

Wireless Monitoring of the Green House System Using Embedded Controllers

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Abstract--Plant growth is affected by various factors. The most important factors for the quality and productivity of plant growth are temperature, humidity, light. Continuous monitoring of these environmental variables gives information to the grower to better understand, how each factor affects growth and how to manage maximal crop productiveness. The optimal greenhouse climate adjustment can enable us to improve productivity *and* to achieve remarkable energy savings - especially during the winter in northern countries. The main purpose of a greenhouse is to provide and maintain the environment that will result in optimum crop production or maximum profit. This includes an environment for work efficiency as well as for crop growth. There has been much research and design about environment control using sophisticated technology. [23] In the present paper, authors have given an emphasis on WSN approach for green house monitoring and control. A control system is developed and tested using recent Atmega microcontroller. The farmers in the developing countries can easily use designed for maximizing yield. Atmega microcontrollers are preferred over other microcontrollers due to some important features including 10- bit ADC, sleep mode , wide input voltage range and higher memory capacity.

KEYWORDS: WSN, AVR, RF2.4, MICROCONTROLLERS, GREEN HOUSE, PRECISION AGRICULTURE.

1.INTRODUCTION

A recent survey of the advances in wireless sensor network applications has reviewed a wide range of applications for these networks and identified agriculture as a potential area of deployment together with a review of the factors influencing the design of sensor networks for this application. WSN is a collection of sensor and actuators nodes linked by a wireless medium to perform distributed sensing and acting tasks. The sensor nodes collect data and communicate over a network environment to a computer system, which is called, a base station. Based on the information collected, the base station takes decisions and then the actuator nodes perform appropriate actions upon the environment. This process allows users to sense and control the environment from anywhere. There are many situations in which the application of the WSN is preferred, for instance, environment monitoring, product quality monitoring, and others where supervision of big areas is necessary.

Wireless sensor network (WSN) form a useful part of the automation system architecture in modern greenhouses. Wireless communication can be used to collect the measurements and to communicate between the centralized control and the actuators located to the different parts of the greenhouse. In advanced WSN solutions, some parts of the control system itself can also be implemented in a distributed manner to the network such that local control loops can be formed. Compared to the cabled systems, the installation of WSN is fast, cheap and easy. The only additional costs occur when the sensor nodes run out of batteries and the batteries need to be charged or replaced, but the lifespan of the battery can be several years if an efficient power saving algorithm is applied. [9]

The research on the use of WSN in agriculture is mainly focused primarily on areas such as Proof-of-concept applications to demonstrate the efficiency and efficiency of using sensor networks to monitor and control agriculture management strategies. The attempt is made by the authors to show the effective utilization of this concept into day to day monitoring of the green house for higher yield. [1]

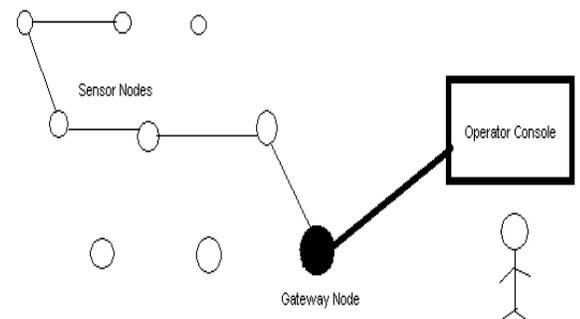


Fig.1. Wireless Sensor Network

2. SYSTEM REQUIREMENTS

2.1 Low-cost, low-power, small size networking devices

The system to be used should be cost effective, small in size and should require less mobility during its functioning. If the system is wireless then it should work on any unlicensed band. It also should require lesser hardware.

2.2 Long battery life

Long battery life is needed for the use in developing countries due to frequent power shortage

2.3 Robust design

Developed prototype of WSN should withstand with variations in the temperature, humidity, rain and wind speed.

2.4 User friendliness

Developed prototype of WSN should have GUI and must be easy to understand and work upon In nutshell, socio-economic status of the farmers needs also to be considered while finalizing the prototype of WSN. [15]

3. EXPERIMENTAL SET-UP

In the proposed hardware, there would be two section master and slave. The slave part would contain the temperature and humidity sensor, soil moisture sensor. The sensor would be connected to the AVR microcontroller. The RF transceiver would be connected to the AVR microcontroller which would wirelessly send the data to the master part. The master part would contain the RF transceiver which would receive the data and give to the microcontroller. The count would be displayed on the graphics LCD. The motor and DC fan would also be connected to the master board. These motor and DC fan would be accordingly controller based upon the relevant temperature and humidity condition. The major components of the proposed hardware, as seen in fig.2, are,

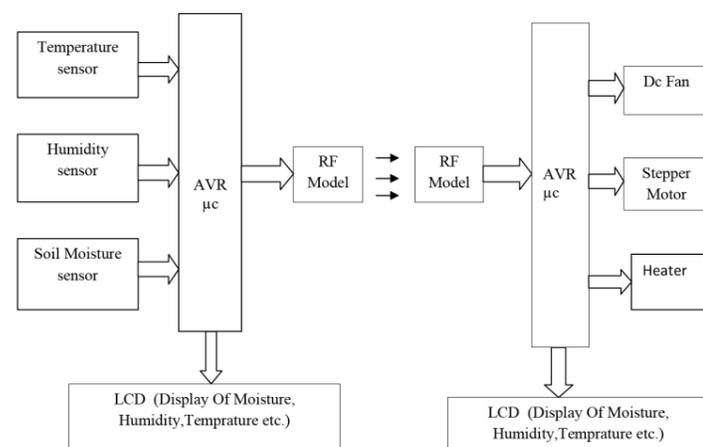


Fig.2 Block Diagram of system.

4. USEFUL FEATURES OF AVR MICROCONTROLLERS

The ATmega16 provides the following features: 16K bytes of In-System Programmable flash Program memory with Read-While-Write capabilities, 512 bytes EEPROM, 1K byte SRAM, 32 general purpose I/O lines, 32 general purpose working registers, a JTAG interface for Boundary scan, On-chip Debugging support and programming, three flexible Timer/Counters with compare modes, Internal and External Interrupts, a serial programmable USART, a byte oriented Two-wire Serial Interface, an 8-channel, 10-bit ADC with optional differential input stage with programmable gain (TQFP package only), a programmable Watchdog Timer with Internal Oscillator, an SPI serial port, and six software selectable power saving modes. The Idle mode stops the CPU while allowing the USART, Two-wire interface, A/D Converter, SRAM; Timer/Counters, SPI port, and interrupt system to continue functioning. The Power-down mode saves the register contents but freezes the Oscillator, disabling all other chip functions until the next External Interrupt or Hardware Reset. In Power-save mode, the Asynchronous Timer continues to run, allowing the user to maintain a timer base while the rest of the device is sleeping.

The ADC Noise Reduction mode stops the CPU and all I/O modules except Asynchronous Timer and ADC, to minimize switching noise during ADC conversions. In Standby mode, the crystal/resonator Oscillator is running while the rest of the device is sleeping. This allows very fast start-up combined with low-power consumption. In Extended Standby mode, both the main Oscillator and the Asynchronous Timer continue to run. The device is manufactured using Atmel's high density nonvolatile memory technology. The On chip ISP Flash allows the program memory to be reprogrammed in-system through an SPI serial interface, by a conventional nonvolatile memory programmer, or by an On-chip Boot program running on the AVR core. The boot program can use any interface to download the application program in the Application Flash memory. Software in the Boot Flash section will continue to run while the Application Flash section is updated, providing true Read-While-Write operation. By combining an 8-bit RISC CPU with In-System Self-Programmable Flash on a monolithic chip, the Atmel ATmega16 is a powerful microcontroller that provides a highly-flexible and cost-effective solution to many embedded control applications.

The ATmega16 AVR is supported with a full suite of program and system development tools including: C compilers, macro assemblers, program debugger/simulators, in-circuit emulators and evaluation kits. [11]

5. RF COMMUNICATION

RF is the wireless transmission of data by digital radio signals at a particular frequency. RF communication works by creating electromagnetic waves at a source and being able to send the electromagnetic waves at a particular destination. These electromagnetic waves travel through the air at near the speed of light. The advantages of a RF communication are its wireless feature so that the user needn't have to lay cable all over the green house. Cable is expensive, less flexible than RF coverage and is prone to damage. RF communication provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment and link quality.

5.1 WHY RF 2.4?

The important features given below make RF 2.4 an ideal choice for green house parameter Monitoring

- The CC2500 is a low-cost 2.4 GHz transceiver designed for very low-power wireless applications. The circuit is intended for the 2400-2483.5 MHz ISM (Industrial, Scientific and Medical) and SRD (Short Range Device) frequency band.[20]
- The RF transceiver is integrated with a highly configurable baseband modem. The modem supports various modulation formats and has a configurable data rate up to 500 kBaud
- CC2500 provides extensive hardware support for packet handling, data buffering, burst transmissions, clear channel assessment, link quality indication and wake-on-radio.[14]
- The main operating parameters and the 64-byte transmit/receive FIFOs of CC2500 can be controlled via an SPI interface. In a typical system, the CC2500 will be used together with a microcontroller and a few additional passive components.

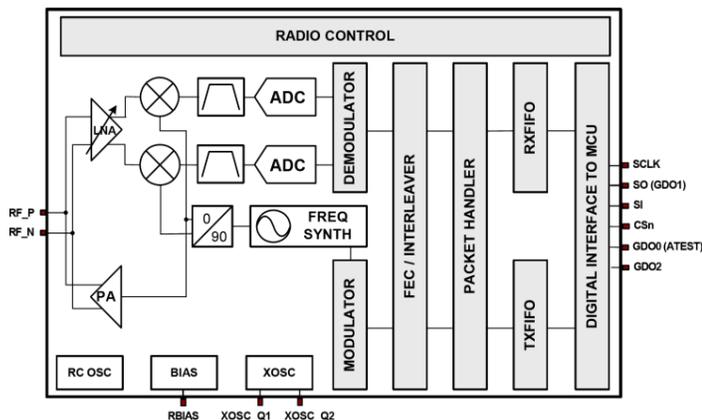


Fig.3 Functional Diagram

In nutshell, the advantages of RF 2.4 are,

- Low power consumption.
- Integrated data filters.
- High sensitivity
- Operation temperature range -40~+85 deg C
- Available frequency at : 2.4~2.483 GHz- No certification
- Required from government
- High accuracy
- Low cost

6. SENSORS

I. TEMPERATURE SENSOR

In this project for the measurement of Temp, temp sensor should have the following parameters,

- **Linearity:** Temperature sensor should have linear temperature to voltage characteristics.
- **Sensitivity :** Should be able to produce voltage for small change in temperature input
- **Minimum Drift:** Should give similar reading for same input over the years.

Basically, IC temperature sensors are nothing but silicon PN junctions. Surrounding Temperature increases reverse saturation current producing voltage (output voltage) across the fixed load resistor. The output voltage is directly proportional to absolute temperature. The various IC temp sensors available are, [17]

- **LM135, LM235, and LM335** – it provides an output of 10mV/K
- **LM35** –it provides an output of 10mV/°C
- **LM34** –it provides an output of 10mV/°F

National semiconductor's LM35 IC has been used for sensing temperature, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The LM35 thus has an advantage over linear temperature sensors calibrated in ° Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of

above 15°C hastens flower development, while lower temperature around 13.5°C delays it.

Depending on the temperature inside the greenhouse, the moisture should be kept in line for the best results. For example, if the temperature is 24 degrees, 60% humidity is suitable.

Hence, variable temperature and humidity control for different crops using wireless technique for WSN environment using low cost technique was the main objective. Low power consumption during testing was another objective. Hence, selection of the sensors and most importantly, microcontroller, was very important keeping power consumption at remote places in view. To bring the temperature within control limit, exhaust fans were made automatically ON and for humidity control, water pump was made ON-OFF.

8. FIELD OBSERVATIONS

Readings were taken for 03 months (March, May, and August). ON-OFF action of the hardware was tested. Satisfactory results were achieved. Fig. shows the photographs of the green house structures used to take readings.



Fig. 5: Green house near Nasik growing roses was used for testing of suitable control action for green house parameters with the help of AVR based green house controller.



Fig. 6: Green house near Nasik growing roses: Complete sections of the green are seen. Vents are used to regulate the temperature, naturally.

9. RESULTS

Results are found to be satisfactory. Area A and B (each admeasuring 10 meters x 10 meters) were selected. Area A is used to take reading without temperature and humidity control. Readings in Area B were taken after suitable automatic control action with the help of AVR based green house controller. It is found that the designed hardware has shown consistently faithful readings and also proved to be accurate in the humid atmosphere of the green house. Following readings and graphs show some of the readings in Area A and corresponding readings after corrective action in Area B.

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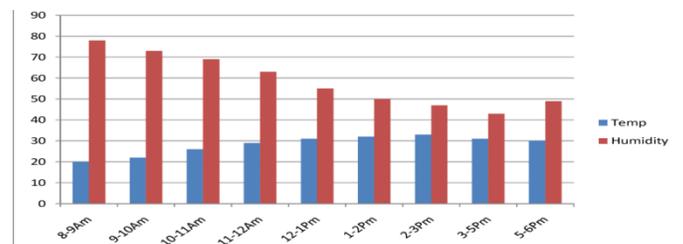


Fig. 7: Green house parameters in AREA A (without control action)

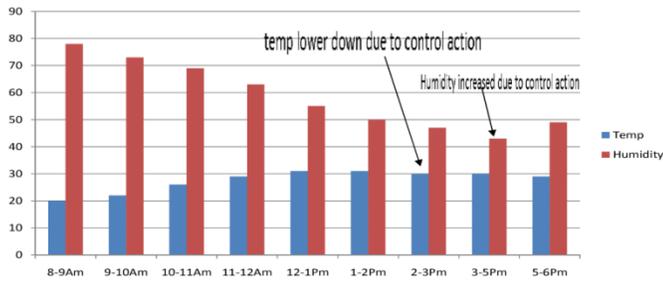


Fig. 7: Green house parameters in AREA B (with control action). Humidity values are increased and temperature values are decreased due to automatic control action of AVR based wireless green house controller.

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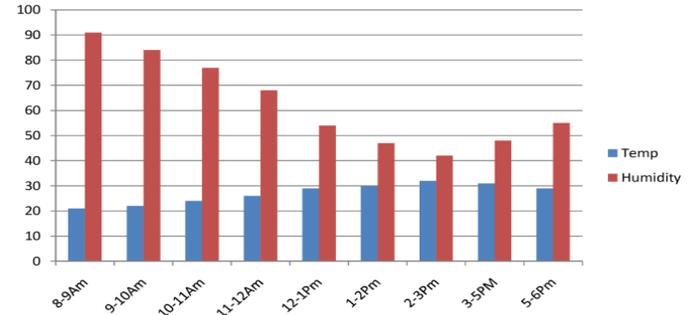


Fig. 9: Green house parameters in AREA A (without control action)

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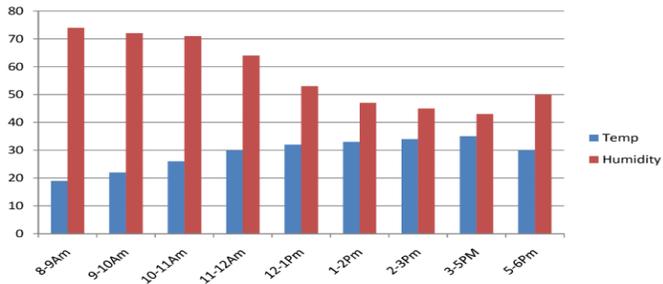


Fig. 8: Green house parameters in AREA A (without control action)

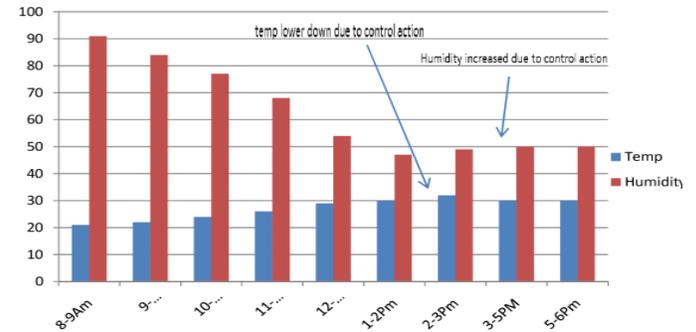


Fig. 9: Green house parameters in AREA B (with control action). Humidity values are increased and temperature values are decreased due to automatic control action of AVR based wireless green house controller.

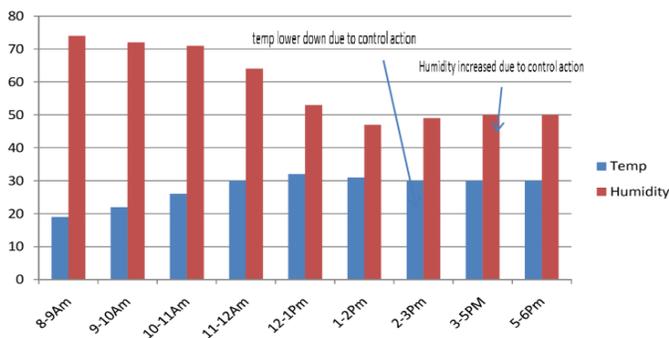


Fig. 8: Green house parameters in AREA B (with control action). Humidity values are increased and temperature values are decreased due to automatic control action of AVR based wireless green house controller.

Sr No.	RANGE AT MACRO LEVEL	RANGE AT MICRO LEVEL
1	LOW	LOWEST - 0% TO 10%
2	(0% TO 30%)	LOWER - 11% TO 20%
3		LOW - 21% TO 30%
4	MEDIUM (31% TO 60%)	LOWEST MEDIUM- 31% TO 40%
5		LOWER MEDIUM- 41% TO 50%
6		LOW MEDIUM - 51% TO 60%
7	HIGH (61% TO 100%)	HIGH - 61% TO 70%
8		HIGHER - 71% TO 80%
9		HIGHEST - 81% TO 100%

Fig.10 result of soil moisture measurement

10. CONCLUSIONS

- I. The green house control system is a cheaper solution as compared to other similar technologies and hence suitable for the developing countries such as India.
- II. Low cost and maintenance free sensors are used to monitor environment. The system has several advantages in term of its compact size, low cost and high accuracy.
- III. The green house system considers design optimization and functional improvement of the system
- IV. The reprogramming and flexibility are the main features.
- V. The same system can be used to monitor industrial parameters also.

- VI. The system developed has shown consistency, accuracy and precise control action over a period of 15 days and did not fail even once during testing.
- VII. Green house control system found effective even in humid atmosphere.
- VIII. Quality of roses in area B found to good than area A.
- IX. Owner of the green house said that the good quality roses are sold at 1.5 time's higher rate than medium quality roses. Hence, the system, if implemented, can increase the profit margin.
- X. The cost of the system is less than Rs. 2500/- if produced in multiple.
- XI. For one acre green house, we need only 5 sets of AVR based green house controllers.
- XII. Projected increase in the profit is in the range of 4-5 lakhs per acre.

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