ARM Based Remote Monitoring and Control System for Environmental Parameters in Greenhouse

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***Abstract* — The work is implemented for remote monitoring and control of greenhouse parameters with the help of sensors and GSM communication. It overcomes the disadvantages of wired and wireless constraints such as complicated wiring, difficult maintenance and distance, to monitor and control the applications. The application will have embedded system which consists of ARM7 microcontroller, real time operating system, sensors, GSM modem and control devices to monitor the environmental parameters condition namely temperature, humidity, CO_2 concentration and light intensity in greenhouse. The threshold levels of the sensors will be set with the help of push button keys or remotely via GSM communication mode. By this, environmental parameters in greenhouse can be monitored and controlled manually as well as remotely. The hardware and software modules of the application system are discussed in detail. This embedded application is implemented and tested for its correct functionality. The experimental results show that the developed monitoring system has the following features, such as simple structure, high reliability, good extensibility and flexible configuration. It will control automatically the environmental parameters in every greenhouse and has project practicality and vendibility.**

Keywords — Greenhouse; GSM; ARM7; Temperature; Humidity; Light intensity;, CO_2; PIR;

I. INTRODUCTION

A greenhouse is a building in which plants are grown. These structures range in size from small sheds to very large buildings. For the large rural distract, the greenhouse production has become a way of being rich. The growth of crop in greenhouse depends on temperature, CO_2, humidity, light intensity and other parameters in greenhouse. So it is important to real-timely and properly measure and adjust the temperature, CO_2, humidity, light intensity and other parameters in the greenhouse. With the continued expansion of production scale, the disadvantages of traditional wire monitoring system are more and more prominent, such as complicated arrangement, difficult maintenance and so on. Then the Remote monitoring system is developed, which based on wireless communication technology, does not need cables, adds or reduces configuration at random, possess simple system construction. Moreover, it is characterized by its low power consumption. Therefore, it proves to be simple and of practical significance.

Greenhouse environment parameters monitoring system based on wireless communication technology has been developed to control remotely, which realizes the measurement, summary and control of temperature, CO_2, humidity, light intensity and the other parameters.

A. Back Ground

In greenhouse more number of the parameters is to be control because, the varieties of the crops are large. They are increasing day by day because of the development in agriculture technology. The automation is possible with simple hardware by using microcontroller where only the controlling is possible but user (farmer) will not get information about the greenhouse. On progress towards the improvement to monitor and control, an attempt was made using wireless technology. There are many technologies can be used for wireless application. It was tried to adopt the wireless communication like Infrared, Bluetooth, Zigbee and RF technology. But the attempt has failed because of technology constraints.

In this situation, the wireless sensor network with additional hardware and software is a solution for greenhouse control. If parameters still increase, then for WSN technology bandwidth may not be sufficient [1]. A Control System of Environment Parameters of Greenhouse based on CAN Bus is existing and requires wired system [2].

The Wireless Measurement and Control System for Environmental Parameters in Greenhouse [3], overcomes the

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disadvantages of wired monitoring system, such as complicated wiring & difficult maintenance.

This project is designed to overcome the above mentioned disadvantages, using which the environmental parameters in every greenhouse can be measured and controlled by microcontroller remotely. The Parameters settings can be made in two modes i.e. by using push button keys or by GSM communication mode remotely. A user can know the greenhouse status or control the system at any time by sending the commands through the GSM technology.

The user can use mobile phone to set the sensor parameters from any place by sending a setting command message to the GSM modem. Also the monitoring device will send the environmental conditions to the user on request at any time. The system can be switched ON or switched OFF just by sending a power ON/OFF command.

II. OVERVIEW

The Fig. 1 shows the block diagram of ARM based Monitoring and Control system architecture. It contains two modules, namely monitoring unit and controlling unit.

Where T_U: Upper Threshold Temperature
T_L: Lower Threshold Temperature
H_U: Upper Threshold Humidity
H_L: Lower Threshold Humidity
L_U: Upper Threshold Light Intensity
L_L: Lower Threshold Light Intensity
CO_{2U}: Upper Threshold CO_2
CO_{2L}: Lower Threshold CO_2

A. Monitoring Module

The monitoring module will be placed at the greenhouse. This module will consist of a microcontroller (LPC2129) which is designed on ARM7 Architecture. This microcontroller is a 32 bit and is chosen because of its low power consumption, inbuilt 10 bit ADC, and UART based serial communication and is well suited for application requirement.

The sensor array will have five sensors namely temperature sensor, humidity sensor, CO_2 sensor, light intensity sensor and passive infrared sensor. The microcontroller monitors the sensors; these sensors will give an analog output i.e. variable voltage output. To read this information the microcontroller needs to convert this analog signal to digital form. This is done with the help of analog to digital convertor (ADC).

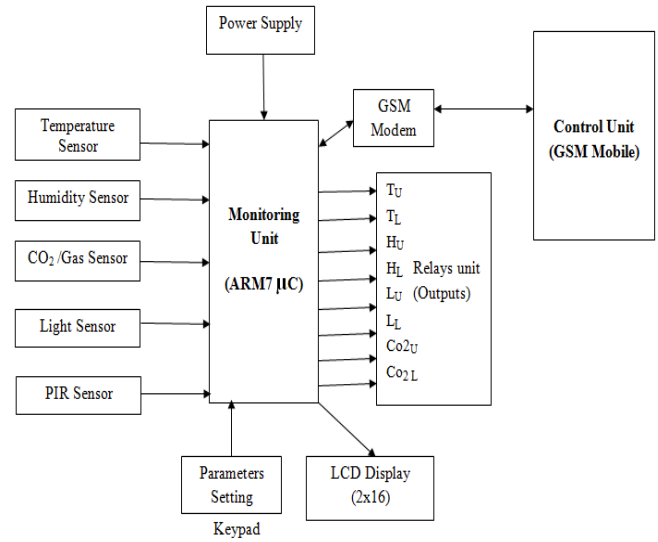

Fig. 1. Overview of ARM based monitoring and control system architecture

B. Temperature Sensor

The temperature sensor will give a variable output voltage with respect to the temperature variation. LM-35 is used as temperature sensor which is a precision integrated-circuit temperature sensor, Calibrated directly in ° Celsius (Centigrade), Linear + 10.0 mV/°C scale factor with accuracy 0.5°C (at +25°C) with rated for full −55° to +150°C range. Here we will set the minimum temperature value to 20º C and maximum temperature values to 30º C (for demo purpose, in real time the settings will vary with respect to plantation in the greenhouse). If the current temperature rises above the maximum threshold range relay1 will be triggered and the cooler connected to it will switched on. If the temperature falls below the minimum threshold, then relay2 will be triggered to switch on the heater. If the current temperature is from 20º C to 30º C both relay1 and relay2 will be switched off.

C. Humidity Sensor

Humidity is the quantity of water content in atmosphere. The sensor output will be a variable voltage with respect to the humidity level. Humidity will be measured in percentage. The SY-HS-220 humidity sensor is used which converts relative humidity to the output voltage with operating humidity range 30% - 90% RH and accuracy is ± 5% RH (at +25°C). In normal condition the humidity will be around 50% to 70%. In our module we will be setting minimum level to 50% and maximum level to 65%. If the current reading falls below the minimum level the relay3 will be triggered to switch ON the water sprinkler, which will spray water to raise humidity level. Similarly if the humidity rises above maximum limit relay4

will be triggered which in turn OFF the water sprinkler or connect drier fan to it.

D. CO_2 Sensor

This sensor is used to sense the concentration of CO_2 in a greenhouse. MQ-7 sensor is used as CO_2 sensor which is high sensitivity to LPG, natural gas, sensitivity to alcohol, smoke. The CO_2concentration detection range is 200ppm to 10000ppm. The concentration of CO_2can be measured in PPM or %.If the concentration of CO_2 is above the upper threshold level the relay5 will be triggered to open the ventilator. Similarly, if the concentration of CO_2 falls below the minimum threshold level, the relay6 will be triggered to close the ventilator. This sensor is also used as gas sensor to detect the smoke if occurs in greenhouse.

E. Light Sensor

Light sensors are nothing but the light dependent resistors in which the resistance will vary with respect to the light intensity falls on it. This is a variable resistor and the concept of voltage divider is used to read the light intensity. The output will be read in terms of Lux. The light dependent resistor is used to detect the light intensity. It has two cadmium sulphide (cds) photoconductive cells with spectral responses. The cell resistance falls with increasing light intensity and it can detect the minimum light intensity i, e moonlight 0.1 lux. Here we will be using artificial lights to maintain the light intensity as the sun light falls below the required quantity as it becomes evening and night. If the light intensity is above the maximum threshold level, the relay7 will be triggered to turn lights OFF. Similarly, if the light intensity is falls below the minimum threshold level, the relay8 will be triggered to turn lights ON.

F. PIR Sensor

The PIR (Passive Infra-Red) sensor is a device that detects motion by measuring changes in the infrared levels emitted by surrounding objects. This motion can be detected by checking for a high signal on a single I/O pin. The PIR used is the 555-28027 part number. This is about how the sensors and respective devices can be monitored and controlled with respect to the environmental conditions. The keypad is used to configure the parameters. The LCD is used to display the sensor outputs. The input parameters settings can be made in two modes, i.e. by using push button keys or with the help of GSM communication mode. The GSM modem is interfaced to the microcontroller to communicate and it is done with the help of UART (universal asynchronous receiver transmitter) serial communication. A valid SIM card will be inserted into the modem to enable wireless communication. The GSM module functionality is such that the microcontroller enables the GSM module to send the message to the configured mobile and vice versa.

G. Control Module

The user can use GSM mobile phone as a remote control module to monitor the greenhouse and can set/control the sensor parameters from any place by sending a setting command message to the GSM modem which is at the greenhouse monitoring system. Also the monitoring device can send the environmental conditions to the user on request any time. The system is implemented with password privilege to protect from unauthorized users.

H. Specifications

TABLE I. TEMPERATURE SPECIFICATIONS

Optimal values of air temperature in °C						
Vegetable Name	Germination process	Development process		Harvesting process		Young Plants
		Day	Night	Day	Night	
Watermelon	17-18°C	22-30°C	17-18°C	25-30°C	18-20°C	13-15°C
Tomato & Beans	10-12°C	20-27°C	10-13°C	22-28°C	15-17°C	8-10°C

TABLE II. HUMIDITY, CO_2 AND LIGHT INTENSITY PARAMETERS SPECIFICATIONS

Vegetable Name	Relative Humidity (%)	CO2 Concentration (1000 PPM)		Light Intensity (Lux)	
		Min	Max	Min	Max
Watermelon	65-75%	0.01%	0.03%	45Lux	50Lux
Tomato & Beans	50-60%	0.01%	0.03%	45Lux	50Lux

III. SOFTWARE IMPLEMENTATION

The Fig. 2 shows the main control flow diagram of the project. This control flow is carried out at the monitoring unit by FreeRTOS real time operating system. It is started with initializing all the hardwares such as analog to digital converter, GSM modem, keyboard, display and interrupts. Then all the six tasks tGSM, tKeypad, tActuator, tDaq, tDisplay and tPIR/tSmoke will be spawned. Finally RTOS starts scheduler to schedule the tasks based on priorities and keeps running all the tasks for indefinite of time which is mentioned as while (1).

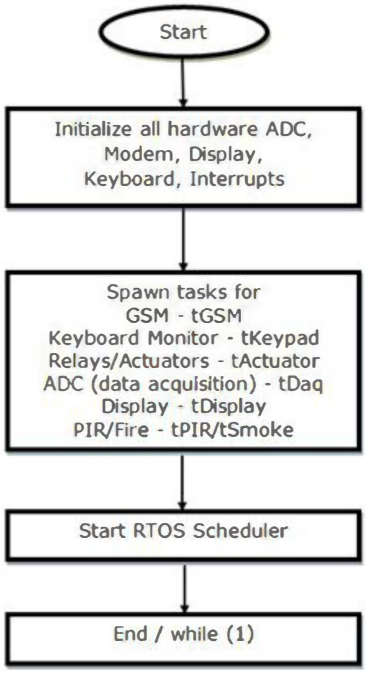

Fig. 2. Main flow diagram

A. Software Modules

There are six tasks to handle software modules. The TABLE III describes the software module names and their task names. Each task is assigned with priority, where 5 is the highest priority and 0 is the lowest priority. These tasks are handled by the FreeRTOS real time operating system at the monitoring system.

TABLE III. SOFTWARE MODULES

Sl. No.	Module Name	Task Name	Priority
1	GSM Modem	tGSM	5 (Highest)
2	Keypad	tKeypad	4
3	Relays / Actuators	tActuator	3
4	ADC (data aquisition)	tDaq	2
5	LCD Display	tDisplay	1
6	PIR / Fire	tPIR / tSmoke	0 (Lowest)

B. GSM Software Module

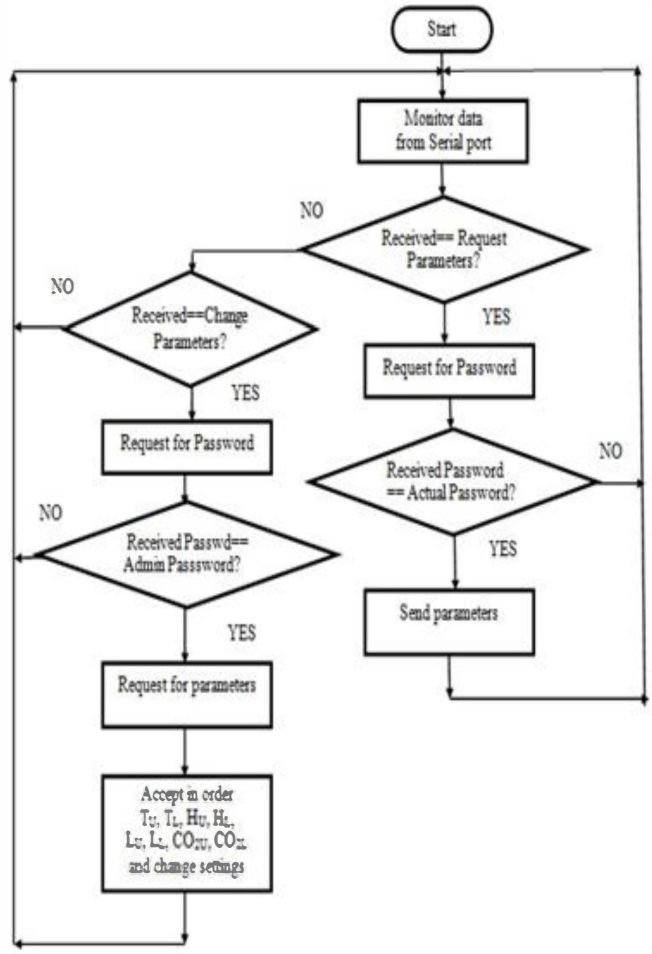

Fig. 3. GSM driver dataflow diagram

C. ADC Software Module

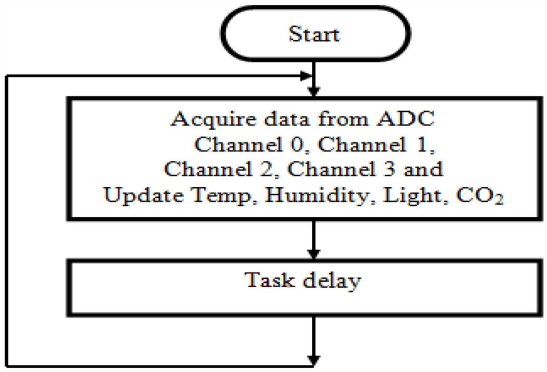

Fig. 4. ADC driver dataflow diagram

D. *Actuators Software Module*

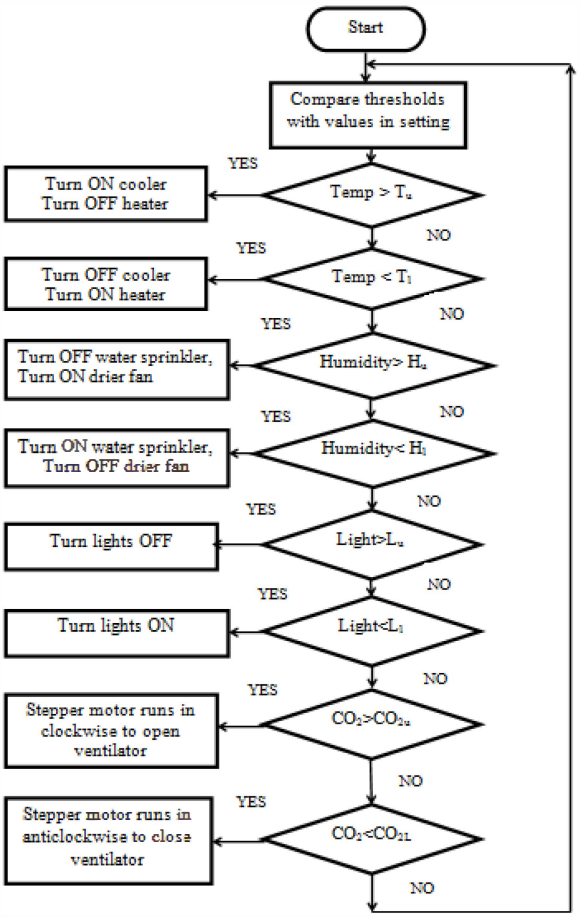

Fig. 5. Actuators driver dataflow diagram

IV. RESULTS

The architecture is implemented with FreeRTOS using embedded C and simulated in Keil IDE. The simulation outputs are as shown below.

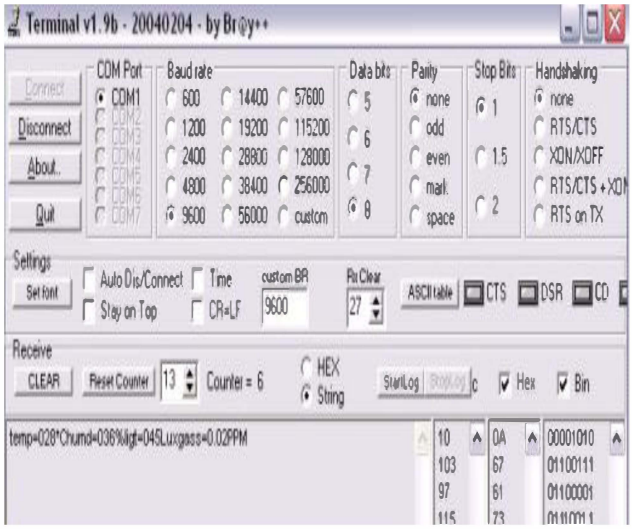

Fig. 6. Output of monitored parameters

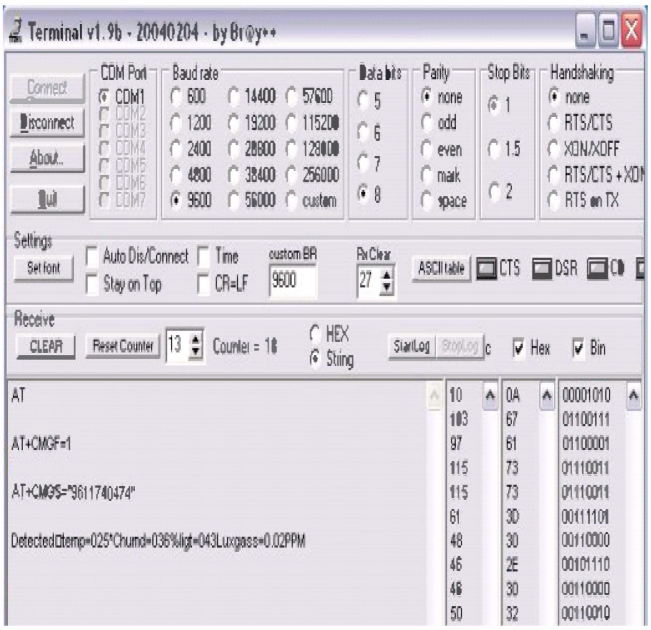

Fig. 7. Detecting unauthorized person

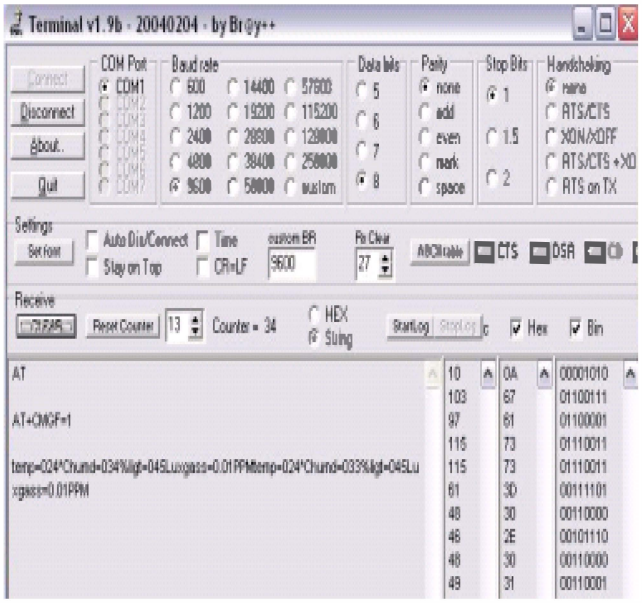

Fig. 8. Detecting an authorized person

V. CONCLUSION AND FUTURE WORK

The remote monitoring and control system for environment parameters in greenhouse based on global system for mobile communications technology is developed and initially experimented. The experimental results indicate that the system has some features as follows: 1) It can be used in agriculture vegetable greenhouse to monitor and control the environmental parameters to overcome the disadvantage of traditional measuring and controlling. 2) It can be kept long distance, real time monitoring for parameter of greenhouse and the information can be obtained of greenhouse at any time. 3) It has the advantages of GSM technology , not needing cables, low power consumption, cheap cost, good robustness, flexible extension, convenient installing over the traditional measurement and control system.

Future enhancement is part of all products life cycle. This lists out some missing things in the current product. It also indicates adding more features to the existing product. Following are the future enhancements which could be implemented.

1) Incorporating Fuzzy Logic in arriving at different specifications of environmental parameters in greenhouse for different vegetables cultivation for the complete cycle from germination to harvesting process. 2) It can be implemented with GPRS to control through internet. 3) Adopting touch screen based Human Machine Interface to monitor and control.

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