# IOT Based Greenhouse Environment Monitoring and Controlling System using Arduino Platform

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*Abstract*— **Greenhouses are controlled area environment to grow plants. In order to achieve maximum plant growth, the continuous monitoring and controlling of environmental parameters such as temperature, humidity, soil moisture, light intensity, soil pH etc. are necessary for a greenhouse system. The main aim of this project is to design a simple, low cost, Arduino based system to monitor the values of environmental parameters and that are continuously updated and controlled in order to achieve optimum plant growth and yield. DHT11 sensor, Soil Moisture sensor, LDR sensor and pH sensor are the main sensors used in this project which give the exact value of temperature, humidity, water content, light intensity and soil pH respectively. All environmental parameters are sent to android mobile phone via offline and online. A GSM (Global System for Mobile communication) modem is used to send SMS (Short Message Service) which displays the present status of the environmental parameters. The SMS is sent to the user when the sensor value exceeds a defined level. All farmers can control their greenhouses from any place by knowing the status of their greenhouse parameters at any time and they can control actuators (cooling fan, exhaust fan, water pump, artificial light and motor pump) to adjust environmental parameters by sending SMS. Ethernet is also used to send the data parameters to mobile phone which eliminates the SMS charges. All environmental parameters are sent to server through Ethernet and stored in the database. So the user can monitor and control parameters through android mobile application.**

*Keywords*—**Greenhouse, Monitoring, Controlling, Arduino, Sensors, GSM, Ethernet.**

## I. INTRODUCTION

In today's greenhouses, monitoring and controlling of many parameters are important for the good quality and productivity of plants. But to get the desired result some parameters like temperature, humidity, soil moisture, light intensity and soil pH are important for better plant growth. So an Arduino based greenhouse environment monitoring and controlling system using sensors has been designed. For this project, Arduino microcontroller is used. Arduino can receive input from a variety of sensors and it can control motors, lights and other actuators. Four sensors, DHT11 sensor, LDR sensor, Soil moisture sensor and pH sensor are used. DHT11 sensor is used to measure temperature and humidity. Soil moisture sensor measures the water content in soil. pH sensor measures pH of the soil. LDR sensor is used to measure light intensity [1]. A cooling fan, exhaust fan, water pump, artificial light and motor pump are also connected to the Arduino [2]. All environmental parameters are sent to android mobile phone via offline and online. A GSM modem and Ethernet are used to send environmental parameters to android mobile phone.

When temperature exceeds a defined level, the system sends SMS to the mobile user and the mobile user turns on the fan by sending another SMS. When the temperature comes to the normal range, the mobile user turns off the fan by sending another SMS [3]. When humidity exceeds a defined level, the system sends SMS to the mobile user and the mobile user turns on the exhaust fan by sending another SMS. When the humidity comes to the normal range, the mobile user turns off the exhaust fan by sending another SMS. When pH of the soil exceeds a defined level, the system sends SMS to the mobile user and the mobile user turns on the motor pump which sprays acidic or alkaline solution by sending another SMS. Similarly, when light intensity is lower than a defined level, the system sends SMS to the mobile user and the mobile user turns on the artificial lights by sending another SMS. Finally, when the soil moisture sensor does not sense moisture in soil then the system sends SMS to the mobile user and the mobile user turns on the water pump by sending another SMS. In order to eliminate SMS charges, all environmental parameters are sending to the server through Ethernet and stored in the database. So the user can monitor and control parameters through android mobile application. This device is very much helpful to the farmers to monitor and control environmental parameters at their farms. The farmers need not to go their farms. Any change in the environmental parameter can lead to financial loses in agricultural and pharmaceutical industries and can be life threatening to the users of biomedical industries. By controlling immediately these losses can be prevented.

The rest of the paper is organized as follows: Section II deals with the system overview. Section III presents the flowchart of the system. Section IV gives results and analysis. Finally section V presents concluding remarks.

## II. System Overview

The implemented greenhouse system consists of two section, monitoring section and controlling section. The monitoring section consists of DHT11 sensor, LDR sensor, Soil moisture sensor and pH sensor to monitor the environmental parameters. A GSM modem and Ethernet are also used to send environmental parameters to android mobile phone. The controlling section consists of cooling fan, exhaust fan, water pump, artificial light and motor pump. Arduino microcontroller forms the heart of the system. The block diagram of greenhouse monitoring and controlling system is shown in fig. 1.

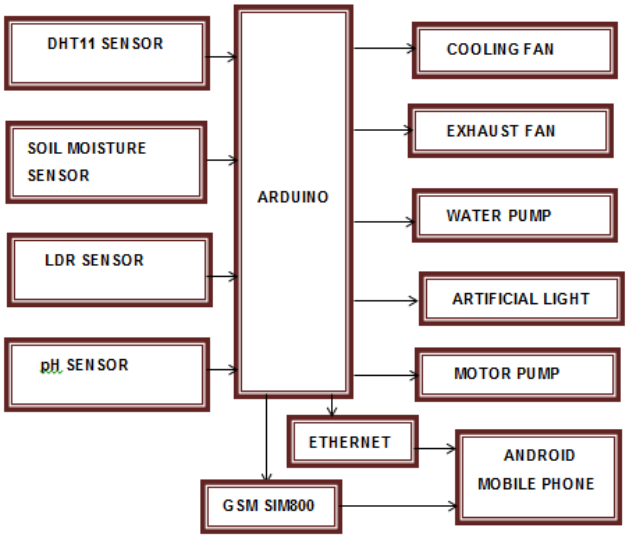


Fig. 1. Block Diagram of Greenhouse Monitoring and Controlling System

### *A. Arduino*

Arduino is an open source device. It consists of ATmega328P microcontroller. It provides 5V and 3.3V output voltage options. It takes input voltage from the computer using USB cable or from a portable power supply using a coaxial cable. The Arduino board can read twitter messages. Arduino IDE is used to upload sketches. Different types of Arduino boards are Arduino Uno, Arduino Mega, Arduino Yun etc. In this system Arduino Uno board is used. It is cheap and feasible [4]. Fig. 2 shows Arduino Uno.

Fig. 2. Arduino Uno

"Uno" is an Italian word and meaning is one. It has 14 digital input or output pins, 6 analog input pins, 16 MHz crystal oscillator, power jack and ICSP header. Operating voltage is 5V and recommended input voltage is 7 – 12V [5].

### *B. Sensor*

Four sensors, DHT11 sensor, LDR sensor, Soil moisture sensor and pH sensor are used.

### *DHT11 Sensor*

DHT11 sensor is used to measure both temperature and humidity. It is a low cost temperature and humidity sensor. It has high reliability, high efficiency and long-time stability. It has a thermistor for measuring the temperature and a humidity measuring component for measuring humidity [6]. Fig. 3 shows DHT11 sensor.

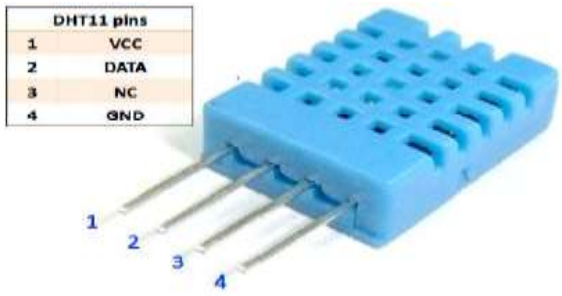


Fig. 3. DHT11 Sensor

A thermistor is a variable resistor. The resistance of thermistor changes with change in the temperature. Humidity sensing component has two electrodes with moisture holding substrate between them. So as the humidity changes, resistance between the electrodes changes. This change in resistance is measured. The operating voltage is 3.3V and 5V.

The equation used to calculate temperature from output voltage is:

$$\text{Temperature} = (\text{Vout} * 100) / 5\ ^{0}\text{C} \quad (1)$$

The equation used to calculate relative humidity from output voltage is:

$$\text{RH} = ((\text{Vout} / \text{Vsupply}) - 0.16) / 0.0062\ \% \quad (2)$$

### *Soil Moisture Sensor*

Soil moisture sensor measures the moisture content in soil. This soil moisture sensor consists of two metal rods held apart at a fixed distance by some insulating material [7]. Fig. 4 shows soil moisture sensor.

Fig. 4. Soil Moisture Sensor

Two metal rods pass current through the soil and resistance is measured. If the water is more, resistance is low and if the water is less, resistance is high. It also consists of a potentiometer to vary the sensitiveness of the sensor. Features are low power consumption, high sensitivity, Arduino compatible interface and the operating voltage is 5V [8].

*LDR sensor module*

LDR (Light Dependent Resistor) sensor module is used to measure light intensity. It has both analog output pin and digital output pin. If light intensity increases, resistance of LDR decreases. If light intensity decreases, resistance of LDR increases. The sensor has a potentiometer knob that can be used to adjust the sensitivity of LDR towards light [9]. Fig. 5 shows LDR sensor module.

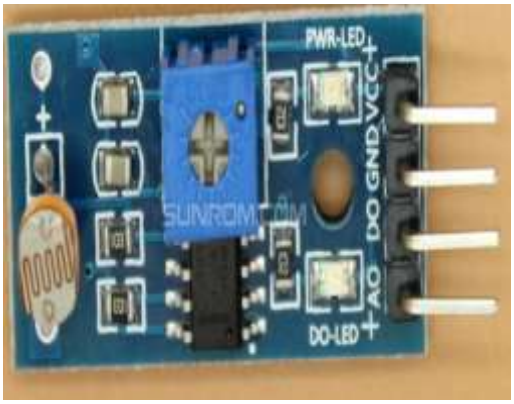


Fig. 5. LDR Sensor Module

LDR is also known as photoconductor. Cadmium Sulphide (CdS) is used to make LDR. Cadmium Sulphide is deposited on an insulator in the shape of a zigzag line. The reason for zigzag path is to increase dark resistance and therefore decrease the dark current [10]. Fig. 6 shows light sensor circuit.

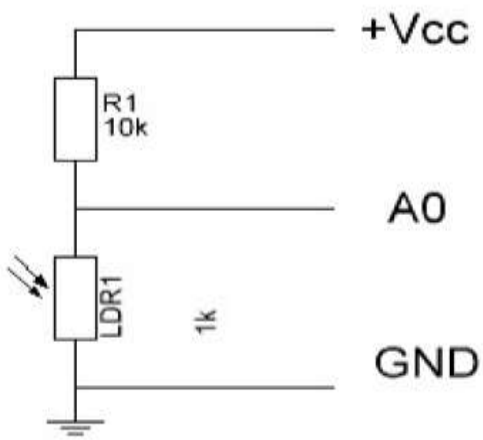


Fig. 6. Light Sensor Circuit

If 5V supply is given to the circuit, LDR gives out an analog voltage which is proportional to the input light intensity falling on it. The Arduino has inbuilt ADC (Analog to Digital Converter) that converts the analog voltage (from 0-5V) into a digital value (0-1023).

In the above circuit resistor 10KΩ is the upper part of the voltage divider and LDR is the lower part. Therefore output voltage is:

$$V_{OUT} = (5 * R_{LDR}) / (10 + R_{LDR}) \quad (3)$$

From (3)

$$R_{LDR} = (10 * V_{OUT}) / (5 - V_{OUT}) \quad (4)$$

ADC assumes 5V is 1023 and voltage less than 5V is the ratio between 5V and 1023.

$$5/1023 = V_{OUT} / \text{Analog reading}$$

$$V_{OUT} = 0.0048875 * \text{Analog reading} \quad (5)$$

The equation used to calculate the light in Lux from the LDR resistance is:

$$\text{Lux} = 500 / R_{LDR} \quad (6)$$

(4) in (6)

$$\text{Lux} = 500(5 - V_{OUT}) / (10 * V_{OUT}) \quad (7)$$

*pH sensor*

pH sensor is used to measure pH of the soil. The pH indicates a solution's acidity or alkalinity. pH sensor consists of a pH probe and a pH sensor module. Fig. 7 shows pH sensor.

Fig. 7. pH Sensor

The pH probe has two electrodes, one is a glass electrode and other is reference electrode. Both electrodes are hollow bulbs containing a potassium chloride solution with a silver chloride wire suspended into it. pH probe measures the electrochemical potential between a known liquid inside the glass electrode and an unknown liquid outside. pH sensor module consists of potentiometer to vary the value of the sensor.

*C.GSM SIM800*

GSM SIM800 is a quad band GSM device. It works on frequencies 850 MHz, 900 MHz, 1800 MHz and 1900 MHz. It can transmit voice, SMS and data information with low power consumption. It is very compact in size. It is easy to use as plug in GSM modem. It supports Bluetooth function. Its operating voltage is 3.3V to 5V [11]. Fig. 8 shows GSM SIM800.

Fig. 8. GSM SIM800

*D Arduino Ethernet Shield*

The Arduino Ethernet Shield allows Arduino board to connect to the internet. It is based on the Wiz net W5100 Ethernet chip. The wiz net W5100 provides a network (IP) stack capable of both TCP and UDP. It supports up to four simultaneous Socket connections. Fig. 9 shows Arduino Ethernet Shield.

Fig. 9. Arduino Ethernet Shield

## III. System Flowchart

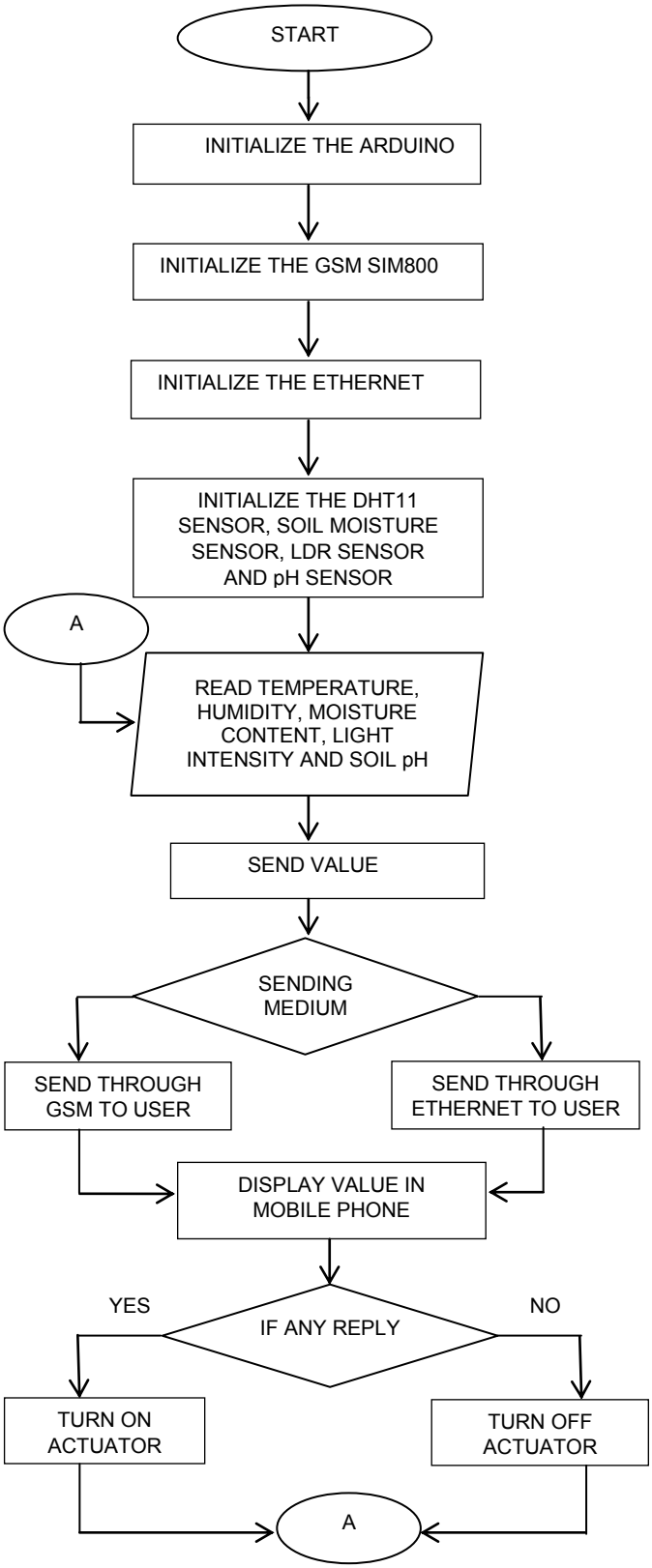


Fig. 10. Greenhouse System Flow Chart

Fig. 10 shows flow chart representing the working of the greenhouse system. The Arduino, Ethernet, DHT11 sensor, soil moisture sensor, LDR sensor and pH sensor are initialized by supplying the required power of +5V. The GSM800 is initialized by supplying the required power of +12V. The GSM800 sends SMS to the user when the sensor value exceeds a defined level. The user turns on the actuator by sending another SMS. All environmental parameters are sending to server through Ethernet and stored in the database. So the user can monitor and control parameters through android mobile application.

## IV. Results and Discussion

All the components are initialized by supplying the required power of +5V. Four sensors, DHT11 sensor, LDR sensor, Soil moisture sensor and pH sensor are used. A cooling fan, exhaust fan, water pump, artificial light and motor pump are also connected to the Arduino. An Ethernet is used to send environmental parameters to android mobile phone. All environmental parameters are sending to server through Ethernet and stored in the database. So the user can monitor and control parameters through android mobile application. For this, an android application is developed. The user can log in the application by using username and password. Username and password is stored in database. A GSM modem is also used to send SMS which displays the current status of the environmental parameters. DHT11 sensor is used to measure temperature and humidity. High temperature causes leaves to wilt and affect the ability of crops to produce fruit. An overheated greenhouse causes the soil to dry out quickly and use more water. By using a monitoring system, users can be alerted to threatening conditions. When temperature exceeds a defined level, the system sends SMS to the mobile user and the mobile user turns on the fan by sending the SMS “FANON”.

The present status of the environmental parameters is sent to the mobile user when the mobile user sends the SMS “STATUS”. When the temperature comes to the normal range, the mobile user turns off the fan by sending the SMS “FANOFF”. High humidity affects plants transpiration and photosynthesis process. When plants absorb water and minerals from the soil through their roots, transpiration assists these nutrients to the leaves. If the humidity is too high, the process slows down, preventing the absorption of nutrients. Without the release of moisture, plants lose their ability to cool themselves. When humidity exceeds a defined level, the system sends SMS to the mobile user and the mobile user turns on the exhaust fan by sending the SMS “EFANON”. When the humidity comes to the normal range, the mobile user turns off the exhaust fan by sending the SMS “EFANOFF”. Working model of greenhouse monitoring and controlling system is shown in fig. 11.

Fig. 11. Working Model of Greenhouse Monitoring and Controlling System

LDR sensor measures light intensity. As the light quantity decreases the photosynthetic process decreases. When light intensity is lower than a defined level, the system sends SMS to the mobile user and the mobile user turns on the artificial light by sending the SMS “LIGHTON”. When the light intensity comes to the normal range, the mobile user turns off the artificial light by sending the SMS “LIGHTOFF”. Soil moisture sensor measures the moisture content in soil. Water is very important for plant growth. When the soil moisture sensor does not sense moisture in soil then the system sends SMS to the mobile user and the mobile user turns on the water pump by sending the SMS “MOTORON”. When the moisture in soil comes to the normal range, the mobile user turns off the water pump by sending the SMS “MOTOROFF”.

pH sensor is used to measure pH of the soil. The pH indicates a solution's acidity or alkalinity. The pH value usually varies between 0 and 14. A solution with a pH value less than 7 is acid and greater than 7 is alkaline. Plants need mildly acidic soil. The optimum pH range for most plants is from 5.5 to 7.5. If the soil is either high acidic or alkaline, soil tends to become sticky and hard to cultivate. High rainfall, fertilizer use, plant root activity and acid rain are the main sources of high acidity in soil. Under high acidic conditions, the concentration of metal ions increases to toxic level. Aluminium is the primary toxic metal, but high levels of iron and manganese can also inhibit plant growth. Aluminium inhibits root growth. High soil acidity can cause limited availability of some nutrients such as phosphorus, molybdenum, calcium and magnesium. To increase the pH of acidic soil, lime ($CaCO_3$) is used. Lime contains calcium.

As the pH of the soil increases, some metals such as aluminium, iron, manganese, and zinc precipitate out of the soil solution and are no longer plant available. Under high alkaline conditions, the solubility of minerals decreases and nutrient deficiencies occur. Nutrient deficiency is the main cause for poor plant growth. Phosphorus is also less available in alkaline soils and high levels of calcium may inhibit the uptake of potassium and magnesium. Acidifying fertilizers such as ammonium sulphate is used to decrease the pH of alkaline soil. When pH of the soil exceeds a defined level, the system sends SMS to the mobile user and the mobile user turns on the motor pump which sprays acidic or alkaline solution by sending the SMS "ACIDICON" or "BASICON". Arduino serial monitor output and mobile output of greenhouse monitoring and controlling system are shown in fig. 12 and 13 respectively.

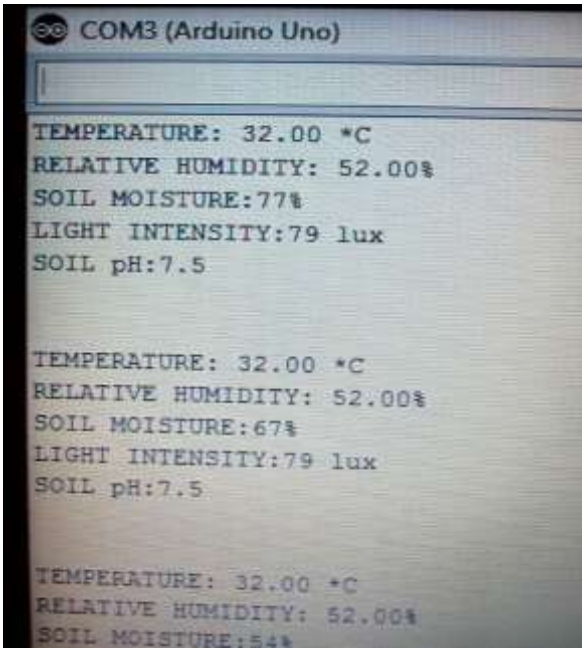


Fig. 12. Arduino Serial Monitor Output

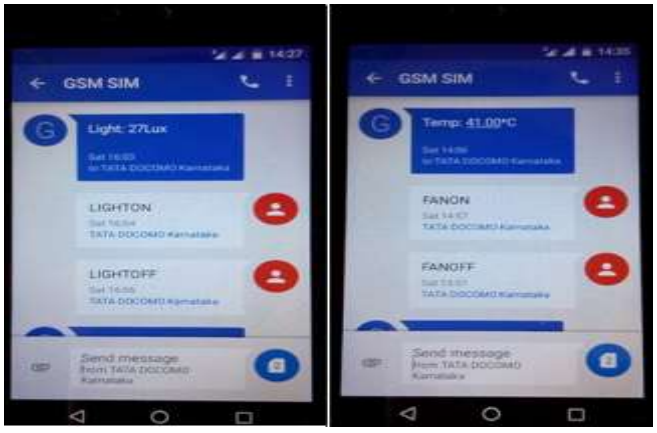


Fig. 13. Android Mobile Output

## V. CONCLUSION

An Arduino based greenhouse monitoring and controlling system is designed. DHT11 sensor, Soil Moisture sensor, LDR sensor and pH sensor are the main sensors used in this project which give the exact value of temperature, humidity, moisture content, light intensity and soil pH respectively. This system is designed for controlling and monitoring environmental parameters in greenhouse by a simple SMS from anyplace via the GSM network. Ethernet is also used to send the data parameters to mobile phone which eliminates the SMS charges. This system reduces the power consumption, maintenance and complexity. This project can be used in agricultural field, in nursery and in botanical garden.

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