Design and Implementation of a Temperature and Humidity Control System for a Poultry House Prototype

By

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ABSTRACT

This paper presents a Microcontroller based temperature-humidity measuring and control system which can be implemented in a poultry farm. The control of temperature and humidity have, overtime, become a major part of control systems operated in environment where these quantities are crucial entities. In this project, DHT11 temperature-humidity sensor is used for the sensing of the temperature and humidity of the poultry house, which is an input to the microcontroller. The microcontroller will get the temperature and humidity of the poultry from the temperature-humidity sensor and then compare it with the desired temperature for the poultry. If the measured temperature and/or humidity is not within the desired temperature and humidity of the poultry house, the control mechanism will be activated. The control of temperature and humidity is achieved through the use of some control mechanisms which include: fan, automated windows and heat source. The microcontroller used is the ATMEGA328p microcontroller. The temperature and humidity of the poultry is displayed on a Liquid Crystal Display (LCD). The result obtained is the control of the temperature and humidity of the poultry house.

Keyword: Microcontroller, poultry, temperature, humidity, Sensor (DHT11)

INTRODUCTION

Poultry farming refers to the act and practise of raising birds (such as chicken, turkeys, geese etc.) for the production of meat or egg. However, several factors (such as ambient temperature, relative humidity, presence of ammonia, dust etc.) influence the microclimatic conditions in the poultry house (Corkery et al., 2013) and if these factors are not properly maintained, it could result in the reduced level of meat and egg production, and sometimes, increased mortality among poultry birds.

The demand of accurate temperature and air ventilation control has conquered many industrial (and local) domains where suitable air is required to provide a comfortable environment for its occupants (Levărdă & Budaciu, 2010). The poultry house (farm) is one of the domains that really requires suitable temperature and humidity. However, due to varying climatic conditions, the ambient temperature as well as the Relative Humidity (RH) can sometimes be too high or too low.

The level of humidity influences the ability of the bird to cool itself through panting; and influences ammonia production. It is recommended that Relative Humidity(RH) be maintained between 50-70 percent throughout the grow out period, including the brooding period. Dusty conditions in the poultry house are associated with relative humidity below 50 percent. Relative Humidity of 70 percent or greater provides environmental conditions suitable for microbial growth in the litter, which consequently raises the level of diffuse ammonia in the house. Research shows that increased ammonia impairs the immune system and increases respiratory disease in birds (Fairchild, 2012). Therefore, RH of over 70% is undesirable and should be contained through use of ventilation in buildings (Corkery et al., 2013). Also, high RH has also be found to encourage outbreak of poultry diseases (Elijah & Adedapo, 2006).

When birds are kept in environmental temperatures above or below their comfort zone, more energy must be expended to maintain body temperature. This extra energy will ultimately be supplied by the feed consumed (Fairchild, 2012). When exposed to colder temperatures, birds eat more feed to sustain normal body temperature. When feed is used for warmth, it is not converted to meat; also, when temperatures become too warm energy is also wasted as birds attempt to keep cool (Corkery et al., 2013).

This births the need for a temperature and humidity control mechanism; and in order to achieve a suitable temperature-humidity control for a poultry system, a microcontroller-based system that is capable of monitoring and regulating these quantities is implemented. This is the main aim of this project, that is, to use a microcontroller to control the temperature and humidity of the poultry (prototype) in order to maintain a comfortable environment for the poultry birds.

"A duo of measurement and control can be made intelligent enough when some kind of programmable components are added to them. To monitor and control a physical variable normally a microprocessor or microcontroller is employed" (Joshi & More, 2012). It is very much effective to implement microcontrollers to control process variables (temperature, humidity light, pressure etc.) in industrial and research-oriented requirements (Goswami et al., 2009).

As the era of microcontroller is large, the selection of controller depends on complexity, size, system hardware requirement and cost effectiveness. Too many microcontrollers based intelligent process control systems have been developed. The systems may include PIC family (Levărdă & Budaciu, 2010), fuzzy logic microcontroller (Markande & Katti, 2004), or it may be Intel's 8751 microcontroller (Idachaba, 2010). In some cases, because of the complexity and nature of the parameters being observed, hybridization of two methods can be implemented such as fuzzy-PID controller (Aborisade & Stephen, 2014).

An embedded system was used for monitoring and controlling temperature and light using microcontroller AT89S52 in (Goswami et al., 2009). Also, a microcontroller-based system for temperature control automation was designed using PIC 16F877 microcontroller in (Khairurrijal et al., 2008).

A low-cost silkworm house temperature and humidity automatic control system based on DHT11 sensor was developed using DHT11 temperature-humidity and AT89C51 microcontroller in (Dong-lin et. al., 2010). A work was done on the design of temperature humidity wireless sensor network node based on DHT11 sensor (Ying-mei & Jian-ping, 2011). It has many advantages such as low power consumption, low cost, high integration, small size and stable operation. Also, single bus sensor DHT11 was applied in temperature-humidity measure and control system (Tianlong, 2010). It introduced the concept of 1-wire bus and expounded the basic principles and the application methods of DHT11 on temperature and humidity control system.

MATERIALS AND METHOD

The block diagram for the proposed system is shown in the Figure 1. It consists of an Atmega328p microcontroller which is interfaced with the following components: DHT11 sensor - for measuring temperature and humidity; system's input button - for imputing the desired temperature range; Liquid Crystal Display - for displaying the operations of the system; Servomotor - for opening or closing the windows of the poultry house prototype; DC fan - for cooling the poultry house; Electric bulb - for heating the poultry house whenever the temperature within is below the desired range.

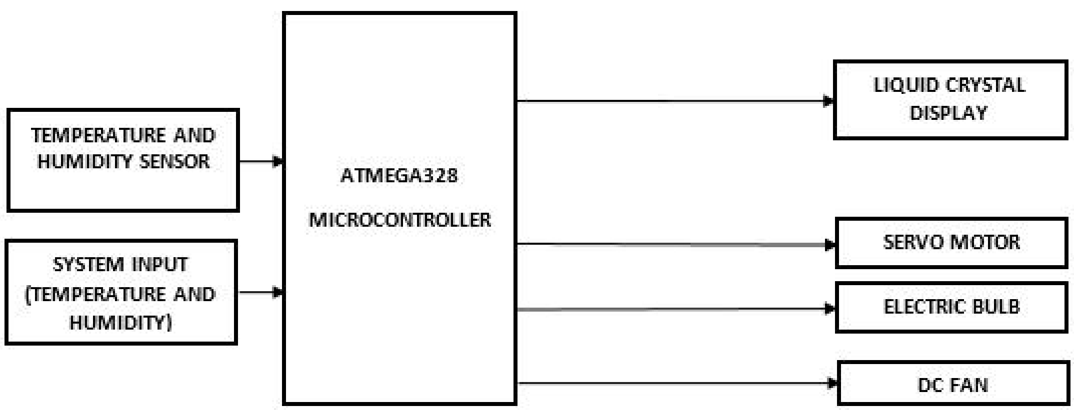

Figure 1: Block Diagram for the Temperature-Humidity control system

Hardware Design

The whole system is made of several units which are listed below.

i. Power supply section (AC and DC source)
ii. Sensing section
iii. Input section
iv. Controller section
v. Display section
vi. Temperature-humidity controller section

Power

The power supply unit was designed to step-down 220V AC mains supply to 12V AC. A full-wave bridge rectification circuit is needed to convert the 12V output of the transformer into 12V DC. The rectification circuit consists of four diodes. The result of the rectification is a 12V DC supply, which is used to charge the batteries used in the system. The heat source is connected to AC supply; the fan uses 12V DC supply from the batteries; while the other components (such as: the microcontroller, servomotors, LCD, DHT11 sensor etc.) make use of 5V DC supply.

Sensing Section

For the measurement of temperature and humidity of the poultry house, a DHT11 temperature-humidity sensor (Figure 2) is used. DHT11 is a low-cost humidity and temperature sensor which provides high reliability and long-term stability. It generates calibrated digital output which can be interfaced with any microcontroller (Electronic Hub., 2017).

Figure 2: DHT11 Temperature-Humidity Sensor

Input Section

The input section basically consists of push buttons which are to be used to input desired temperature range. A total of six push buttons are present in the input section of the project. Figure 3 is a picture of the push buttons of the input section, each of which are used to select the desired temperature range.

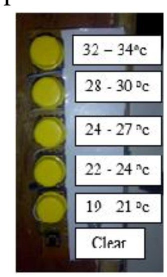

Figure 3: Temperature Input Buttons.

Controller Section

The controller is an important section of the system. The microcontroller used for this project is Atmega328p microcontroller. It is the data processing element of the system and it is responsible for receiving the signal from the temperature-humidity sensor and also from the input button. It compares the measured temperature and humidity to the desired control temperature and humidity and provides an output signal to the control elements (fan, windows and Heat Source).

Display Section

The display unit is the unit that shows information and provides feedback to the users. A 16x2 Liquid Crystal Display is used in the circuit design to continually display the measured temperature of the poultry room. A liquid-crystal display (LCD) is a flat-panel display or other electronically modulated optical device that uses the light-modulating properties of liquid crystals. Liquid crystals do not emit light directly, instead using a back-light or reflector to produce images in colour or monochrome (Wikipedia, 2017).

Temperature-Humidity Controller Section

The Temperature-Humidity control section consists of circuit and components that are responsible for the control of the temperature and humidity of the system. There are three (3) temperature and humidity control mechanism implemented:

i. Automated opening of the windows of the poultry room. This is achieved servomotors which are affixed to the windows of the room.

ii. The use of DC Fan. It helps to expel warm air from the room, therefore providing a cool atmosphere for the poultry house.

iii. The use of a Heat Source. This is important because it helps to provide warmth for the poultry house whenever the room temperature is low. An 100watt electric bulb was used as a source heat in order to heat the air in a room.

The circuit was designed and simulated with the aid of an electronic design/simulator software. This is important in order to verify the operation of the design before being physically implemented. The Figure 4 shows the complete circuit diagram which was adhered to in the design of the hardware. After completing the circuit design, it was simulated.

The system was constructed by building and testing each unit of the system. A section approach was employed in testing the hardware aspect of the work. All components that used were individually tested to determine whether or not they are properly functioning; the controller used was connected with all the required components; also, the power circuit was constructed on a line Vero-board and the connections were properly checked; and finally, the power circuit was interfaced with the microcontroller circuit. The constructed system is shown in Figure 5.

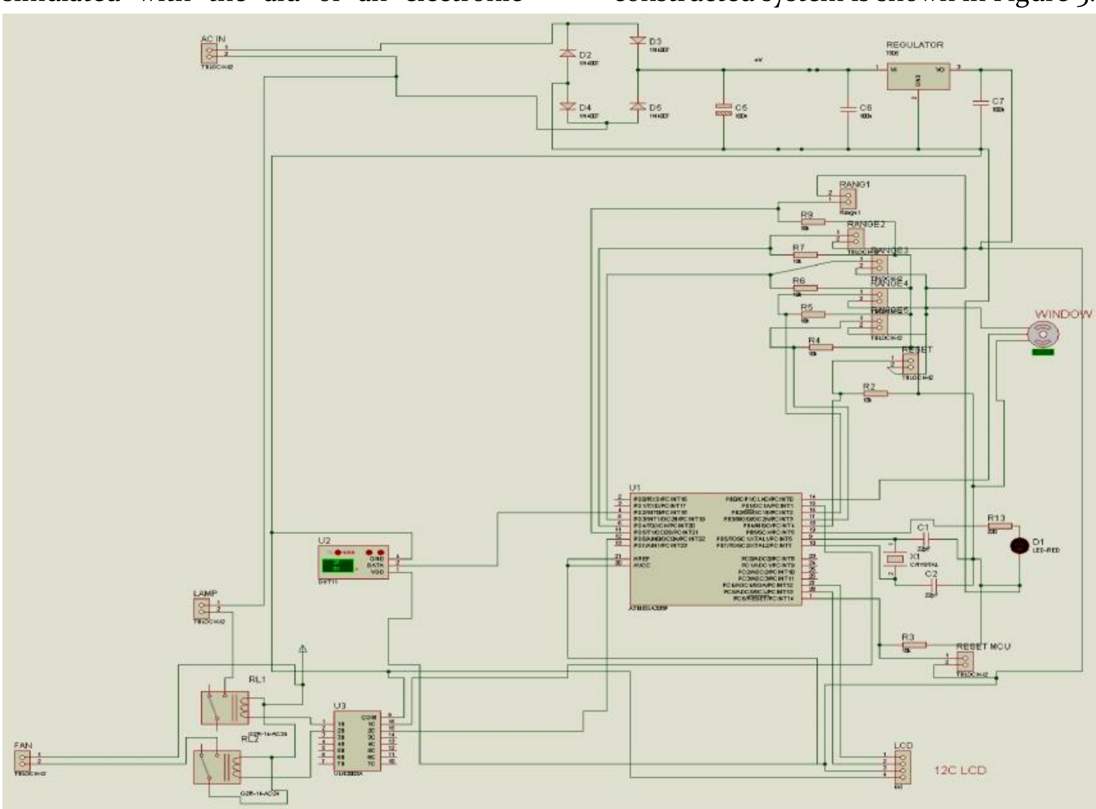

Figure 4: Circuit Design of the system.

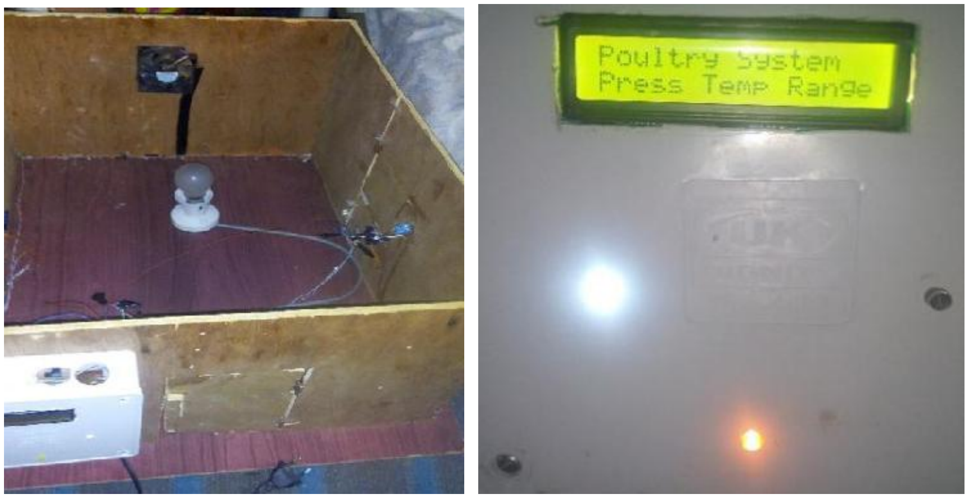

Figure 5: Controller Hardware Circuit

Software Design.

Microcontroller Programming

The Atmega328p microcontroller was programmed using an Arduino board programmer. The codes for the system operation were written using the Arduino Software (IDE). The program code was then compiled using the compiler that is provided in the Arduino IDE. With the aid of a USB cable (used for interfacing the arduino board to the PC), the compiled program code was then uploaded to the Arduino board (on which the Atmega328p microcontroller was connected).

Table 1: Button temperature range configuration

Button No	Temperature Range(°C)
1	32 – 34
2	28 – 30
3	24 – 27
4	22 – 24
5	19 – 21
6	Clear

The humidity range that was used is 50 - 70% as recommended in Fairchild, (2012).

System Algorithm

The algorithm implemented for performing temperature-humidity measurement and control of poultry is shown below.

Step 1: Start.

Step 2: Initialize LCD.

Step 3: Input temperature range.

Step 4: Measure poultry temperature and humidity (by the DHT11).

Step 5: Compare the measured values with the input values.

Are the measured values within the desired range?

Step 5.1: If yes, go to stage 6.

Step 5.2: Else, go to Step 4.

Step 6: Start the control mechanism.

Step 7: Stop.

RESULT AND DISCUSSION

The microcontroller is interfaced to DHT11 Temperature-Humidity sensor, Liquid Crystal Display, Servo motor, Heat Source and Fan. Upon putting the system ON, the controller carries out all the necessary initialization process. Once the initialization process is completed, the LCD displays "Press Temp Range", which prompts the user to input the desired temperature range for the poultry farm. After, the temperature range has been provided (by pressing the button), the microcontroller then gets the instantaneous temperature and humidity values of the system and then compares these values to the desired temperature and humidity. Therefore, based on the result of the comparison, necessary control actions will be activated. The Table 2 gives the conditions necessary for different control actions.

The time elapsed from the instance of temperature and humidity measurement to the time the control action begins is 13 seconds. After of a minimum of 26 seconds delay, the system begins the humidity-and-temperature-measuring-and -control process.

Table 2: Table showing the different conditions with its corresponding control action.

S/N	Conditions	Control Action
1	When both the instantaneous temperature and humidity is lower than the required temperature and humidity	Fan is OFF; Heat Source is ON; Windows are slightly OPENED
2	When both the instantaneous temperature and humidity is greater than the required temperature and humidity	Fan is ON; Heat Source is OFF; Windows are CLOSED
3	When the instantaneous humidity is lower than the desired humidity and the instantaneous temperature is greater than the desired temperature	Fan is ON; Heat Source is OFF; Windows are OPENED
4	When the instantaneous humidity is greater than the desired humidity and the instantaneous temperature is lesser than the desired temperature	Fan is OFF; Heat Source is ON; Windows are CLOSED
5	When instantaneous temperature is lower than the required temperature and the instantaneous humidity is within the desired humidity range	Fan is OFF; Heat Source is ON; Windows are CLOSED
6	When instantaneous temperature is greater than the required temperature and the instantaneous humidity is within the desired humidity range	Fan is ON; Heat Source is OFF; Windows are OPENED
7	When instantaneous humidity is lower than the required humidity and the instantaneous temperature is within the desired temperature range	Fan is OFF; Heat Source is OFF; Windows are OPENED
8	When instantaneous humidity is greater than the required humidity and the instantaneous temperature is within the desired temperature range	Fan is OFF; Heat Source is ON; Windows are CLOSED.

Observed Performance

The following observations were noted when some birds (five five-week old chicks as shown in Figure 7) were put into the poultry house (prototype): First, the chicks adjusted to the system's environment easily, which is because the microclimatic condition of the developed system is similar to a natural environment; secondly, the chicks' behaviour was observed to be normal i.e. their feeding rate as well as their movement within the system; and finally, the system was observed to have maintained the desired temperature and humidity range by the continuous operations of the control mechanisms.

Figure 7: Five five-week old chicks used for testing the performance of developed system

CONCLUSION

In this paper, a microcontroller-based temperature, humidity measuring and control system was implemented in a poultry house prototype. The DHT11 temperature-humidity sensor is used to sense and measure the temperature and humidity of the poultry house, and parameters are sent as input signals to the microcontroller. Also, as an input to the microcontroller, is a set of push buttons which is used to select a desired temperature range. The temperature and humidity of the poultry house is displayed on a Liquid Crystal Display (LCD). The control of temperature and humidity was achieved by the use of some control mechanisms such as: fan, windows and heat source. The result obtained is the control of the temperature and humidity of the poultry house, which upon careful observations, showed overall healthy environment for the birds.

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