Greenhouse Monitoring and Automation System Using Microcontroller

Pradeep kumar S[#1], Byregowda B K[#2]

[#1]Assisstant Professor, Department of Telecommunication Engineering, Sir MVIT, VTU University

[#2]Assisstant Professor, Department of Information Science and Engineering, Sir MVIT, VTU University

Department of TCE, Sir MVIT, Bangalore – 562157, Karnataka, India

Department of ISE, Sir MVIT, Bangalore – 562157, Karnataka, India

Abstract: *In the previous decade a poly house concept was implemented by which real time controlling against the field environment like temperature, light intensity, humidity, soil moisture was done manually. The control action had done in a way that the sensor from sensing station or a sensing system generates the output related to the estimated parameter but it seems lack of general purpose automation system. The proposed system is an embedded system which will closely monitor and control the microclimatic parameters of a greenhouse on a regular basis round the clock for cultivation of crops or specific plant species which could maximize their production over the whole crop growth season and to eliminate the difficulties involved in the system by reducing human intervention to the best possible extent. The system comprises of sensors, Analog to Digital Converter, 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 microcontroller then performs the needed actions by employing relays until the strayed-out parameter has been brought back to its optimum level. Since a microcontroller is used as the heart of the system, it makes the set-up low-cost and effective nevertheless. As the system also employs an LCD display for continuously alerting the user about the condition inside the greenhouse, the entire set-up becomes user friendly. Thus, this system eliminates the drawbacks of the existing set-ups and is designed as an easy to maintain, flexible low cost solution.*

Keywords: *Microcontroller, ADC, DAC, Threshold, sensors and actuators.*

1. INTRODUCTION

The quantity and quality of growth made by landscape plants is dependent on interactions between their genetic potential and the above- and below-ground environment in which they are growing. The principal environmental requirements for plant growth include adequate space for root and canopy development, sufficient light, water, oxygen, carbon dioxide, and mineral elements, and temperature suitable for essential physiologic processes. Developing a landscape maintenance schedule that provides for timely pruning, watering, mulching, pest control, and fertilizing when necessary, will promote individual plant health and ultimately protect and enhance the entire landscape[1][2].

Fig.1 Green house

1.1 ENVIRONMENTAL FACTORS AND PLANT GROWTH

As a plant grows, it undergoes many developmental changes, including formation of tissues and organs such as leaves, stem, flowers and roots. The main source of nutrients used to aid this development process is often found in its surroundings. In other words, the development of a plant is solely dependent on the conditions of the environment in which plants are grown. The environment consists of many different factors including light, ambient temperature, soil temperature, humidity, soil moisture, and CO_2.

These climate factors play an important role in the quality and productivity of plant growth. Either directly or indirectly, most plant problems are caused by environmental stress. In some cases, poor environmental conditions can either damage a plant directly or indirectly. In other cases, environmental stress could weaken the plant and strip off its immunity and protection against diseases and harsh weather conditions. A good understanding of these climate factors allows the grower to be more aware of any potential problems that may affect the development of the plants and appropriate actions can be drawn to prevent these problems from happening.

*1.2 **TEMPERATURE EFFECTS***

Temperature influences most plant development process including photosynthesis, transpiration, absorption, respiration and flowering. In general, growth is promoted when the temperature rises and inhibited when temperature falls. The growth rate of a plant will not continue to increase with the increasing of temperature. Each species of plant has a different temperature range in which they can grow. Below this range, processes necessary for life stop, ice forms within the tissue, tying up water necessary for life processes. Above this range, enzymes become inactive and again processes essential for life stop. Therefore, the temperature should be maintained at optimum level whenever possible.

1.3 HUMIDITY EFFECTS

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. Due to this phenomenon, plants growing in a dry room will most likely lose its moisture overtime. The damage can be even more severe when the difference in humidity is large. Plants stressed in this way frequently shed flower buds or flowers die soon after opening. High humidity can also affect the development of plant. Under very humid environments, fungal diseases most likely to spread, on top of that air becomes saturated with water vapor which ultimately restricts transpiration. At time of reduced respiration, the water uptake is low, and therefore transport of nutrients from roots to shoots is also restricted. Plants are exposed to high humid environment for a long period of time and may suffer deficiencies.

1.4 LIGHT EFFECTS

All things need energy to grow, human and animals get energy from food. Plants, on the other hand, get energy from 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 even greater degree and, weak plants result.

1.5 CARBON DIOXIDE (CO2) EFFECTS

Carbon dioxide (CO2), according to its chemical structure is a natural gas, which is very dangerous to humans in high concentrations, but a lifeline for trees and plants. It comprises 40-50% of the dry matter of a living organism. The air consists of nitrogen, oxygen and carbon dioxide. Air, on average, contain slightly more than 0.03 (300ppm) percent of CO2. As the result of climatic changes, the concentration of CO2 in today's environment is slightly higher (varies between 350~400ppm). Plants acquire energy from light through a process called photosynthesis. This process involves the absorption of energy from sunlight and uses it in conjunction with CO2 and water to produce sugar and other organic compounds, such as lipids and proteins. The sugars are then used to provide energy for the plant. The carbohydrates are transferred to various parts of the plant and transformed into other compounds need for the growth and maintenance of the plant. This conversion process is in the following equation.

CO2+Water+ Energy from sunlight →Carbohydrate Oxygen

As high CO2 enhances photosynthesis, it generally improves both production and quality. However, the effect of CO2 may not always be an increase in quality and yield. Yield can be increased at the expense of quality. The response can shorten the period between planting and production, with plants become bigger and bulkier, faster seedling germination and growth, or faster maturation of the flowers. These effects may not always be desirable, especially if quality is the main goal. Therefore, CO2 should always be maintained at an optimum level whenever possible

1.6 SOIL MOISTURE

Water is taken by the root system and lost through transpiring leaves. Evaporation from the leaves is the driving force for transfer of water across the plant and only a small proportion of the uptake water is used for growth. It was calculated that the water lost per day by transpiration from some plants is equal to twice the weight of the plant. The rate of water lost depends on the condition of soil, air flow, relative humidity in air and the temperature of the environment. Loss of water from the soil by means of drainage is quite common during the dry season. When absorption of water by the roots fails to keep up with the rate of transpiration, loss of turgor occurs, and the stomata close. This immediately reduces the rate of transpiration as well as photosynthesis. If the loss of turgor extends to the rest of the leaf and stem, the plant will eventually wilt. In more extreme cases burns may begin on the margin of leaves and spread inward affecting whole leaves.

While necessary to point out the importance of having soils well moistened, it is also important for the growers to be aware of the effects of overly moist soil on the development of plants. If the soil is flooded with water, the oxygen content of the plants root substrate is reduced by the higher average water content in the pores, resulting in damage to the roots. A plant with damaged roots cannot extract water and essential nutrients from soil properly and will eventually wilt and die in a short of period of time. Therefore, water is needed to be supplied to the plants often enough so that there is a sufficient amount for plants at all time, but not so often that the air is limited in the soil.

1.7 CONCLUSION

The environment which plants are grown in is the driving force behind the development of plants. The environments consist of many different factors that affect the developmental process of plants in a more or less strong way. Not only that various environment factors are interrelated and they cannot be considered singly without regard to the effect on the others, as well as the total effect on the plant. Some of these relationships are obscure, others are clear but all are easily overlooked. Therefore, a good understanding of the effects of these climate factor and their relationships will allow for prevention and early detection of any potential problems.

2. SYSTEM DESIGN

2.1 WORKING OF THE PROJECT:

The working of the project is such that the two LDRs present on either sides of the solar panel measures the amount of sunlight. The comparator in the two LDR's measures and compares the values of the amount of light falling on the east-faced and the west-faced LDRs [3] [4] [5].
The solar panel rotates towards the direction with the maximum amount of incident light. The tilting of the solar panel is done with the help of a stepper motor used in conjunction with the solar panel. The stepper motor is driven by a current driver, ULN2003.

The other sensors that are used in the project are temperature sensor, humidity sensor and soil moisture level sensor. These sensors are implemented to measure the temperature, relative humidity and the soil moisture level respectively, of the greenhouse [6] [7] [8]. The values detected by the sensor are displayed on an LCD display which enables the farmer or the person accessing the greenhouse to monitor the values of the respective sensors. With respect to the crops or plants grown, certain thresholds are defined for the values of the temperature, humidity and soil moisture level, if these threshold values are crossed, then, the system will automatically take some necessary action to bring it down to the allowable level or value which is preprogrammed in the Microcontroller, PIC16F877A. For example, when the temperature of the greenhouse crosses the threshold temperature then, a fan is automatically switched on inside the greenhouse. Similarly, when the soil moisture content is below certain threshold, the sprinter automatically gets activated and the plants are watered.

2.2 BLOCK DIAGRAM AND DESIGN

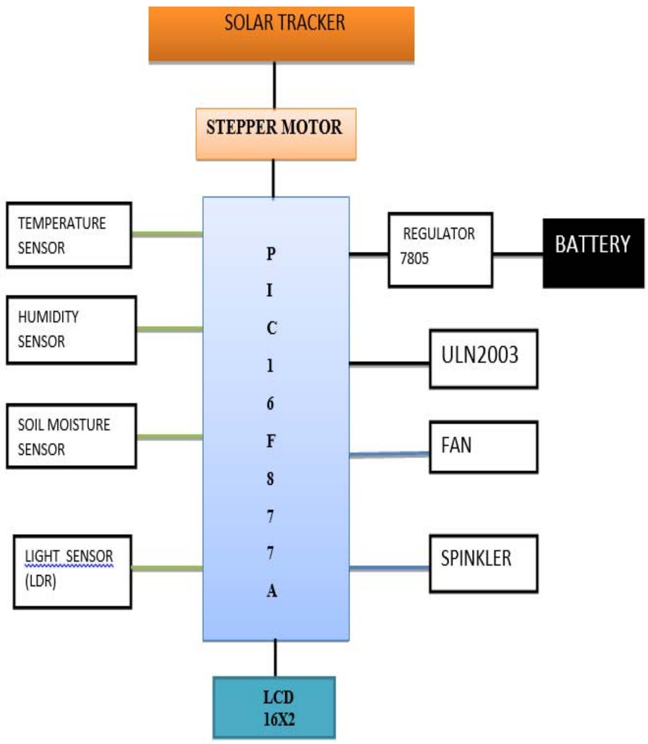

Fig.2 Block diagram

Figure 2.2 shows the block diagram of an implementation. Three general steps can be followed to appropriately select the control system:

Step 1: Identify measurable variables important to production. It is very important to correctly identify the parameters that are going to be measured by the controller's data acquisition interface, and how they are to be measured. The set of variables typically used in greenhouse control is shown below: An electronic sensor for measuring a variable must readily available, accurate, reliable and low in cost. If a sensor is not available, the variable cannot be incorporated into the control system, even if it is very important. Many times variables that cannot be directly or continuously measured can be controlled in a limited way by the system. For example, fertility levels in nutrient solutions for greenhouse production are difficult to measure continuously.

Step 2: Investigate the control strategies. An important element in considering a control system is the control strategy that is to be followed. The simplest strategy is to use threshold sensors that directly affect actuation of devices. For example, the temperature inside a greenhouse can be affected by controlling heaters, fans, or window openings once it exceeds the maximum allowable limit. The light intensity can be controlled using four threshold levels. As the light intensity decreases one light may be turned on. With a further decrease in its intensity a second light would be powered, and so on; thus ensuring that the plants are not deprived of adequate sunlight even during the winter season or a cloudy day. More complex control strategies are those based not only on the current values of the controlled variables, but also on the previous history of the system, including the rates at which the system variables are changing.

1. Temperature affects all plant metabolic functions.
2. Humidity Affects transpiration rate and plant's thermal control mechanisms
3. Soil moisture Affects salinity, and pH of irrigation water Affects photosynthetic rate, responsible for most thermal load 4 Solar Radiation during warm periods.

Step 3: Identify the software and the hardware to be used. It is very important that control system functions are specified before deciding what software and hardware system to purchase. The model chosen must have the ability to:

1. Expand the number of measured variables (input subsystem) and controlled
2. Devices (output subsystem) so that growth and changing needs of the
3. Production operation can be satisfied in the future.
4. Provide a flexible and easy to use interface.
5. It must ensure high precision measurement and must have the ability resist
6. Noise.
7. Hardware must always follow the selection of software, with the hardware required being supported by the software selected. In addition to functional capabilities, the selection of the control hardware should include factors such as reliability, support, previous experiences with the equipment (successes and failures), and cost.

3. HARDWARE DESIGN

The modules taken and integrated to meet specific needs are Light Sensor: Light Dependent Resistor (Ldr), Temperature Sensor: Lm35, Humidity Sensor, Soil Moisture Sensor, Stepper Motor, Dc Motor , Microcontroller: Pic16f877a, Solar Tracker, Regulator 7805, Uln2003, Liquid Crystal Display-Lcd [9] [10] [11] [12].

4. SOFTWARE IMPLEMENTATION

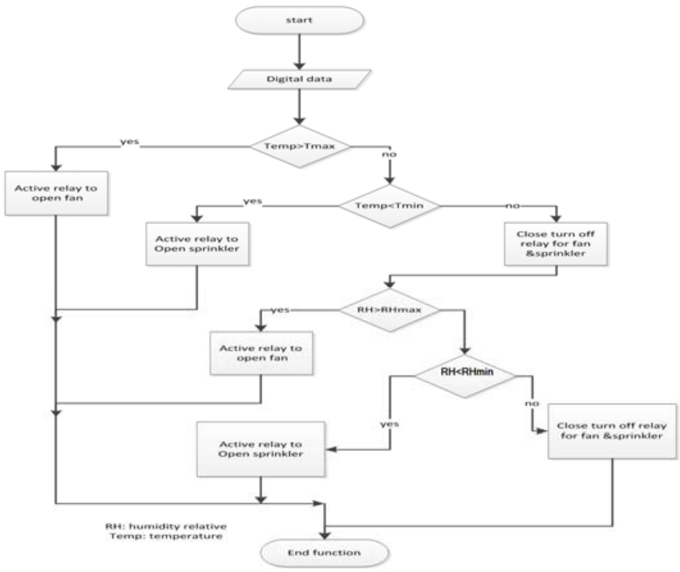

Fig 3: Flow chart of Relay

The flow chart in fig 3 depicts the functions that take place when there I a variation above the threshold value. If the temperature the temperature is above ar below the threshold the fan gets switched on and switched off respectively.If the humidity is above or below the threshold the values also will be monitored.

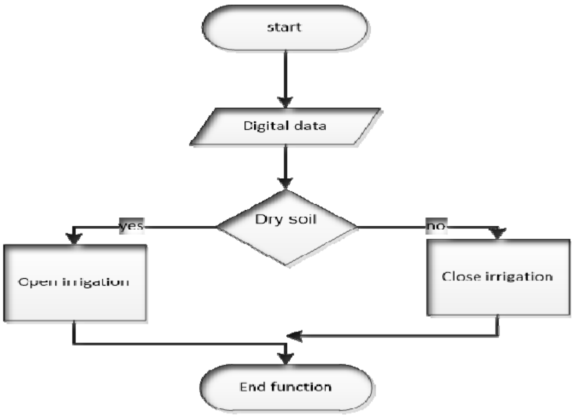

Fig 4. Flow chart of soil moisture sensor

The flow chart fig.4 depicts the working of a soil moisture sensor. The converted digital data is sensed by the soil moisture sensor and if the moisture content in the soil is less than the threshold moisture the sprinkler is turned on in the system else there is no water supply.

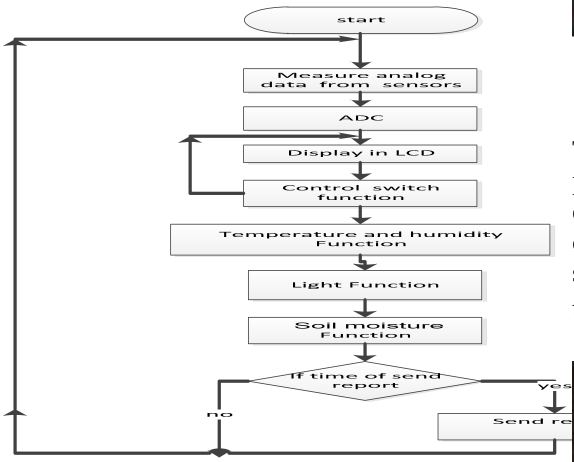

Fig 5. Flow functions of LCD

From the figure 5 tells that start the analogous data are sensed by the sensors used in the system. These analog data are converted to digital data using the ADC convertor port pins in the PIC microcontroller and the surrounding present values are displayed in the LCD. The functions include temperature, soil moisture and humidity. If there is change in the values the system reports the change in the values and updated values are shown on the LCD display.

5. RESULTS

The Fig.5 denotes the 45 degrees rotation of the solar panel towards the right because more sunlight is falling on the right LDR. Therefore, for the maximum capturing of the available light by the solar panel, the stepper motor is programmed to automatically make the solar panel rotate in the respective direction

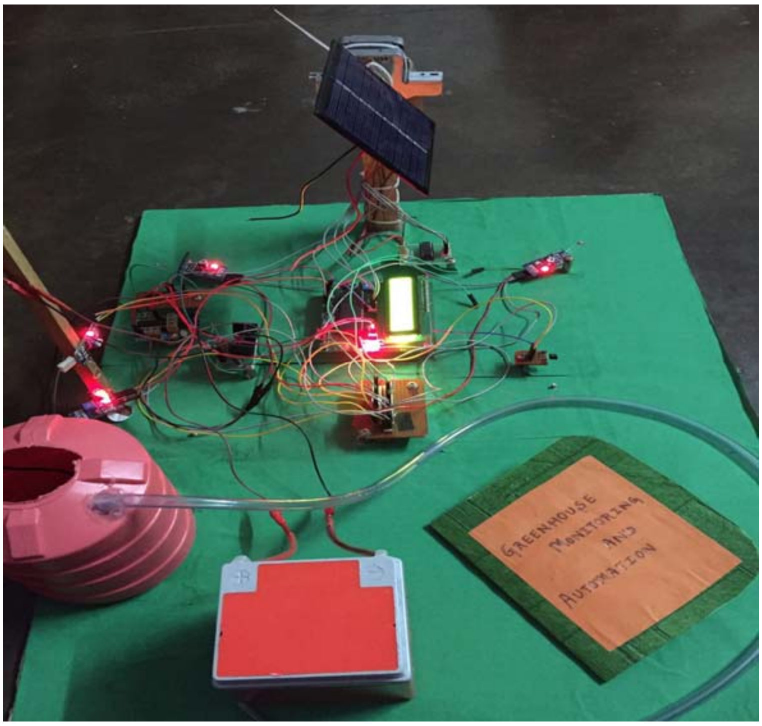

Fig.5 Solar panel tilting Right

The Fig.6 denotes the 45 degrees rotation of the solar panel towards the left because more sunlight is falling on the left LDR. Therefore, for the maximum capturing of the available light by the solar panel, the stepper motor is programmed to automatically make the solar panel rotate in the respective direction.

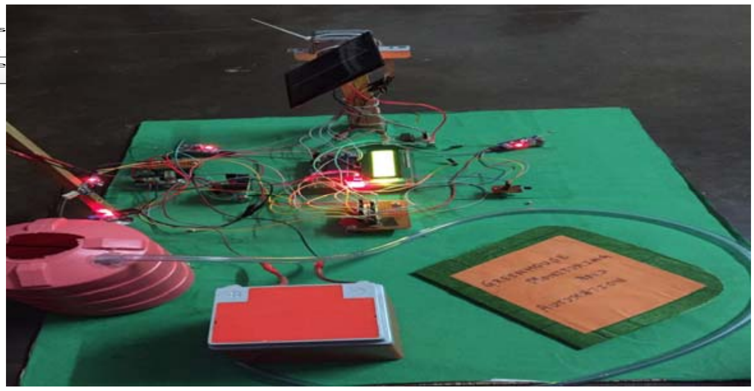

Fig.6 Solar Panel Tilting Left

The Fig.7 shows the position of the solar panel when the sunlight is falling on both the LDRs in equal amounts. Since the light is falling equally on both the LDRs, the solar panel is in the middle position or the default position. If more light falls on one of the LDRs then the solar panel, with the help of a stepper motor, rotates 45 degrees towards that respective side which is shown as below.

In case the temperature increases more than the threshold value set, here we've set it to 39 degree Celcius, then the fan is switched ON.

In case the Soil moisture level is lower than the threshold, then the sprinkler is Switched on to water the plants.

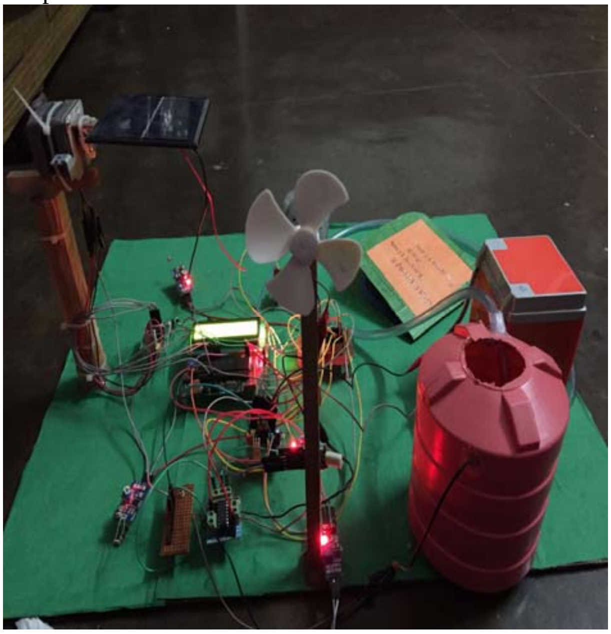

Fig.7 Fan and Water Pump working

6. SCOPE FOR FURTHER DEVELOPMENT

- The performance of the system can be further improved in terms of the operating speed, memory capacity, and instruction cycle period of the microcontroller by using other controllers. The number of channels can be increased to interface more number of sensors which is possible by using advanced versions of microcontrollers.
- The system can be modified with the use of a data logger and a graphical LCD panel showing the measured sensor data over a period of time.
- This system can be connected to communication devices such as modems, cellular phones or satellite terminal to enable the remote collection of recorded data or alarming of certain parameters.
- Time bound administration of fertilizers, insecticides and pesticides can be introduced.
- A multi-controller system can be developed that will enable a master controller along with its slave controllers to automate multiple greenhouses simultaneously.

7. CONCLUSION

The main advantage of this project is that, all the functions to be performed by the Fan and Sprinkler to control the climatic conditions like temperature, relative humidity and soil moisture levels in the Greenhouse environment are all automated and it does not require any human intervention. This is particularly an important factor because the presence and availability of the human cannot always be trusted on. For important structures like the greenhouses, we need a more dependable and reliable way for its management which is easily achieved by this project. Greenhouses are very important as they are responsible for the efficient growth of crops that are either necessary to feed the population or necessary for the economic growth of any country. Therefore, the management of these greenhouses is very important and the Green aims at providing just that.

7.ACKNOWLEGDMENT

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