Design GSM-SMS based system for old structured greenhouses with monitoring and logging network sensors

Mohammad Javad Manashti¹, Houshang Ghamarnia¹*, Soheila Amirian¹, Ramin Mohammad Nezhad²

¹- Department of Water Resources Engineering, Compass of Agriculture and natural Resources, Razi University, P.O. Box: 1158, post code: 6715685438, Kermanshah, Iran.
²- School of Computer Engineering, Iran University of Science and Technology, post code: 16846-13114, Tehran, Iran.

*Corresponding Author Email: hghamarnia@razi.ac.ir and hghamarnia@yahoo.co.uk

Abstract

Designing a new greenhouse is mostly aimed at reaching higher productivities. Currently, there are numerous greenhouses in Iran and other developing countries insufficiently equipped to control inside temperature, humidity, and air circulation. The cost of plant production is much higher in such greenhouses, and therefore, it is not economically reasonable for the owners. The objective of the present study is to design and test a simple microcontroller-based system in order to manage and control different environmental parameters including temperature and humidity in old greenhouses. A wired network sensor has been designed and connected to the main system via RS-485 protocol to reach for users and managers on their cell-phones and short-messaging systems. The main system collects environmental parameters inside greenhouse tunnel every 10 seconds. The parameters are collected by a network sensor, and after being logged, they are sent as short messages to the users as an event-based system. This designed system was installed and run in thirty old greenhouses in Iran for more than 5 years. The results showed that the system is capable of controlling different phenomena including chilblain, freezing, heating stresses, and quantity and quality of production increases. The cost-effectiveness and ease of access associated with low-cost logging and monitoring give its advantages over costly industrial quality control systems.

Keywords: greenhouse, microcontroller, sensor network, GSM, monitoring, logger

Introduction

Most of the old greenhouses in Iran and other developing countries, while compared to modern and automatic ones, are poorly equipped with proper devices and systems to control temperature and humidity variations. In traditional greenhouses, such monitoring of different parameters is either impossible or too expensive. Moreover, the production of controlling equipment is costly due to their high energy requirements. Also, the quality of the available equipment is too poor, mainly because of low temperature and humidity and low carbon dioxide fluctuations. More importantly, the old greenhouses are the affected by frost phenomena during night or winters. The temperature is controlled by a simple mercury thermometer system. Hence, by ignoring human errors or shortage of electricity, fuel (i.e., gasoline) and gas, the temperature in greenhouse will drop to the freezing point in less than one hour. In this case, the plants are damaged and efforts to reach an economic yield production process fail. On the other hand, since almost all small-scale greenhouses are built in areas less than one hectare, it is not possible to create complete automated systems for all or a number of them together. The present study indicates that the only equipment used in such greenhouses include heaters, ventilation fans and simple cellulose cooling systems with analogue or digital thermostat. Although, the thermostat can control
temperature in greenhouses, electricity blackouts or gas or gasoline shortages make the control of greenhouse impossible as a result of which, the plant is ceased to produce. A broken fan heater causes blast damages in the old greenhouses. The results indicate that out of fifty greenhouses under study, two (i.e., greenhouses number two and five) were damaged because of blast and freezing events. Simple, traditional greenhouse controlling practices are ineffective since human guards need to be assigned during days and nights to ensure greenhouse control. Therefore, an intelligent system is required to control temperature, humidity and power. Usually, during nights and in some hours of the day, greenhouse owners are not physically present in the greenhouse while guards may not perform duties well putting the greenhouse in dangerous situation. A proper equipment that may be used to manage such situations safely seem to be mobile cell phones. The study shows that a short message service (SMS) can be used for alerting and notifying the concerned people at any time of the day. In order to be able to make decisions reliably and quickly, it is necessary that all data be stored on a flash memory. The information can be exported directly into an Excel Worksheet or other software for further use.

Online monitoring and analysis of images in greenhouses has been investigated by Fukatsu, Kiura et al. (2011). Díaz, Pérez et al. (2011) designed a wireless sensor network for precise control of irrigation in greenhouses. Mahan, Conaty et al. (2010) compared a low-cost wireless sensor and an infrared temperature sensor with the industrial expensive sensor to measure the plants temperature; they concluded that the low price sensors can be used instead of industrial sensors. LI, SONG et al. (2010) developed an intelligent equipment to facilitate agricultural data. Fisher and Kebede (2010) also developed a device for measuring and storage temperature in shadow, soil and air and soil moisture sensors for low cost automation in the field. Tik, Khuan et al. (2009) designed an implementation of a sensor network for commercial greenhouse. They used different devices such as sensors, microcontroller and wireless transmitter module that were easily accessible with accuracy rate of 70%. Shane (2009) designed a Field Monitoring Server System (FMSS), which can work with solar energy. Green, Nadimi et al. (2009), too, designed wireless temperature sensors to use in the grass; Robust began to design an appropriate model for the masses against damage caused by chemical and physical effects of grass. By using GSM-MODULE TC35i, Xiushui (2008) designed a system for monitoring environmental parameters in the greenhouse. The device can send short messages to greenhouse owners.

This study focuses upon designing a new device for collecting environmental parameters including temperature and humidity by a network sensor to monitor, log and send records to the users by event-based short message service.

**Material and methods**

**Device Description**

The greenhouse under the study consisted of a tunnel with different climatic conditions; a network of sensors was designed to be used to monitor temperature and humidity variations.

This network shows the temperature and humidity on a screen and is connected to the main device by four cables. The main unit is usually installed in a control room; also temperature and humidity sensors display the information they receive on a screen. The monitoring system allows the user hundreds of meters away to be alerted about the greenhouses situation. The user can make monitoring more conveniently by connecting the main device to the computer. Also, by sending messages to the concerned people, the user can be notified about the greenhouse situation. The information can be stored on a memory stick.

As shown in Fig. (1), the main device generally consists of three parts: Main unit, Sensors and Computer software.

**Main unit**

The main device unit is designed and built in order to exchange information with sensors, computers. It communicates information via GSM and GPRS and stores it on memory sticks to be used later by respective user the desired settings and user information, alert system and finally to the power supply and battery charging device. The main system components include: motherboard, display and touch screen (Fig. (3) and (4)) and battery and charger. The flow chart of main board software is shown in Fig (5).

Motherboard (or main board) is built of two metalized sides with other SMD components. It is mainly composed of the following components: microcontroller, communication ports, module GSM / GPRS and data storage (Fig. (2)).

**Microcontroller**

1498
The main components included an AVR microcontroller with ATMEGA 128 model (Fig. 6), a product of ATMEL Company. BASCOMAVR was used to program applications. A 5000 line program was developed for this purpose.

**Communication device**

Three communication ports, namely a RS-485 to communicate with different sensor packages, a RS-232 to communicate with computer and a USB to communicate with computer were provided to the main device for the purpose of communication.

**RS485 Connection to Sensor Package**

A communication port is provided to communicate with the computer and serial communication MAX232IC. In order to convert serial converters with voltage-level microcontroller to PC, serial voltage level was used. However, due to the fact that the serial ports are being removed from computers and laptops, FT232IC was used to convert serial to USB microcontroller. The computer program can support both the original devices with the computer. No differences are observed in terms of speed and communication.

**Module GSM / GPRS**

Since the greenhouses are mostly located in suburbs and owners live within a considerable distance (mostly in the cities), also due to the fact that people with insufficient knowledge are usually assigned to control greenhouses during nights, the communication between owners and guards is made through mobile cell phones. Fixed telephone lines were widely used in the past. However, they would have the following disadvantages:

- Due to long distance between call centers and greenhouses in Iran, only a few owners may possess fixed telephone line.
- The fact is that only a small portion of information can be transmitted by telephone. For example, it takes almost two minutes and thirty seconds to report temperature and humidity of eight sensor packages by phone. By developing mobile network coverage over urban areas, SIM Cards and band GSM have been introduced as an alternative. For example, all 40 greenhouses under this study were covered by two mobile operators.
- Other advantages of mobile networks may include: low set-up cost, high speed transmittance and large transmissibility. GSM/GPRS SIM300 (see Fig. (7)) was installed on the controlling device. This module can be used to send and receive text messages, making and answering calls and exchange data via internet connection.

**Data Storage**

Temperature, humidity and other environmental parameters recorded inside and outside a greenhouse can help mitigate risky situations that may occur. The information obtained by the temperature and humidity sensor packages can be exported into an Excel Worksheet at one time intervals and saved on a 64 MB to 2 GB memory stick (SD) or a Multi Media Card (MMC) as shown in Fig. (7) to store. The SD card can be used for the next several months.

**Display and touch screen**

An LCD display screen with 128x64 pixels was used in this study (Fig. 9). A menu was designed to graphically display Persian letters and numbers. The display was touch-screen type for the ease of use. Although the coding rate and volume of applications increased significantly, the results of investigation showed that most of users could easily use the screen.

**Battery and Charger**

A 12 V, 7 A/h batteries was used as the power supply during electrical interruptions and fluctuations. The battery could be recharged automatically by a charger and survives for 5 hours.

**Sensor Package**

A series of sensors was made in order to display and transmit data to the main device package.
**Sensors**

Different types of sensors for greenhouses, irrigation systems, mushroom growing rooms, or research centers are designed and used. The packages can be set up for different applications, although the most common and important parameters needed to be controlled in greenhouses are temperature and humidity. The sensors used in this project were SHT11 type sensor (Fig. 10). This sensor was used to measure air temperature and relative humidity with automatic humidity and temperature correction system.

Since the sensors broke in highly humid environment (humidity higher than 95%), the temperature sensor SMT160 with aluminum sheath was used (Fig. 11) for mushroom cultivation in the halls and open-environment and soil temperature measurements.

One of the problems with the use of SHT11 sensor is the increase of temperature due to being exposed to direct sunlight. The sensors must be also protected against water and other sprayed materials. The sensors were protected by using white chambers. For sensors protection against water drops due to high humidity inside greenhouses, a plastic cover was placed over the sensor chamber and display box (Fig. 12).

**Communication protocol**

First, RS-232 standard was used for a special kind of serial communication to exchange data with the original device. Because of the limited number of devices connected simultaneously to the cable and also rather short cable length, as well as high environmental noise inside greenhouse, this standard was not applicable. Therefore, RS-485 standard was used. According to the manufacturer's information, up to 1200 meter cable length can be used and simultaneous connections to 128 devices on a cable are possible. Four wires were used to connect the main device to the sensor package. Two wires were used to connect to 12-volt power supply while other two wires were used for RS-485 communication (Fig. 13).

Possibilities are offered to establish other communications or use other types of sensors to the control system in the sensor package. Moreover, a specific code was defined for each type of package. Sensors with activation code 077 wait for a number of other sensors to respond. The main unit sends sensor number (e.g. 1) and the package of sensors with number 1 becomes activated, and finally, temperature and humidity information is sent by 10 characters. A new package of sensors was also provided to measure soil temperature, outside air temperature, and water temperature. Up to 4SMT160 sensors can be installed in this package. The temperature sensor is also included in this package.

**PC programming**

Computer programming can be used for online and offline recording of the information. During online recording, the computer was directly connected via serial or USB port and information displayed momentarily as shown in Fig. (14).

During off line recording, SD Memory card can be removed and connected to the computer by RAM Reader. All recorded information are then transferred to data bank. Viewing the measured parameters by the sensor package and chart, stored in access database is also possible for graph making. Figure (15) shows the software menu. The user could update database from MMC.

Also, if the computer is connected to the internet, the online data base and related charts and graphs can be viewed by the greenhouse owner. However, due to the low size of data, the internet connection can be made via GSM/GPRS MODEM.

**Device testing**

The device was installed and tested for a 5 year period in operation for about 30 old greenhouses under different climates of different cities across the country including Kermanshah, Shiraz and Karaj. The results were satisfactory for the daily and weekly records as shown in Fig. (16) and Fig. (17), respectively.
Fig. (1). Different parts of the main designed device

Fig. (2). Main system components

Fig. (3). Main mother board
Fig. (4). Display and touch screen

Fig. (5). The flow chart of main board software
Fig. (6). AVR microcontroller with ATMEGA 128 model.

Fig. (7). Modules, GSM / GPRS SIM300

Fig. (8). Memory card SD (Multi Media Card (MMC))
Fig. (9). Display and touch screen

Fig. (10). Sensors for humidity and temperature measurement

Fig. (11). Sensor SMT160 with aluminum sheath
Fig. (12): Plastic rain covers over sensor chamber and display box

Fig. (13): Diagram of communication protocol

Fig. (14): Diagram of online recording
Fig. (15). A Menu of program to updates database from MMC.

Fig. (16). Diagram of daily temperature and humidity recording
Fig. (17). Diagram of weekly temperature and humidity recording

References


