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DESIGN AND IMPLEMENTATION INTELLIGENT GREENHOUSE SYSTEM WITH LESS POWER CONSUMPTION

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By

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Raghda Awad Shaban NASERI

DEDICATION

In the name of Allah, the Most Merciful, the Most Compassionate and say: "Work (righteousness): Soon will Allah observe your work, and His Messenger, and the Believers”

To Allah, Almighty has spoken the truth
“O Allah”, the night is not good without thanking you... The day is not good except by obeying you... The moments are not good except for reminding you... The hereafter is only good for you. Paradise is only good to see you.

To those who taught me success and patience ... To those who missed him in the face of difficulties And Life didn't give him time, so I can be satisfied from his tenderness

(My Late Father Dr. Awad Shaban)

To those who taught me and suffered difficulties to get to what I am ... And when the concerns Overwhelmed me. I swim in her sea of tenderness to soften my pain

(My mother's Rawdhah Jasim)

To the pure and kind hearts and the innocent souls of my life

(my brothers Yasser and my sister Reem)

To whom we walked together, and we are moving together towards success and creativity and helped me and gave me a helping hand and provided me with sufficient information to complete this research (my colleague Hameed)

To those who taught us letters of gold and phrases of the highest and most beautiful expressions in the science ... To those who drafted for us a letter and a light to enlighten us the life of science and success to my dear professors, (Dr. Sefer KURNAZ) supervisor of my letter.

To my wounded country (Iraq) and all my family and loved ones, I have given them this message.

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Thanks **God**, for your blessings in the heavens and the Earth and all between them abound with Your praises.

Thank you for your countless blessings that made me patient and strong and gave me the energy to be able to fulfill this message and to make me happy to achieve this dream that I have long had waited so long for.

((My Lord, Praise be to you until the Praise be satisfied and praise when you will be satisfied and praise you after the satisfaction))

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Finally, I would like to express my gratitude to all those who helped me and get this research done.

ABSTRACT

DESIGN AND IMPLEMENTATION INTELLIGENT GREENHOUSE SYSTEM WITH LESS POWER CONSUMPTION

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Pages: 77

Plant growth depends of several ideal environment conditions such as temperature, humidity, light and other mineral nutrients or oxygen. Providing the plants with an adequate amount of water or keep the normal temperature in the greenhouse can be a tricky process but not if you could do it using the technology, so in the presented study, a system will be developed for managing humidity, temperature, air conditioner, and watering the plant in the greenhouse at optimal way. All this can be done using different types of sensors for the purpose of measuring the state of the environment and sending the info to the management system that control the greenhouse and system decide whether the plant need watering by measuring soil moisture and adjusting watering period, air temperature and humidity adjustment by using fans and light condition adjustment by using additional lighting. The sensors which used to monitoring the soil and climate inside the greenhouse are: DH11 humidity and temperature sensor, soil moisture sensor and light sensor LDR. Also, the presented system will be less power consumption by powering it using clean energy solar power system and build special microcontroller as small as possible that connected to LCD screen to exchange the information, scheduling jobs, and making reports. So the plant can growth in best environment condition.

Keywords: Greenhouse, Arduino, Atmega328, Solar Penal

ÖZET

ENERJI TÜKETİMİ İLE AKILLI SERA SİSTEMİ TASARIMI VE AZ UYGULAMASI

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Bitki gelişimi, sıcaklık, nem, ışık ve diğer mineral besinler veya oksijen gibi çeşitli ideal ortam koşullarına bağlıdır. Bitkilere yeterli miktarda su sağlamak veya normal sıcaklıkları serada tutmak zor olabilir ancak teknolojiyi kullanarak yapılabilir, bu projede sıcaklığı, nemi ve bitkiyi sulamayı en uygun şekilde yönetin için bir sistem oluşturacağız. Bitkileri seradaki optimum şekilde sulanması. Bütün bunlar çevre durumunu ölçmek için farklı tipte sensörler kullanılarak yapılabilir ve bilgileri, serayı ve sistemi kontrol eden yönetim sistemine, toprak nemini ölçerek ve sulama süresini, hava sıcaklığını ve nem ayarını ayarlayarak bitkinin sulamaya ihtiyacı olup olmadığına karar verir. Ek aydınlatma kullanarak fanları ve ışık durumu ayarını kullanarak. Sera içindeki toprağı ve iklimi izlemek için kullanılan sensörler toprak nem sensörü, DH11 nemi ve sıcaklık sensörü ve ışık sensörü LDR'dir. Ayrıca, sistem, temiz enerji güneş enerjisi sistemi kullanarak güç sağlayarak daha az güç tüketimi sağlayacak, işleri planlamak ve raporları hazırlamak için LCD ekrana bağlı, mümkün olduğu kadar küçük özel bir mikrodenetleyici kuracaktır. Böylece bitki en iyi çevre koşullarında büyüyebilir.

Anahtar Kelimeler: Sera, Arduino, Atmega328, Güneş Paneli.

TABLE OF CONTENTS

Pages

LIST OF TABLES

Pages

LIST OF FIGURES

Pages

LIST OF ABBREVIATIONS

DHT11	Digital temperature and humidity
LDR	Light Dependent Resistor

1. INTRODUCTION

Modern agriculture must be the path taken to improve agriculture. As the economy is rapidly developing, the research and applications of agricultural technology became of high importance today, particularly greenhouses are very significant to have effective agriculture. The significant role regarding the modern agricultural production is detecting and controlling certain considerable factors of agricultural production environment such as, soil moisture content, humidity, air temperature, carbon dioxide content, and so on. With regard to agricultural planting, the environment of greenhouses is very associated to energy exchange and biological growth. Achieving greenhouses scientific and automatic production management depends mainly on environmental monitoring [1].

As a result of implementing analysis regarding the monitoring data, in addition to development law and crop growth, and controlling the environmental conditions, high yield, high quality and high effective cultivation can be accomplished. Modern facilities of agriculture which are represented through vegetable green houses are considered to be of high importance in modern agricultural production [2]. Certain greenhouses factors including carbon dioxide, humidity, and temperature in are associated to growth of fruits and vegetables. Yet, nowadays, the majority of detecting and controlling greenhouses carbon dioxide, humidity, and temperature is done through labor management, that unavoidably result in high labor intensity, low control precision and not timely control and other flaws. Such flaws are possible to result in severe losses and result in increasing costs and waste of humans. Furthermore, the required results will be rarely reached [1].

Greenhouses are defined as extraordinarily outlined homestead structure building used for providing more manageable environments for having more effective harvest generation, transplanting, product seeding, and crop security. Furthermore, the area’s accessible space to develop yields was totally lessening, after more area space has been actively used for commercial ventures and housing in the course of current periods. With regard to the majority of tropical countries, using greenhouses was introduced for inexpensive farming, for example vegetable generation, new blossoms and organic products. The efficiency related to plant production in greenhouses mainly depend on consistency regarding perfect atmosphere development conditions for achieving high returns at low natural burden, superior quality, and low costs. As a matter of fact, plants in greenhouse have the ability to get rid of climate and output more. The main goal of greenhouses environment control is controlling the environment via using up-to-date equipment and technologies. Furthermore, the control system of greenhouses have the ability of reducing the manual work which might result in control accuracy improving the speed of response. Auto-control can be considered as the tendency of artificial greenhouse [3].

In Japan, USA, and Netherlands, controlling greenhouses with a lot of accuracy reached higher levels, as they have developed to using combination control instead of single factor control. Yet, until the present day, the majority of environment control systems of greenhouses are carried forward, the structure related to the industry control and greenhouses control has its own domain. It cannot be simply transplanted from industry control system. In comparison to industry, there is a long cycle with less returns in agriculture production, also the the operators are less educated. Thus, the system must be operated simply and cost less in maintenance and construction [4,5]. The technology of industry control is very developed that “the problem of applicability” come to key in greenhouses control [6,7]. “The problem of applicability” determine if the greenhouses control have the ability of maintaining healthy developments [8]. In the presented study, based on medium single-span greenhouses, a novel control system that have efficient area of applications for greenhouses will be introduced, and smart sensor block is considered to be vital design for the presented system.

1.1 PROBLEM STATEMENT

Which are the variables to be collected? This is the first and the main question to solve before designing an automatic greenhouse. Wanted here is a greenhouse that able to provide a convenient climate for the plants. That’s mean it must get data from the environment to be able to make decisions. The second main issue is energy. The greenhouse will be low power consumption by using special microcontroller containing only the required pins and supplied by solar penal energy. To achieve these goals the components of the greenhouse need to be known. Our Greenhouse’s most important specifications for its components at this point are:

1. Sensors: the type and number of sensors very important to get the required data. Otherwise, our decision about the climate will be incorrect.
2. Microcontroller: a simple, powerful with low power consumption microcontroller board to control the whole system.
3. Power: here we need a solar panel with a suitable voltage and current to supply our system with clean energy.

1.2 THE AIMES

The main idea of this work is to get data from the greenhouse environment using different type of sensors placed in a specific location, so we can ensure the accuracy of these reading according to the overall state of the greenhouse environment, the sensors will be used are soil moisture sensor, humidity sensor, temperature sensor, and light intensity sensor. All these sensor are going to be sending their reading to micro-controller that responsible to control watering motor, heater, fan and light in addition to send/receive the information wirelessly to the management system that installed in the base station, for deciding the best condition that should provide according to each type of plant, remotely real-time monitoring, and making daily, weekly and monthly report for the state of the greenhouse. In addition to make use of the solar clean energy to power the greenhouse.

1.3 CONTRIBUTION

The major aim of this study is building smart greenhouse management system with less power consumption. There are many factors that we are proposed to achieve this aim:

1. We will build our microcontroller board by using low-power microchip for example ATtiny85, Atmega328... etc. That’s mean we will not use Arduino boards which are available in the markets. We will build our board from the microchip control and the required components such as Crystal, Capacitor, Voltage Regulator and Resistors.
2. We will use the solar energy to supply our greenhouse sensors, control board and the other components. We will supply the greenhouse with solar cells to get the solar energy. The solar

cells will charge the battery which is the power supply of the system. The size of solar cell and battery will choose after calculating the total system power requirement.

1.4 PROPOSED SYSTEM

The design of the Smart Greenhouse will go through several steps which will explain below:

1 Step 1: first step we will design a greenhouse model using simple material like a transparent plastic glass to build the outside structure with suitable size for the project.
2. Step 2: using suitable type of soil for the plant growth.
3. Step 3: using various sensor types including: temperature sensor, soil moisture sensor, humidity sensor, and light intensity sensor to calculate data.
4. Step 4: build a suitable less power consumption microcontroller.
5. Step 5: connect the microcontroller with base station system using sensors connection.
6. Step 6: installing solar panel system to provide the power to the Greenhouse
7. Step 7: build the management system for the base station to manage, real-time monitoring, and making periodic reports for the green house.
8. Step 8: use a suitable type of a plant to growth and test in this project.

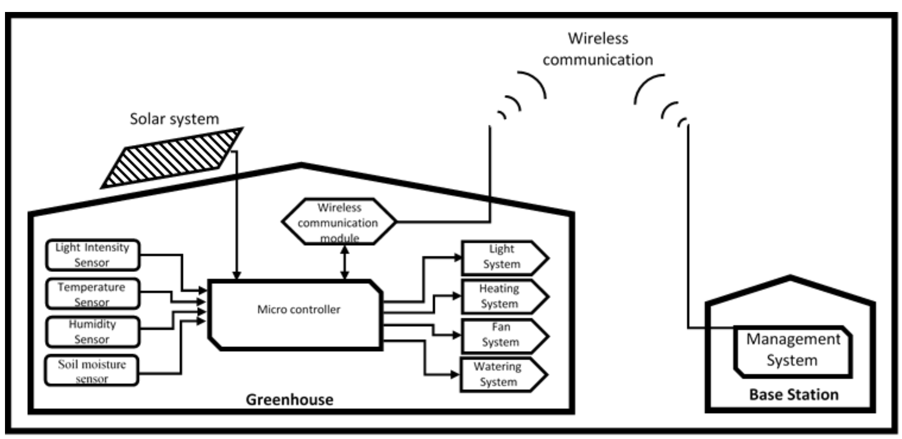

Figure 1.1: System Components Diagram.

1.5 THISIS ORGINAZATION

This thesis contains 6 chapters. Chapter one will present an overview to the Greenhouse, the purpose of the research, our contribution to the research and the proposed system. the second chapter contains an overview and previous studies on this subject. the third Chapter contains the physical components of sensors, microcontroller device (atmega328), solar cell panels and display screen. Chapter four included the physical components is connected to the Arduino environment and display screen. In Chapter five we discussed the results obtained from the implementation of the work of the system. Chapter 6 will present the conclusions and future works.

2. LITERATURE REVIEW

2. 1 OVERVIEW

Greenhouses production can be considered as costly and high-risk approach to produce crops. Whereas there is an increase in the financial advantages of having the ability of providing crops at any time of the year, also there is an increase in the cost of growing crops and managing facilities. Certain degree of environment control is provided by greenhouses. The plainest structure have been covered with translucent materials which work on protecting the crop from unfavorable environment conditions. High-level greenhouse have the ability of providing accurate control of temperature via cooling and heating, shade cloth and supplemental lighting to for ensuring the precise light range and top-quality systems of control for the purpose of automating plants' production from start to end. Some parameters impacting the growth of plants are CO2 concentrations, water content in soil, sunlight, temperatures, and air humidity. It is complicated to control these parameters in greenhouses, also automated designs should be developed.

1. Temperature impact: A major advantage of growing crop in greenhouses is the capability of controlling all factors of the production environment, temperature con be considered as one of the major significant parameters that must undergo monitoring due to the fact that it is related to plants' growth and development. Various species of crops have different ideal temperatures for growing, such ideal temperatures could be changed for root and shoot environment also for various stages of growth in the crop's life. As the interest is typically in quick growth and development of crops, the ideal temperatures should be provided during the life cycle of cropping. In the case when the greenhouses are like commercial or residential building, to control temperature will be simple due to the insulation of such buildings in order to considerably reduce the effect of outside conditions [9].
2. Humidity impacts: One of the major parameters affecting the crops in greenhouses is the water vapor. Humidity is very significant factor to plants since it control the plant's moisture loss. There are very small pores in the plant leaves, through these pores, the CO2 enter the plant, also

water and oxygen leave through these pores. The rates of transpiration reduces in proportion to the amount of humidity in air, since the water diffuse from higher concentration areas to lower concentrations areas [10]. Because of such process, plant that grow in room wil possibly lose its moisture with time. In the case when there is large difference in humidity, the damage could be more. Controlling humidity is complicated since when the temperature change, the relative humidity will change inversely. Same actuators are used for controlling humidity and temperature. Since it is the major aspect in the growth of crops, the major importance is for controlling temperature. According to the value of the inside relative humidity, the set-point of temperature could be modified for controlling humidity in specified range. Thus, it is very hard to control the needed humidity. To control humidity properly, the internal air could be exchanged with outside air through correctly control ventilations of greenhouses [11].

3. Light impact: The energy is needed for the growing process; food is the main energy source for animals and human. A process referred to as photosynthesis provides the plants with energy from sunlight. This is how the plant growth is affected via light. The plant might not have the required energy for growing without light. In addition to its impact via photosynthesis, the light impacts the growth of individual organs or of whole plants in less direct way. When a plant is growing in normal light and the same plant is growing in darkness, this is when the real impact of light can be perceived. The growth of plant in darkness will produce plants with small leaves, spindling and tall stem, also the stem and leaves will be pale yellow as they lack chlorophyll. There will be different response for the plants grown in shade rather than darkness. Balanced shading tend to decrease transpiration more than it does photosynthesis. Thus, plants grown in shades might have larger and taller leaves since there is a better supply of water in the growing tissues. In extreme shading, photosynthesis will be decreased, and this will result in weak plant [10].

Water levels in soil impacts: The growth of crops is also impacted via soil water. Thus, there is high importance in monitoring the control related to the conditions of the soil, since good yield is produced via good soil conditions. The suitable fertilizations and irrigations are different for each climate, age, type, and phase. Some of the major factors are the soil’s temperature, moisture contains, pH value, and electric conductivity. The condition of the soil is monitored via the pH values as well as the other factors. Irrigation methods such as sprinkles and drift in greenhouses are used to control moisture and temperature. The soil's temperature and the inside temperature regarding greenhouses are considered to be interrelated factors, that could be, control via suitable ventilation setting. The suitable set point could be adjusted for controlling the temperature of the soil because of controlling the temperature depend on the used screen material and direct sun radiation. The set point values of temperature depend on actual temperature of outside and inside greenhouses [12].

2.2 PREVIOUS WORKS

The use of recent technology to increase productivity in agriculture is becoming widespread day by day. Parameters such as soil moisture, air temperature, air relative humidity are measured and controlled by systems designed for this purpose in order to increase productivity in agriculture. This section includes a review of some of these systems that are designed to increase productivity.

Stipanicev and Marasovic (2003**)** suggested a system that is and embedded Web server unit on the basis of TINI board, through getting the data from distributed sensors and activate the connected actuators through the use of simple 1-wire local networks. On other side, dial-up network or ethernet are used to connect the web server to the internet. The researchers indicate that the proposed system show all the benefits of Network Embedded System Technology (NEST), such as the potential to change the low costs and dimension and physical topologies when compared to systems based on PC, and at the same time maintaining the total functionality [13].

Wu et al (2006) presented designing and implementing Greenhouses Wireless Data Acquisition Systems on the basis of CC2420, as inexpensive transceiver that is developed mainly for low voltage and low power RF applications at 2.4 gigahertz un-licensed ISM band [14].

Nachidiet al (2006) suggested a system for controlling the humidity and temperature in greenhouses through the use of simultaneous heating and ventilation systems by means of Parallel Distributed Compensation (PDC) and Takagi-Sugeno (T-S) fuzzy model. Also they have indicated that efficient fuzzy controller effectively achieve the demanded conditions of climate in greenhouses, utilizing T-S fuzzy model, the problems related to control design and stability analysis could be decreased to suitable conditions defined as Linear Matrix Inequalities (LMIs) [15].

Qianet al (2007) have put to comparison the benefits of ZigBee with the other 2 comparable protocols of wireless, Bluetooth and Wi-Fi, also a wireless solution was suggested for monitoring greenhouses and controlling system on the basis of ZigBee. As explorative application related to the technology of ZigBee greenhouses of China, it might be promoting Chinese protected agriculture. Through the abilities of self-healing, self-configuring, self-diagnosing, self-organizing, the monitoring and controlling system that is based on ZigBee provide almost un-limited installation, significantly, decrease the cost, increasing the robustness of the network and facilitating transducers. Thus, they indicated that the monitoring and controlling system that is based on ZigBee technology could be optimum solution for controlling and monitoring greenhouses [16].

Elmusratiet al (2008) indicated dissimilar method to implement WSN in the environment of greenhouses through using commercial wireless sensing platform supplied via Sensinode Inc. The system's hardware design include Sensinode's Micro 2420U100 that is operating as a basic measuring node, with 4 commercial sensors (CO2, temperature, humidity, and light). The main goal of such improvement is testing the robustness and simplicity of prototype wireless environment monitoring system in the commercial greenhouses. Experimental results have indicated that the network have the ability of detecting local difference in greenhouses climate resulted via different environment's disturbances [17].

Palaniappanet al (2009) suggested embedded controlling and monitoring system for greenhouses for the purpose of providing very detailed micro-climate data for the plants in greenhouses environment through the use of new approach to grow temperate crop in the tropical environments through the use of micro-climatic conditions. Greenhouses has been equipped with standard wired sensors which supply analyses related to the intensity of light, temperature of air and the nutrient solution temperature in mixing tank. Concentration and acidity regarding the nutrient solution have been measured in manual way and regulated correspondingly, and the high-resolution data, collected by presenting network of wireless sensors for providing adequate data to create pa model for the purpose of growing the crops within aeroponic conditions. The study indicated that there is quite high reliability in the start network, with various nodes operating with the rate of data transmission ninety percent, and the minimum data transmission rate for all nodes has been seventy percent [18].

Minh Vu (2011**)** suggested a system that has the ability of intelligent controlling and monitoring the greenhouses climate conditions in programmed way. The suggested system consisted of 3 stations: Central station, Coordinator station, and Sensor Station. Sensor station has been equipped with a lot of sensor elements like soil moisture temperature, humidity, CO2, light, and temperature. Communications between coordinator station and sensor station is implemented through wireless modules of ZigBee technology and the communications between the central station and the coordinator station will be implemented via RF modems of long range. The results of the study concluded that the modules of ZigBee are considered to be a solution to reduce the installation costs, increasing robustness and flexibility and creating a management system related to greenhouses which operates on the basis of wireless nodes [19].

Jin and Yang (2011) suggested a control system related to greenhouses that operates on the basis of RS485. In the cases of normal system operation, control targets will be achieved via smart modules spread in all greenhouses, whereas remote login, state monitoring and data collecting are achieved via upper PCs. In the case when manual control is required, auto-control is going to be isolated in 2 levels, that guarantees the greenhouse could be controlled in the case when extreme climate or system breakdown occurs [20].

Jun (2011), Designed system has AT89C52 microcontroller. A system that control air humidity and air temperature. In this designed system, air temperature and air humidity balance is ensured with some equipment like air humidity increaser equipment, air humidity decrease equipment, air temperature increaser equipment and air temperature decrease equipment. In addition, this designed system includes a warning system. As a result, this system met air humidity and air temperature requirements of greenhouse [21].

Purna Prakash Dondapati (2012) suggested Automated Multi-Sensor Greenhouse Management system that defined the way of overcoming the impact resulted from the drawbacks of normal cultivation with no human observations. Also, it defined the efficient function of sensors in allowing the project to be automated for yielding more valuable outcomes in cultivation [22].

Uday A. Waykole (2012) suggested System of Greenhouses Automation where Zigbee and WSN has been utilized to facilitate communication. The data could be collected from point to point through using wireless sensor network. Data taken from greenhouses will be analyzed through the sensors and the data which are collected is going to be sent to the receiver. LCD screen will be used to display the data [23].

Sumit A. Khandelwal (2012) suggested a system for Automated Greenhouses Management through the use of GMS Modem that describe designing totally automated greenhouses management systems. In addition to providing automatic control regarding devices like motor pump, light, and shade yet also tackle vital conditions such as fire, lack of light and rain. Therefore, such construction, productivity of cropping could be unceasingly improved so as to manage the worldwide famine problem. Also, it presents the facility which provide remote access control to the users [24].

Indu Gautam in Innovative (2012) suggested designing novel GSM Bluetooth based remote controlled embedded system for irrigation. The suggested system inexpensive, the information in the system is exchanged by SMS on the GSM network. There benefit of using the system is that Bluetooth is applied in the case when the user is within the range of ten meters of the system. Using Bluetooth cut down SMS costs when the user is limited range of the system. For the system to be implemented efficiently, GSM network must be available. The suggested system is of high importance for accurate irrigation in the farm fields and therefore might result in effective using of men power and water [25].

Rajeev G Vishwakarma and Vijay Choudhary (2012) indicated how the mobile technology were of high advantage to a lot of farmers in rural India through supplying solutions for irrigation problems resulted from intermittent electrical power supply [26].

Ibrahim and Munaf (2012) suggested a system to control and monitor the conditions of environment in greenhouses, the system consisted of central and local stations. Local stations are utilized for measuring the parameters and controlling the actuators and for all the local stations a PIC micro-controller will be installed that collect the date and send it to the central stations and receive control signals needed for actuators to be operated [27].

Deore and Umale (2012) presented the importance of WSN method for controlling and monitoring greenhouses. A system of control has been created and tested through the use of modern ATmega micro-controller. In the advancing countries, farmers have the ability of simply using the developed system to maximize yield. ATmega micro-controllers are considered to be better that other micro-controllers because of certain significant properties such as high memory capacity, sleep mode, 10bit ADC, and wide input voltage range. The designed system take into consideration optimizing and functional enhancements of system. There are many advantages of the presented system with regard to high precision, low costs and compact size [28].

Song et al (2012) suggested system on the basis of WSN, in which they used Atmega128L chip as well as low-power RF chip from TI i.e. CC2530 for designing sensor nodes and sink nodes in WSN. The center of management and monitoring could control the humidity and temperature of greenhouses, measuring carbon dioxide, and collecting information related to intensity of the illumination, etc. Multi-level energy memory is used by the system. Energy transfer and energy management is combined in the system, that will make the energy collected through solar energy batteries to be utilized suitably. Thus, the system of self-managing energy supply will be developed. Furthermore, synchronization problem and the node deployment approach will be examined exhaustively. The presented system have the ability of solving the problem of complex cabling with the benefits of high robustness, low costs, low consumption of power, and extended flexibility. An efficient tool is offered analysis and monitoring of greenhouses environment [29].

Sahu and Mazumdar (2012) suggested plain, simple to install Atmel circuit on the basis of micro-controllers for monitoring and recording values of soil moisture, humidity, temperature and sunlight regarding natural environment which are unceasingly changed and controlled for the purpose of optimizing them to have extreme growth and yield of plants. Micro-controllers are communicating with different sensor modules in real-time for the purpose of controlling light, drainage and aeration effectively in greenhouses via actuating a cooler, fogger, dripper and lights respectively with regard to the required conditions of crop. Integrated LCD is utilized for Realtime presentation of data collected from different sensors and status of the different devices [30].

Attalla and Tannfelt Wu (2013) suggested an automated greenhouses system to investigate the reliability of the watering system and whether a required range of temperatures could be preserved. Arduino UNO is the micro-controller utilized for creating automated greenhouses. There are 2 sensors used in this system, temperature sensor and soil moisture sensor. Sensors have been controlling the 2 actuators that were pump and heating fan. Pump is utilized for watering the plants while the heating fan was applied for changing temperature. The system of temperature control as well as the watering system has been verified together and separately. The results indicated that temperature can be preserved in the required range. The results obtained from soil moisture sensor have been imbalanced and thus defined as undependable [31].

Dhumal and Chitode (2013) sugested control system and wireless monitoring greenhouses on the basis of Zigbee to solve certain like inadequate Realtime data acquisition, extreme manpower necessity and for overcoming the drawbacks of wired systems like the complex wiring [32].

Alausa Dele and Kolawole (2013) suggested greenhouses controlling device that is on the basis of micro-controller, the device is utilized in automatic monitoring and controlling quantities and equipment like soil moisture levels, cooling, screening installation, lighting, heating in addition to other quantities/conditions in greenhouses, with efficient monitoring regarding all the quantities there, thus the human monitoring will not be needed anymore. With enhance able feature it integrate and automate through turning ON or OFF all the devices used for monitoring in the house in addition to providing ideas for remedies when needed. The suggested system has efficiently overcome certain drawbacks regarding the present systems through decreasing the consumption of power, complexity and maintenance, at decreased costs and offering accurate and flexible form of maintaining environment [33].

Nikhade and Nalbalwar (2013) presented an approach which have the ability of providing effective control system of micro-climate into the greenhouse via implementing infrastructure regarding WSNs for controlling the parameters of environment. This will enable Realtime action processes with the aim of atomizing the tasks of network. According to the benefits acquired from networks of small size, low costs distributed sensing networks which could be used anywhere and also with extreme environment greenhouses crop are in vital need for WSAN system that provide more efficient monitoring-controlling and thus eliminating crops' damage because of certain instability in the parameters such as leaf temperature, humidity, temperature, soil moisture as well as other factors that impact the growth of crops and may result in diseases. The system is concentrating more on the automation jobs, enhancing response time, and offering instant solution [34].

Nandurkar and Thool (2014) designed A system that measures the moisture of soil and manages the irrigation system ac- cording to these measurements. The irrigation in operation was made using a solenoid valve and drip irrigation system. In the case when the soil moisture was lower than a certain threshold value, the valve was kept open until the soil moisture reach the required value and the valve was closed when the soil moisture reaches the desired value. In this way, excessive irrigation was prevented, and the human power used for irrigation has been removed and electricity saving was achieved. The quality of product was increased by the system. Because the smart system we designed was used in the greenhouse, not only irrigation but also weather conditions were controlled to increase product yield [35].

Patel, Raut, Choudhari and Bharani (2014) they introduced A monitoring system which include soil moisture sensor, air humidity sensor and air temperature sensor. In this system, values measured form sensors, were transmitted wirelessly to the relevant units (irrigation, ventilation etc.) via microcontroller. Among of these units, only irrigation has been tested. Other units have not been tested because of the difficulty of implementing of all units together. same sensors are used for the designed smart system but tested not only irrigation units but also heater and ventilation system [36].

Priyatharshini (2015) presented A spectroscopy sensor with light emitting diode that produce light of different wave- lengths. The absorption of different wavelengths of light emerging from this light by the leaf was monitored with different photo diodes for light in each wavelength. The information obtained from the photo diodes was analyzed for the nitrogen and potassium requirement of the plant. Using irrigation system, which is built on the field of farming and capable of moving horizontally, potassium and nitrogen were supplied to plant [37].

Arif and Abbas (2015) the researchers suggested an effective automatic irrigation system on the basis of estimating different changes needed in greenhouses through the use of WSN and utilizing client web service and a server for monitoring and controlling. The presented model has 2 major aspects that are reducing the power to control and monitor over long distance. There have been 5 sensors used in the suggested system, light sensor, temperature, humidity, soil moisture, and CO2, each one of these sensors has measure changes in environment in greenhouses. Results have indicated that the control model was measure sensing data and precise tool to calculate the values of used sensors in addition to self-control output plugged devices. Furthermore, the results showed that there are a number of advantages related to the system, like: ease of network management and control motors and valves [38].

Teslyuk, Denysyuk, Kernytskyy, and Teslyuk (2015) Arduino-based control system for mini greenhouses. For measuring greenhouse environment, a sensor module that includes temperature, humidity, light values of measurements is used. Heater, cooler, irrigation pump and lighting are used for greenhouse environment changes. In addition, a real-time module with its own battery is used for the real time required for the system to run. Ventilation method and the sensor used to measure air humidity and air temperature are same both the system described in and our smart system implementation. But no detailed information has been given for other units used in this system. The operation of our system is displayed on the led screen [39].

Abdullah, Enazi, and Damaj (2016) was introduced a smart system designed for agriculture, called AgriSys, air temperature, soil moisture, soil PH, air humidity, and light were measured with sensors. In this system, the blinds unit was used to prevent more light, but no lighting unit was used for less light. Irrigation method was used for water and nutrient needs. The cooling unit was used to protect the plant from high temperatures, but the no heating unit was used for low temperatures. In implementing the designed AgriSys system, it is claimed that it saves water and reduces the human power used in agriculture [40].

Patil, Beldar, Naik and Deshpande (2016) they designed irrigation system using Arduino Uno is described. In this designed system, Arduino compatible Ethernet shield and Arduino compatible Motor shield are used. In general, in the system, soil moisture is measured by the sensor of soil moisture. The measured value is evaluated by Arduino: If it is below a predetermined threshold value, the servo motor that is connected to motor shield is turned on and irrigation started. When the moisture value of the soil exceeds the value of the threshold, the servo motor is turned off and irrigation is finished. All of these processes and instant value information are presented to the user through Ethernet shield. this system also reduced the human power consumed for irrigation. However, the use of additional Motor shield has increased the setup cost [41].

Saini , Kumari , Yadav , Bansal, and Ruhil (2016) They are presented A system in which only the amount of water and light can be controlled for a single plant. In this system, light and irrigation control was carried out in a greenhouse environment which could be called a mini greenhouse since only one plant grows. In the system, irrigation system which depends on soil moisture and a curtain system that prevents the plant from getting too much light were used. In this system, goals such as increasing the target quality of the plant, re-usability have been achieved. But the system cost was high because it was designed for only one plant [42].

Shirsath, Kamble, Mane, Kolap and More (2017) work has provided a smart green-house model that was helpful for farmers to automatically perform the work in farms without using much manual regulation. Their agriculture field irrigation has been performed with the use of automatic drip irrigation that operates based on the threshold of soil moisture which has been defined accordingly, in order to apply the most suitable water amount to plants. According to soil health card data, suitable amounts of nitrogen, potassium, phosphorus, and other mineral elements are applied with the use of methods of drip fertigation. Suitable tanks of water management have been made and filled with water post measuring the current level of water with the use of ultrasonic sensors. In addition to that, plants are provided with the necessary wave-length light at the time of night with the use of growing light. Temperature and air humidity are regulated with sensors of temperature and humidity and a fogger has been utilized for controlling the same. A tube has been regulated with the use of a GSM module (SMS or missed call). Bee-hive boxes have been utilized for pollination and boxes are monitored with the use of ultrasonic sensors for measuring honey and sending mails to buyers after they are filled. In addition to that, the readings that have been recorded from containers of storage were uploaded to a cloud service (i.e. Google drive) and forwarded to a company of e-commerce. The result that the system reduced efforts and time of farmer and made farming with higher efficiency and profitability [43].

3. HARDWARE COMPONENTS

3.1. ARDUINO

Arduino is an open source, in each of its software specifications and hardware specifications in a way that hobbyists are capable of assembling simplest modules of Arduino manually. More advanced pre-assembled modules of Arduino may be bought and their prices are rather modest. There is a wide variety of format specifications for the hardware, which range from small wearable devices to large surface mounted modules. The main computer connection mode is through USB, Bluetooth, as well serial and ethernet form factors. Arduino software is free and open source. The platform of programming has been based on common Wiring language. The IDE has been based on Processing, which is a popular language amongst designers. In contrast to the majority of interfaces of micro-controller, it is across-platform; which may be operated on operating systems such as Linux, Windows, and Macintosh OS X. Arduino gives the ability for the users to have a simple path-way for creating interactive objects which may obtain the input from sensors and switches, and regulate physical outputs such as a motor, an actuator, or a light. Due to the fact that the language is based on well-used frameworks, Arduino is capable of interacting with other types of software such as Flash or even web APIs such as Twitter [44]. Components which are used to build our Arduino are:

1. Atmega328 IC Chip
2. 16 MHz Clock Crystal.
3. 22 pF Ceramic Capacitor – 2 Pcs.
4. 10 uF Capacitor.
5. L7805 Voltage Regulator.

3.1.1 Advantages of Arduino

1. Larger library collection and Low power consumption.
2. Huge support and documentation.
3. Open source and Low power consumption.
4. No extra programmer/burner hardware needed for programming board and highly customizable.
5. Simpler and more user-friendly programming language.

3.1.2 Arduino in the Greenhouse

Arduino is the heart of Intelligent Greenhouses. Its boards are capable of receiving, analyzing and sending data for maximizing plant health as well as its growth. Fig. 3.1 illustrates the fundamental board of Arduino (which is the Atmega328), and Fig. 3.2 shows the Arduino Atmega328 block diagram.

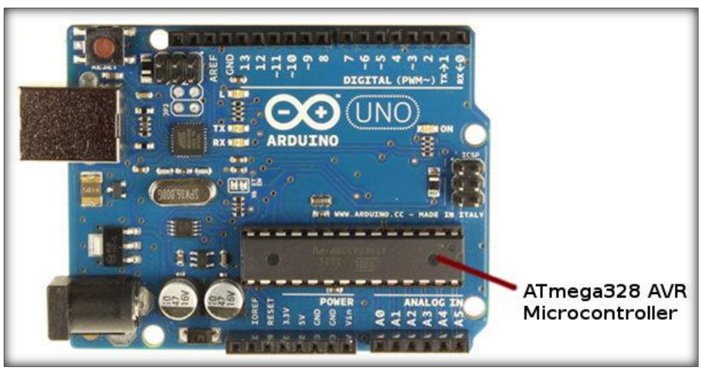

Figure 3.1: The basic Arduino board ATmega328

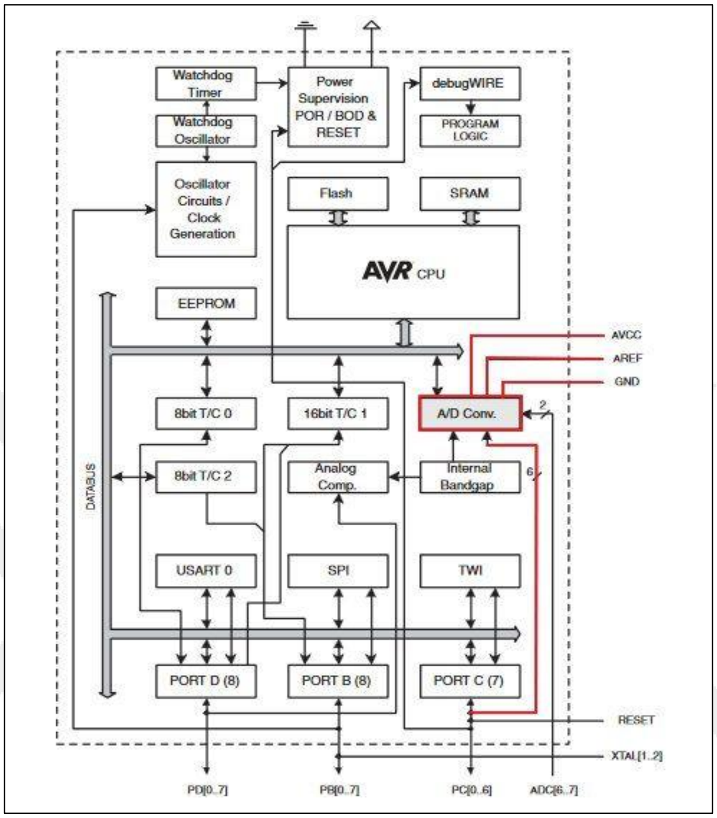

Figure 3.2: Block diagram of Arduino ATmega328.

3.2 ATMEGA328 IC CHIP

ATMEGA328 micro-controller that plays the role of the processor for Arduino boards. It usually includes of 28 pins, from which the inputs may be regulated via the transmission and reception of inputs to and from an external device. In addition to that it includes pulse width modulation (PWM) which is utilized for transmitting the whole signal in a pulse modulation. Input power supply like G nd and Vcc are utilized. Those ICs mostly include digital and analog inputs, which are utilized in certain applications. The ATMEGA328 includes 6 analog inputs, depicted in the diagram of the pin. Analog inputs may be denoted from PC-0 to PC-5. The analog pins possess the continuous time signal acting like an analog system input. In addition to that, it 12 digital inputs as well. Which are denoted from PD-1 to PD-11 acting as ports of digital input which are based on the PWM, which transmit signals in discredited form. Both types of ports may be utilized for a variety of applications for input power supply, GND and VCC pins are utilized. Pins PB-6 and PB-7 act as crystals for generating clock signals. With the use of those crystals, it is possible to produce clock signals which can be used for input sources. The PC-6 pin is the one that may be utilized as a reset option. Program resetting may be done with the use of the PC-6 pin [45].

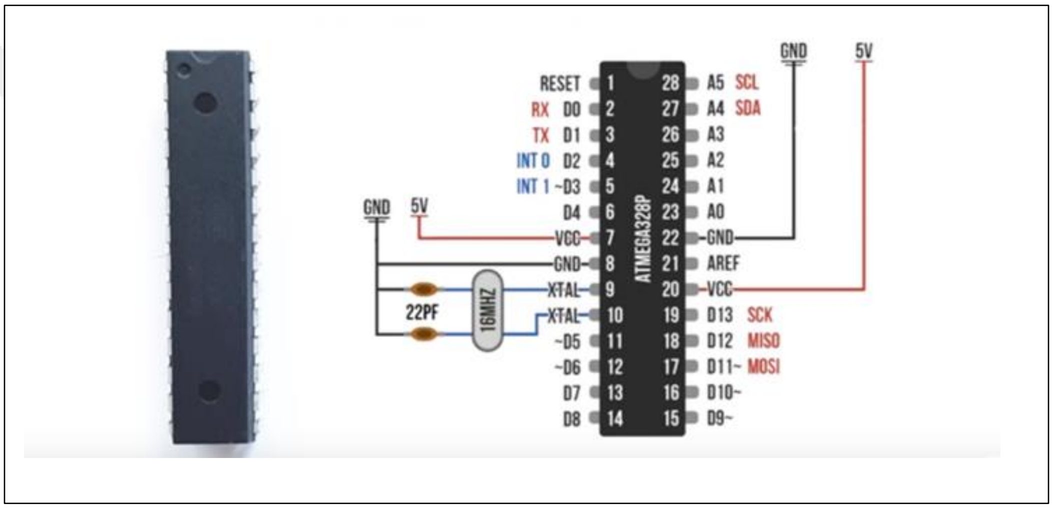

Figure 3.3: ATmega328 IC Chip

3.3 SOIL MOSITRUE MOSITRUTE SENSING TECHNOLOGY

Moisture is unwanted no matter if it appears in buildings, agriculture, packaging materials, textiles, dry food process, or electronics [46]. The detection of moisture has an importance in a wide variety of cases. For instance, measuring moisture of the soil is beneficial in order to minimize the irrigation water amount, which is applied for growing plants and the optimization of plant growth. This elementary inexpensive sensor of soil moisture includes 2 probes (the Ordinary galvanized nails or metal rods), which are held apart at a predefined distance with the use of a material of insulation. They are utilized for sensing the moisture in soil. Two wire pieces, 2' long each, and strip ½" off the ends. One end of each wire is wrapped around the head of each nail. Cover the wire-nail connection with a generous amount of solder. By measuring the resistance between the two nails stuck in the soil, water requirement of soil can be determined. More the water in the soil more is the conductivity. It uses the two probes to pass current through the soil and to measure the resistance to get the moisture level. More water makes the soil more conductive (less resistance), while for dry soil conductivity is poor (more resistance), LDR- Light Dependent Resistor [47]. 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, and batch counting and burglar alarm systems. The sensor contains two parts as shown in figure below:

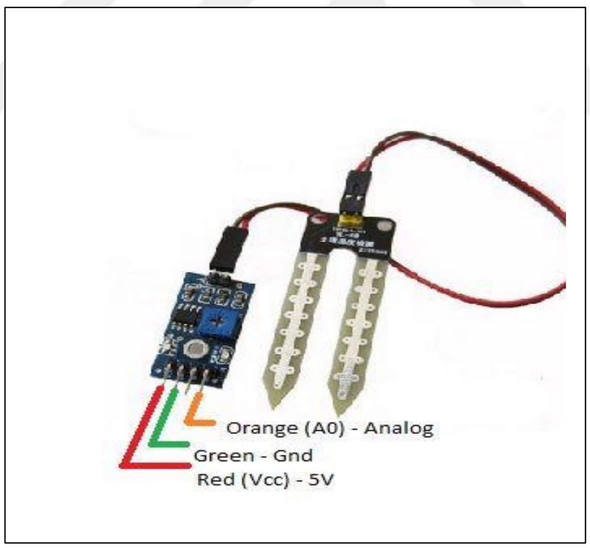

Figure 3.4: Soil Moisture

3.4 DHT11 SENSOR

DHT11 digital temperature and humidity sensor" is a composite sensor containing a calibrated output of digital signal of humidity and temperature [48]. The sensor of humidity is utilized to sense vapors in the air. The variation of Relative Humidity (RH) of the surroundings results in displaying values [49]. This sensor consists of a humidity measurement component which is of a resistive type in addition to an NTC component of temperature measurement and links to a high performance 8bit micro-controller, which offers timely response, outstanding quality, cost-effectiveness, and anti-interference capability. Temperature sensing technology is a very commonly utilized sensing technology nowadays. It offers the ability of detecting temperatures in a variety of applications and protects from extreme excursions of temperature. The DHT-11 which is illustrated in Fig. 3.3 has been chosen in this application. DHT-11 is an elementary, inexpensive digital sensor for humidity and temperature. It utilizes a capacitive sensor of humidity as well as a thermistor for measuring the air around and displays a digital signal on the data pin (without any need for any analog input pin). It is easily used; however, it needs precise timing for grabing data. The only actual down side of this sensor is that it is only possible to get new data from it once every 2 sec. Table 3.1 shows technical specification of DHT 11.

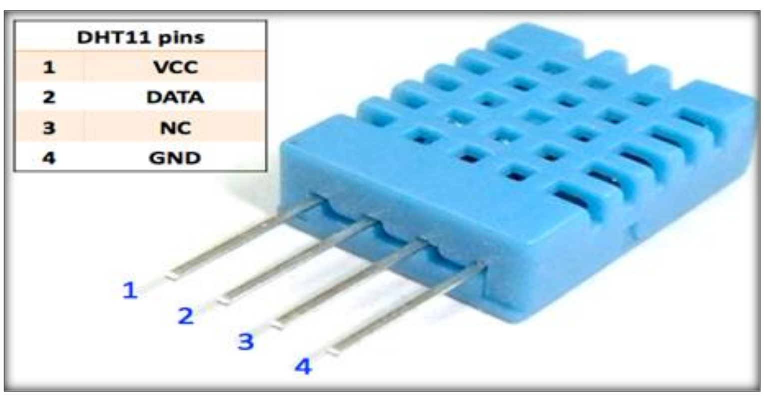

Figure 3.5: DHT11 Sensor

Table 3.1: Technical specification of DHT11

Specification	Value
Resolution 1	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

3.5 LIGHT DEPENDENT RESISTOR (LDR)

An LDR, or a photo resistor can be defined as the device whose resistivity is a function of the incident electro-magnetic radiation. As a result, it is a light sensitive device. Which is also referred to as the photo conductive cell, photo conductor, or merely photocell. It consists of semi-conductor materials which are highly resistant. Such as photometric sensors, an LDR measures the visible light as viewed by human eyes. It is essentially a resistor which has internal resistance increasing or decreasing according to light intensity level that impinges on the sensor's surface. The sensor of the light is made with the use of an LDR. The LDR resistance can vary based on the intensity of the light which falls on the surface. When turning a torch on, the LDR resistance drops, and that allows the current to pass through it [50].

In case of a lack of sun-light in the greenhouse the detector can sense it and send a signal to the micro-controller. As a result, this micro-controller transmits a matching signal to the device of interfacing in order to turn lights on. In addition to that, when the sun-light is at a preferable level the micro-controller transmits a signal for turning lights off based on the output of the sensor. For turning lights on or off in the green-house based upon the intensity of the sun-light [51]. The plants use the light in a range between 400nm and 700nm which is usually known as Photo-synthetically Active Radiation (PAR). It is necessary to monitor PAR for the sake of ensuring that the plants are getting a sufficient amount light for the photo-synthesis. LDR which is illustrated in Fig. 3.4 has been chosen in the present application. LDR is fundamentally a resistor having internal resistance which decreases or increases according to light intensity level which impinges on the sensor surface where it measures visible light as it is seen by human eyes with fast response, and small in size. Table3.2 lists the technical specifications of the LDR

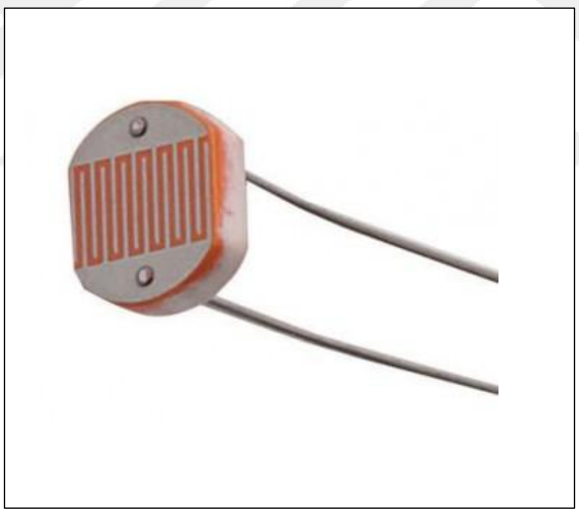

Figure 3.6: The light dependent resistor

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

3.6 POWER SOURCE

Wireless sensor unit limitation may be discussed based on the power that will be considered crucial in deploying the sensor section, which should have low power consumption in addition to having portability and flexibility. For meeting those requirements, a portable power source has been proposed. Monitoring of environmental behavior should be done for duration of complete season. To supply our system with power, we used 3 lithium batteries each one with 3.7 voltage and 2000 m Ah. We connect them in serial form, so the result was 11.1 volt and 2000 m Ah. Our system using solar clean energy as a source of power. To recharge the batteries, we need to supply them with power source with at least 1.5 time of voltage. So, we used three solar panel each one with 6 volt and 350 m Ah. After connecting them in serial the output voltage is 18 volt which is suitable to recharge out batteries.

Figure 3.7: Solar cell.

3.7 DEVICES

1. Cooling Fan: using to decrease the greenhouse's humidity and temperature. The fan is typically activated in the last cooling stage, where fans cannot keep the desired temperature for the greenhouse. It can be controlled by a thermostat, controller or computer. As the controller and computer provide multiple stages of cooling, these are the preferred controls. To prevent excessive greenhouse humidity in warm weather, the pump on the evaporative cooling system could be controlled by a humidistat. and pad systems need to be sized appropriately to achieve the maximum cooling efficiency. When a fan and pad system cannot be justified, in some situations passive ventilation with open sided greenhouses may provide adequate cooling for a given crop without using any energy. In the case where biosecurity or insect exclusion is a priority a closed greenhouse with a fan and pad system may be necessary. cooling pads require regular maintenance to ensure they remain efficient. Algae and mineral build up can reduce air movement and lower efficiency. When plants evaporate water into the surrounding air, they modify the properties of the air. The surrounding air temperature and the vapor pressure are decreased, while the relative humidity is increased. Whenever greenhouse air is exchanged with outside air, this also has an effect, due to the change in temperature and the relative moisture content of the exchanged air. the fan-pad cooling

systems can be used effectively to keep the internal greenhouse temperatures and relative humidity at the desired levels. However, the greenhouse cooling can be done with fans which are a controllable and economically justifiable [52].

Figure 3.8: Cooling Fan.

2. Water pump: Pumps ensure ways to move water through the system at usable working pressures. The operation and maintenance of these pumps are some of the most important duties for many water utility operators. There are two basic types of pumps used in water and waste water systems. The most common type of pump is the centrifugal pump. The other type is the positive displacement pump.it is using to supply the plants with water. Water is a major factor in successful production of greenhouse plants. An adequate water supply is needed for irrigation, pesticide application, evaporative cooling (if applicable), growing media preparation and clean-up. Plants require an adequate supply of moisture for optimum growth which is affected by many variables. The amount of water needed depends on the area to be watered, crops grown, weather conditions time of year and the environment control system [53]. The following factors can increase or decrease the amount of water needed:

- Shading: Using shading inside or outside reduces the levels of radiation on plants. According to the shade level, this reduces evapotranspiration and, as a result, needs for water.
- Solar radiation: The radiation level reaching the plants is decreased by 10 to 40 percent because of glazing and structural members in the greenhouse. Which decreases transpiration.

- Types and sizes of plants: Small potted plants or seedlings need a smaller amount of water compared to full-grown tomatoes or crops of cucumber. Large root masses or heavy leaf canopies increase the requirements for water.
- Air movement**:** Systems of fan ventilations maximize evapotranspiration rate. In accordance to the location and the near greenhouses or any other buildings, vents of sidewalls and open-roof designs might be influential as well. A breeze of 5 miles per hour might increase evapotranspiration by nearly 20%.
- Leaching: Usually, it is recommended that a minimum of 10% of applied water to be permitted to leach out for removing excess salts of fertilizer increases the amount of used water. Usually, leaching is responsible for a considerably higher percentage and might highly increase the needs for water. The used growing mixture type also plays a role in water holding capacity amount and as a result, the watering frequency.
- Irrigation system type: 20% of irrigation water only is applied with a system of overhead sprinkler could reach soil in a crop of potted plants with large foliar canopies. In-pot drip systems have a considerably higher level of efficiency as all water which is applied with in-pot drip systems gets into the soil. Systems of sub irrigation like ebb and flood systems, flooded floors and hydroponics conserve water via the recycling and reuse of excess water.

Figure 3.9: Water Pump

3. Light: the technology of light sensing is a very commonly utilized sensing technology in modern day industry and it is using to supply the plants with light. There are a wide range of light sensors on the market that are available for many applications. Therefore, a careful selection of light sensors is essential. Plants absorb sunlight and use it to fuel the

photosynthesis process. Sunlight in range of 400 to 700 nanometers are normally used by plants and are often referred to as Photo- synthetically Active Radiation or PAR [15]. Monitoring PAR is important to ensure the plants are receive adequate light for photosynthesis process [5]. The amount of light that a plant receives has a tremendous impact on plant quality and marketability. Plants can be thought of a “light counters”, in other words, they count the number of particles of light that they are able to absorb. The intercepted light then fuels photosynthesis and growth. This is the beauty of using Daily Light Integrals (DLI) to describe the greenhouse light environment, since it is a direct measure of the number of particles of light delivered to the plant. Adding artificial lighting in a greenhouse enables a host of benefits to plants by acting as a supplement in Winter months when natural light hours are limited, or during strange seasonal changes or just when radiation from the sun is low. Just like sunlight new LED chips can produce all possible colors from the spectrum. Using the new control ability of LEDs, you can easily fine tune the amount and type of light your specific plants need during each growing phase [54]. Using automated LED lighting greenhouse growers are capable of meeting the requirements of plants better, as they have scheduled and real-time adjustments of intensity and spectrum, which enable:

- Enhanced performance of plants and the capability of meeting year-round schedules of growing.
- Increasing weights and yields with the supplementation of natural day-light during short winter days or merely to daily valleys and peaks as a result of cloud cover and storms.
- Lower bills of electricity.
- Tweaking plant size, colors, and cold tolerance.
- Adding more lighting with no increase in the electrical infrastructure.

light sensing technology is one of the most widely used sensing technologies in modern day industry and it is using to supply the plants with light. There are a wide range of light sensors on the market that are available for many applications. Therefore, a careful selection of light sensors is essential. Plants absorb sunlight and use it to fuel the photosynthesis process. Sunlight in range of 400 to 700 nanometers are normally used by plants and are often referred to as Photo- synthetically Active Radiation or PAR [15]. Monitoring PAR is important to ensure the plants are receive adequate light for photosynthesis process [5]. The amount of light that a plant receives has a tremendous impact on plant quality and marketability. Plants can be thought of a “light counters”, in other words, they count the number of particles of light that they

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- Improved plant performance and ability to meet year-round growing schedules
- Lower electricity bills
- Increased yields and weights by supplementing natural daylight during shorter winter days or just to daily peaks and valleys due to storms and cloud cover.
- Add additional lighting without increasing electrical infrastructure
- Tweak the colors, size and cold tolerance of plants.

3.7 DISPLAY UNIT

The gathered and processed data could require being displayed. An LCD is a thin, flat displaying device which consists of numerous monochromes or color pixels which are arrayed in front of a reflector or a source of light. It is usually used in battery-powered electronic devices due to the fact that it utilizes quite a small amount of electric power. Which is why, an LCD 2x16 which is depicted in Fig. 3.11 and Table3.4 has been utilized due to cost efficiency and simplicity.

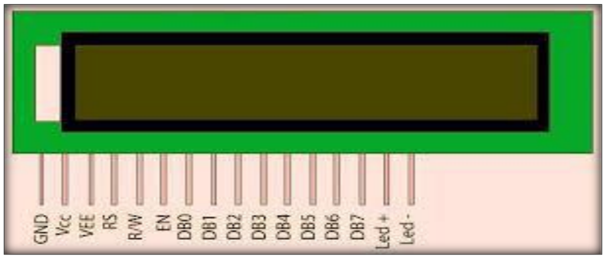

Figure 3.10: LCD And Its Pin Out.

Table 3.3: Technical Specifications Of the LCD

Specification Value	**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

4. SYSTEM INTEGRATION

4.1 INTRODUCTION

The Greenhouse system is one of the important artificial control and intelligence systems. Which aims to improve the agricultural reality and the use of digital technology in solving the problems facing the agricultural sector. Therefore, the greenhouse is one of the smart projects that contribute effectively and significantly to solving many of these problems. One of the benefits of the greenhouse is that it is financially inexpensive, self-controlled, minimizing the workforce and overcoming changes in environmental conditions. Which it is automatically controlled levels of humidity, temperature, light and the amount of air needed are controlled automatically by sensors and connected to the microcontroller. In this chapter, we focused on connecting the physical components of the sensors, air fan, microcontroller, and the shape and design of the greenhouse, which were used in this project.

4.1 INTELLIGENT SYSTEM DESIGN

In this thesis, an intelligent system for greenhouses has been designed and implemented. With the system designed in the thesis, basil cultivation in the greenhouses was done. The controllers are the core of the system in which a different sensor like (soil, indoor and outdoor humidity and temperature) and actuators (such as display screens and LED lights) are connected and linked to the controller. The measurements from the sensors, evaluation and operation of the mechanical systems are provided. For a correct operation of the system, ideal soil moisture, ideal soil temperature, ideal temperature and ideal humidity information are needed. Our project smart greenhouse is designed in a simple and orderly way with the lowest possible costs. It is designed in a small rectangle of plastic. It has a known dimensions 39 cm length measurement, 26 cm width measurement, 25 cm height measurement. Figure 4.1 shows the shape of the green house.

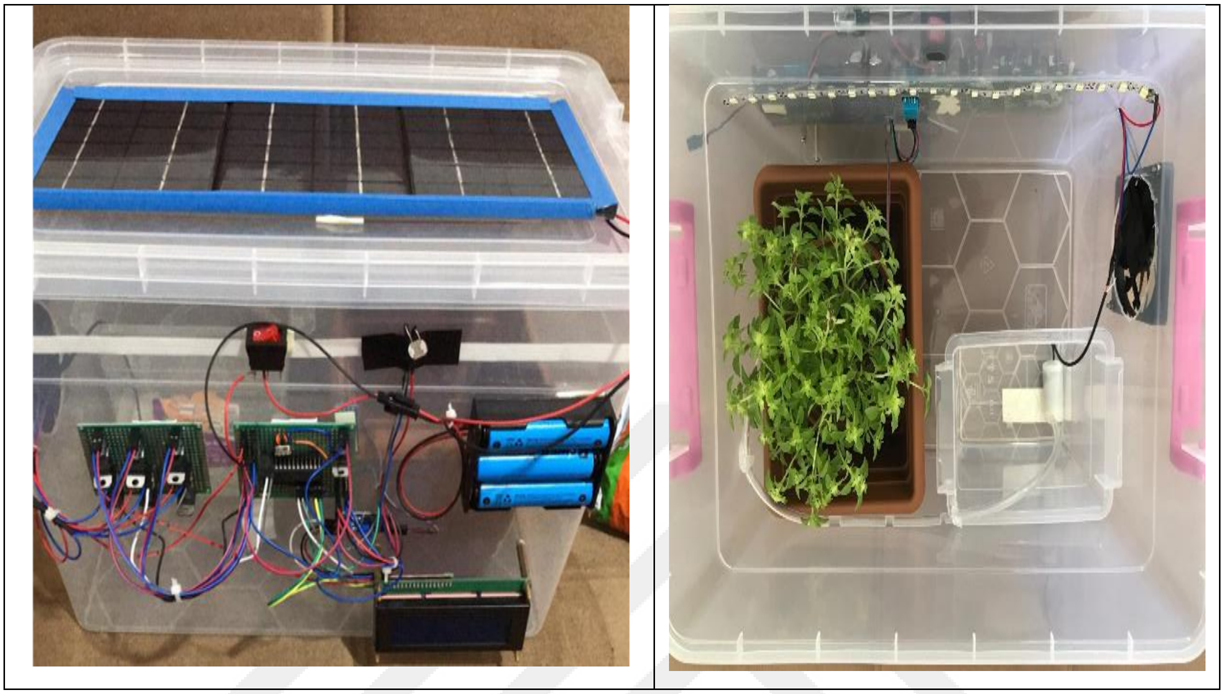

Figure 4.1: a) The Electric and Control Circuits   b) The Plant in the Greenhouse.

Our project also contains three solar panels installed at the top of the project, each measuring 13 * 10. These panels function to provide the device with electricity at the time of need for operation and supply our system with power. we connect the Solar panels in serial form, so the result was 11.1 volt and 2000mAh. The interior design of the smart greenhouse system contains a soil container and for the growth of the plant inside it. The dimensions of this container are 20 cm length, 15cm width and 12 cm height. This container contains a measure of soil moisture level. The interior design v also contains an internal water basin measuring 15 cm in length and 11 cm width and 14 cm height. This basin contains a water pump used to supply the plant with water when needed and maintain soil moisture level. The air fan is used in 8 * 8 dimensions to change the internal air and maintain the proper environment for the plant as required.

4.2 SYSTEM CONNECTION

All components of the system, such as sensors, air fans, solar panels, batteries and reading screen, connect through the Pins allocated to each of them with the microcontrollers. The microcontroller is responsible to Set up all the functions that must performed by these components according to the requirements of plants. Table 4.1 shows the pins number assigned to each component of the system to connect with the microcontroller.

Table 4.1 Pins number in microcontroller.

Pin	Pin Description	Pin Job
23	A0 Analog Input	Soil Moisture Sensor Readings
24	A1 Analog Input	Sun Light Sensor Readings
25	A2 Analog Input	DHT11 Sensor Readings
27	A4 Analog Input - SDA	LCD Screen
28	A5 Analog Input - SCL	LCD Screen
12	D6 Digital Pin 6	Fan Turn ON/OFF Signal (transistor)
13	D7 Digital Pin 7	Water Pump Turn ON/OFF Signal (Transistor)
14	D8 Digital Pin 8	Light Turn ON/OFF Signal (Transistor)

In the previous table (4.1) we note that each pin is dedicated to a specific part of the system components. The pin number 23 represents A0 (Analog Input), which is connected to the sensor readings of the soil moisture. The pin number 24 is A1 (Analog Input), and its function is to link the sensor readings to the sunlight. The pin number 25 represents Analog Input (A2) and its function is the DHT11 sensor readings. While the pins number 25, 26 are used to connect the display screen (LCD) which is represented by Analog inputs (A4, A5). The pin numbers 12 is used to connect the fan on / off signal (transistor) and it is represented by digital input (D6). The Pin Number 13 is used to connect the water pump on / off signal (transistor) and it is represented by digital input (D7) and finally used pin number 14 to connect the signal light on / off (transistor) and represents digital input (D8). Figure 4.2 represents the general configuration of the system components.

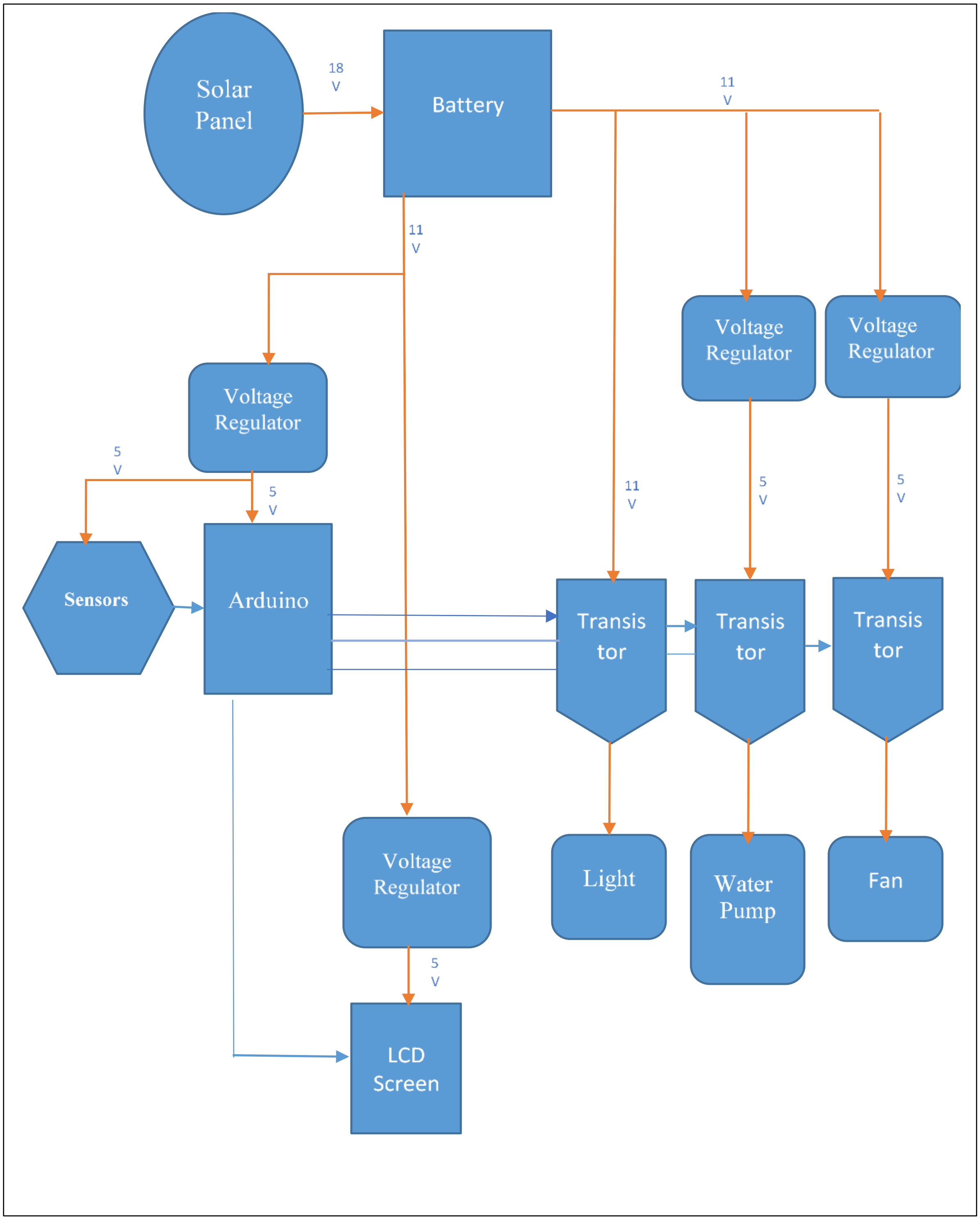

Figure 4.2: General configuration of the system components.

4.2.1 Sensor Connection

The sensors which used in our system are:

4.2.1.1 Soil moisture sensors connection

Is measuring the volumetric water content in soil. The sensor contain two parts as shown in figure below:

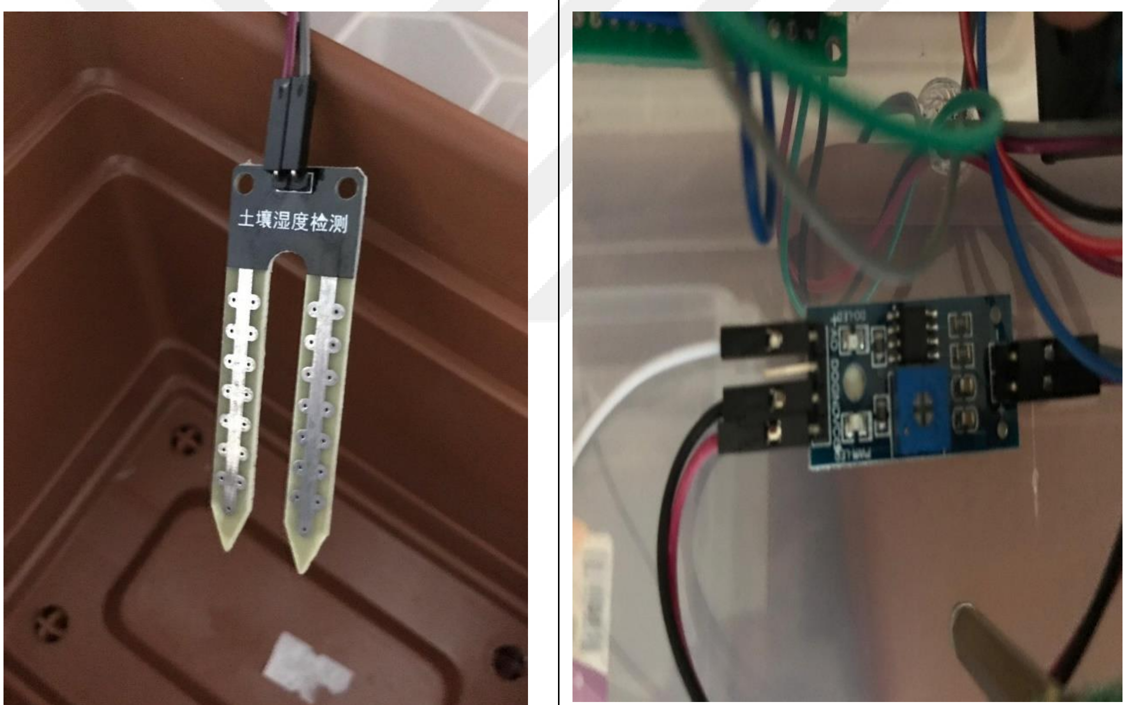

Figure 4.3: Soil moisture sensors connection.

This sensor contain 4 pins first take 5 voltage power. The second connect to the ground. The third and fourth pins for digital and analog signal. for connecting the sensor in analog mode, it is required to utilize the analog sensor output.

4.2.1.2 Air humidity and temperature sensor connection

This sensor measures the humidity and the temperature of the air. It contain 3 pins power, data and ground. Supply Voltage: +5V. Temperature range: 0°C-50°C. Humidity: 20-90% RH. The DHT11 sensor of temperature and humidity includes a resistance-type component for measuring moisture and an NTC component of temperature measurement for measuring temperature. Figure 4.4 shows air humidity and temperature sensor. DHT11 can transmit measured values up to 20 meters, has low energy consumption and is small. The temperature sensitivity is between 2% and 5% [6, 16]. For use with Arduino, the output pin must be connected to a 10 kΩ resistor. The DHT11 library needs to be added to Arduino such that Arduino acquire measurement results from DHT11.

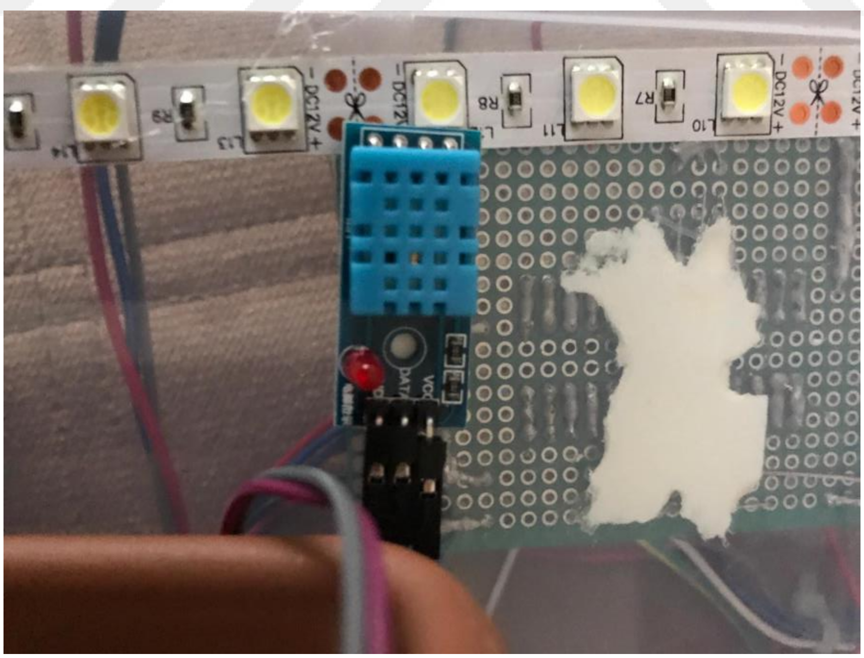

Figure 4.4: The DHT11 Connection.

4.2.1.3 Light dependent resistor sensor connection

An LDR can be defined as the component which has a (variable) resistance changing with the intensity of light falling on it. Which allows them to be utilized in circuits of light sensing. The photoresistor’s resistance reduces with the increase in incident light intensity. A photoresistor consists of a highly resistant semi-conductor. The sensor has 2 legs. One of the legs of LDR is connected to VCC (5 V), and the other one is connected to the analog pin 0 on Arduino. A 100 K resistor is connected to the same leg as well and grounded.

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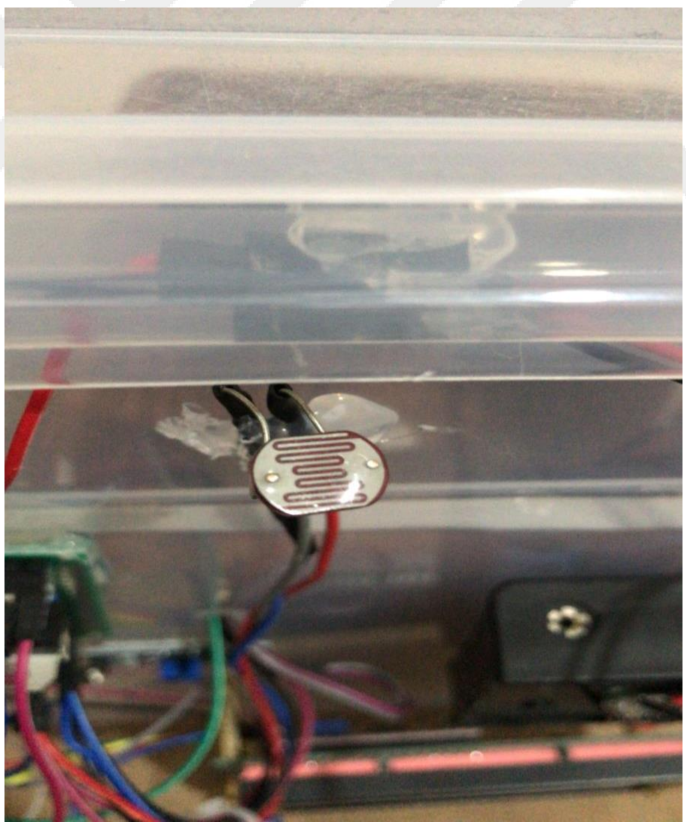

Figure 4.5: LDR Sensor Connection.

4.2.2 Arduino Connection

As mentioned previously, we built our own processor which was built using Atmega328 for the purpose of using a processor that consumes less energy than the processors available in the market. The processor components are connected as shown below in figure 4.6

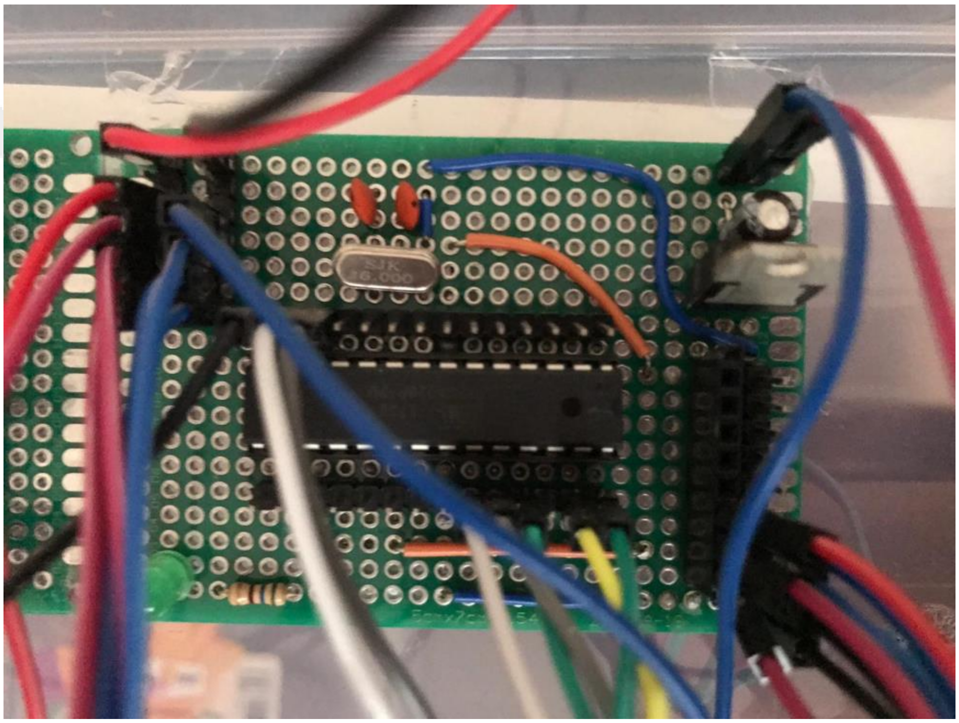

Figure 4.6: Arduino connection.

The processor works only 5 volts and as mentioned formerly the batteries supply the system with 11 volts, so the voltage regulator was used with the processor to reduce the voltage from 11 to 5 volts. The processor receives readings of the sensor temperature, humidity, humidity sensor, soil and light sensor. On the basis of these values, the processor sends the signals of operation, lighting,

lighting, fan and water pump. For the purpose of running these components the processor sends a signal to the transistor.

The transistor acts as an electrical switch between the device (e.g. the water pump) and the source of energy (batteries). When the water level in the plant soil drops, the processor sends its signal to the transistor. The transistor activates the pump by electrically connecting it to the source of energy. Figure 3 represents the transistor and regulator used in our work.

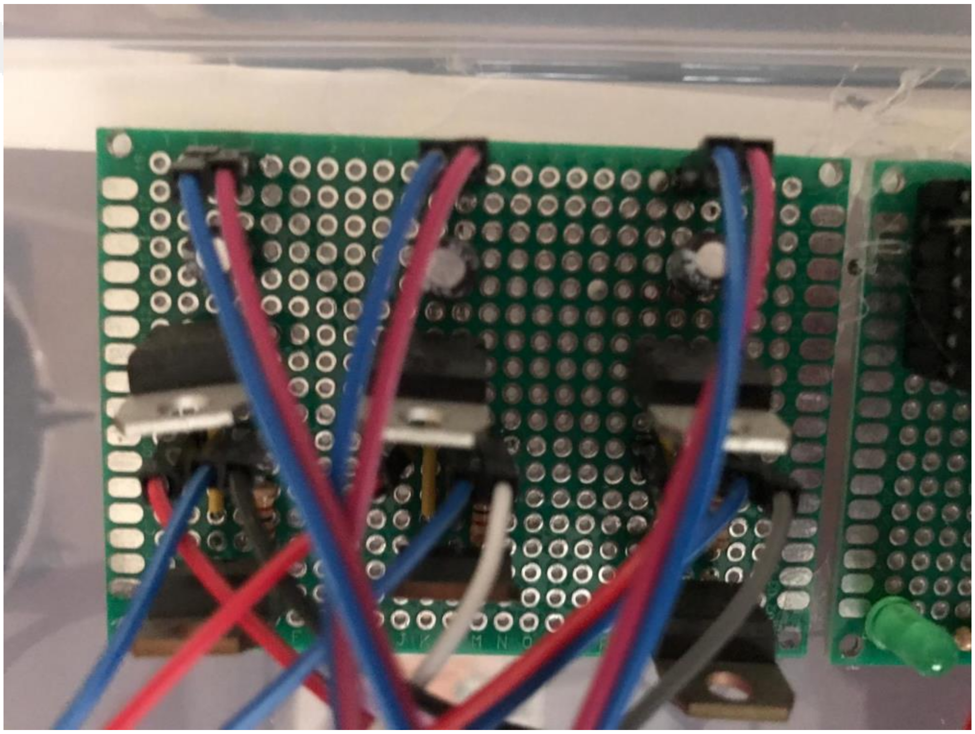

Figure 4.7: Transistor and Regulator Connection.

4.2.3 Devices Connection

The system contains three devices which are water pump, fan and lighting.

1. Water Pump: using to supply the plants with water. Figure (4.8 a) shows the water pump connection
2. Cooling Fan: using to decrease the greenhouse's humidity and temperature. Fig. (4.8 b) shows the cooling fan connection
3. Light: using to supply the plants with light.

The light works on 11 volts, so it does not need a voltage regulator, but it is connected directly to the batteries. The water pump and the fan operate on 5 volts, so we used two voltage regulator one for the water pump and the second for the fan to convert the power source from 11 volts to 5 volts. Each device is connected with a transistor. When the Arduino sends the operating signal to the transistor, the transistor connects the electricity to the device.

Figure 4.8: a) Water pump connection b) Cooling fan connection

These devices work depending on the readings of the sensors. For any sensor, if the readings below the threshold the Arduino will give the order to turn on the responsible device. In order to build such circuit, we used TIP 122 transistor. Transistor is a chip work as an automatic switch. When it is receiving a signal from the Arduino its turn on and allow the power to go throw to the device. Figure (4.9) below showing the TIP122 transistor.

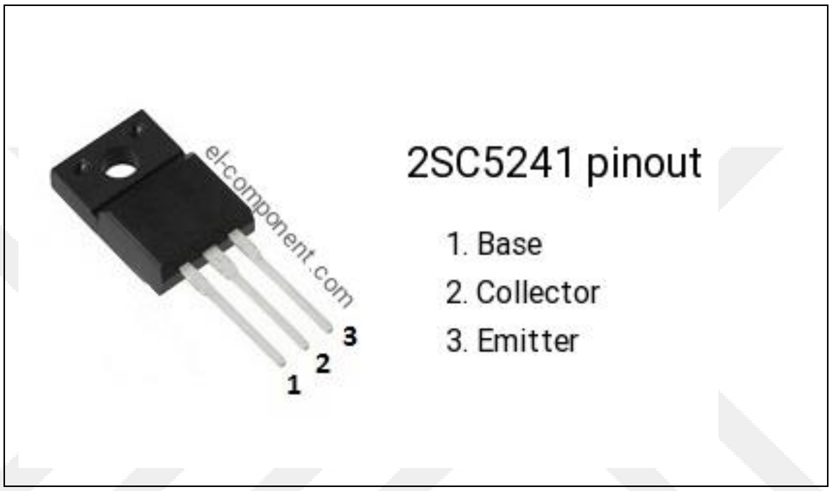

Figure 4.9: TIP122 Transistor.

The base pin is connecting to the Arduino pin. The collector connecting to the power source while the emitter connecting to the device. The tip122 transistor work as NPN negative, positive, negative which mean that is connecting to the negative side (ground) for the devices and the power supply.

The water pump and the fan work with 5 volts so we used voltage regulator to convert the voltage which is coming from the power source from 11.1 to 5 volt. The light using voltage between 7 and 12 so it is not requiring using voltage regulator.

4. LCD Screen: The system also contains a screen for displaying readings of the sensors and the status of the devices working or not working (ON / OFF). We used a 20x4 LCD screen. The screen is connected to the processor. The screen works on 5 volts, so we used a voltage regulator to reduce voltage from 11 to 5 volts. Figure (4.10) shows connection of the LCD screen we used in our work.

Figure 4.10: LCD Screen Connection.

5. Solar cells are cells that convert the sunlight into electrical energy to run household and electronic appliances that need electric power. Those cells require no direct sun-light in order to operate. Which is capable of generating electricity even on cloudy days, because it has the capacity to store energy and generate it when needed. Solar cells were connected respectively as shown in Figure (4,3) In this work.

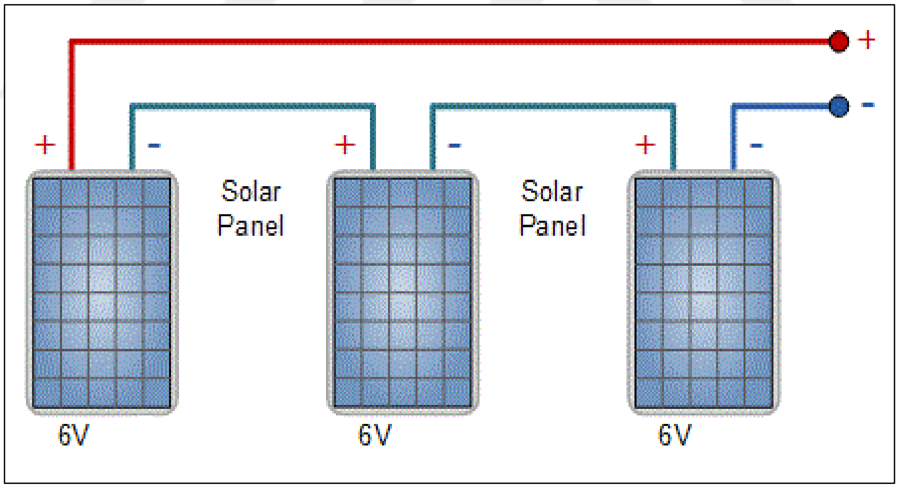

Figure 4.11: The scheme of connecting the solar cells respectively.

Three solar cells are used as shown above, each one of them 6 volts when connected in a respectively. The output is 18 volts and is enough to charge the 11-volt batteries. Cells are connected directly to the batteries. Three lithium batteries, each with a capacity of 2000 mAh and 3.7 V, were used. The batteries were connected to the receiver so the voltage input to the system became 11.1 volts. The voltage regulator is utilized for the reduction of voltage to 5 volts and is responsible for regulating the power current. Where the microcontrollers and all the sensors used operate a 5 volt. Solar panels are installed on the top of the greenhouse. Our system using solar clean energy as a source of power. In order to recharge the batteries, we need to supply them with power source with at least 1.5 time of voltage. So, we used three solar panel each one with 6 volt and 350 mAh. After connecting them in serial the output voltage is 18 volt which is suitable to recharge out batteries. Our project consists of three solar panels each measuring 13 * 10, as shown in figure (4.12) of the solar cells used and installed at the top of the project.

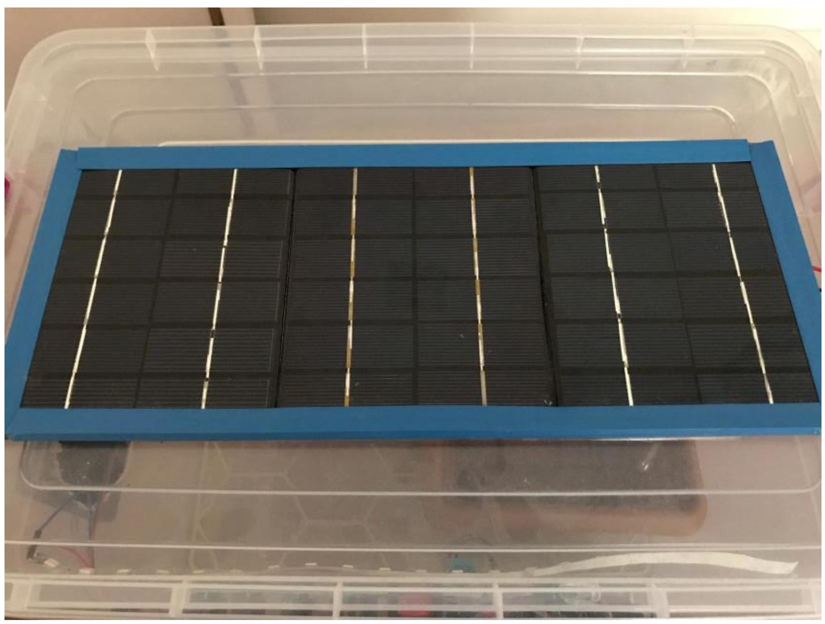

Figure 4.12: Solar cell connection.

4.3 SYSTEM SWOFTWARE

The software which control the system by reading the data from the sensors, giving instructions to the device and display all the information on the LCD screen written by the Arduino Integrated Development Environment (IDE) or as knowing Arduino Software. The Arduino Software (IDE) includes a text editor to write code, a text console, a message area, a toolbar with buttons for common functions and a sequence of menus. In order to use Arduino on a computer, the Arduino driver must first be down- loaded to the computer. Then, the Arduino driver must be installed on your computer manually through the device manager. After installing the driver, the virtual serial port number which Arduino is connected to is going to appear. Then the Arduino IDE, the interface program of Arduino should be downloaded from [55] and run on the computer. Figure 4.11 shows the Arduino IDE and a sample program.

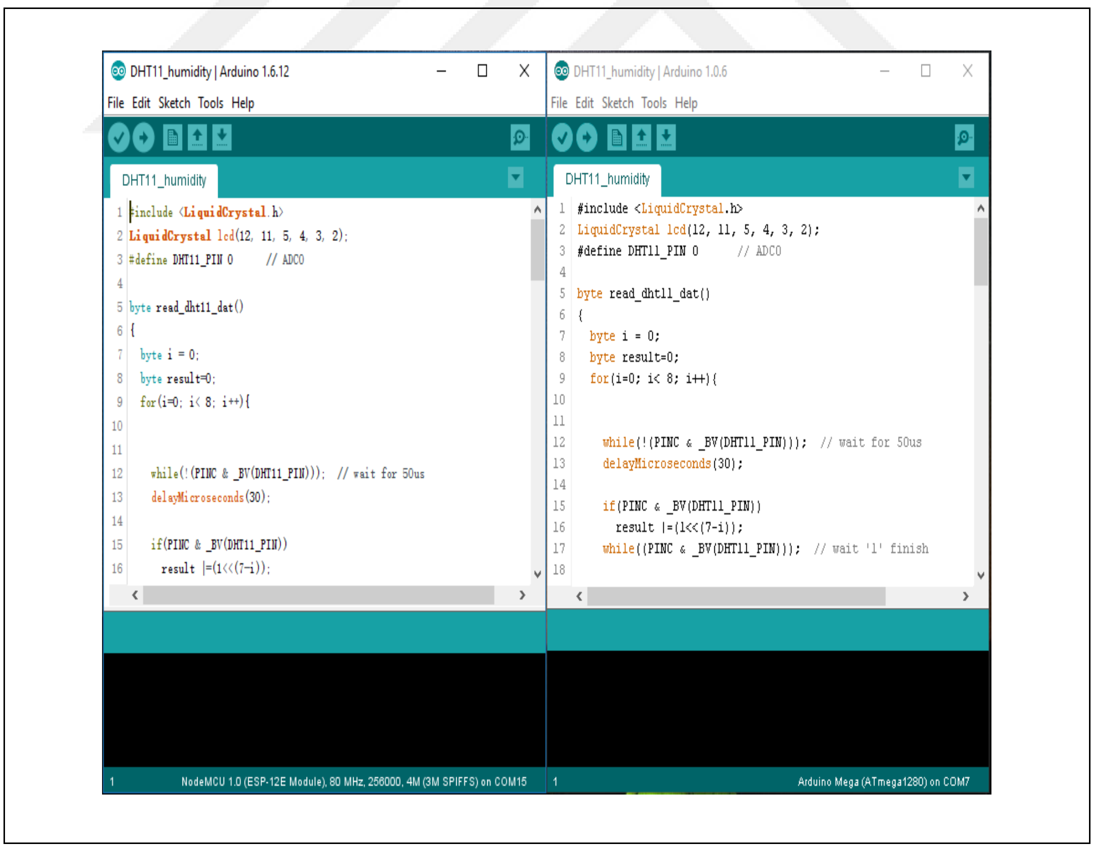

Figure 4.13: IDE Arduino.

5. RESULTS

After assembling the components of the system, the greenhouse become ready for growing up any type of plants. The data of the sensors and the state of each device are showed in the LCD screen of the greenhouse. Figure (5.1) showing the starting message and the data and devices states from the LCD screen.

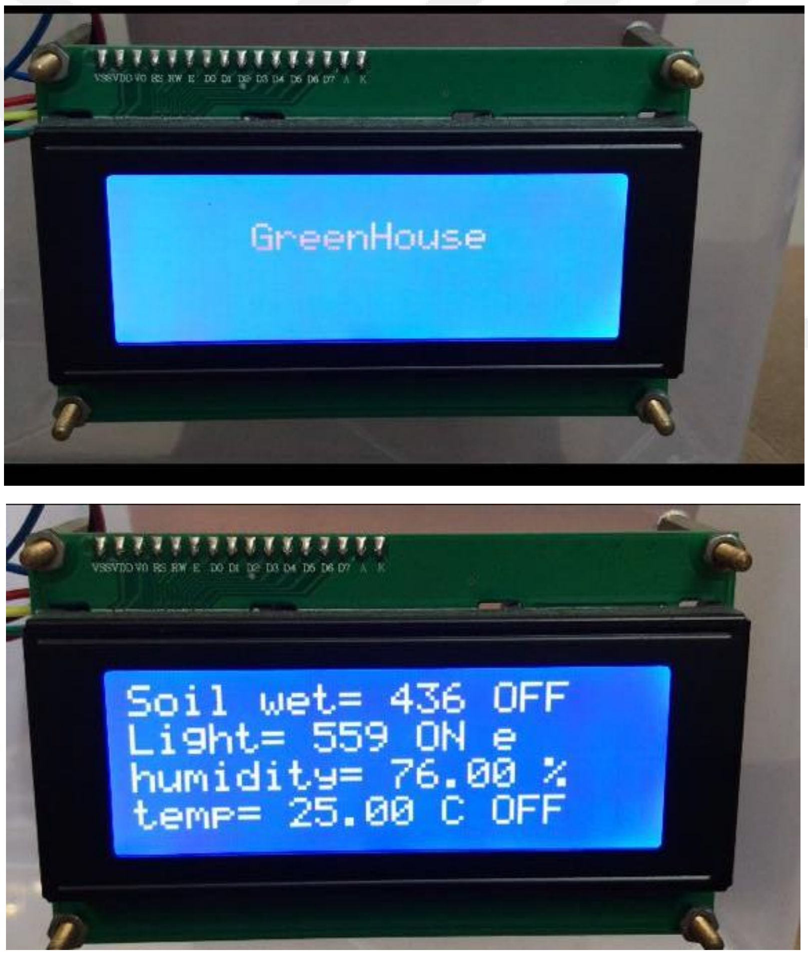

Figure 5.1: LCD Screen Showing the Sensors Data and Devices States.

The table 5.1 shows the data took from the sensors and the corresponding devices state depending on these data.

Table 5.1 Sensors data and devices state

Soil wetness level	Water pump state	Light level	Light state	Humidity ratio	Temperature degree	Fan state	Time
959	ON	742	OFF	76	24	OFF	Midday
961	ON	824	OFF	75	24	OFF	Midday
455	OFF	819	OFF	70	31	ON	Midday
434	OFF	760	OFF	81	28	ON	Midday
436	OFF	559	ON	76	25	OFF	Midday
602	OFF	579	ON	76	26	OFF	Midday
1033	ON	620	ON	82	27	ON	Midday
982	ON	332	OFF	47	20	OFF	Night
722	OFF	403	OFF	55	21	OFF	Night
690	OFF	278	OFF	41	19	OFF	Night

The reading of the data sensors for plant conditions at night and midday was observed as shown in the previous table Depending on the weather. Where the plant does not need the light at night, so the light does not work at night. As well as humidity and temperature decreases at night, so the fan at night not work. therefore, the energy consumption is low at night and the devices automatically work according to the need of the plant to provide suitable environment for the plant. The water pump starting work when the level of the water decrease in the plant soil. The threshold of the sensor reading is equal to 800. When the sensor read more than 800 the microcontroller turning on the water pump until the value become less then the threshold. The LCD screen will show the state of water pump (ON/OFF).

The lights starting work when the level of the light decrease. The threshold of the sensor reading is between 700 and 500. When the sensor read more than 500 or less than 700, the microcontroller turning on the lights until the value become suitable. The 700 is the maximum value of the required light in the day when the sun light become low. The 500 is the value of the light in the night and in that time, we do not need for lighting the greenhouse. The LCD screen will show the state of light (ON/OFF).

The fan instruction work depending on two factors which are the temperature and humidity. The fan starting work when the level of the humidity become more then 80% or the temperature become more than 30 C degree. The microcontroller turning on the fan until the value become less then the threshold for the humidity and the temperature. The LCD screen will show the state of fan (ON/OFF).

Figure (5.2) showing how the soil moisture decreasing after running the water pump for number times of sensor readings.

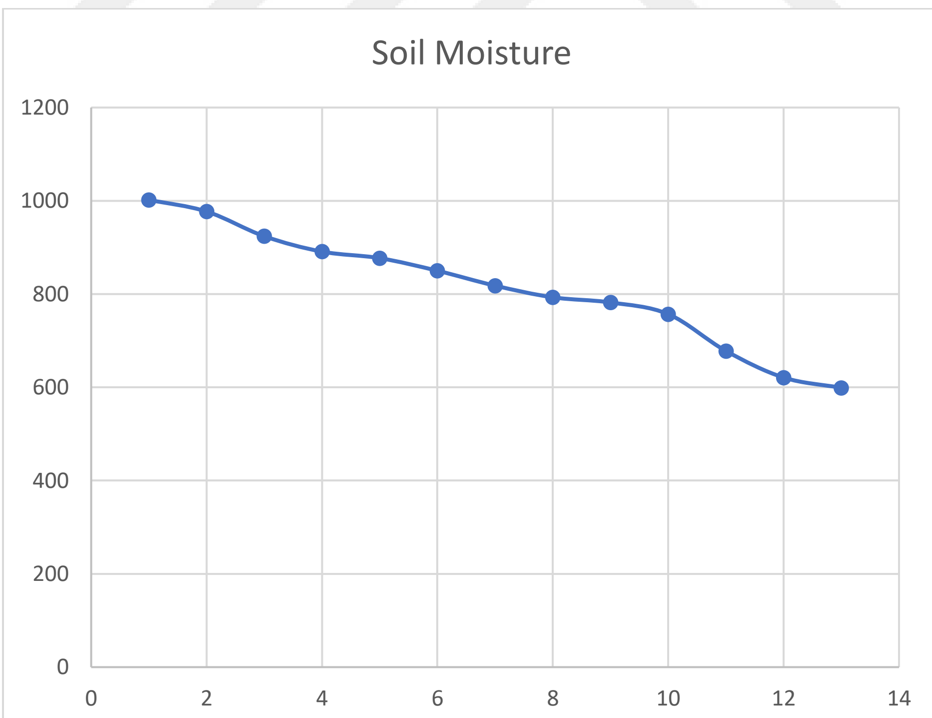

Figure 5.2: The soil moisture sensor reading before and after running the water pump.

Figure (5.3) showing how the light level be fixed between the two threshold 700 and 500 after turning on the lights in the greenhouse.

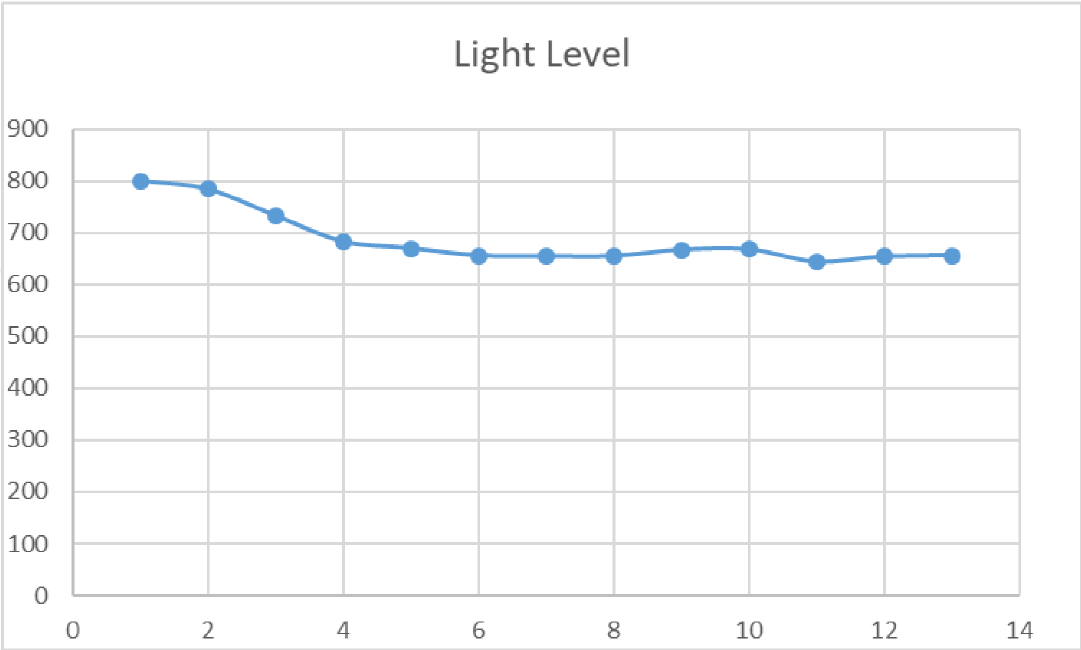

Figure 5.3: The light level sensor during light up the greenhouse.

Figure (5.4) showing how the temperature degree and humidity ratio decreasing after running the fan for number times of sensor readings.

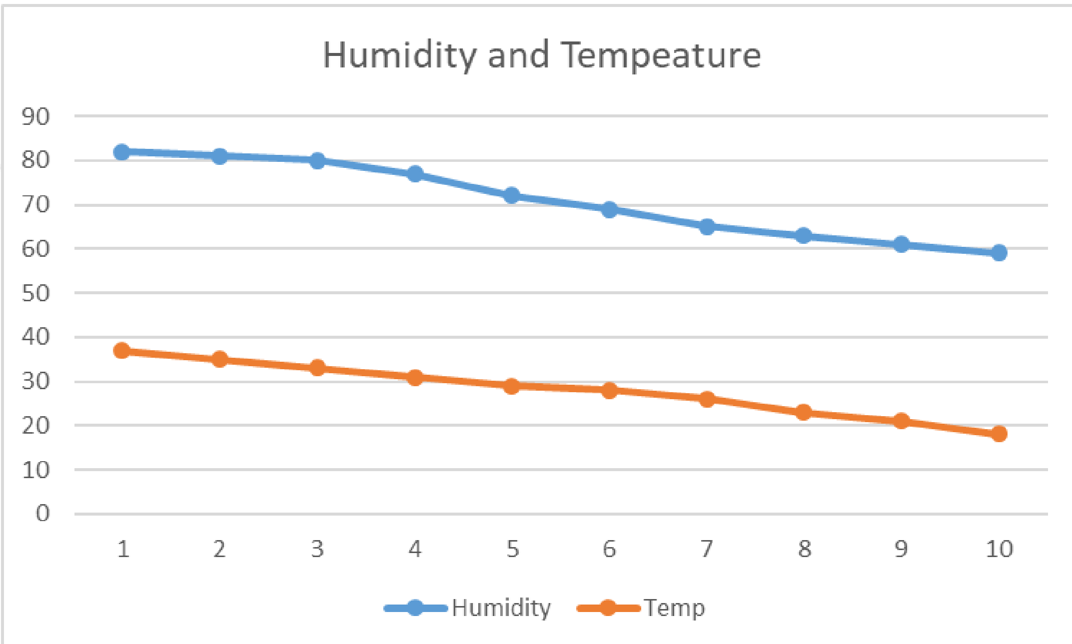

Figure 5.4: The humidity and temperature during running the fan.

6. CONCLUSION AND FUTURE WORK

6.1 CONCLUSION

This research present implementing of a smart less power consumption greenhouse system. The main idea can be two parts. First one is built smart system to control greenhouse climate. The control system work by gathering data from within the greenhouse by the use of sensors like the sensor of soil moisture, DHT11 sensor and light sensor. Then depending on this data, the microcontroller gives and instructions to number of devices such as water pump, lights and fan to adjustment the weather inside the greenhouse. The second part is making this system less power consumption by build special microcontroller which does not need too much power. The microcontroller built using the atmega328 chip. Also, we supplied the greenhouse with clean energy by using solar panels on the greenhouse roof. The result showed that the solar panel able to charge the system batteries and the greenhouse worked perfectly to provide a suitable environment depending on the sensors data to monitoring any type of plants.

6.2 FUTURE WORK

The following are some recommendations for potential future work.

1. It is possible to add more sensors with the aim off getting other environmental parameters like the level of soil pH, airflow, carbon monoxide, as well as the leveld of oxygen.

2. The thresholds in the system can be set depending on an expert person for proving a perfect environment for special types of plants which may be impossible to grow up them in normal weather conditions.

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APPENDIX A

```
#include <Wire.h>          // this library allow to communicate with I2C / LCD screen.
#include <LCD.h> // this library for supporting the LCD screen.
#include <LiquidCrystal_I2C.h> // this library for supporting the LCD screen.
#include "dht.h" // this library for supporting the DHT11 sensor.
LiquidCrystal_I2C lcd(0x27, 2, 1, 0, 4, 5, 6, 7, 3, POSITIVE); // set up the screen.
dht DHT;          // define DHT variable to get access to the DHT11 sensor.
int lightLevel =0; // define light variable to save light value from the sensor.
void setup()  // setup part of the program.
{
   pinMode(6, OUTPUT); // output pin for the fan signal.
   pinMode(7, OUTPUT); // output pin for the water pump signal.
   pinMode(8, OUTPUT); // output pin for the light signal.
   lcd.begin(20,4); // setup the lcd size which is 20 characters in 4 rows.
   lcd.backlight(); // Turn on the blacklight of the screen.
   lcd.setCursor(5,1); // set the position of the massage which will be appear.
   lcd.print("GreenHouse"); // the massage which will be appear at the starting.
   delay(1000); // delay 1 second.
}
void loop() // this part of the software will repeat in an infinity loop.
{
```

```
int SoilValue= analogRead(A0); //Soil moisture sensor readings.
lightLevel = analogRead(A1);  //sun light sensor readings.
DHT.read11(A2); //Humidity and Temperature sensor readings.
lcd.setCursor(0,0); // set the position of the massage which will be appear.
lcd.print("Soil wet= "); // print the name of the sensor.
lcd.print(SoilValue); // print the readings of the sensor.
if (SoilValue > 800) // Threshold of soil moisture sensor.
{
  digitalWrite(7,HIGH); // signal for turn the water pump ON.
  lcd.print(" ON "); // print ON in the screen to referring to the water pump.
}
else
{
  lcd.print(" OFF"); // print OFF in the screen to referring to the water pump.
}
lcd.setCursor(0,1); // set the position of the massage which will be appear.
lcd.print("Light= "); // print the name of the sensor.
lcd.print(lightLevel); // print the readings of the sensor.
if (lightLevel < 700 && lightLevel > 500) // Threshold of light sensor.
{
  digitalWrite(8,HIGH); // signal for turn the light ON.
  lcd.print(" ON "); // print ON in the screen to referring to the light.
}
```

```
else
{
lcd.print(" OFF"); // print OFF in the screen to referring to the light.
}
lcd.setCursor(0,2); // set the position of the massage which will be appear.
lcd.print("humidity= ");// print the name of the sensor.
lcd.print(DHT.humidity); // print the readings of the humidity.
lcd.print(" %"); // print the % to referring to percentage.
lcd.setCursor(0,3); // set the position of the massage which will be appear.
lcd.print("temp= "); // print the name of the sensor.
lcd.print(DHT.temperature); // print the readings of the temperature.
lcd.print(" C"); // print the C to referring to Celsius degree.
if (DHT.humidity > 80 || DHT.temperature > 30) // Threshold of DHT11 sensor.
{
  digitalWrite(6,HIGH); // signal for turn the fan ON.
  lcd.print(" ON "); // print ON in the screen to referring to the fan.
}
else
{
  lcd.print(" OFF"); // print OFF in the screen to referring to the fan.
}
delay(5000); //Wait 5 seconds before accessing sensor again.
digitalWrite(6,LOW); //turn off the fan.
```

```
  digitalWrite(7,LOW); //turn off the water pump.
  digitalWrite(8,LOW); //turn off the light.
  delay(5000); //Wait 5 seconds again then start the system.
}
```