MICROCONTROLLER-BASED SYSTEM FOR POULTRY TEMPERATURE AND HUMIDITY REGULATION.

BY

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CERTIFICATION

This is to certify that this project titled "MICROCONTROLLER BASED SYSTEM FOR POULTRY TEMPERATURE AND HUMIDITY REGULATION" by ISIFE, OLISAEMEKA FREDRICK (CPE/12/0887), submitted in partial fulfilment of the requirements for the degree of Bachelor of Engineering (B. ENG.) in COMPUTER ENGINEERING of Federal University Oye-Ekiti, during the academic year 2012-2017, is a bonafide record of work carried out under my guidance and supervision.

Dr. Engr. O. M. Olaniyan ………………………… 13:12:17 ……………………

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Dr. I.O. Adeyanju ………………………… ……………………

(Head of Department) Signature Date

DEDICATION

This report is dedicated to God Almighty who saw me through the course of this project. Without His help, it would have been a struggle.

ACKNOWLEGDEMENT

First of all, I give thanks to God who kept me in His infinite mercies and helped me during the course of my project.

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ABSTRACT

This project presents a Microcontroller-based temperature and 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 environments 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, and it is then controlled using a microcontroller. The microcontroller will get the temperature 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 ATMEGA328/p 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.

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LIST OF ACRONYMS

LCD	Liquid Crystal Display
PLC	Programmable Logic Controller
RTD	Resistance Temperature Detectors
RH	Relative Humidity

CHAPTER ONE

INTRODUCTION

1.1. General Overview.

Poultry farming refers to the act and practise of raising birds (such as chicken, turkeys, geese etc.) for the production of meat or egg. It could be done commercially or subsistently. However, several factors (such as ambient temperature, relative humidity, light, dust etc.) influence the microclimatic conditions in the poultry house 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 control 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. Therefore, a mechanism for temperature and humidity control is needed.

"Temperature control is a process in which change of temperature of a space (and objects collectively there within) is measured or otherwise detected, and the passage of heat energy into or out of the space is adjusted to achieve a desired average temperature" (Joshi & More, 2012).

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 in order to maintain a comfortable environment for the poultry birds.

"A microcontroller is a complete computer on a chip, containing all of the elements of the basic microprocessor along with other specialized functions." (Bernstein, 2009)

1.2. Problem Statement.

Broiler performance has been linked to some environmental factors (which include temperature, relative humidity, carbon dioxide (CO_2), ammonia (NH_3), and air circulation) in the bird's microclimate (Lott, 1998). When the temperature of the bird's microclimate is either too high or low, and the cross-air ventilation is poor, it affects the behaviour of the birds as well as their body weight. Also, "increased stocking density can create more stress for the birds, especially heat stress, as broilers have difficulty dissipating their body heat as a result of their close proximity to one another. With adequate ventilation and sufficient air circulation, the heat that is produced by the broilers can be removed effectively" ((Feddes, 2003); (Lott, 1998)).

The effect of climatic variables (temperature, rainfall, wind speed and relative humidity) has been found to contribute to the variance in poultry egg production, feed intake and outbreak of disease in poultry production by about 81%, 96% and 43% respectively. While temperature has an inverse relationship with poultry feed intake, high relative humidity in the study area (Ilorin, Kwara state, Nigeria) usually encourage outbreak of poultry diseases which consequentially reduces egg production (Abiodun & Adedapo, 2006).

By understanding the relationship between these climatic variables and the productivity of the broilers, proper adjustments can be done to achieve suitable microclimatic condition.

This project is therefore aimed at the design and development of a microcontroller-based system, which can be used to measure, monitor and control the temperature and relative humidity of the poultry house and also provide the suitable microclimatic condition for the birds through some mechanisms (as discussed in chapter three).

1.3. Aim and Objectives.

Aim

The aim of this project is to design and develop a microcontroller-based system for monitoring and controlling the temperature and relative humidity of a poultry house.

Objectives

1. To design a responsive system that is capable of receiving signal (temperature and humidity) and making decisions in response to the received signal.
2. To implement the system design in (1) above.
3. To test the performance of the developed system.

1.4. Justification.

The main motive of the project is to design a system that is capable of monitoring and regulating the temperature and relative humidity of a poultry farm. This is as a result of the fact that the poultry birds have different behavioural reactions to different temperature value. However, one may not be able to know when the temperature is too high or too low for the birds until the birds start to act in response to the temperature change. When the ambient temperature is too low, birds are inclined to: shake their feathers out; shiver; eat more feed to sustain normal body temperature etc. Also, when the ambient temperature is too high, the birds are inclined to: reduce muscular efforts; pant; drink lots of water etc. (Gietema, 2005). These reactions can be noticed and it is as a result of unsuitable temperature conditions which, if necessary action are not taken, can lead to low productivity level and sometimes death of the birds.

It is recommended that relative humidity (which is the percentage of water saturation of air at any given temperature) be maintained between 50-70 percent throughout the growout period, including the brooding period. (Fairchild, 2017)

Relative humidity above 70 percent is undesirable as it improves conditions for microbial growth in poultry litter. As this microbial population increases, more ammonia is generated from nitrogen sources found in the bird fecal matter. Ammonia is a gas that has a negative impact on bird health and performance. Increased levels of ammonia in poultry buildings can reduce total weight gains for birds. Also, dusty conditions are associated with relative humidity below 50 percent. (Fairchild, 2017)

Therefore, it is required that a system that can measure and control the temperature and relative humidity (RH) of a poultry house is developed. The goal of developing this system is to achieve the desired temperature and RH that is suitable for the birds thereby, resulting in better productivity.

1.5. Scope of Study.

The project will start with making research to determine the different stages in the development of the broiler starting from hatching stage to the slaughter stage. It will be proceeded by the determination of the suitable temperature as well as the unsuitable temperature for broilers in each of these stages; the design of the microcontroller-based system with the use of some simulation and modelling tools; the purchase of the required components for the implementation of the design; the development (and building) of a prototype (physical model) of the poultry house; the incorporation of the microcontroller system into the developed prototype; and the evaluation of the performance the developed system.

CHAPTER TWO

LITERATURE REVIEW.

2.1. Poultry.

Poultry Farming is the commercial raising of chickens, turkeys, ducks, and geese for their meat and eggs. Since the 1930s and 1940s, the poultry industry has become one of the most efficient producers of protein for human consumption. It expanded rapidly during World War II because of the shortage of beef and pork, which require a much longer time to develop; only seven weeks are required to produce a broiler and five months to produce a laying hen (Ostrander, 2008). However, poultry can also be raised for other purposes like leather and feather production, and sometimes, for sporting events (Gates, n.d.). For the purpose of this project, poultry farming would be restricted to the rearing of "Broiler" (Figure 2.1) and "Layers" (Figure 2.2) for meat and egg production respectively.

Figure 2.1: Broiler chicken for meat production (Source: Wengerfeeds.com)

Figure 2.2: Layer chicken for egg production (Source: Gzsihal.com)

2.2. Poultry Housing.

There are several reasons why poultry houses should be properly constructed. They include:

i. To protect from sun, rain and floods,
ii. To protect them from predators - dogs, cats, snakes, birds of prey, rats and thieves
iii. To prevent mice, rats and other birds from eating their feed and transmitting disease
iv. To give hens a safe place to lay their eggs (Farrell, 2017).

In view of these highlighted reasons, a poultry house should have the following essential features:

i. A watertight roof
ii. Proper ventilation
iii. Inner surfaces which are easy to clean
iv. Rat and wild bird proof floor, walls and roof
v. Correct/suitable location (Gietema, 2005).

Poultry production spans the globe, ranging from simple backyard coops to highly advanced, technologically sophisticated rearing operations (Gates, n.d.) . Generally, poultry housing systems vary from the small backyard flock only having simple night shelter ('extensive' poultry farming), to modern poultry houses with thousands of birds in controlled environment houses ('intensive' poultry farming) (Gietema, 2005).

2.3. Production System.

There are four production systems identified by the Food and Agriculture Organization of the United Nations (FAO) in a Poultry Development Review (Glatz & Pym, 2013). They are:

- Large-scale commercial farms
- Medium-scale commercial farms
- Small-scale commercial farms
- Small-scale semi-scavenging system using indigenous birds

2.3.1. Large-scale Commercial farms.

Large-scale commercial farms are clear-span structures with litter on the floor for meat birds or cages for laying hens. The commercial chicken meat industry in some developing countries is vertically integrated, with single companies owning feed mills, breeder farms, hatcheries and processing plants. Arrangements typically involve agreements in which the farmer or landowner provides the housing, equipment and labour, while the company provides the chicks, feed, medication, transport and supervision.

2.3.2. Medium-scale commercial farms.

In developing countries, most medium-scale commercial layer and chicken meat houses rely on natural airflow through the shed for ventilation. Where required, meat birds and layers are given radiant heating early in their lives, to maintain body temperature. Laying hens may be kept in commercial wire cages in open sheds, or in sheds with wire sides to exclude wild birds, scavenging poultry and predators.

2.3.3. Small-scale commercial farms.

Houses of various shapes and dimensions are typically constructed using local building materials consisting of timber or mud bricks and bamboo. These small-scale commercial facilities may have several rooms or compartments where chicks are brooded, pullets are reared and layers are housed in a floor-based system or in cages. Meat birds are often kept in single-age groups of 50 to 100 chickens within the house.

2.3.4. Small-scale semi-scavenging system using indigenous birds.

Shelters are made from various materials, including wood and leaf material from local trees or shrubs. Birds in the household flock are typically housed overnight in the shelter, and are let out in the morning to forage during the day.

2.4. Conditions in the Chicken House (The 'Climate')

The following factors influence the climate in a chicken house:

- Temperature
- Relative humidity
- Composition of the air in the house (air quality)
- Interior air circulation and speed
- The volume of the house
- Light (daylight and artificial light)
- Dust, flies (Gietema, 2005).

"The climate in a chicken house has a great influence on the health and production level of the chickens. Especially young and highly productive birds are sensitive in this respect." (Gietema, 2005)

2.5. Temperature.

Poultry are warm-blooded and do not have sweat gland, and therefore must have a satisfactory environment in order to maintain their body temperature. Adult poultry can maintain their body temperature on about the same level of 41– 42°C over a wide range of ambient (surrounding) temperatures (Gietema, 2005) . "Body temperature is kept quite constant and is regulated by part of the chicken brain (the hypophyse). This part of the brain is comparable to a thermostat. Contraction and widening of blood vessels and the speed of respiration influence heat emission and retention which consequently influence the body temperature" (PoultryHub, 2017).

The temperature zone in which birds are able to keep their body temperature constant with minimum effort is known as the comfort zone. It depends on the feeding level and housing conditions. There is also a temperature zone called the thermoneutral zone, which is the temperature zone in which the birds are able to keep their body temperature constant with the aid of physical heat regulation. Physical heat regulation refers to the several mechanisms which birds use to keep their body temperature constant whenever the micro-climate's temperature is not within the comfort zone. Physical heat regulation are behavioral responses to temperature values that are above or below the comfort zone. Behavior of poultry when temperature is too low or too high (Gietema, 2005).

1. When the ambient temperature is below the comfort zone.

   The poultry is inclined to:

   i. Shake its feathers out (thermal insulation)

ii. Eat more food (this generates more body heat)
iii. Shiver thus generating heat (muscular movement)

"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." (Corkery *et al.*, 2013)

2. When the ambient temperature is above the comfort zone.

The poultry is inclined to:

i. Reduce or avoid muscular effort and to seek out cool regions
ii. Wings are held away from the body, to increase the body surface for heat exchange and to reduce insulation; the neck is stretched out
iii. When this is not enough, the birds start panting: more respiration; this means a more intense heat exchange in the lungs as more water vapour is breathed out (the chickens will need more water; try to provide relatively cool drinking water)
iv. If this continues for a longer period of time, without interruption by cool periods (at night), feed consumption drops especially when there is not enough drinking water; this leads to a decreased generation of body heat. At the same time production decreases.

Of course this is not without its effects. Some of the effects, as reviewed by (Elijah & Adedapo, 2006) , include: increase in poultry body temperature, a decrease on feed consumption and efficiency, reduction in poultry live weight and growth speed, high mortality, low productivity and reduction in the quality of the eggs – when the temperature is high.

2.5.1. Recommended Temperatures for Broilers

The best suitable ambient temperatures for laying hens (Layers) are between 20 – 24°C. When temperatures rise above 24°C, shell quality and egg weight will reduce. The critical temperature for layers is 20°C. For every 1°C lower than 20°C, the birds require an extra 1.5 g of feed per day. However, the critical temperature for broilers is dependent on age.

The table below shows the suitable temperature for broiler at different growth stage.

Table 2.1: Recommended Temperatures for Broilers

Age	Temperature (^{0}C)
First day	32-34
1st week decrease	30
2nd week decrease	26
3rd week decrease	22
4th week decrease	20

Source: PoultryHub – Climate in Poultry Houses (www.poultryhub.org)

2.6. Humidity

Humidity refers to the amount of moisture in the air or the moisture content of the atmosphere. "The ability of air to hold moisture depends upon its temperature. Warm air can hold more moisture than cold air. The term relative humidity refers to the percent of water saturation of air at any given temperature." (Fairchild, 2017)

Humidity has a great deal of influence in the health and physiological performance of poultry birds. "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 be maintained between 50-70 percent throughout the growout 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. As the microbial population increases, more ammonia is generated from nitrogen sources found in bird fecal material" (Fairchild, 2017).

A high level of ammonia will provoke irritation of the mucous membranes, which can cause conjunctivitis and air sac lesions; Ciliary activity in the trachea will be reduced; increased susceptibility to parasitic diseases such as coccidiosis and reduced growth through lower feed intake (Hubbard Company, 2017.).

The key to controlling the production of ammonia is to control the humidity level; the control of humidity is achieved by properly regulating the ventilation. Managing the poultry house ventilation rates to keep relative humidity between 50 and 70 percent is recommended to minimize ammonia production and dust (Fairchild, 2017).

2.7. Ventilation.

The supplying of air motion in a space by circulation or by moving air through the space is known as ventilation. (Clark, 2007) . "Ventilation is needed to regulate temperature and remove carbon dioxide, ammonia, other gases, moisture, dust and odours. Fresh air must be introduced uniformly, mixed well with house air, and circulated properly throughout the house" (Fairchild, 2017).

There are two basic types of ventilation system: Natural Ventilation and Power Ventilation (Controlled/Closed environment housing)

2.7.1. Natural Ventilation: Open-Sided Housing

Natural ventilation refers to an open-sided house with, most commonly, curtains (although flaps or doors can also be used) on the sidewalls. The operation of open-sided houses involves opening and closing the curtains or flaps to allow convection currents (wind or breezes) to flow air into the house. Generally speaking, open-sided houses are best managed only when the ambient conditions are close to the required set point temperature in the house (Ross, 2017).

2.7.2. Power Ventilation (Controlled Environment Housing)

Power ventilation in controlled or closed environment houses is the most popular form of broiler house ventilation system due to the ability to provide better control of the internal environment under varying ambient conditions. The most common form of controlled environment housing is that which operates under a negative pressure. These houses usually have solid sidewalls and exhaust fans which draw air out of the house, and automated inlets through which fresh air is drawn into the house (Ross, 2017).

2.8. Microcontroller

A microcontroller is a small computer on a single integrated circuit containing a processor, memory, and programmable input/output peripherals. Program memory is also included on chip and a small amount of RAM. Microcontrollers are designed for embedded applications (Aneja *et al.*, 2011).

A microcontroller already contains all components which allow it to operate standalone, and it has been designed in particular for monitoring and/or control tasks. In consequence, in addition to the processor it includes memory, various interface controllers, one or more timers, an interrupt controller, and last but definitely not least general purpose I/O pins which allow it to directly interface with its environment.

Microcontrollers also include bit operations which allow you to change one bit within a byte without touching the other bits. Today, microcontroller production counts are in the billions per year, and the controllers are integrated into many common appliances (Gridling & Weiss, 2007).

The figure below shows the block diagram of a typical microcontroller. All components are connected via an internal bus and are all integrated on one chip. The modules are connected to the outside world via I/O pins.

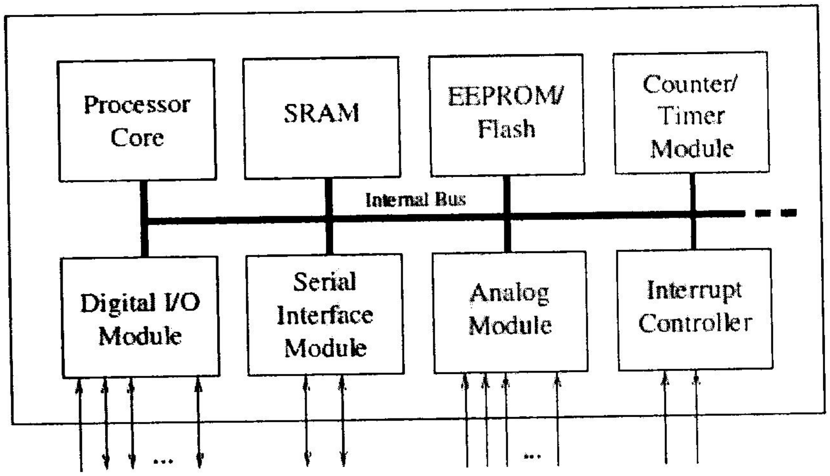


Figure 3: Basic layout of a microcontroller (Source: Gridling & Weiss, 2007).

i. **Processor Core**: The CPU of the controller. It contains the arithmetic logic unit, the control unit, and the registers.

ii. **Memory**: The memory is sometimes split into program memory and data memory. In larger controllers, a DMA controller handles data transfers between peripheral components and the memory.

iii. **Interrupt Controller**: Interrupts are useful for interrupting the normal program flow in case of external or internal events. In conjunction with sleep modes, they help to conserve power.

iv. **Timer/Counter**: Most controllers have at least one and more likely 2-3 Timer/Counters, which can be used to timestamp events, measure intervals, or count events. Many controllers also contain PWM (pulse width modulation) outputs, which can be used to drive motors or for safe breaking (antilock brake system, ABS). Furthermore the PWM output can, in conjunction with an external filter, be used to realize a cheap digital/analog converter.

v. **Digital I/O**: Parallel digital I/O ports are one of the main features of microcontrollers. The number of I/O pins varies from 3-4 to over 90, depending on the controller family and the controller type.

vi. **Analog I/O**: Apart from a few small controllers, most microcontrollers have integrated analog/digital converters, which differ in the number of channels (2-16) and their resolution (8-12 bits). The analog module also generally features an analog comparator. In some cases, the microcontroller includes digital/analog converters.

vii. **Interfaces**: Controllers generally have at least one serial interface which can be used to download the program and for communication with the development PC in general. (Gridling & Weiss, 2007).

2.8.1. Atmega328p Microcontroller

ATmega328P-PU is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. It provides the following features: 32Kbytes of In-System Programmable Flash with read-while-write capabilities, 1Kbytes EEPROM, 2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6-channel 10-

bit ADC (8 channels in TQFP and QFN/MLF packages) , 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 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 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 (Atmel, 2016).

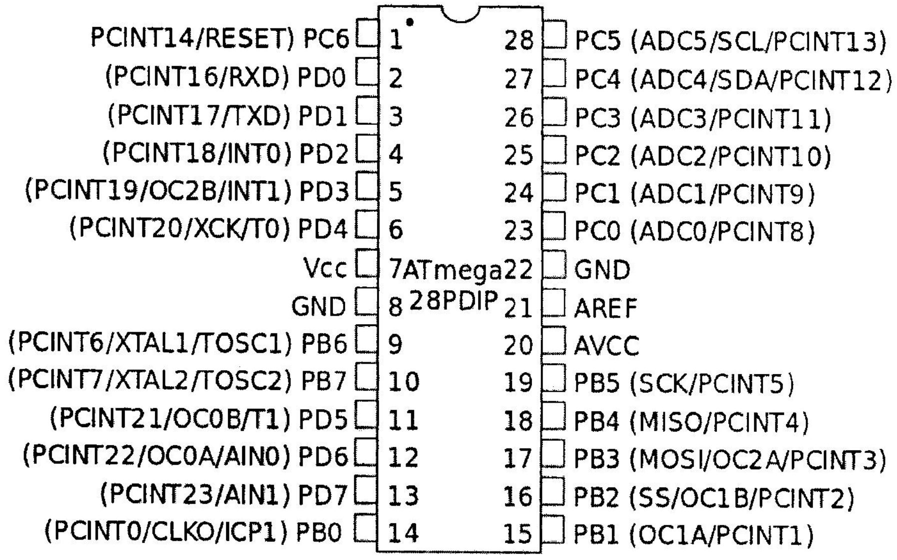


Figure 2.4: Pin configurations of atmega328p (Source: Wikipedia).

2.9. Temperature Sensor.

Sensing elements are the elements that receive a signal or stimulus (as heat or pressure or light or motion etc.) and responds to it in a distinctive manner (Aneja *et al.*, 2011). Sensors used for temperature control are:

- Thermocouples (Doc. Dr. RNDr Listopadu, 2000)
- Thermistors (Goswami *et al.*, 2008)
- Rsistance temperature detectors (RTD) (Joshi & More, 2012)
- IC temperature sensors (Levărdă & Budaciu, 2010)

With time thermocouples, thermistors, RTDs were replaced by IC temperature sensors like LM 35, SMT 160-30, and DS 1820 (Aneja *et al.*, 2011) . The mostly used temperature sensor IC's are:

2.9.1. SMT 160-30

Transducer SMT 160-30 is a compact temperature transmitter with output signal in pulse width form, suitable for computer processing (Akter *et al.*, 2012). Transducer has 3-pin package with 2 pins for voltage (5 V) and one pin for output signal. Measured temperature is given by:

$$T(w)/T(p) = 0.320 + 0.00470T \qquad (1)$$

T = measured temperature

T (w) = width of pulse

T (p) = period of output signal

2.9.2. LM35.

The LM35 is an integrated-circuit temperature devices with an output voltage linearly proportional to the Centigrade temperature. The LM35 device has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from the output to obtain convenient Centigrade scaling (Texas Instruments, 2016). Listed below are the features of the LM 35 temperature sensor (as identified by (Texas Instruments, 2016)):

- Calibrated Directly in Celsius (Centigrade)
- Linear + 10-mV/°C Scale Factor
- 0.5°C Ensured Accuracy (at 25°C)
- Rated for Full −55°C to 150°C Range
- Operates from 4 V to 30 V
- Less than 60-μA Current Drain
- Low Self-Heating, 0.08°C in Still Air
- Non-Linearity Only ±¼°C Typical
- Low-Impedance Output, 0.1 Ω for 1-mA Load

The sensor LM 35 can be combined with microcontrollers like PIC18F452, AT89S52 and PLCs (Aneja, *et al.*, 2011). In (Goswami *et al.*, 2009), an embedded system was for monitoring and controlling temperature and light using microcontroller AT89S52.

2.9.3. DS 1820.

Single circuit smart temperature sensor DS1820 converts temperature in number form and communicates with environment by the one-wire DALLAS bus (Doc. Dr. RNDr Listopadu, 2000). Circuit is made on 3 pin or 16-pin package. Sensor can be loaded by voltage through data bus. Final temperature is given by:

$$t = T - 0.25 + (N(j) - N(z))/N(j) \qquad (2)$$

t = final temperature

N (j) = number of oscillations corresponds to 1 degree centigrade

N (z) = number of oscillation cycle corresponds to zero

The table 2.4 gives a comparative analysis of the common temperature sensor ICs (Aneja *et al.*, 2011).

Table 2.2: Comparative Analysis (Source: Aneja, et al., 2011).

Temperature sensor	**Loading voltage variation**	**Temperature range**
SMT160-30	475-700 volts	(-45) – 130 degree Centigrade
LM35	4-30 volts	(-55) – 150 degree centigrade
DS1820	2.7-5.5 volts	(-55) – 127 degree centigrade

2.10. Humidity Sensor.

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.

DHT11 is a part of DHTXX series of Humidity sensors. The other sensor in this series is DHT22. Both these sensors are Relative Humidity (RH) Sensor. As a result, they will measure both the humidity and temperature. However, DHT11 Humidity Sensors are cheaper and slower than DHT22 Humidity sensors (ElectronicHub., 2017).

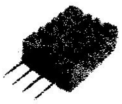


Figure 2.5: DHT11 Temperature - Humidity Sensor (Source: Amazon.com)

2.10.1. Description of DHT11 Humidity and Temperature Sensor.

The DHT11 Humidity and Temperature Sensor consists of 3 main components. A resistive type humidity sensor, an NTC (negative temperature coefficient) thermistor (to measure the temperature) and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal. This digital signal can be read by any microcontroller or microprocessor for further analysis.

DHT 11 can measure temperature within the range of 0-50 °C within an error of ± 2 °C; it can also measure humidity within the range of 20 – 90% RH with ± 5% RH error (ElectronicHub., 2017).

2.10.2. Pin Description

DHT11 Humidity Sensor consists of 4 pins: VCC, Data Out, Not Connected (NC) and GND. The range of voltage for VCC pin is 3.5V to 5.5V. A 5V supply would do fine. The data from the Data Out pin is a serial digital data (ElectronicHub., 2017).

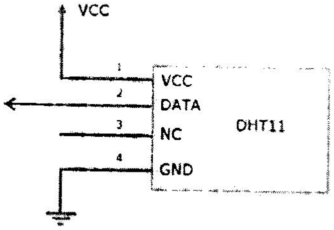


Figure 2.6: DHT11 block diagram (Source: ElectronicHub., 2017).

2.11. Related Works.

Industrial processes are critical in the advancement of technology. This process over time has been converted from manual controlling to automated controlling system. Physical process requires measurement and controlling of process variable involved in processing and controlling. Temperature, air flow, humidity, pressure etc. are some of the examples of process variables (Joshi & More, 2012) . However, the process of variable of concern is temperature.

Now, temperature control is a process in which change of temperature of a space (and objects collectively there within) is measured or otherwise detected, and the passage of heat energy into or out of the space is adjusted to achieve a desired average temperature (Aneja, *et al.*, 2011).

Nowadays, the demand for accurate temperature control and air ventilation control has conquered many of industrial domains such as process heat, alimentary industry, automotive, industrial spaces or office buildings where the air is cooled in order to maintain a comfortable environment for its occupants. One of the most important concerns involved in heat area is to achieve the desired temperature as well as optimization of consumption. This consequentially results in the need to develop suitable control strategies. (Levărdă & Budaciu, 2010).

"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 microcontroller 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 (Idachaba, 2010) microcontroller. 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)

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

The temperature controller (microcontroller or microprocessor) accepts a temperature sensor such as a thermocouple or RTD or LM35 sensor as input. It compares the measured temperature to the desired control temperature or set point and provides an output to a control element. (Latha *et al.*, 2013)

Dong-lin *et. al.* (2010) proposed a low cost silkworm house temperature and humidity automatic control system based on DHT11 sensor. It was based on the use of DHT11 digital temperature and humidity sensor and AT89C51 microcontroller.

Ying-mei & Jian-ping, (2011) worked on the design of temperature humidity wireless sensor network node based on DHT11 sensor. It has many advantages such as low power consumption, low cost, high integration, small size and stable operation.

In Tianlong (2010), single bus sensor DHT11 was applied in temperature-humidity measure and control system. 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.

A wireless solution, based on GSM networks for the monitoring and control of humidity in industries was developed using HSM-20G humidity sensor and ARM LPC2148 controller (Ramamurthy *et. al.*, 2010).

A review of several designs of control systems which implemented micro-controller and sensor is shown in the table below (Aneja *et al.*, 2011).

Table 2.3: System Analysis (Aneja et al., 2011).

S/N	REPRESENTATIVE	SETUP
1	Smart Temperature Sensors For Measurement And Control - Doc. Dr.RN, Dr. Katedra (1997)	Sensors SMT 160-30 and LM 35 with microcontroller PIC16C65A5
2	A Microcontroller Based Temperature Measurement Module For The LEP2SCRF Cavities - R. Brun, E. Ciapala, M. Pirotte(2005)	Sensor PT100 with microcontroller 80C52
3	Temperature Control System Using ANFIS - T. P. Mote, Dr. S. D. Lokhande (2012)	Sensor LM35 with microcontroller 89S52
4	Design Of An Embedded System For Monitoring And Controlling Temperature - Goswami, T. Bezboruah, K.C. Sarma (2009)	Sensor LM 35 with microcontroller AT89S52
5	Boiled Water Temperature Measurement System Using PIC Microcontroller - A.T. Karuppiah, Azha Periasamy, P. Rajkumar (2013)	Sensor LM 35 with microcontroller PIC18F452
6	Geothermal Power Plant Design Using PLC And SCADA - Aman Soni, Debashish Singh Deo (2013)	Sensor LM 35 with Omron PLC
7	Temperature Control Of Hot Plate Using Microcontroller Based PWM Technique - Tabinder Akter, Fazlul Huq, Farzana Alam (2012)	Sensor SMT 160-30 with microcontroller PIC16F877A
8	Monitoring Temperature Using A Microcontroller With High Level Language - Dogan Ibrahim (2004)	Sensor LM 35DG with controller PIC16F84
9	Real Time Cost Effective Temperature Controller - M.P. Joshi and More V.A (2012)	Sensors LM 35 and PT100 with controller 89C51RD2
10	The Design Of Temperature Control System Using PIC18F4620 - Bogdan Levarda, Cristina Budaciu (2010)	Sensor LM 335 with microcontroller PIC18F4620

CHAPTER THREE

MATERIALS AND METHODOLOGY

3.1. Overview of the Microcontroller-based Poultry temperature and humidity control system

The use of microcontroller for monitoring and controlling temperature have been implemented in several industrial domains. This project implements microcontroller and some other circuitries to measure, monitor and control the temperature and humidity of a poultry house. Figure 3.1 shows the block diagram for poultry temperature and humidity system.

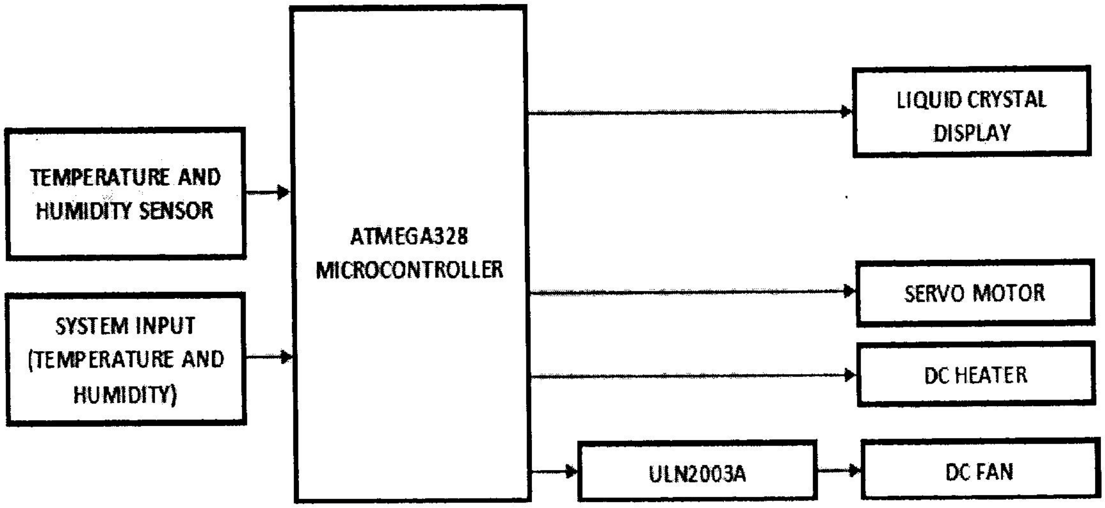


Figure 3.1: Block diagram of the poultry temperature monitoring and controlling circuit.

The inputs to the microcontroller is the temperature and humidity reading from the sensor (DHT11). The temperature and humidity of the poultry obtained from the DHT11 is displayed on the Liquid Crystal Display (LCD). The servomotor, fan and Heat Source are the components used to achieve temperature control for the poultry house. The temperature and humidity control mechanism is activated when either the measured temperature or humidity of the poultry is greater or lesser than the desired poultry temperature and humidity. The microcontroller implemented is the Atmega328/p. The block diagram for the poultry temperature monitoring and controlling system is shown in the Figure 3.1.

3.2. System Description.

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

3.3. Power Supply Section

This section is responsible for the supply power required for the operation of the whole system. The power supply unit was designed to step-down 220V AC mains supply to 12V AC, the primary voltage Vp is 220V while that of the secondary voltage is 12v. A rectification circuit is needed to convert the 12V output of the transformer into 12V DC. The rectification circuit used in the design is a full-wave bridge rectifier which comprises of four diodes. Figure 3.2 shows the bridge rectification circuit.

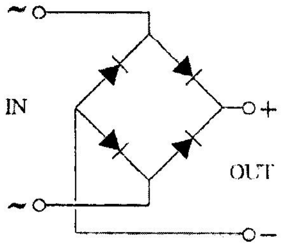


Figure 3.2: The Bridge Rectifier (EEtech, 2016).

The rectification circuit is connected to the output of the transformer which converts AC to DC voltage. Diodes configured as a bridge rectifier at the output of the transformer converts AC to DC voltage having a wave form shown in Figure 3.3.

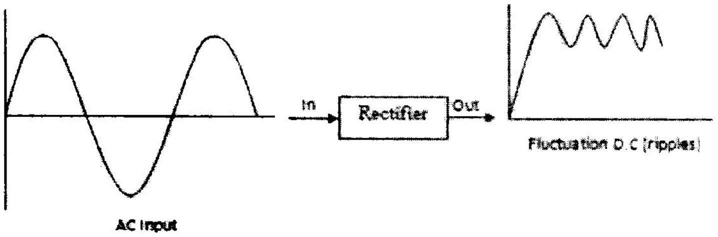


Figure 3.3: Rectification of AC to DC

Because of unidirectional DC, this is not suitable for driving some electronics devices, due to its fluctuations. At the output of the rectifier, a capacitor was introduced (a filtering capacitor) which regulates the fluctuation of the wave and filter off the ripples to give a linear supply, thereby giving a better wave form as shown in Figure 3.4.

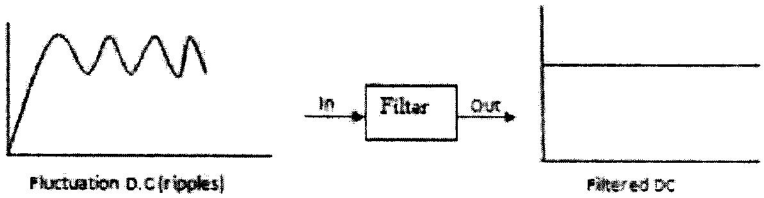


Figure 3.4: The Filtration Ripples D.C to Filtered D.C

The major components of the power circuit are discussed below.

3.3.1. Transformer

Transformer is an electrical device consisting of one coil of wire placed in close proximity to one or more other coils, used to couple two or more alternating-current (AC) circuits together by employing the induction between the coils (see Electricity). The coil connected to the power source (input) is called the primary coil, and the other coil (output) is known as secondary coil (Encarta, 2008).

They are classified according to their frequency of operation (power frequency, audio frequency, and radio frequency), mode of operation (voltage or current transformer). No matter the category of transformer the principle of operation remains the identical (Theraja, 2005). The transformer used in this project is 12V, 300mA Transformer. It was chosen because of the voltage required to charge the batteries and to power the heat source (i.e. the 100watts bulb) is 12V.

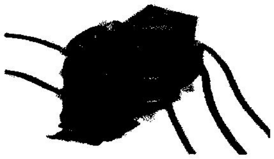


Figure 3.5: Transformer

3.3.2. Capacitor

Capacitor is an electrical component which stores charges temporarily and consists of two conducting surface separated by a layer of an insulating medium know as dielectric. It widely used in various range of application as part of electrical circuit in many electrical devices such as filter for smoothing the output of the rectifier. The capacitor use in this unit is 470µF, 25V capacitor. It was selected because the voltage value of the capacitor should not be less than two times output of the transformer.

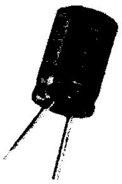


Figure 3.6: Electrostatic Capacitor.

3.3.3. Resistor

Resistor is an electrical components that opposes or resists the flow of electric current in a circuit. The resistance of a resistor is the ratio of the voltage across the resistor to the current flowing through the circuit. The relationship between apply voltage (V), resistance of the conductor (R) and current (I) across the circuit is represented below by ohms law. I=V/R where: V is the potential difference across the conductor (in volts); R is the resistance in ohms (Ω); and I is the current in amperes (Amp).

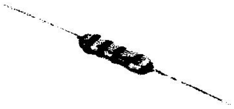


Figure 3.7: Typical axial-lead resistor.

3.3.4. Rectifier

Rectifier is a circuit which comprises of one or more diose and converts an alternating current to direct current, a process known as rectification. Rectifiers are used as components or power supply and as detectors of radio signals. Rectifiers may be a solid state diodes, vacuum tube diodes, mercury arc valves and other components. The rectification circuit used in the design is a full-wave bridge rectifier which comprises four diodes(Figure 3.2).

3.3.5. Voltage Regulator

It is any electrical or electronic device that maintains the voltage of a power source within acceptable limits. The voltage regulator is needed to keep voltages within the prescribed range that can be tolerated by the electrical equipment using the voltage. Electronic voltage regulators utilize solid-state semiconductor devices to smooth out variations in the flow of current (Britannica, 2017). The type of voltage regulator that was implemented for this project is LM317. It is an adjustable three-terminal positive-voltage regulator capable of supplying more than 1.5A over an output-voltage range of 1.25V to 37V.

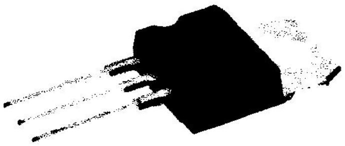


Figure 3.8: Voltage Regulator.

3.3.6. Battery

Battery is a device that converts stored chemical energy into valuable electrical energy. This part is responsible for the storage, supply of the required voltage and distribution of the voltages to several components. The batteries are charged using electric power from the output of the rectification circuit. Six rechargeable Lithium cells of about 3.7 – 4Volts each were used for this project. The overall volt supplied by these cells is 12Volts.

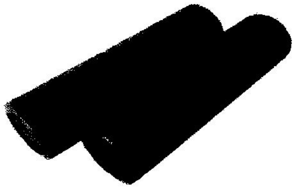


Figure 3.9: Rechargeable battery cells.

3.3.7. Relay and Relay Driver

A relay is an electrically operated switch. An electromechanical, solid-state, or digital device operated by variations in the input that, in turn, operate or control other devices connected to the output. Relays are usually used to isolate circuits or to use a low-power input to control higher-power input Current flowing though the coil of the relay creates a magnetci field which attracts a lever and changes the switch contacts. The coil current can be on or off so relays have two switch positions and they are double throw switches (BuildCircuit, 2017).

The relay's switch connections are usually labeled COM(POLE), NC and NO. COM/POLE - Common, NC and NO always connect to this, it is the moving part of the switch; NC - Normally Closed, COM/POLE is connected to this when the relay coil is cont magnetized; NO - Normally Open, COM/POLE is connected to this when the relay coil is connected to this when the relay is MAGNETIZED and vice versa (BuildCircuit, 2017). A relay is shown in Figure 3.10

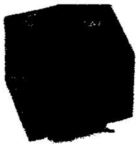
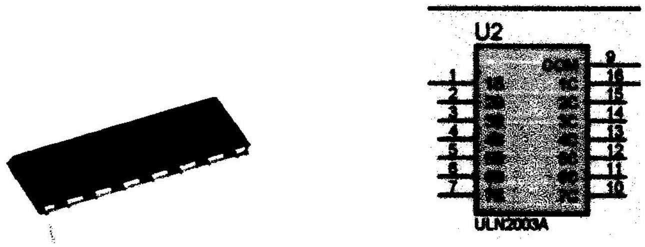


Figure 3.10: Relay.

A relay driver (Figure 3.11) can be powered by a 5V source and can control higher-power appliances. The relay driver implemented for this project is the ULN2003AN. The ULN2003 is known for its high-current, high-voltage capacity i.e. with low current and/or voltage in its input circuit, it can activate a larger current and/or voltage in the output circuit. Relay Driver main specifications:

- 500 mA rated collector current (single output)

- 50 V output (there is a version that supports 100 V output)
- Includes output flyback diodes
- Inputs compatible with TTL and 5-V CMOS logic



(a) (b)

Figure 3.11: (a) Relay Driver (b) Relay driver block diagram

As stated above, the fan is one of the temperature mechanisms implemented. However, 12V is required to power the fan whenever the temperature of the poultry room is high. The relay driver requires 5V to be operated. The 12V source is connected to the fan as well as to the relay driver, therefore, when the relay driver is activated, the fan is also activated.

3.4. Sensing Section

For the measurement of temperature and humidity of the poultry house, a DHT11 (figure 3.12) temperature-humidity sensor is being 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.

3.4.1. Description of DHT11 Humidity and Temperature Sensor.

The DHT11 Humidity and Temperature Sensor consists of 3 main components. A resistive type humidity sensor, an NTC (negative temperature coefficient) thermistor (to measure the temperature) and an 8-bit microcontroller, which converts the analog signals from both the sensors and sends out single digital signal. This digital signal can be read by any microcontroller or microprocessor for further analysis.

DHT11 Humidity Sensor consists of 4 pins (as depicted in Figure 3.10): VCC, Data Out, Not Connected (NC) and GND. The range of voltage for VCC pin is 3.5V to 5.5V. A 5V supply would do fine. The data from the Data Out pin is a serial digital data.

DHT 11 can measure temperature within the range of 0-50 °C within an error of ± 2 °C; it can also measure humidity within the range of 20 – 90% RH with ± 5% RH error.

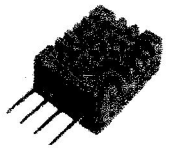


Figure 3.12: DHT11 Temperature-Humidity Sensor

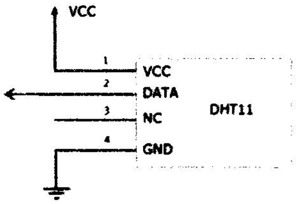


Figure 3.13: DHT11 Block Diagram

3.5. 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. The Figure 3.14 is a picture of the push buttons of the input section, each of which are used to select the desired temperature range.

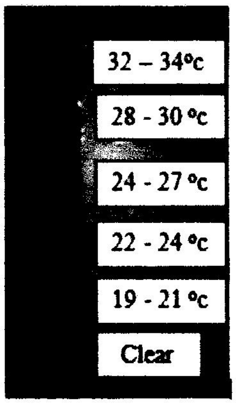


Figure 3.14: Temperature Input Buttons.

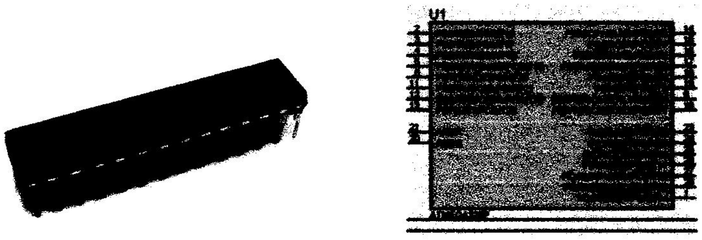
3.6. Controller Section

The controller is an important section of the system. The microcontroller used for this project is ATMEG-328P microcontroller. It is the data processing element of the system and it is responsible for the 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 to the control elements (fan, windows and Heat Source).

3.6.1. Atmega328P Description.

ATmega328/P is a low-power CMOS 8-bit microcontroller based on the AVR enhanced RISC architecture. It provides the following features: 32Kbytes of In-System Programmable Flash with Read-While-Write capabilities, 1Kbytes EEPROM, 2Kbytes SRAM, 23 general purpose I/O lines, 32 general purpose working registers, Real Time Counter (RTC), three flexible Timer/Counters with compare modes and PWM, 1 serial programmable USARTs , 1 byte-oriented 2-wire Serial Interface (I2C), a 6-channel 10-bit ADC (8 channels in TQFP and QFN/MLF packages) , a programmable Watchdog Timer with internal Oscillator, an SPI serial port, and six software selectable power saving modes. Operating Voltage range is 1.8 - 5.5V. Temperature Range is -40°C to 105°C.

The Atmega 328p Microcontroller and its block is shown in Figure 3.15.



(a) (b)

Figure 3.15: (a) ATMEGA 328p Microcontroller (b) ATMEGA 328p Block Diagram.

3.6.2. 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). Upon completion of the uploading process, the microcontroller was then detached from the Arduino board and placed unto the circuit board.

3.7. 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. It is shown in the Figure 3.16. 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) . In order for the LCD to display the measured temperature, it is interfaced with the microcontroller.

A 16x2 LCD means it can display 16 characters per line and there are 2 such lines. In this LCD each character is displayed in 5x7 pixel matrix. This LCD has two registers, namely, Command and Data. The command register stores the command instructions given to the LCD. A command is an instruction given to LCD to do a predefined task like initializing it, clearing its screen, setting the cursor position, controlling display etc. The data register stores the data to be displayed on the LCD (Xiamen, 2008). The data is the ASCII value of the character to be displayed on the LCD.

Figure 3.16: Liquid Crystal Displays.

3.7.1. LCD Pin Description

The Table 3.1 gives the description of the pins of the Liquid Crystal Display (LCD)

Table 3.1: LCD Pin Description

Pin No.	**Function**	**Name**
1	Ground (0V)	Ground
2	Supply voltage; 5V (4.7V – 5.3V)	V_{CC}
3	Contrast adjustment; through a variable resistor such as a potentiometer.	V_{EE}
4	Selects command register when low; and data register when high	RS (Register Select)
5	Low to write to the register; High to read from the register	Read/write
6	Sends data to data pins when a high to low pulse is given	Enable
7	8- bit data pins	DB0
8		DB1
9		DB2
10		DB3
11		DB4
12		DB5
13		DB6
14		DB7
15	Backlight Vcc (5V)	Led +
16	Backlight Ground (0V)	Led -

3.8. Temperature and Humidity Control 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. This is such that when the temperature and humidity measured by the DHT11 is not within the required temperature and humidity range, necessary mechanism for controlling the temperature and humidity is implemented. There are three (3) temperature and humidity control mechanism implemented:

i. Automated opening of the windows of the poultry room
ii. The use of DC Fan.
iii. The use of a Heat Source

3.8.1. Automated control of the windows of the poultry room.

This is achieved through the use of servomotor. A servomotor is a rotary actuator or linear actuator that allows for precise control of angular or linear position, velocity and acceleration (Wikipedia, 2017). The servomotor (Figure 3.17) is connected to the windows and therefore controls the opening of the window. Therefore, when the temperature of the poultry is high, the microcontroller sends control signal to the servomotor, which in turn opens the window. Two servomotors were implemented in this project to control two windows.

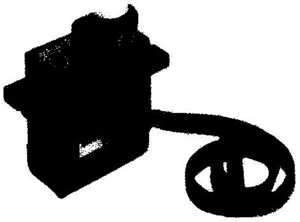


Figure 3.17: Servomotor.

3.8.2. The use of a 12V DC fan.

The second control mechanism implemented makes use of a DC fan (figure 3.18). This is important because it helps to expel warm air from the room, therefore providing a cool atmosphere for the poultry house. The figure shown below is fan implemented for the design.

Figure 3.18: DC Fan.

3.8.3. Heat Source

An electric bulb (Figure 3.19) was used as a source heat in order to heat the air in a room or system. This is important because it helps to provide warmth for the poultry house whenever the room temperature is low.

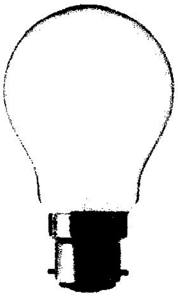


Figure 3.19: An 100 watts Electric Bulb.

3.9. Circuit Design

The overall circuit design for the monitoring and control of the temperature of the poultry house is shown in figure 3.20.

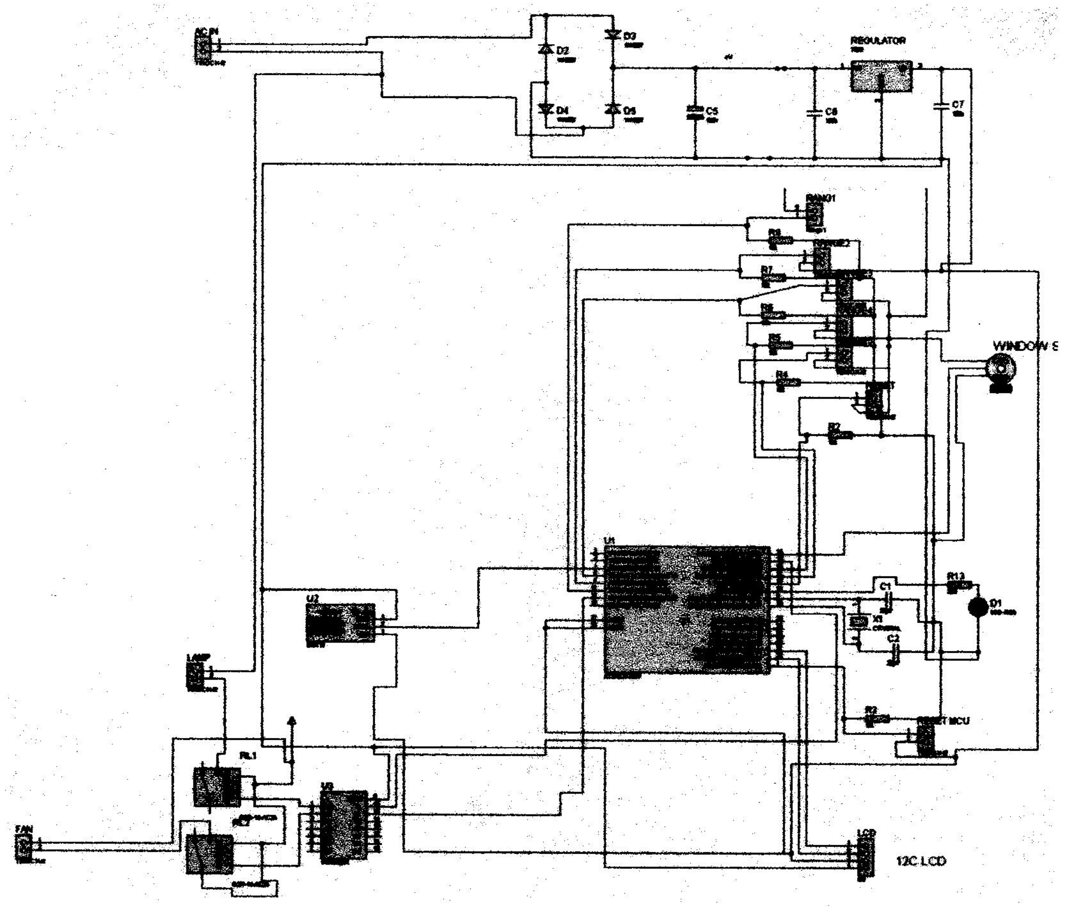


Figure 3.20: Circuit Design of the system.

3.10. System Operation Principle

The microcontroller is interfaced to DHT11 Temperature-Humidity sensor, liquid crystal display, Servo motor, Heat Source and Fan. Once the system switches ON (activated), 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. This is done by the pressing button which corresponds to the age of the poultry birds. The temperature range (shown in Table 3.2) was designed based on the age of the poultry birds.

Table 3.2: Recommended Temperature for broilers.

Age	Optimum Temperature (^{0}C)	Adopted Temperature Range
Day 0 – 2	32-34	32 – 34
1st week decrease	30	28 – 30
2nd week decrease	26	24 – 27
3rd week decrease	22	22 – 24
4th week decrease	20	19 – 21

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 activated. The Table 3.3 gives the conditions necessary for different control actions.

Table 3.3: 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.

3.11. Design Algorithm and Flow Chart.

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.

The flowchart of the system function is shown in Figure 3.21.

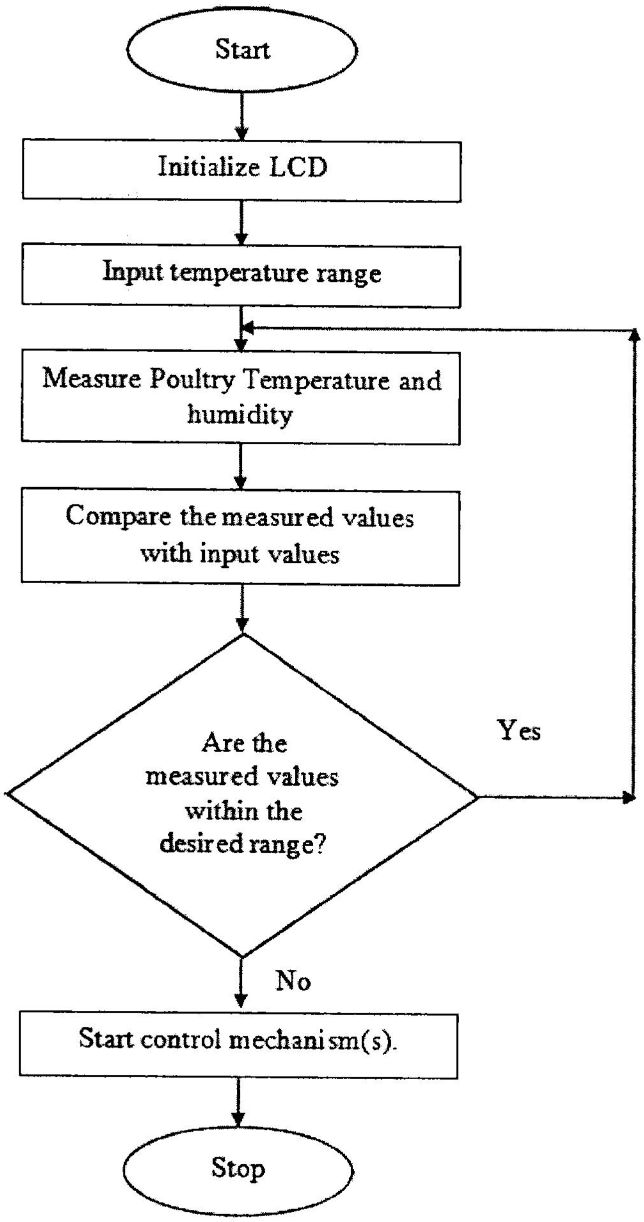


Figure 3.21: Flowchart for monitoring and controlling poultry temperature and humidity.

3.12. Modelling of the Poultry House

The 3D-design model of the developed system is shown in the Figure 3.22. It is a representation of the poultry house into which the temperature-humidity control circuit would be incorporated.

The two servomotors are connected to the two windows of the poultry house. This is to control the opening and the closing of the windows. Also, the fan is affixed to the wall of the poultry house. Therefore, whenever the temperature and humidity of the poultry house is not within the desired range, the control mechanism is activated.

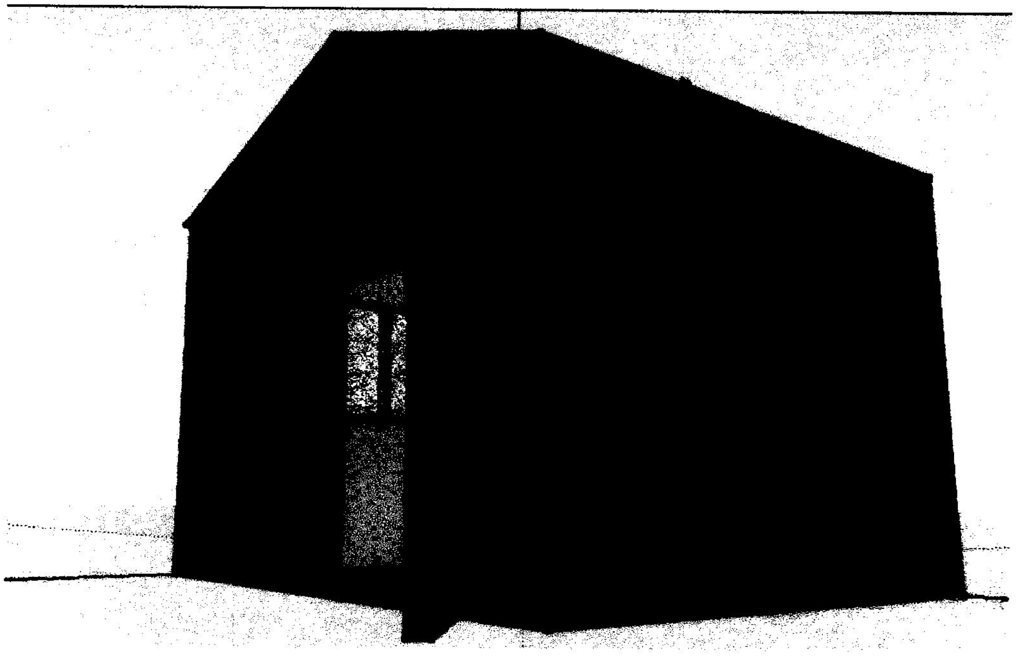


Figure 3.22: 3D Design of the poultry house.

CHAPTER FOUR

IMPLEMENTATION AND RESULTS

This Chapter primarily discusses the project design and simulation; design implementation and construction; and the evaluation of the performance of the developed system.

4.1. Circuit Simulation Result

The circuit was initially 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 3.19 shows the complete circuit diagram which was adhered to in the design of the hardware.

After completing the circuit design, it was simulated. However, before circuit simulation can be performed, the program code needs to be incorporated into the circuit design. Hence, the program code was infused, which was proceeded by the circuit simulation. The Figure 4.1 shows the snapshot of some parts of the simulation process.

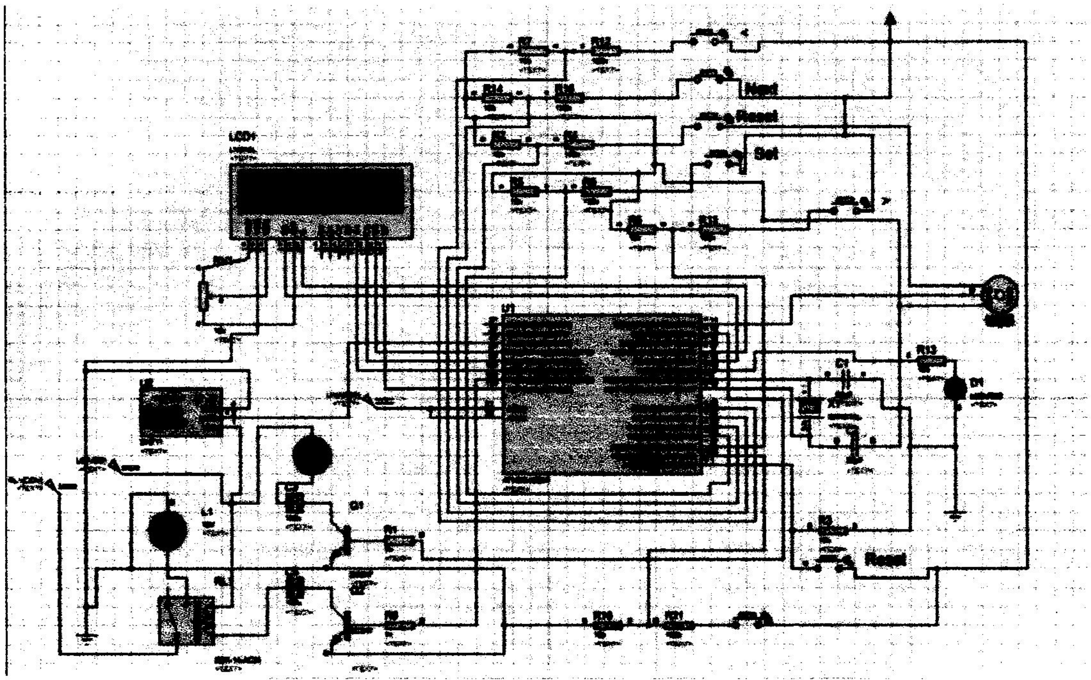


Figure 4.1: Circuit design simulation result.

4.2. System Design Implemention and Construction.

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. Firstly, all components that used were individually tested to determine whether or not they are properly functioning. Secondly, the controller used was connected with all the required components. A line Vero-board was used for the construction of the controller circuit. Every connection made on the board was properly checked for continuity with the aid of digital millimetre; and every continuous track that needs to be discontinued was properly ensured. Thirdly, the power circuit was also constructed on a line Vero-board and the connections were properly checked. Finally, the power circuit was interfaced with the microcontroller circuit. The overall circuit (i.e. the power circuit and the microcontroller circuit) was properly tested. Every point where two or more wires were connected was properly insulated. The completely constructed system is shown in Figure 4.2.

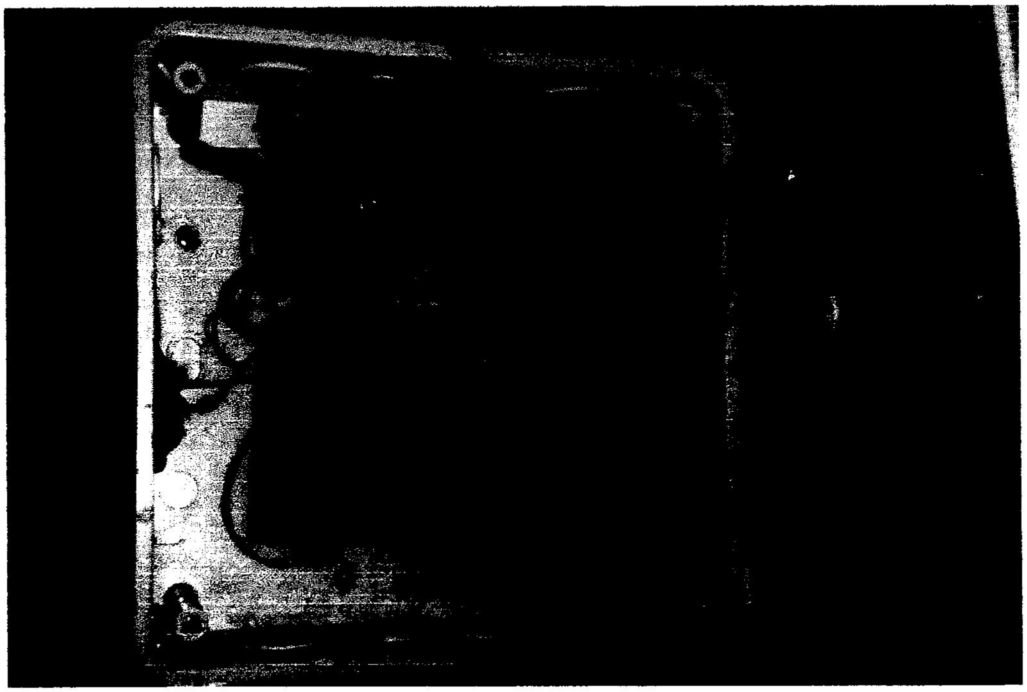


Figure 4.2: Complete Controller and Power circuit.

4.3. Project Coupling

The whole system was properly constructed and also connected with the temperature-humidity control components (Servos, fans, electric bulb). It was properly tested and examined to confirm its correct operability. After confirming the system is operating properly, it was then incorporated in a prototype of a poultry house as shown in Figure 4.3.

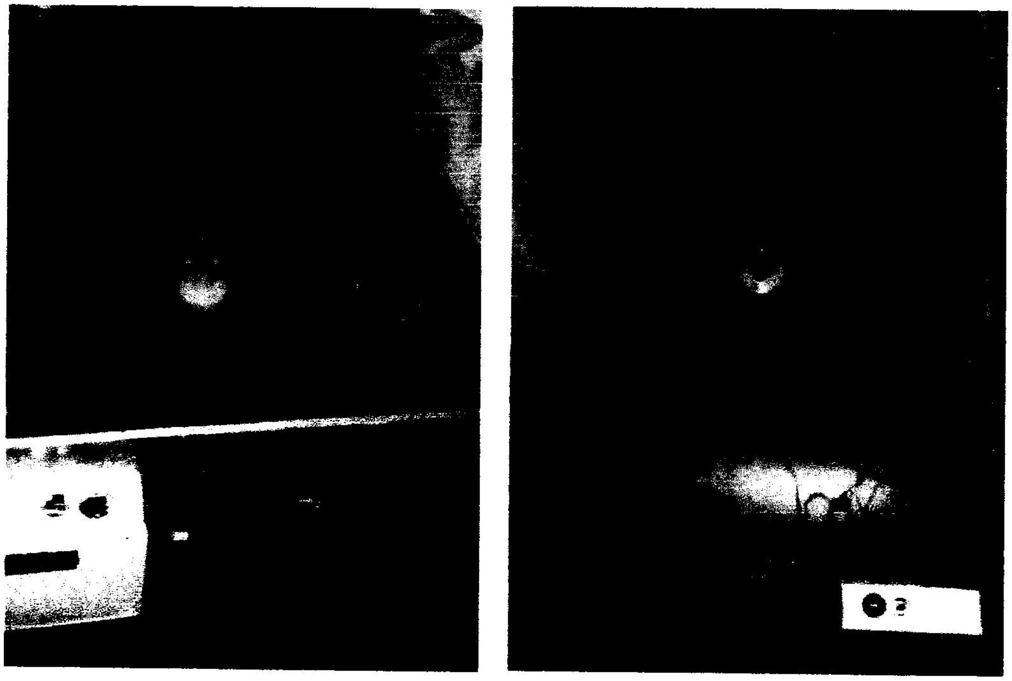


Figure 4.3: The prototype of the microcontroller based system for poultry Temperature-Humidity regulation

4.4. Testing and Results

After the developed system has been incorporated into the poultry house prototype, some tests were carried out. These tests include Hardware tests, Power Source test and Temperature-Humdity control tests.

4.4.1. Hardware Testing

In the hardware testing, several sections of the developed system were tested in order to ensure that every component is in good working condition. The result of the hardware tests show that all the system components are appropriately.

4.4.2. Power Source Testing

The source of power to the system needs to be properly tested, because any wrong connections can damage the system. The outcome of the test shows that the voltage required by the individual components were appropriately supplied. The presence of power source to the system is indicated by a white light from the LED as shown in Figure 4.4(a). Also, the amber-coloured glow from the LED (shown in Figure 4.4(b)) denotes that system is ON. Finally, the light-blue glow from the LED (shown in Figure 4.5) indicates that the heat source is on

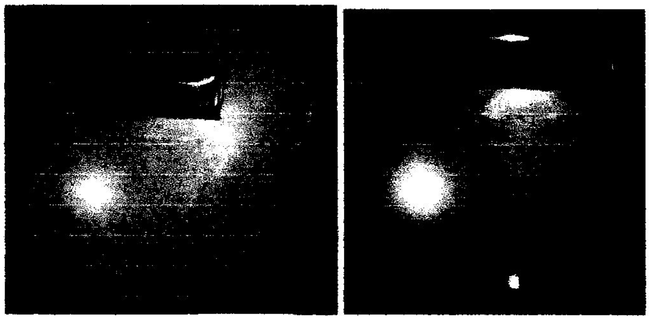

(a) (b)

Figure 4.4: (a) Power Source (b) System Power-On Indicator

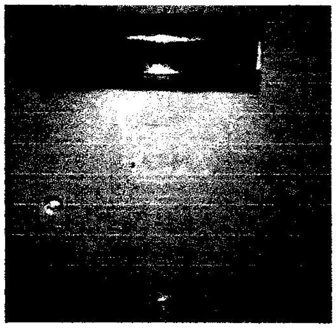


Figure 4.5: Heat Source Indicator.

4.4.3. System operation Testing

System operation test was carried out in order to verify the operation of the system of the developed system. Firstly, the system has to be switched ON, and then the controller carries out all the necessary initialization processes. 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. This is done by the pressing button which corresponds to the age of the poultry birds. The temperature range (shown in Table 3.2) was designed based on the age of the poultry birds. After the desired temperature range has been selected, the system continuously gets the instantaneous values of the temperature and humidity and compares these values to the desired temperature and humidity values. Hence, whenever the instantaneous values of temperature and humidity are not within the desired range, the control mechanism(s) would be initiated. The Table 3.3 shows the different conditions that initiate the temperature and humidity control mechanism.

4.4. Performance Observations

The performance of the developed system was observed using five (5) five-week old chicks (Figure 4.6) and the following observations were noted:

I. 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.

II. The chicks' behaviour was observed to be normal i.e. their feeding rate as well as their movement within the system.

III. The system was observed to have maintained the desired temperature and humidity range by the continuous operations of the control mechanisms.

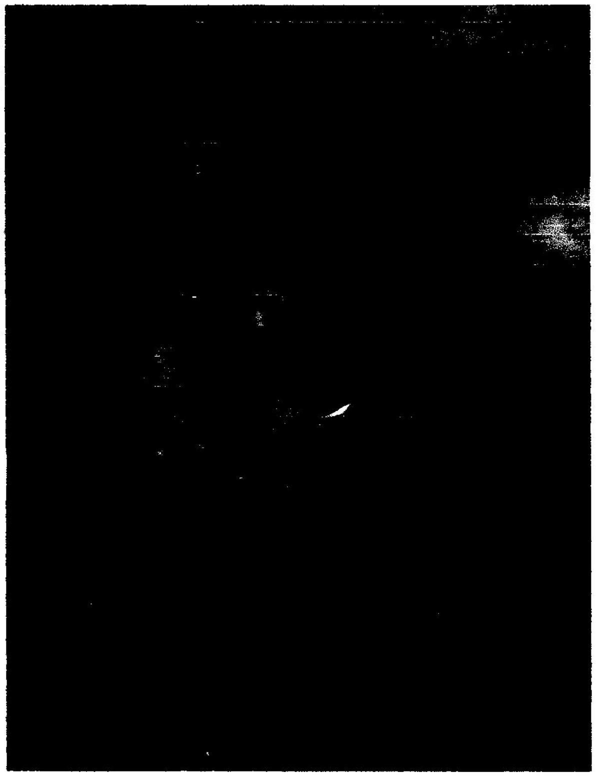


Figure 4.6: Five five-week old chicks used for testing the performance of developed system.

CHAPTER FIVE

CONCLUSION

5.1. Conclusion

In this project, a Microcontroller-based temperature and humidity measuring and control system which was implemented in a poultry farm was designed and developed.

The DHT11 temperature-humidity sensor is used to sense and measure the temperature and humidity of the poultry house, and it is then controlled using a microcontroller. The microcontroller will get the temperature 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 by the use of some control mechanisms such as: fan, 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.

5.2. Recommendations

Although the aim of this project was achieved, however, some improvements are recommended. These include:

1. The project can be more efficient if, in addition to measuring the temperature and humidity within the poultry house, the environmental (outside the poultry) temperature and humidity can also be measured. These values obtained can be compared and used to make better decision in order to achieved optimum control for the poultry house.

2. Batteries of higher capacity (as opposed to 12V lithium battery) can be used for increased power supply.

3. Also, rechargeable batteries can be augmented by making use of a solar power supply. This would ensure the continuous and steady operation of the system regardless of availability of electricity.

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APPENDIX

APPENDIX A: Bill of Engineering Measurement and Evaluation

S/N	Component Name	Quantity	Unit Price (₦)	Price (₦)
1	Servo-Motor	2	675.00	1,350.00
2	DC Fan	1	400.00	400.00
3	Bulb	1	100.00	100.00
4	Lamp Holder	1	200.00	200.00
5	Voltage Regulator	1	150.00	150.00
6	Transformer	1	550.00	55.00
7	Relay Driver	1	100.00	100.00
8	Relay	1	300.00	300.00
9	Rechargeable Lithium batteries	6	550.00	3300.00
10	Microcontroller	1	1,500.00	1,500.00
11	Oscillator	1	200.00	200.00
12	Liquid Crystal Display	1	700.00	700.00
13	DHT11 Sensor	1	250.00	250.00
14	Push Button	7	20.00	140.00
15	Circuit Box	1	1,300.00	1,300.00
16	Switch	1	70.00	70.00
17	Vero-board	1	200.00	200.00
18	LEDs	3	50.00	150.00
19	Miscellaneous		10,000.00	7,000.00
			TOTAL	**20,475.00**

APPENDIX B: System Operation Guide

1. Put on the system by pushing the power switch to the ON position

2. Wait for a while for the completion of the initialization process. When the initialization process is complete, the LCD displays 'Enter temp range'

3. In order to select the temperature required, press the button that corresponds to the age of the chicks

4. After the temperature range has been provided (by pressing the button), the system begins the temperature-humidity measurement and control process.

5. In case a wrong tempearture range was selected, or in order to change to another temperature range, wait till the LCD displays 'Refreshing', and while the refreshing process is on-going, press the clear buton for about ten (10) seconds. After waiting for about ten (10) seconds, the LCD display 'Enter temp range'. This allows user to re-enter the temperature range.

6. In order to put off the system, push the power switch to the OFF position.

7. In order to charge the system, connect the power cable to an AC power source.