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Development of AVR Based Embedded System to Precise Monitor and Control the Humidity of Polyhouse

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ABSTRACT

For proper crop growth and hence yields, humidity is one of the most important parameter at polyhouse. On literature survey it is found that, an optimum Humidity range of 50% to 80% is necessary for most of the crop species for proper growth. Holistically it is also found that, for most of the crops humidity requirement at day time may differ from that of night time. Therefore, every crop should get sufficient humidity level as per its requirement. Hence, AVR ATmega32 based embedded system is developed to cater the precise controlled humidity environment in polyhouse. A smart Humidity sensor SY-HS-220 is interfaced with AVR ATmega32 microcontroller to measure the humidity of polyhouse. The humidity dependent analog signal at the output of sensor is digitized by implementing on chip ADC of AVR Microcontroller. The digital readout is ensured by interfacing the LCD module to the microcontroller. The fogger and fan are wired with microcontroller using optocouplers and TRIACs to maintain the humidity in required range. The firmware is developed in embedded C using Code Vision IDE. The system is calibrated and standardized to the Relative Humidity in %RH. The results regarding implementation of the system are interpreted in this paper.

Keywords: *AVR Microcontroller, Polyhouse, Relative Humidity, Embedded System.*

1. Introduction

The literature survey shows that in case of polyhouse applications, the measurement and control of various parameters such as humidity, temperature, soil moisture, light intensity, salinity and pH of water etc. have an important role in the growth of crop [1, 2]. Moreover, the modern agriculture can better yield any seasonal crop in any season due to controlling of environmental parameters of polyhouse by using electronic technology. An electronic agricultural instrumentation plays a vital role in today's agriculture field for the measurement and control of many agricultural parameters. Therefore, most of the researchers are showing more interest in designing of various embedded systems for measurement and controlling of polyhouse parameters [3, 4, 5]. It makes tremendous revolutionary changes in the design and development of agricultural electronics embedded devices.

The humidity is one of the essential parameter responsible for crop growth. Basically humidity is the measure of water vapor content of the atmosphere [6, 7]. If concentration of H_2O in the air increases, humidity also increases. It results into decrease in plants transpiration which reduces plant growth and it may also promote to increase the fungus [8, 9]. Moreover, due to higher humidity and temperature, the air becomes more humid, which causes the incidence of plant diseases [10]. Therefore, every crop should get proper amount of humidity as per its requirement so as to maintain the quality of product and increase the crop yield.

Every crop requires specific humidity level at day time and it may be different at night time as per Table 1.

The farmers never furnish the humidity requirement of crops in any environment. Therefore, it is proposed to design and develop an embedded system for precise measurement and control the relative humidity of polyhouse as per the crop need. For various dedicated applications, the high performance microcontroller [11] based embedded systems are found most reliable. Most of the designers are designing the systems based on 8031 and 8051 microcontrollers having limited on chip resources. As a result, the applications based on these microcontrollers are more constrained. The ARM, AVR and PIC microcontrollers have advanced characteristics and more on chip resources such as ADC, DAC. However, to develop embedded systems, the microcontrollers from AVR families are more suitable. Hence, an embedded system for monitoring and controlling the humidity of polyhouse is designed by using AVR ATmega32 microcontroller and humidity sensor SY-HS-220 and is presented in this paper.

Sr. No.	Plant Name	Humidity in RH% at	
		Day time	Night time
1	Tomato	80% to 90%	65% to 75%
2	Potato	50% to 85%	50% to 85%
3	Strawberry	60% to 75%	60% to 75%
4	Cucumber	60% to 70%	70% to 90%
5	Watermelon	60% to 80%	60% to 80%
6	Onion	65% to 75%	65% to 75%
7	Lettuce	50% to 70%	50% to 70%
8	Sunflower	50% to 60%	50% to 60%
9	Pepper	50% to 70%	50% to 70%
10	Rose	60% to 70%	60% to 70%

Table 1: The Humidity Requirement of various crops

2. DESIGNING OF THE SYSTEM

Based on AVR ATmega32 microcontroller, the Humidity monitoring and controlling system is designed for polyhouse applications by using the hardware such as Humidity sensors SY-HS-220 along with its signal conditioning, Thumb Wheel Switch (TWS), LCD display module, control unit, Fan and Fogger, power supply circuit etc. and implemented successfully. The block diagram of the designed system is presented in Figure 1 and schematic of the circuit designed for embedded system is depicted in Figure 2.

For healthy growth of crops inside the polyhouse, precise Humidity measurement and its control is very important. Therefore, a precision humidity module, SY-HS-220 is deployed in the present system to sense the relative humidity of polyhouse, which produces relatively proportional analog voltage at the output. The module SY-HS-220 is capacitive type and having on board signal conditioning stage [12], due to which it becomes very smart. It is excited with +5 V power supply and having the current consumption less than 3 mA. The operating temperature range of this module is 0-60 °C and it operates in the humidity range of 30-90 % RH. At 25°C and 60 % RH, it gives the standard DC output voltage of 1.980 mV [13].

For more accuracy, two humidity modules are deployed in the present system to measure the humidity of polyhouse. The Humidity dependent voltage of first and second module is extracted and given to ADC channel 0 and 1 of the AVR ATmega32 microcontroller respectively for signal conditioning and further processing. The humidity of polyhouse is calculated by averaging both the signals. The signal conditioning is achieved by CMOS operational amplifier, TLC 271, having very high input impedance due to which the sensor gets isolated from remaining analog part of the hardware [14, 15]. The on-chip ADC of AVR ATmega32 has 8 input channels with 10 bit resolution. The output of ADC is displayed on the LCD module, which is interfaced to the microcontroller using Port D (data lines) and Port B (control lines) as depicted in figure 2. As per earlier discussion, each crop requires specific humidity range for day and night mode. The present system, in which humidity of polyhouse can be controlled as per crop requirement is applicable for ten

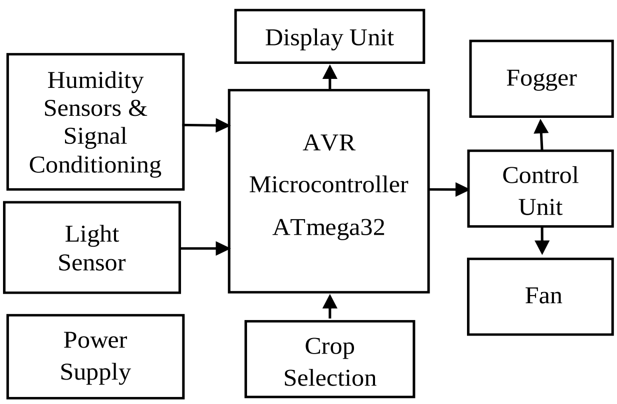

Figure 1: Block diagram of the Humidity measurement and control system under investigation.

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different crops. By changing number on Thumbwheel Switch (TWS), the specific crop can be selected. The Table 2 specifies ten different crops for which TWS BCD signal is encoded.

Number on TWS	**Equivalent BCD Code**	**Encoded Crop**
0	0 0 0 0	Tomato
1	0 0 0 1	Potato
2	0 0 1 0	Strawberry
3	0 0 1 1	Cucumber
4	0 1 0 0	Watermelon
5	0 1 0 1	Onion
6	0 1 1 0	Lettuce
7	0 1 1 1	Sunflower
8	1 0 0 0	Pepper
9	1 0 0 1	Rose

Table 2: Thumbwheel switch encoding for various crop selections

The single digit TWS is deployed in the system, which gives simple BCD output. The switch is interfaced to Port C (PC4-PC7) of the microcontroller and used to select the crop along with its required humidity range. The light detecting sensor, LDR, is deployed along with operational amplifier LM324 to detect day and night mode automatically [16, 17]. The operational amplifier is configured in non-inverting comparator mode and generates high level output for day mode and low level output for night mode. The output of comparator is then applied to Port pin PC0 of the microcontroller for further action.

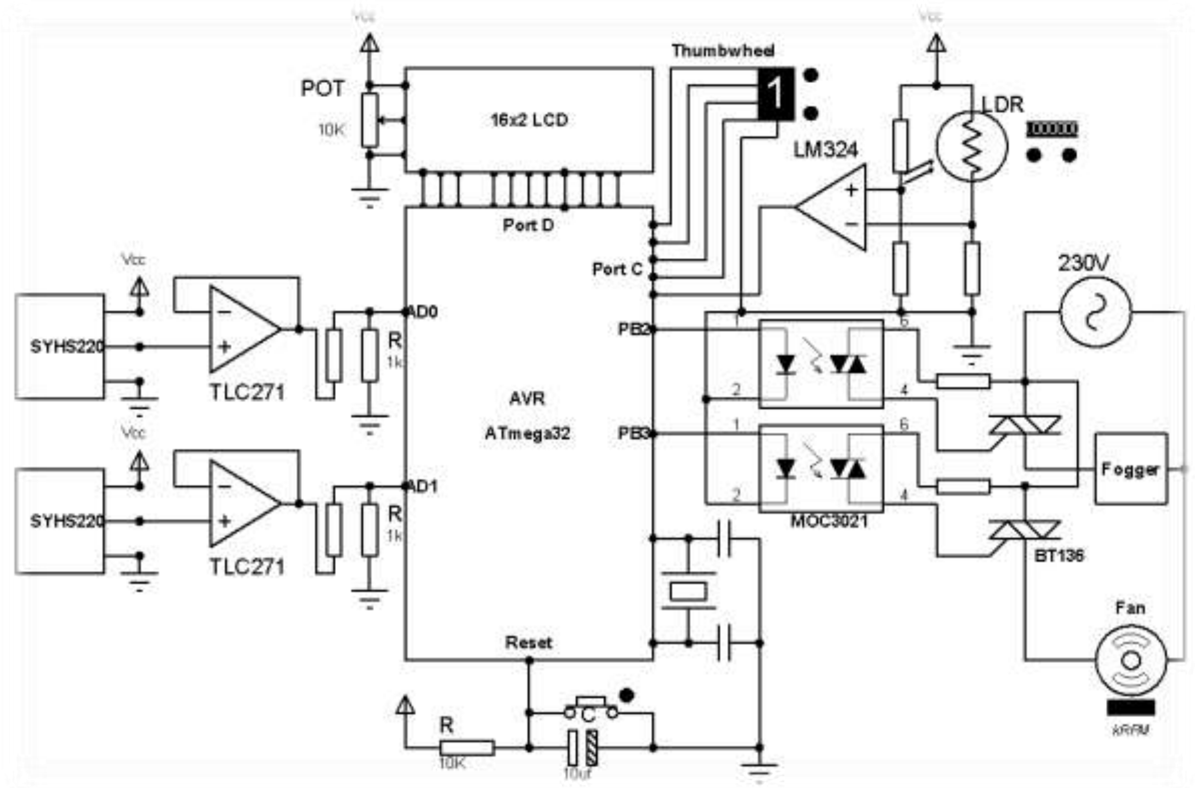

Figure 2: Circuit schematic of the system.

The Fogger and Fan are interfaced to the microcontroller at Port pins PB2 and PB3 respectively by using optocoupler MOC 3021 and TRIAC BT 136 as depicted in Figure 2 to control the humidity of polyhouse within the particular range of selected crop. To increase the humidity of polyhouse, Fogger is turned ON by making PB2 line at high state. Similarly, the Fan is turned ON with high state of PB3 line to decrease the humidity. By comparing the Humidity of polyhouse with cut-off limits of the selected crop, microcontroller executes the switching action of the Fogger and Fan in day and night mode automatically. To run the embedded system as per design considerations, the hardware and software are two inherent things. The previous paragraph illustrates necessary hardware for development of the system. However, by using Code Vision Integrated Development Environment (IDE), the firmware is consequently designed in embedded C. The flow chart of main firmware is depicted in Figure 3a and that of day & night humidity control subroutine is depicted in Figure 3b. The hex file of program is generated after successful building of the project and burned into the target device AVR ATmega32 microcontroller which ensures the synthesized embedded system for controlling the humidity of polyhouse.

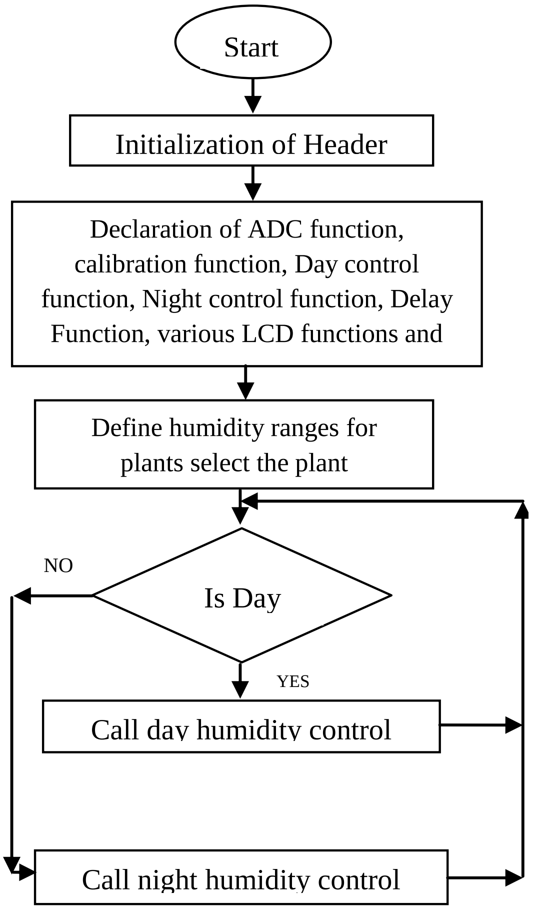

Figure 3a: The flow chart of main firmware for present system.

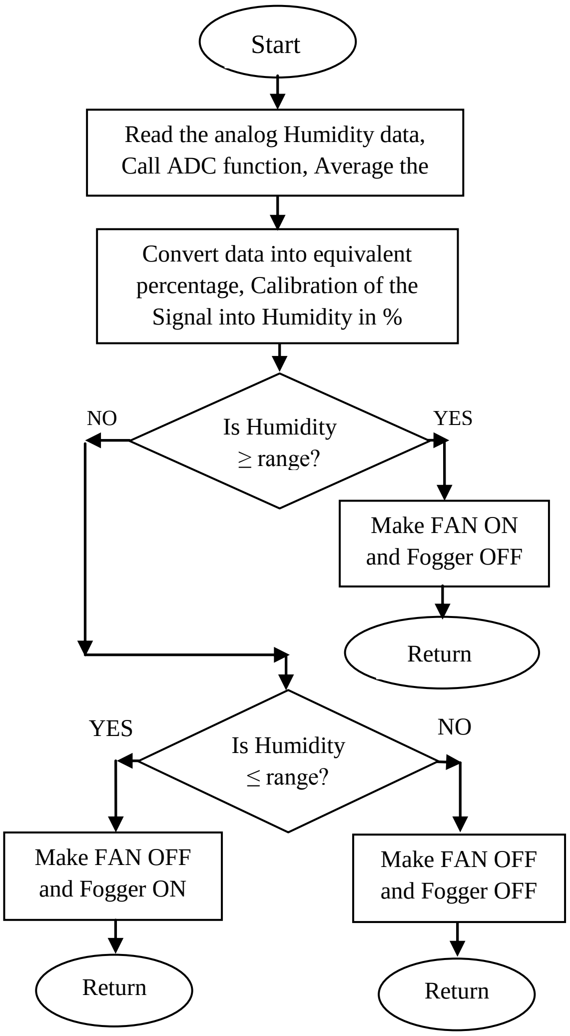

Figure 3b: The flow chart of day & night humidity control subroutine for present system.

3. EXPERIMENTAL

In present work, humidity of the polyhouse is measured and controlled for different crops by developing an embedded system. As depicted in Figure 4, a system is developed in the laboratory and used for testing along with standard humidity chamber and results are discussed. As humidity is one of the important parameter for crop growth, the crops are cultivated in polyhouse by providing humidity controlled environment. Hence, humidity of the polyhouse is measured by deploying a smart humidity sensor SY-HS-220 and controlled to desired value by using Fogger and Fan.

Figure 4: Prototype of developed System

For accurate measurement of humidity, the calibration of designed system to its engineering unit has a prime importance. For precise calibration, the humidity of different values ranging from 30 RH% to 95 RH% with accuracy of 1 RH% is applied to the sensor, SY-HS-220 using highly sophisticated humidity chamber, model Gayatri Scientific Ltd. Mumbai and humidity dependent voltage V_H is recorded. The plot of V_H in mV against applied humidity in RH% is depicted in the figure 5. For precise linearization of the developed system the least square method of curve fitting is employed and empirical relation is produced, as

$$\text{RH in \%} = (V_H + 7.4257) / 7.1446 \quad \text{-------- (1)}$$

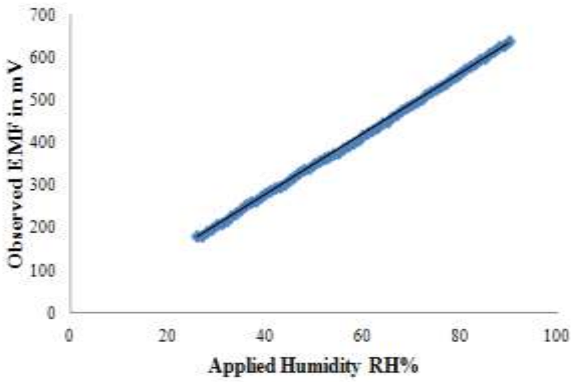

Figure 5: Plot of observed emf V_H against applied humidity

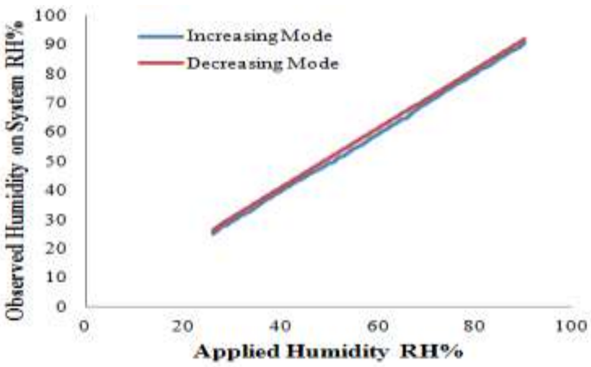

Figure 6: Plot of observed humidity on system against applied humidity.

The imperial relation 1 is executed in the firmware to get relative humidity in RH% scale. Hence, the present system is calibrated and standardized to humidity in RH%. For validation, the system is implemented along with the standard humidity chamber and observations are recorded and plotted. The plot of applied humidity and humidity recorded by the present system is shown in figure 6. The humidity readings shown by the present system and that of humidity chamber are closely matched, which supports the reliability in the system design.

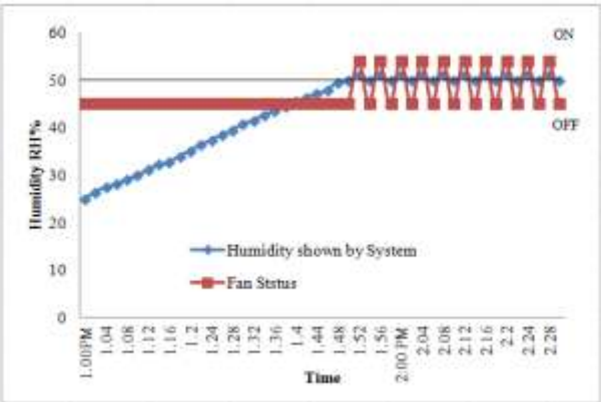

Figure 7(a): Plot of observed humidity against time for 50 %RH.

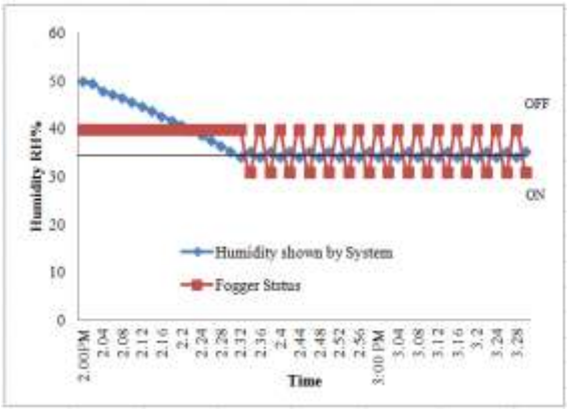

Figure 7(b): Plot of observed humidity against time for 35 %RH.

4. MONITORING THE HUMIDITY OF POLYHOUSE

The present system is designed for monitoring and controlling the humidity of polyhouse environment in RH% precisely. Actually it is deployed to monitor the humidity of the prototype polyhouse in the laboratory for two fixed humidity values in day mode. At first, it is controlled above the normal humidity, 46.3 RH%, at 50 RH% and for next time below the normal humidity, 45.8 RH%, at 35 RH%. The instantaneous values of humidity observations given by the system under investigation are recoded and plotted against time as shown in figure 7(a) and 7(b) in which the instantaneous status of the auto controlled Fogger and Fan are also depicted to fix the humidity of the environment.

Thus, AVR ATmega32 microcontroller based embedded system is developed and tested successfully for precise measurement and controlling the humidity of polyhouse. The observations of the system are presented in Figure 7, which shows that humidity of the polyhouse is precisely controlled by the system.

5. CONCLUSION

By emphasizing embedded technology, a smart system is designed using AVR microcontroller, ATmega32 to monitor and control the environmental Humidity inside the polyhouse. The system is calibrated for Humidity in RH% by deploying empirical relations. Experimental results shown by the present system to control the humidity of polyhouse are more precise which reveal the preciseness in the development of the system.

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