Asian Journal of Electrical Sciences
ISSN: 2249-6297 (P) Vol.8, No.1, 2019, pp.40-43

DOI: https://doi.org/10.51983/ajes-2019.8.1.2334

# Intelligent Greenhouse Monitoring System (IGMS) Integrated with GSM Technology

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(Received 20 January 2019; Revised 5 February 2019; Accepted 18 February 2019; Available online 23 February 2019)

***Abstract* - GSM technology can be used to monitor different parameters of environment like temperature, humidity, light intensity etc. Within greenhouse the soil and weather shall not depend on the natural agents. Greenhouses are controlled-area-environment to grow plants. Due to lack of availability of land for growing plants, greenhouses are the need of the day for growing crops and other plants. Intelligent greenhouse monitoring system (IGMS) is an advanced technological approach through which farmers of rural areas will be benefitted. Through this approach the direct human supervision is not required, which will save man power. In this communication an intelligent greenhouse monitoring system based on GSM technology is discussed within practical limits. In this current work, an automatic intelligent greenhouse monitoring system is built and tested in which the integrated GSM module sends information about temperature, humidity, light intensity, soil moisture and status of appliances (fan, artificial lights and water, pump etc.) that are connected for controlling the above mentioned greenhouse parameters. It has been found that the control obtained through this proposed system is excellent, and has the potential to be used commercially. To control the parameters according to preset values arduino has been programmed.**
***Keywords:* GSM Technology, Arduino, Environment Monitoring; Greenhouse Monitoring**

## I. INTRODUCTION

Some of the most important factors considered for the quality and productivity of plant growth are humidity, temperature, soil moisture, and light intensity. To get information on how each of these factors affects growth and how to maximize crop productiveness continuous monitoring of these environmental variables is required [1]. The optimal greenhouse micro climate adjustment can enable us to improve productivity and to achieve remarkable energy savings.Greenhouses provide an optimal temperature for plants, protect them from extreme weather, extend the growing season by allowing sowing plants earlier and harvesting plants later, and also allow economic crops to grow successfully [2].

Various researches have been done in order to improve the conditions and cultivation of crops within greenhouse. Qian *et al.,* [3] proposed wireless system solution for greenhouse monitoring and control. Their system consists of wireless sensors integrated with PIC 16F877 and ZigBee module. After the data is being dealt through control algorithm, control commands are sent to the actuators and PIC 16F877. All the wireless nodes are based on ZigBee module.

Zhou Jianjun *et al.,* [4] proposed a system that consists of a data acquisition controller and greenhouse remote monitoring and control software. The system monitors temperature, humidity, soil water content and concentration of carbon dioxide inside the greenhouse. The data is then saved to a database. According to the current indoor temperature, the target temperature and the offset temperature, PID control method is used to control temperature control in greenhouse. The system is implemented using low power wireless components, and easy to be installed.

Ibrahim and Munaf [5] proposed a system to control and monitor the environment inside greenhouse. The system consists of a number of local stations and a central station. The local stations are used to measure the environmental parameters and to control the operation of controlled actuators to maintain climate parameters at predefined set points. For each local station, a PIC Microcontroller is used to store the instant values of the environmental parameters, send them to the central station and receive the control signals that are required for the operation of the actuators. The communication between the local stations and the central station is achieved via ZigBee wireless modules.

Kun Han *et al.,* [6] proposed the design of an embedded system development platform based on GSM communications. Through its application in hydrology monitoring management, the authors discuss issues related to communication reliability and lightning protection, suggest detailed solutions, and also cover the design and realization of middleware software.

In this present communication, an arduino based intelligent greenhouse monitoring system is designed integrated with GSM module. The objective of the present work is to 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 maximum possible extent.Moreover the proposed system is a very low-cost system which can be easily used in rural areas of our country.

## II. SYSTEM MODEL

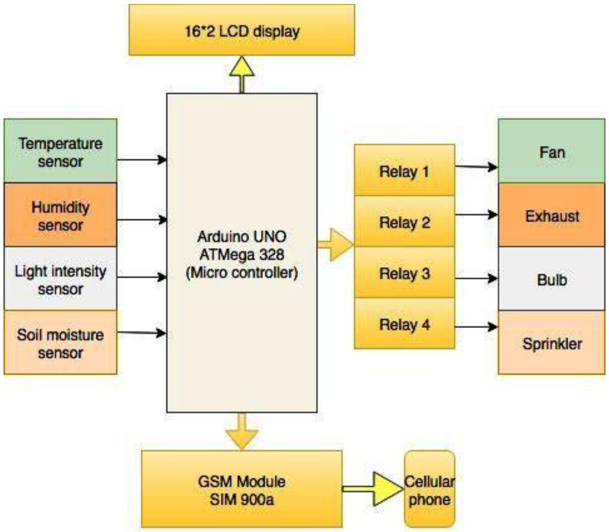


Fig. 1 Block diagram of the proposed system

The proposed system consists of various sensors, viz. soil moisture, light intensity, humidity and temperature. These sensors sense the parameters like soil moisture, light intensity, humidity and temperature and are then sent to the Arduino UNO microcontroller. The microcontroller constantly monitors the digitized parameters of the various sensors and verifies them with the predefined threshold values and checks if any corrective action is to be taken for the condition at that instant of time.

In case such a situation arises, it activates the actuators to perform a controlled operation. Arrays of actuators are used in the system such as relays, contactors, and change over switches etc. They are used to turn on AC devices such as fans, motors, coolers, pumps, fogging machines, sprinklers, etc. A LCD display is attached to the microcontroller, which gives the latest reading of the sensors. A GSM module is also attached which transmits a message whenever any action is required and also can receive any command and can work accordingly.

## III. METHODOLOGY

### *A. Air Temperature and Humidity Control*

A temperature sensor is used for sensing the variations in the ambient temperature within the greenhouse. Whenever the temperature exceeds a predefined level or threshold level, the system automatically turns on the fan and a notification message is sent to the owner by the system via GSM Module. And when the temperature comes within normal range or falls below the threshold level, the fan is turned off automatically, and like the previous time it is notified via sms.

Similarly, humidity is measured by using the humidity sensor. If the humidity of the environment is above the defined levels, exhaust fans are automatically turned on and if the humidity level drops below the defined level, sprinklers are automatically turned on. A message is also sent to the owner with information of all parameters (temperature, humidity and electrical appliance's status etc.). The DHT11 sensor is used for temperature and humidity sensing application. The DHT11 sensor is compatible with most of the popular microcontroller development boards, like Arduino [7-8].

### *B. Controlling Light Intensity*

It is a crucial factor for the plant growth. In case of low light intensity, artificial lights can be used. For detecting light intensity, LDR is used [9-10]. Generally light intensity is measured in LUX. When light intensity is lower than cut-off level, the artificial lights are automatically turned on, and when the light intensity comes within normal range, artificial lights turn off and a notification message is sent to the owner.

### *C. Soil Moisture Monitoring and Control*

Here FC-28 module is used as soil moisture sensor, for detecting moisture content of the soil [11]. Two probes of soil-moisture-sensors are used and placed in the soil. When the sensor senses dryness of the soil, the system turns on the water pump until the required level of moisture is reached. A notification is sent to the owner with status of water pump like 'motor on' or 'motor off'. For sensing soil moisture a transistor can be used as a switch.

Arduino microcontroller (ATmega 328) is used to control all these sensors. GSM SIM 900a is used for transmitting and receiving messages. Arduino IDE (software) is used to control the microcontroller.

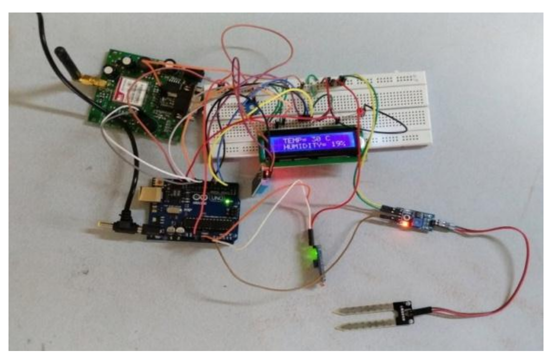

Fig. 2 Actual designed system

## IV. EXPERIMENTAL RESULTS AND DISCUSSION

The system designed has been tested in real time environment for continuous 45 hours, and the results are recorded. The uncontrolled parameters outside the greenhouse and the controlled parameters within the intelligent greenhouse are shown in Table I.

TABLE I SENSOR READINGS OVER 45 HOURS

| | Sl. No. | Time (hh : mm) | Light intensity (LUX) | | Humidity (% RH) | | Temperature (Celsius) | | Soil moisture (%) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Uncontrolled | Controlled | Uncontrolled | Controlled | Uncontrolled | Controlled | Uncontrolled | Controlled |
| Day 01 | 1. | 21 : 00 | 2560.93 | 41694.18 | 83 | 86 | 23 | 29 | 98 | 97 |
| Day 02 | 2. | 00 : 00 | 1729.14 | 43069.24 | 83 | 83 | 23 | 29 | 97 | 97 |
| | 3. | 03 : 00 | 1500.16 | 42648.14 | 87 | 82 | 22 | 28 | 92 | 97 |
| | 4. | 06 : 00 | 7128.49 | 42978.98 | 87 | 82 | 22 | 28 | 85 | 97 |
| | 5. | 09 : 00 | 102196.58 | 101106.46 | 81 | 83 | 29 | 29 | 72 | 97 |
| | 6. | 12 : 00 | 125235.13 | 124169.18 | 74 | 84 | 32 | 30 | 60 | 96 |
| | 7. | 15 : 00 | 130013.75 | 126000.37 | 65 | 84 | 34 | 32 | 47 | 95 |
| | 8. | 18 : 00 | 6762.75 | 43148.69 | 70 | 86 | 31 | 30 | 40 | 94 |
| | 9. | 21 : 00 | 3167.19 | 42006.98 | 89 | 86 | 27 | 29 | 97 | 96 |
| Day 03 | 10. | 00 : 00 | 2620.76 | 43158.34 | 92 | 86 | 27 | 29 | 96 | 96 |
| | 11. | 03 : 00 | 1614.73 | 41567.64 | 94 | 84 | 26 | 29 | 93 | 95 |
| | 12. | 06 : 00 | 8491.75 | 43268.15 | 87 | 84 | 28 | 29 | 89 | 95 |
| | 13. | 09 : 00 | 100984.66 | 100800.26 | 85 | 81 | 29 | 32 | 76 | 94 |
| | 14. | 12 : 00 | 133041.11 | 120000.19 | 67 | 81 | 34 | 34 | 61 | 94 |
| | 15. | 15 : 00 | 4126.48 | 42921.96 | 97 | 80 | 21 | 35 | 52 | 92 |
| | 16. | 18 : 00 | 7126.85 | 41904.47 | 92 | 81 | 22 | 32 | 52 | 96 |

The sensor readings of the variation in ambient temperature with time outside the greenhouse and within the greenhouse are illustrated in Fig. 3 below. We have set the threshold values for control of temperature within a range of 30-40°C. The graph clearly shows that the temperature inside the greenhouse is efficiently controlled within the predefined threshold level, which will promote plant growth.

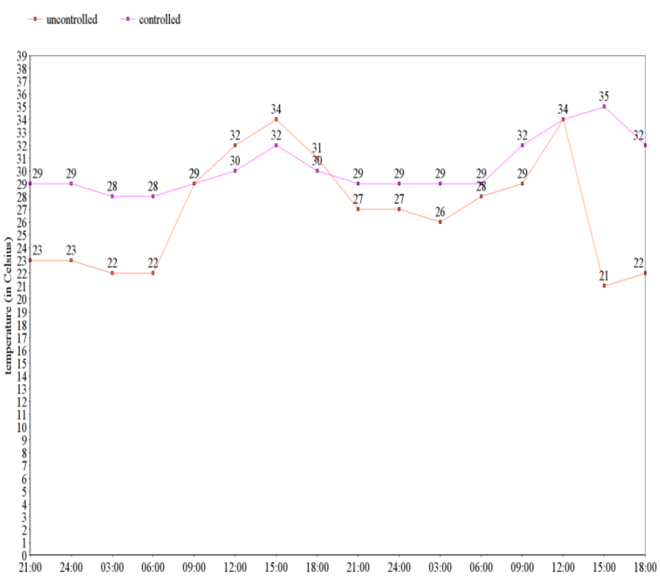


Fig.3 Variation of temperature with time

The sensor readings of variation in ambient humidity with time both within and outside the greenhouse are illustrated in Fig. 4 below. Here we have set the threshold values of humidity within 75-85%. Again the graph shows that the humidity is controlled throughout the test period with high accuracy.

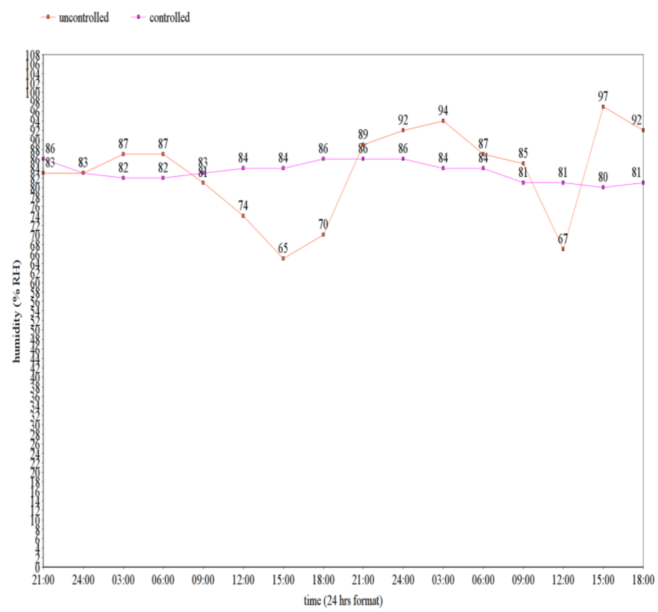


Fig.4 Variation of humidity with time

Similarly Fig. 5 depicts the sensor readings of variation in light intensity with time both in controlled and uncontrolled environment. We have set the threshold values of light intensity within 12000-50000 LUX. Again the graph shows that within the greenhouse the light intensity is controlled according to the pre-specified values.

The sensor reading of variation in soil moisture with time is illustrated in Fig. 6 below, where both readings in controlled and uncontrolled environment have been illustrated. In this case, we have made a choice of threshold value between 90-100%. Like the previous cases, this graph also confirms that our proposed intelligent system is working perfectly.

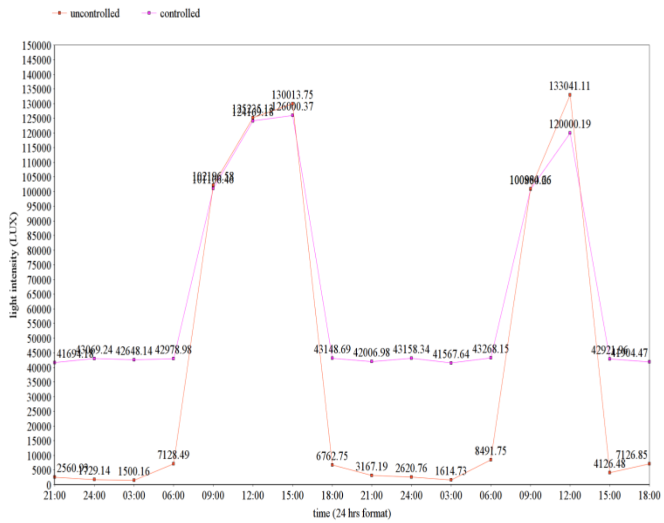


Fig.5 Variation of light intensity with time

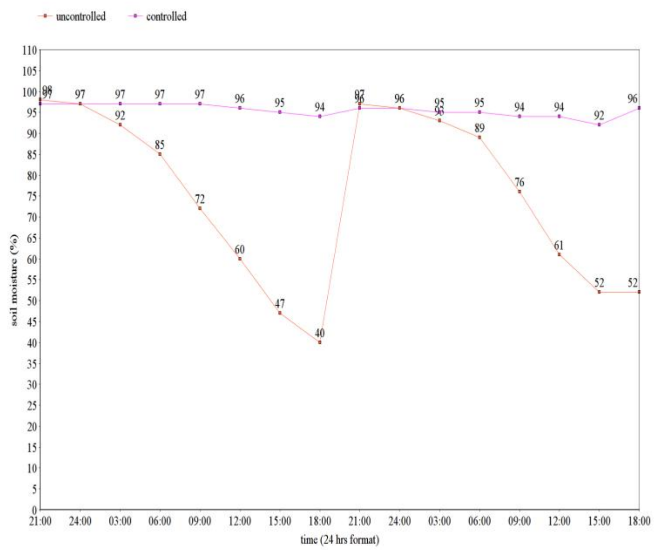


Fig. 6 Variation of soil moisture with time

## V. CONCLUSION

A step-by-step approach in designing the arduino based system for measurement and control of the four essential parameters for plant growth, i.e. temperature, humidity, soil moisture, and light intensity, has been followed. The sensors sense different parameters like temperature, humidity, soil moisture and light intensity and send to the Arduino microcontroller. Control actions are taken by the Arduino microcontroller after comparing these measured values with predefined threshold values. Each time the sensor senses any parameter where any action has to be taken like switching on fan, or light, or sprinkler etc, it immediately sends a sms to the user of IGMS. The results obtained from the measurement have shown that the system performance is quite reliable and accurate. IGMS eliminates risk of greenhouse not being maintained at specific environmental conditions due to human error and labour cost can be reduced and it is eco-friendly. Pests are eliminated by this system and also the quality of yield can be increased. Moreover power consumption for the system is also very less. In a developing country like India, where a major section of the people is dependent on irrigation, this system can be efficiently utilized. Moreover due to globalization, of late we find that there is a growing demand of different crops which are mainly of the cold countries. These crops can be effectively grown in the proposed IGMS without much human interaction. Moreover, in future, a mobile application can be developed which will further simplify the monitoring and updating process. Also some other parameters can be measured in the IGMS like concentration of $CO_2$, UV radiation, etc. This user-friendly, easy to understand yet modern farming application will benefit farming and farmers alike.

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