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Digitally Greenhouse Monitoring and Controlling of System based on Embedded System

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Abstract - Monitoring and control of greenhouse environment play an important role in greenhouse production and management. To monitor the greenhouse environment parameters effectively, it is necessary to design a measurement and control system. The objective of this project is to design a simple, easy to install, microcontroller-based circuit to monitor and record the values of temperature, humidity, soil moisture and sunlight of the natural environment that are continuously modified and controlled in order optimize them to achieve maximum plant growth and yield. The controller used is a low power, cost efficient chip manufactured by ATMEL having 8K bytes of on-chip flash memory. It communicates with the various sensor modules in real-time in order to control the light, aeration and drainage process efficiently inside a greenhouse by actuating a cooler, fogger, dripper and lights respectively according to the necessary condition of the crops. An integrated Liquid crystal display (LCD) is also used for real time display of data acquired from the various sensors and the status of the various devices. Also, the use of easily available components reduces the manufacturing and maintenance costs. The design is quite flexible as the software can be changed any time. It can thus be tailor-made to the specific requirements of the user. This makes the proposed system to be an economical, portable and a low maintenance solution for greenhouse applications, especially in rural areas and for small scale agriculturists.

Index Terms – Wireless sensor network, Digital Agriculture, Environment Monitoring; Greenhouse Monitoring, Environment Parameter

1 INTRODUCTION

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 [1].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 [10]. 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 and low cost solution.

2.1 Parts of the System

2 SYSTEM MODEL

2.1 Basic Model of the System

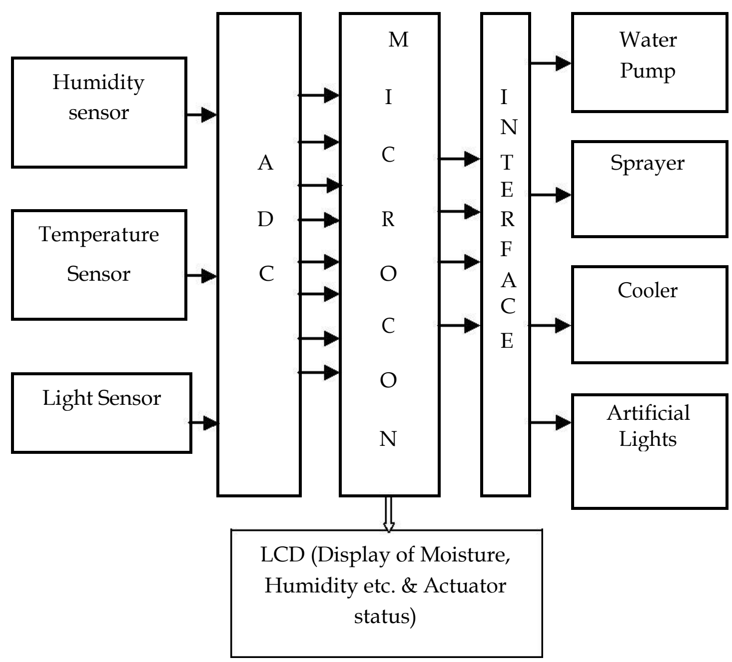

Fig 1. Block Diagram of the System

- Sensors (Data acquisition system)

i. Temperature sensor

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ii. Humidity sensor
iii. Light sensor (LDR)

- Analog to Digital Converter
- Microcontroller (AT89C51)
- Liquid Crystal Display
- Actuators – Relays
- Devices controlled
  i. Water Pump (simulated as a bulb)
  ii. Sprayer (simulated as a bulb)
  iii. Cooler (simulated as a fan)
  iv. Artificial Lights (simulated as 2 bulbs)

2.2 Steps Followed In Designing the System

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.

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.

Step # 3: Identify the software and the hardware to be used. 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 [2].

3 HARDWARE DESCRIPTION

3.1 Transducers

A transducer is a device which measures a physical quantity and converts it into a signal which can be read by an observer [9] .It can also be read by an instrument [3]. The sensors used in this system are:

1. Light Sensor (LDR (Light Dependent Resistor))
2. Humidity Sensor
3. Temperature Sensor

3.2 Analog to Digital Converter

In physical world parameters such as temperature, pressure, humidity, and velocity are analog signals. A physical quantity is converted into electrical signals. We need an analog to digital converter (ADC), which is an electronic circuit that converts continuous signals into discrete form so that the microcontroller can read the data. Analog to digital converters are the most widely used devices for data acquisition [7].

Analog world	Transducer	Signal Conditioning	Analog to Digital Converter	Micro-controller

Fig. 2 Getting data from the analog world

3.3 Microcontroller (At89s51)

The microcontroller is the heart of the proposed embedded system [4]. It constantly monitors the digitized parameters of the various sensors and verifies them with the predefined threshold values [5]. It 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 [6].

3.4 Liquid Crystal Display

A liquid crystal display (LCD) is a thin, flat display device made up of any number of color or monochrome pixels arrayed in front of a light source or reflector [4]. Each pixel consists of a column of liquid crystal molecules suspended between two transparent electrodes, and two polarizing filters, the axes of polarity of which are perpendicular to each other [6].

3.5 Relays

A relay is an electrical switch that opens and closes under the control of another electrical circuit. In the original form, the switch is operated by an electromagnet to open or close one or many sets of contacts. Because a relay is able to control an output circuit of higher power than the input circuit, it can be considered to be, in a broad sense, a form of an electrical amplifier.

3.6 Power Supply Connection

The power supply section consists of step down transformers of 230V primary to 9V and 12V secondary voltages for the +5V and +12V power supplies respectively.

4 SOFTWARE

4.1 Keil Software

Keil Micro Vision is an integrated development environment used to create software to be run on embedded systems (like a microcontroller). It allows for such software to be written either in assembly or C

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programming languages and for that software to be simulated on a computer before being loaded onto the microcontroller.

4.1.1 Device Database: A unique feature of the Keil µVision3 IDE is the Device Database, which contains information about more than 400 supported microcontrollers.

4.1.2 Peripheral Simulation: The µVision3 Debugger provides complete simulation for the CPU and on-chip peripherals of most embedded devices.

4.2 Programmer

The programmer used is a powerful programmer for the Atmel 89 series of microcontrollers that includes 89C51/52/55, 89S51/52/55 and many more. Major parts of this programmer are Serial Port, Power Supply and Firmware microcontroller. Serial data is sent and received from 9 pin connector and converted to/from TTL logic/RS232 signal levels by MAX232 chip [8]. A Male to Female serial port cable, connects to the 9 pin connector of hardware and another side connects to back of computer.

4.3 Proload Programming Software

ProLoad' is a software working as a user friendly interface for programmer boards from Sunrom Technologies. The programmer connects to the computer's serial port (Comm 1, 2, 3 or 4) with a standard DB9 Male to DB9 Female cable. Baud Rate - 57600, COMx Automatically selected by window software. No PC Card Required [5].

5 RESULT ANALYSIS

Readings taken at room temperature of 27$_0$C

TRANSDUCER'S READINGS

5.1 SOIL MOISTURE SENSOR

Tolerance= ± 0.2 V

TABLE 1
SOIL MOISTURE SENSOR READINGS

Soil Condition	Transducer Optimum Range
Soil is dry	0V
Optimum level of soil moisture	1.9- 3.5V
Slurry soil	>3.5V

5.2 LIGHT SENSOR

Tolerance = ±0.1V

TABLE 2
LIGHT SENSOR READINGS

Illumination Status	Transducer Optimum Range
OPTIMUM ILLUMINATION	0V-0.69V
DIM LIGHT	0.7V-2.5V
DARK	2.5V- 3V
NIGHT	3V-3.47V

5.3 HUMIDITY SENSOR

FORMULA:

Tolerance= ±0.1V

RH = ((V_{out} / V_{cc}) – 0.16)/0.0062, typical at 25°C where, V_{supply} = 4.98V

TABLE 3
HUMIDITY SENSOR READINGS

Percentage RH (RELATIVE HUMIDITY)	Transducer Optimum Range
0%	0-0.8V
0% to 9.81%	0.8-1.1V
12.9% to 20.1%	1.2-1.45V
22.7% to 30.06%	1.5-1.725V
30.8% to 40.5%	1.75-2.05V
41.3%to50.3%	2.075-2.35V
51%to 60.02%	2.375-2.65V
61.6%to70.5%	2.7-2.975V
71%to80.2%	3-3.275V
81.1%to 90%	3.3-3.6V
91%to 100%	3.6-3.9V

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5.4 TEMPERATURE SENSOR

FORMULA:

Temperature (^{0}C) = (V_{out}/5) *100 (^{0}C /V)

TABLE 4
TEMPERATURE SENSOR READINGS

Temperature range in degree Celsius	Temperature sensor output(V_{out})
10 $_0$C	0.5V
15 $_0$ to 20 $_0$C	0.75-1.0V
20 $_0$ to 25 $_0$ C	1.0-1.25V
25 $_0$ to 30 $_0$C	1.25-1.5V
30 $_0$ to 35 $_0$C	1.5-1.75V
35$_0$ to 40 $_0$C	1.75-2.0V
40 $_0$ to 45 $_0$C	2.0-2.25V
45 $_0$ to 50 $_0$ C	2.25-2.5V
50 $_0$ to 55 $_0$C	2.5-2.75V
55 $_0$ to 60 $_0$C	2.75-3.0V
60 $_0$ to 65 $_0$C	3.0-3.25V
65 $_0$ to 70 $_0$C	3.25-3.5V
70 $_0$ to 75 $_0$C	3.5-3.75V
75 $_0$ to 80 $_0$C	3.75-4.0V
80 $_0$ to 85 $_0$C	4.0-4.25V
85 $_0$ to 90 $_0$C	4.25-4.5V
90 $_0$ to 95 $_0$C	4.5-4.75V
95 $_0$ to 100 $_0$C	4.75-5V

6 CONCLUSION

A step-by-step approach in designing the microcontroller 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 results obtained from the measurement have shown that the system performance is quite reliable and accurate.

The system has successfully overcome quite a few shortcomings of the existing systems by reducing the power consumption, maintenance and complexity, at the same time providing a flexible and precise form of maintaining the environment.

The continuously decreasing costs of hardware and software, the wider acceptance of electronic systems in agriculture, and an emerging agricultural control system industry in several areas of agricultural production, will result in reliable control systems that will address several aspects of quality and quantity of production. Further improvements will be made as less expensive and more reliable sensors are developed for use in agricultural production.

Although the enhancements mentioned in the previous chapter may seem far in the future, the required technology and components are available, many such systems have been independently developed, or are at least tested at a prototype level. Also, integration of all these technologies is not a daunting task and can be successfully carried out.

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