1 Then
Waitms 200
Cls
Locate 1 , 1
```

```
Lcd "SAVE " ; Hmin
Print Hmin                              'SEND THE VALUE TO LOCAL
STATION
C = 0
Wait 2
Exit Do
End If
Loop
Cls
Locate 1 , 1
Lcd "Enter Smax:"
'*******CALCAULATE & SEND MAXMUM WATER LEVEL IN SOIL*******
Do
K = Getkbd()                            'GET FROM KEYBAD
If K <> 16 Then Gosub Key7
Waitms 100
Locate 2 , C
Lcd FIf C = 1 Then
Waitms 200
Cls
Locate 1 , 1
Lcd "SAVE " ; Smax
```

```
Print Smax                                    'SEND THE VALUE TO LOCAL
STATION

C = 0

Wait 2

Exit Do

End If

Loop

Cls

Locate 1 , 1

Lcd "Enter Smin:"

‘*******CALCAULATE & SEND MAXMUM WATER LEVEL IN SOIL*******

Do

K = Getkbd()                                  'GET FROM KEYBAD

If K <> 16 Then Gosub Key8

Waitms 100

Locate 2 , C

Lcd F

If C = 1 Then

Waitms 200

Cls

Locate 1 , 1

Lcd "SAVE " ; Smin
```

```
Print Smin                                'SEND THE VALUE TO LOCAL
STATION
C = 0
Wait 2
Cls
Goto L1
Exit Do
End If
Loop

'**********RECIVE DATA FROM LOCALS STATION *************
L1:
Enable Interrupts
On Urxc Display1
Display1:
Do
InputbinBt
S = Chr(bt)
'*******CHOOSE THE LOCAL STATION TO RECIVE DATA FROM*********
If Pina.0 = 1 Then
Portd.2 = 1
Goto W1
```

```
Elseif Pina.0 = 0 Then
Portd.2 = 0
Goto M1
End If
'**** RECIVE & COMPAIRISON THE RECIVE DATA OF FIRST STATION ***
W1:
If S = "1" Then
Locate 1 , 1
Lcd "T:NORM"
Waitms 100
End If
If S = "2" Then
Locate 1 , 1
Lcd "T:HIGH"
Waitms 100
End If
If S = "3" Then
Locate 1 , 1
Lcd "T:LOW "
Waitms 100
End If
If S = "4" Then
```

```
Locate 1 , 9
Lcd "L:NORM"
Waitms 100
End If
If S = "5" Then
Locate 1 , 9
Lcd "L:HIGH"
Waitms 100
End If
If S = "6" Then
Locate 1 , 9
Lcd "L:LOW "
Waitms 100
End If
If S = "6" Then
Locate 2 , 1
Lcd "S:NORM"
Waitms 100
End If
If S = "7" Then
Locate 2 , 1
Lcd "S:HIGH"
```

```
Waitms 100

End If

If S = "8" Then

Locate 2 , 1

Lcd "S:LOW "

Waitms 100

End If

If S = "l" Then

Locate 2 , 9

Lcd "H:NORM"

Waitms 100

End If


If S = "m" Then

Locate 2 , 9

Lcd "H:HIGH"

Waitms 100

End If

If S = "n" Then

Locate 2 , 9

Lcd "H:LOW "

Waitms 100
```

```
End If
'******* COMPAIRISON THE RECIVE DATA OF SECOUND STATION******
M1:
If S = "a" Then
Locate 1 , 1
Lcd "T2:NORM"
Waitms 100
End If
If S = "b" Then
Locate 1 , 1
Lcd "T2:HIGH"
Waitms 100
End If
If S = "c" Then
Locate 1 , 1
Lcd "T2:LOW "
Waitms 100
End If
If S = "d" Then
Locate 1 , 9
Lcd "L2:NORM"
Waitms 100
```

```
End If
If S = "e" Then
Locate 1 , 9
Lcd "L2:HIGH"
Waitms 100
End If
If S = "f" Then
Locate 1 , 9
Lcd "L2:LOW "
Waitms 100
End If
If S = "g" Then
Locate 2 , 1
Lcd "S2:NORM"
Waitms 100
End If
If S = "h" Then
Locate 2 , 1
Lcd "S2:HIGH"
Waitms 100
End If
If S = "i" Then
```

```
Locate 2 , 1

Lcd "S2:LOW "

Waitms 100

End If

If S = "j" Then

Locate 2 , 1 9

Lcd "H2:NORM"

Waitms 100

End If

If S = "k" Then

Locate 2 , 9

Lcd "H2:HIGH"

Waitms 100

End If


If S = "w" Then

Locate 2 , 9

Lcd "H2:LOW "

Waitms 100

End If

Loop

Return
```

```
'************CALCULATE THE SETTING POINT***********************

Key1:

F = Lookup(k , Mat )

Incr C

If C = 1 Then

Tmax1 = F

Tmax = Tmax1

End If

Waitms 50

Return

Key2:

F = Lookup(k , Mat )

Incr C

If C = 1 Then

Tmin1 = F

Tmin = Tmin1

End If

Waitms 50

Return

Key3:

F = Lookup(k , Mat )

Incr C
```

```
If C = 1 Then
Lmax1 = F
Lmax = Lmax1
End If
Waitms 50
Return
Key4:
F = Lookup(k , Mat )
Incr C
If C = 1 Then
Lmin1 = F
Lmin = Lmin1
End If
Waitms 50
Return

Key5:
F = Lookup(k , Mat )
Incr C
If C = 1 Then
Hmax1 = F
Hmax = Hmax1
```

```
End If
Waitms 50
Return
Key6:
F = Lookup(k , Mat )
Incr C
If C = 1 Then
Hmin1 = F
Hmin = Hmin1
End If
Waitms 50
Return
Key7:
F = Lookup(k , Mat )
Incr C
If C = 1 Then
Smax1 = F
Smax = Smax1
End If
Waitms 50
Return
Key8:
```

```
F = Lookup(k , Mat )

Incr C

If C = 1 Then

Smin1 = F

Smin = Smin1

End If

Waitms 50

Return

'***********KEYPAD MATRIX*************************************

Mat:

Data 15 , 14 , 0 , 13 , 12 , 9 , 8 , 7 , 11 , 6 , 5 , 4 , 10 , 3 , 2 , 1
```

B.APPENDIX B

CODE OF LOLAL STATION

```
$regfile = "m16def.dat"

$crystal = 8000000

$baud = 9600

'******************  lcd configuration****************************************

ConfigLcd = 16 * 2

ConfigLcdpin = Pin , Db4 = Portb.4 , Db5 = Portb.5 , Db6 = Portb.6 , Db7 = Portb.7 , E =
Portb.3 , Rs = Portb.2


‘****************** Communication configuration*******************************


Config Com1 = Dummy ,Synchrone = 0 , Parity = None , Stopbits = 1 , Databits = 8 , Clockpol =
0

Enable Interrupts

Enable Urxc

On Urxc Display1

Cursor Off

Cls

'****************** Timer & ADC configuration ***************************

Config Timer1 = Pwm ,Pwm = 8 , Compare A Pwm = Clear Down , Compare B Pwm = Clear
Down , Prescale = 64

ConfigAdc = Single ,Prescaler = Auto , Reference = Avcc

‘********************** DHT11 configuration******************************

Declare Sub Get_th(t As Byte , H As Byte)
```

```
Dht_put Alias Portc.7
Dht_get Alias Pinc.7
Dht_io_set Alias Ddrc.7
Dim T As Byte
Dim H As Byte
Dim CrcAs Byte
Dim MybyteAs Byte
Dim Sensor_dataAs String * 40
Dim Tmp_str8 As String * 8
Dim Count As Byte
Set Dht_io_set
Set Dht_put
‘***************************************************************************
Dim H2 As Byte
Dim H3As Byte
Dim Rx As Byte
Dim TmaxAs String * 64
Dim Rx1 As Byte
Dim TminAs String * 64
Dim Rx2 As Byte
Dim LmaxAs String * 64
Dim Rx3 As Byte
Dim LminAs String * 64
Dim Rx4 As Byte
```

```
Dim HmaxAs String * 64
Dim Rx5 As Byte
Dim HminAs String * 64
Dim Rx6 As Byte
Dim SmaxAs String * 64
Dim Rx7 As Byte
Dim SminAs String * 64
Dim L As Word
Dim Light As Single
Dim S As Word
Dim Soil As Single
Config Portd.2 = Output
Config Portd.3 = Output
Config Portd.6 = Output
Config Portd.7 = Output
Config Portc.0 = Output
Config Portc.1 = Output
Config Portc.2 = Output
Config Portc.3 = Output
'********************LOCAL STATION1 SYSTEM******************************
Cls
Locate 2 , 5
Lcd "NO DATA"
Wait 1
```

```
Cls
'******************RECIVE MAXMUM TEMPERTURE*****************************
Display1:
Do
Inputbin Rx
Tmax = Chr(rx)
Locate 2 , 1
LcdTmax
Wait 1
Cls
Gosub 1
Loop
'******************RECIVE MINMUM TEMPERTURE*****************************
1:
Do
Inputbin Rx1
Tmin = Chr(rx1)
Locate 2 , 1
LcdTmin
Wait 1
Cls
Gosub 2
Loop
'*******************************RECIVE MAXMUM LIGHT ************************
```

```
2:
Do
Inputbin Rx2
Lmax = Chr(rx2)
Locate 2 , 1
LcdLmax
Wait 1
Cls
Gosub 3
Loop
'***************************RECIVE MINMUM LIGHT*************************
3:
Do
Inputbin Rx3
Lmin = Chr(rx3)
Locate 2 , 1
LcdLmin
Wait 1
Cls
Gosub 4
Loop

'****************************RECIVE MAXMUM HUMIDITY **********************
4:
```

```
Do
Inputbin Rx4
Hmax = Chr(rx4)
Locate 2 , 1
LcdHmax
Wait 1
Cls
Gosub 5
Loop
'*************************RECIVE MINMUM HUMIDITY*********************
5:
Do
Inputbin Rx5
Hmin = Chr(rx5)
Locate 2 , 1
LcdHmin
Wait 1
Cls
Gosub 6
Loop
'*******************RECIVE MAXMUM WATER LEVEL IN SOIL ********************
6:
Do
Inputbin Rx6
```

```
Smax = Chr(rx6)
Locate 2 , 1
LcdSmax
Wait 1
Cls
Gosub 7
Loop
'************RECIVE MINMUM WATER LEVEL IN SOIL************************
7:
Do
Inputbin Rx7
Smin = Chr(rx7)
Locate 2 , 1
LcdSmin
Wait 1
Cls
Goto Main
Loop
Return
*********************READ DATA FROM SENSORS****************************
Main:
Cls
Do
Waitms 1500
```

```
 Call Get_th(t , H)                              'READ TEMPERTURE & HUMIDITY FROM
DHT11 SENSOR

Cls

  Locate 1 , 1

Lcd "TMPE: " ; T ; "C"

Locate 1 , 9

Lcd "HUM: " ; H ; "%"


L = Getadc(1)                                     'READ PRECINAGE OF LIGHT FROM LDR
SENSOR

     Light = L

     Light = Light / 10

     Light = Round(light)

     Locate 2 , 9

Lcd "L:" ; Light ; "%"

     Wait 5

S = Getadc(2)                                     'READ WATER LEVEL IN SOIL FROM SOIL
SENSOR

     Soil = S

     Soil = Soil / 10

     Soil = Round(soil)

     Locate 2 , 1

Lcd "S:" ; Soil ; "%"

     Wait 5

     Light = H2
```

```
   Soil = H3
'**************SELECT STATUES OF TEMERATURE IN LOCAL******************
If T > "TMIN" And T < "TMAX" Then
Compare1a = 204                          'NORMAL TEMPERTURE
Compare1b = 0
Portd.3 = 0
Portd.2 = 0
Print "a"
Wait 1
End If
If H > "TMAX" Then
Compare1a = 255                          'HIGH TEMPERTURE
Compare1b = 0
Portd.3 = 0
Portd.2 = 1
Print "b"
Wait 1
End If
If H < "TMIN" Then
Compare1a = 204                          'LOW TEMPERTURE
Compare1b = 0
Portd.3 = 1
Portd.2 = 0
Print "c"
```

```
Wait 1
End If
'**************SELECT STATUES OF LIGHT IN LOCAL**************************
If H2 > "LMIN" And H2 < "LMAX" Then                    'NORMAL LIGHT
Portc.0 = 0
Portc.1 = 0
Portc.2 = 0
Print "d"
Wait 1
End If
If H2 < "LMIN" Then                                    'HIGH LIGHT
Portc.0 = 0
Portc.1 = 1
Portc.2 = 0
Print "e"
Wait 1
End If
If H > "LMAX" Then                                     'LOW LIGHT
Portc.0 = 1
Portc.1 = 0
Portc.2 = 1
Print "f"
Wait 1
End If
```

```
*********SELECT STATUES OF HUMIDITY IN LOCAL**************************
If H > "HMIN" And H < "HMAX" Then
Compare1a = 204                          'NORMAL HUMIDITY
Compare1b = 0
Portd.3 = 0
Portd.2 = 0
Print "j"
Wait 1
End If
If H2 < "HMIN" Then
Compare1a = 255                          'LOW HUMIDITY
Compare1b = 0
Portd.3 = 1
Portd.2 = 1
Print "k"
Wait 1
End If
If H > "HMAX" Then
Compare1a = 255                          'HIGH HUMIDITY
Compare1b = 0
Portd.3 = 0
Portd.2 = 0
Print "w"
Wait 1
```

```
End If
'************************************SELECT STATUES OF WATER ON SOIL IN LOCAL**************************
If H3 > "SMIN" And H3 < "SMAX" Then                    'NORMAL MODE _ NO NEED WATER
Portd.6 = 0
Portd.7 = 0
Portc.3 = 0
Print "g"
Wait 1
End If
If H3 < "SMIN" Then                              'LOW MODE
Portd.6 = 1
Portd.7 = 0
Portc.3 = 1
Print "h"
Wait 1
End If
If H3 > "SMAX" Then                              'HIGHT MODE
Portd.6 = 0
Portd.7 = 1
Portc.3 = 0
Print "i"
Wait 1
End If
```

```
Loop
'****************** DHT11 CALCULATION FUNCTION *************************
Sub Get_th(t As Byte , H As Byte)
 Count = 0
Sensor_data = ""
 Set Dht_io_set
 Reset Dht_put
Waitms 25
 Set Dht_put
Waitus 40
 Reset Dht_io_set
Waitus 40
 If Dht_get = 1 Then
    H = 1
    Exit Sub
 End If
Waitus 80
  If Dht_get = 0 Then
    H = 2
    Exit Sub
  End If
While Dht_get = 1 : Wend

   Do
```

```
  While Dht_get = 0 : Wend
Waitus 30
      If Dht_get = 1 Then
Sensor_data = Sensor_data + "1"
      While Dht_get = 1 : Wend
      Else
Sensor_data = Sensor_data + "0"
   End If
Incr Count
  Loop Until Count = 40
 Set Dht_io_set
  Set Dht_put
Tmp_str8 = Left(sensor_data , 8)
  H = Binval(tmp_str8)
 Tmp_str8 = Mid(sensor_data , 17 , 8)
  T = Binval(tmp_str8)
  Tmp_str8 = Right(sensor_data , 8)
Crc = Binval(tmp_str8)
Mybyte = T + H
  If Mybyte<>Crc Then
     H = 3
  End If
End Sub
```

C. Appendix C

DHT 11 Humidity and Temperature Sensor

DHT 11 Humidity & Temperature Sensor

1. Introduction

This DFRobot DHT11 Temperature & Humidity Sensor features a temperature & humidity sensor complex with a calibrated digital signal output. By using the exclusive digital-signal-acquisition technique and temperature & humidity sensing technology, it ensures high reliability and excellent long-term stability. This sensor includes a resistive-type humidity measurement component and an NTC temperature measurement component, and connects to a high-performance 8-bit microcontroller, offering excellent quality, fast response, anti-interference ability and cost-effectiveness.

All data sheet downloading available:

https://www.openimpulse.com/blog/wp-content/.../DHT11-Datasheet.pdf

D. Appendix D

LDR Light Dependent Resistors Data Sheet

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

RS

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 10 lux	- -	400 9	- -	Ω kΩ
Dark resistance	-	1.0	-	-	MΩ
Dark capacitance	-	-	3.5	-	pF
Rise time 1	1000 lux 10 lux	- -	2.8 18	- -	ms ms
Fall time 2	1000 lux 10 lux	- -	48 120	- -	ms ms

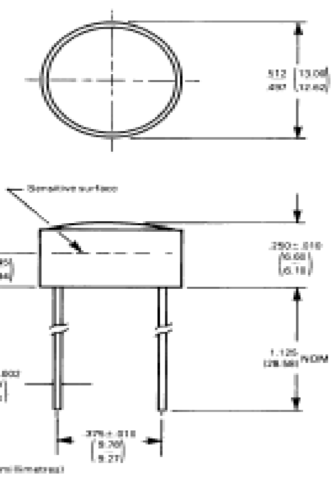
1. Dark to 110% R_L
2. To 10 × R_L

R_L = photocell resistance under given illumination.

Features

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

Dimensions



All data sheet downloading available:

http://www.biltek.tubitak.gov.tr/gelisim/elektronik/dosyalar/40/LDR_NSL19_M51.pdf

E. Appendix E

ATMEGA16 Microcontroller Data Sheet

Features

- High-performance, Low-power Atmel® AVR® 8-bit Microcontroller
- Advanced RISC Architecture
  - 131 Powerful Instructions – Most Single-clock Cycle Execution
  - 32 × 8 General Purpose Working Registers
  - Fully Static Operation
  - Up to 16 MIPS Throughput at 16MHz
  - On-chip 2-cycle Multiplier
- High Endurance Non-volatile Memory segments
  - 32Kbytes of In-System Self-programmable Flash program memory
  - 1024Bytes EEPROM
  - 2Kbytes Internal SRAM
  - Write/Erase Cycles: 10,000 Flash/100,000 EEPROM
  - Data retention: 20 years at 85°C/100 years at 25°C[1]
  - Optional Boot Code Section with Independent Lock Bits
    In-System Programming by On-chip Boot Program
    True Read-While-Write Operation
  - Programming Lock for Software Security
- JTAG (IEEE std. 1149.1 Compliant) Interface
  - Boundary-scan Capabilities According to the JTAG Standard
  - Extensive On-chip Debug Support
  - Programming of Flash, EEPROM, Fuses, and Lock Bits through the JTAG Interface
- Peripheral Features
  - Two 8-bit Timer/Counters with Separate Prescalers and Compare Modes
  - One 16-bit Timer/Counter with Separate Prescaler, Compare Mode, and Capture Mode
  - Real Time Counter with Separate Oscillator
  - Four PWM Channels
  - 8-channel, 10-bit ADC
    8 Single-ended Channels
    7 Differential Channels in TQFP Package Only
    2 Differential Channels with Programmable Gain at 1x, 10x, or 200x
  - Byte-oriented Two-wire Serial Interface
  - Programmable Serial USART
  - Master/Slave SPI Serial Interface
  - Programmable Watchdog Timer with Separate On-chip Oscillator
  - On-chip Analog Comparator
- Special Microcontroller Features
  - Power-on Reset and Programmable Brown-out Detection
  - Internal Calibrated RC Oscillator
  - External and Internal Interrupt Sources
  - Six Sleep Modes: Idle, ADC Noise Reduction, Power-save, Power-down, Standby and Extended Standby
- I/O and Packages
  - 32 Programmable I/O Lines
  - 40-pin PDIP, 44-lead TQFP, and 44-pad QFN/MLF
- Operating Voltages
  - 2.7V - 5.5V for ATmega32L
  - 4.5V - 5.5V for ATmega32
- Speed Grades
  - 0 - 8MHz for ATmega32L
  - 0 - 16MHz for ATmega32
- Power Consumption at 1MHz, 3V, 25°C
  - Active: 1.1mA
  - Idle Mode: 0.35mA
  - Power-down Mode: < 1µA

ATMEL®

8-bit AVR® Microcontroller with 32KBytes In-System Programmable Flash

ATmega32
ATmega32L

All data sheet downloading available:

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

F. Appendix F

XBee XBee™/XBee-PRO™ OE

XBee®/XBee-PRO® RF Modules

XBee®/XBee-PRO® RF Modules
RF Module Operation
RF Module Configuration
Appendices

Product Manual v1.xEx - 802.15.4 Protocol
For RF Module Part Numbers: XB24-A...-001, XBP24-A...-001

IEEE® 802.15.4 RF Modules by Digi International

Digi International Inc.
11001 Bren Road East
Minnetonka, MN 55343
877 912-3444 or 952 912-3444
http://www.digi.com

90000982_B
2009.09.23

All data sheet downloading available:

https://www.sparkfun.com/datasheets/Wireless/Zigbee/XBee-Datasheet.pdf

G. Appendix G

LM317T Regulator Datasheet

National Semiconductor

July 2004

LM117/LM317A/LM317 3-Terminal Adjustable Regulator

LM117/LM317A/LM317
3-Terminal Adjustable Regulator

General Description

The LM117 series of adjustable 3-terminal positive voltage regulators is capable of supplying in excess of 1.5A over a 1.2V to 37V output range. They are exceptionally easy to use and require only two external resistors to set the output voltage. Further, both line and load regulation are better than standard fixed regulators. Also, the LM117 is packaged in standard transistor packages which are easily mounted and handled.

In addition to higher performance than fixed regulators, the LM117 series offers full overload protection available only in IC's. Included on the chip are current limit, thermal overload protection and safe area protection. All overload protection circuitry remains fully functional even if the adjustment terminal is disconnected.

Normally, no capacitors are needed unless the device is situated more than 6 inches from the input filter capacitors in which case an input bypass is needed. An optional output capacitor can be added to improve transient response. The adjustment terminal can be bypassed to achieve very high ripple rejection ratios which are difficult to achieve with standard 3-terminal regulators.

Besides replacing fixed regulators, the LM117 is useful in a wide variety of other applications. Since the regulator is "floating" and sees only the input-to-output differential voltage, supplies of several hundred volts can be regulated as long as the maximum input to output differential is not exceeded, i.e., avoid short-circuiting the output.

Also, it makes an especially simple adjustable switching regulator, a programmable output regulator, or by connecting a fixed resistor between the adjustment pin and output, the LM117 can be used as a precision current regulator. Supplies with electronic shutdown can be achieved by clamping the adjustment terminal to ground which programs the output to 1.2V where most loads draw little current.

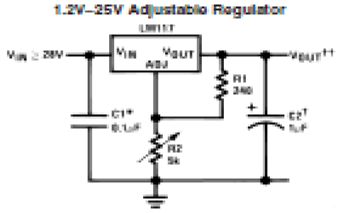
For applications requiring greater output current, see LM150 series (3A) and LM138 series (5A) data sheets. For the negative complement, see LM137 series data sheet.

Features

- Guaranteed 1% output voltage tolerance (LM317A)
- Guaranteed max. 0.01%/V line regulation (LM317A)
- Guaranteed max. 0.3% load regulation (LM117)
- Guaranteed 1.5A output current
- Adjustable output down to 1.2V
- Current limit constant with temperature
- P+ Product Enhancement tested
- 80 dB ripple rejection
- Output is short-circuit protected

Typical Applications

1.2V–25V Adjustable Regulator



Full output current not available at high input-output voltages

*Needed if device is more than 6 inches from filter capacitors.

†Optional — improves transient response. Output capacitors in the range of 1µF to 1000µF of aluminum or tantalum electrolytic are commonly used to provide improved output impedance and rejection of transients.

$$^{††}V_{OUT} = 1.25V\left(1 + \frac{R2}{R1}\right) + I_{ADJ}(R_2)$$

LM117 Series Packages

Part Number Suffix	Package	Design Load Current
K	TO-3	1.5A
H	TO-39	0.5A
T	TO-220	1.5A
E	LCC	0.5A
S	TO-263	1.5A
EMP	SOT-223	1A
MDT	TO-252	0.5A

SOT-223 vs. D-Pak (TO-252) Packages

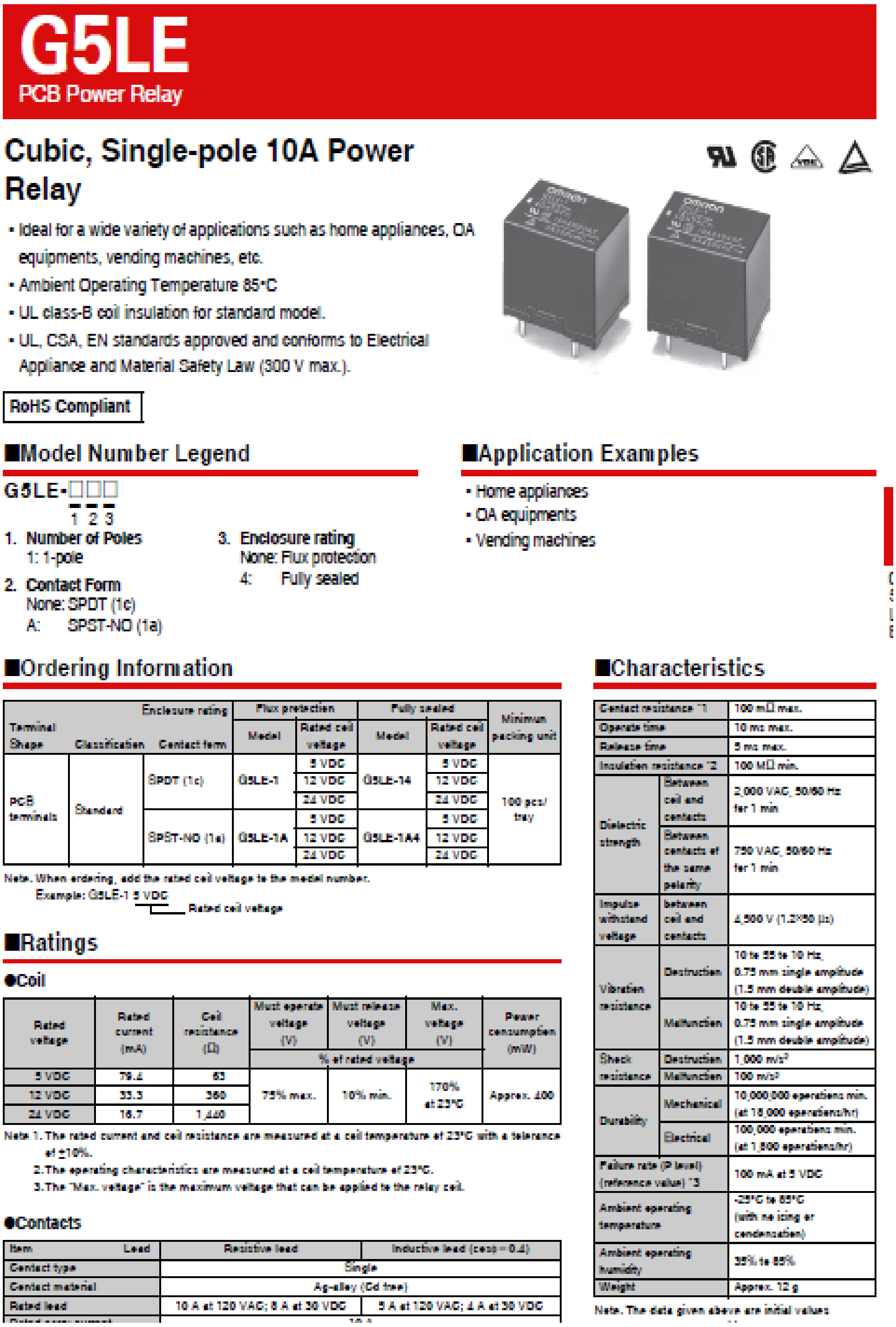
Scale 1:1

All data sheet downloading available:

http://pdf1.alldatasheet.com/datasheet-pdf/view/8604/NSC/LM

H. Appendix H

3-Terminal 1 A Positive Voltage Regulator Datasheet



G5LE

PCB Power Relay

Cubic, Single-pole 10A Power Relay

- Ideal for a wide variety of applications such as home appliances, OA equipments, vending machines, etc.
- Ambient Operating Temperature 85°C
- UL class-B coil insulation for standard model.
- UL, CSA, EN standards approved and conforms to Electrical Appliance and Material Safety Law (300 V max.).

RoHS Compliant

■Model Number Legend

G5LE-□□□

1 2 3

1. Number of Poles
   1: 1-pole
2. Contact Form
   None: SPDT (1c)
   A: SPST-NO (1a)
3. Enclosure rating
   None: Flux protection
   4: Fully sealed

■Application Examples

- Home appliances
- OA equipments
- Vending machines

■Ordering Information

Terminal Shape	Classification	Contact form	Flux protection Model	Flux protection Rated coil voltage	Fully sealed Model	Fully sealed Rated coil voltage	Minimum packing unit
PCB terminals	Standard	SPDT (1c)	G5LE-1	5 VDC	G5LE-14	5 VDC	100 pcs/ tray
				12 VDC		12 VDC	
				24 VDC		24 VDC	
		SPST-NO (1a)	G5LE-1A	5 VDC	G5LE-1A4	5 VDC	
				12 VDC		12 VDC	
				24 VDC		24 VDC	

Note. When ordering, add the rated coil voltage to the model number.
Example: G5LE-1 5 VDC
Rated coil voltage

■Ratings

●Coil

Rated voltage	Rated current (mA)	Coil resistance (Ω)	Must operate voltage (V)	Must release voltage (V)	Max. voltage (V)	Power consumption (mW)
			% of rated voltage			
5 VDC	79.4	63	75% max.	10% min.	170% at 23°C	Approx. 400
12 VDC	33.3	360				
24 VDC	16.7	1,440				

Note 1. The rated current and coil resistance are measured at a coil temperature of 23°C with a tolerance of ±10%.
2. The operating characteristics are measured at a coil temperature of 23°C.
3. The "Max. voltage" is the maximum voltage that can be applied to the relay coil.

●Contacts

Item / Load	Resistive load	Inductive load (cosφ = 0.4)
Contact type	Single	
Contact material	Ag-alloy (Cd free)	
Rated load	10 A at 120 VAC; 8 A at 30 VDC	5 A at 120 VAC; 4 A at 30 VDC
Rated carry current	10 A	

■Characteristics

Contact resistance *1		100 mΩ max.
Operate time		10 ms max.
Release time		5 ms max.
Insulation resistance *2		100 MΩ min.
Dielectric strength	Between coil and contacts	2,000 VAC, 50/60 Hz for 1 min
	Between contacts of the same polarity	750 VAC, 50/60 Hz for 1 min
Impulse withstand voltage	between coil and contacts	4,500 V (1.2*50 µs)
Vibration resistance	Destruction	10 to 55 to 10 Hz, 0.75 mm single amplitude (1.5 mm double amplitude)
	Malfunction	10 to 55 to 10 Hz, 0.75 mm single amplitude (1.5 mm double amplitude)
Shock resistance	Destruction	1,000 m/s²
	Malfunction	100 m/s²
Durability	Mechanical	10,000,000 operations min. (at 18,000 operations/hr)
	Electrical	100,000 operations min. (at 1,800 operations/hr)
Failure rate (P level) (reference value) *3		100 mA at 5 VDC
Ambient operating temperature		-25°C to 85°C (with no icing or condensation)
Ambient operating humidity		35% to 85%
Weight		Approx. 12 g

Note. The data given above are initial values.

All data sheet downloading available:

http://www.datasheetcatalog.com/datasheets_pdf/L/M/7/8/LM7805.shtml

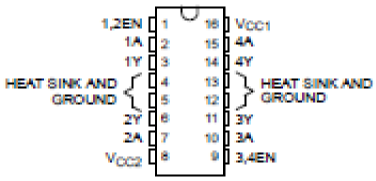
I. Appendix I
L293, L293D Quadruple Half-H Drivers Datasheet

L293, L293D
QUADRUPLE HALF-H DRIVERS

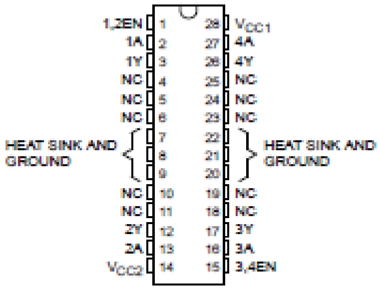
SLRS008B – SEPTEMBER 1986 – REVISED JUNE 2002

- **Featuring Unitrode L293 and L293D Products Now From Texas Instruments**
- **Wide Supply-Voltage Range: 4.5 V to 36 V**
- **Separate Input-Logic Supply**
- **Internal ESD Protection**
- **Thermal Shutdown**
- **High-Noise-Immunity Inputs**
- **Functional Replacements for SGS L293 and SGS L293D**
- **Output Current 1 A Per Channel (600 mA for L293D)**
- **Peak Output Current 2 A Per Channel (1.2 A for L293D)**
- **Output Clamp Diodes for Inductive Transient Suppression (L293D)**

N, NE PACKAGE
(TOP VIEW)



DWP PACKAGE
(TOP VIEW)



description

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications.

All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source. Drivers are enabled in pairs, with drivers 1 and 2 enabled by 1,2EN and drivers 3 and 4 enabled by 3,4EN. When an enable input is high, the associated drivers are enabled and their outputs are active and in phase with their inputs. When the enable input is low, those drivers are disabled and their outputs are off and in the high-impedance state. With the proper data inputs, each pair of drivers forms a full-H (or bridge) reversible drive suitable for solenoid or motor applications.

On the L293, external high-speed output clamp diodes should be used for inductive transient suppression.

A V_{CC1} terminal, separate from V_{CC2}, is provided for the logic inputs to minimize device power dissipation.

The L293and L293D are characterized for operation from 0°C to 70°C.

Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

PRODUCTION DATA information is current as of publication date. Products conform to specifications per the terms of Texas Instruments standard warranty. Production processing does not necessarily include testing of all parameters.

TEXAS INSTRUMENTS
POST OFFICE BOX 655303 • DALLAS, TEXAS 75265

1

All data sheet downloading available:

http://users.ece.utexas.edu/~valvano/Datasheets/L293d.pdf

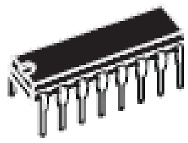
J. Appendix J

ULN 2003 Datasheet

ULN2001A-ULN2002A
ULN2003A-ULN2004A

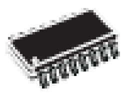
SEVEN DARLINGTON ARRAYS

- SEVEN DARLINGTONS PER PACKAGE
- OUTPUT CURRENT 500mA PER DRIVER (600mA PEAK)
- OUTPUT VOLTAGE 50V
- INTEGRATED SUPPRESSION DIODES FOR INDUCTIVE LOADS
- OUTPUTS CAN BE PARALLELED FOR HIGHER CURRENT
- TTL/CMOS/PMOS/DTL COMPATIBLE INPUTS
- INPUTS PINNED OPPOSITE OUTPUTS TO SIMPLIFY LAYOUT



DIP16

ORDERING NUMBERS: ULN2001A/2A/3A/4A



SO16

ORDERING NUMBERS: ULN2001D/2D/3D/4D

DESCRIPTION

The ULN2001A, ULN2002A, ULN2003 and ULN2004A are high voltage, high current darlington arrays each containing seven open collector darlington pairs with common emitters. Each channel rated at 500mA and can withstand peak currents of 600mA. Suppression diodes are included for inductive load driving and the inputs are pinned opposite the outputs to simplify board layout.

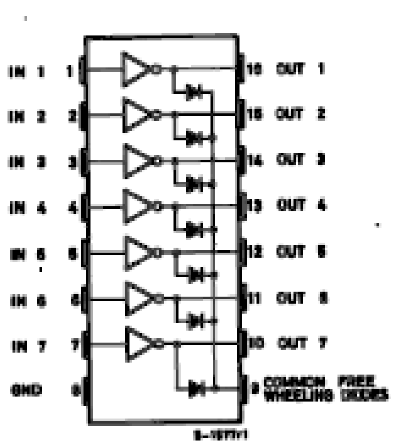
The four versions interface to all common logic families :

ULN2001A	General Purpose, DTL, TTL, PMOS, CMOS
ULN2002A	14-25V PMOS
ULN2003A	5V TTL, CMOS
ULN2004A	6–15V CMOS, PMOS

These versatile devices are useful for driving a wide range of loads including solenoids, relays DC motors, LED displays filament lamps, thermal printheads and high power buffers.

The ULN2001A/2002A/2003A and 2004A are supplied in 16 pin plastic DIP packages with a copper leadframe to reduce thermal resistance. They are available also in small outline package (SO-16) as ULN2001D/2002D/2003D/2004D.

PIN CONNECTION



February 2002 1/8

All data sheet downloading available:

http://pdf1.alldatasheet.com/datasheet-pdf/view/25575/STMICROELECTRONICS/ULN2003.html