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Research Article

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Development of a Computerized Engineering Technique to Improve Incubation System in Poultry Farms

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Abstract Egg incubation is a technology that provides opportunity for farmers to produce chicks from egg without the consent of the mother hen using engineering techniques. Modern day incubators need accurate and precise temperature monitoring for optimal performance and output. The operating temperature range of conventional incubators lies within 92 °F-102 °F (37 °C–39 °C). Hence, the work presented here involves the design of a Microcontroller based proved Incubator System with a preset temperature, which is capable of continuously monitoring and maintaining the operating preset temperature using an automatic switching technique. The incubator system contains temperature sensors that can measure the condition of the incubator and automatically change to the suitable condition for the egg. The health of egg is very important for the development of embryo within the egg. Improper control means that the temperature or humidity is too high or too low. In this project, the light heater is use to give the suitable temperature to the egg. The status condition in the incubator system will appear on the LCD screen display. To make sure all part of egg was heated by lamp, DC motor is very useful to rotate egg-roller at the bottom side and automatically change the position of egg. The entire element will be controlled using AT89S52 Microcontroller. The AT89S52 is a type of microcontroller that can process a data from sensor and will execute the control element to change the condition of the incubator system. This project is user friendly product since the incubator system can be move to other place.

Keywords Incubator, Temperature, Microprocessor, ADC, LCD, etc

1. Introduction

In this present age of information technology, the control and automation of devices, machines and systems are mostly achieved through mechatronic with emphasis on soft control.

Egg incubator is a technology that provides opportunity for farmers to produce chicks from egg without the consent of the mother hen, is also a machine used to transform eggs into chicks. The most important difference between natural and artificial incubation is the fact that the natural parent provides warmth by contact rather than surrounding the egg with warm air.

Incubation of eggs will show you the effects of heat, air, and moisture on hatchability. You will find out how an egg is formed, what its different parts and their functions, and how a chick embryo develops. The incubation of eggs by artificial means can be achieved by the use of programmed microcontrollers. The research work is is geared towards the design of a microcontroller based egg incubator with temperature value display. The electronic system is designed using an AT89S52 microcontroller and real time software written in assembly language.

The Microcontroller based improved Incubator System is an effective artificial intelligence algorithm with temperature sensor to measure the current temperature in the incubator, then, the temperature is regulated at the specific temperature using the microcontroller. A buzzer and a red bulb are used to alert the user on the system error if the temperature in the incubator is below or exceed the specified temperatures.

The improved Incubator System will constantly monitor and maintain the temperature in the incubator to ensure it remains at the preset temperature. The monitoring system uses a temperature sensor to read the temperature in the incubator. The sensor provides an input to the microcontroller to compares the measured values with the preset values. The microcontroller will control the operating of light bulb and DC motor. Table 1.1 shows the time taken and the suitable temperature for hatching different types of eggs.

Table 1.1: Time taken and the suitable temperature for hatching different types of eggs

Condition of Incubation for Various Egg Types				
Species	**Incubation Period**	**Temperature (°F)**	**Temperature (°C)**	**Humidity (°F)2**
Chicken	21	100	37.8	85-87
Duck	28	100	37.8	85-86
Turkey	28	99	37.2	84-86
Goose	28-34	99	37.2	86-88
Pigeon	17	100	37.8	84-86
Guinea Fowl	28	100	37.8	85-87
Pheasant	23-28	100	37.8	86-88
Quail	17	100	37.8	84-87
Muscovy Duck	35-37	100	37.8	85-86

1.1. Problem Statement

Population of most countries of the world are increasing in Geometric Progression whereas, food supply are increasing in Arithmetic Progression. Most existing incubators are not able to incubate various types of egg at different temperature. Again, Mortality rate and low productivity in the poultry farming is very high due to the traditional hatching method. There is therefore the need to transform the traditional farming methods to advance and modern farming methods which is the basis for this research.

1.2. Objective

The main of objective of this research is design and construct a microcontroller based improved Incubator system with preset temperature control for incubation of various egg types. The following research activities were carried out to achieve the main objective:

- To design a microcontroller based incubator with preset temperature control that will be able to incubate various types of egg.
- To simulate the design with Proteus Application and Bread board
- To construct the simulated project

2. Literature Survey

2.1. Embryonic Development

Embryonic development is a continuous process that can roughly be divided into three different phases. They are differentiation, growth and the maturation. Typically, differentiation of organs occurs in the first days of incubation. The growth and the maturation of the organs occur in the later phases of development. Each of these phases requires specific incubator conditions. As the embryo grows, its metabolic rate increases and this is accompanied by increased heat production. Consequently, the natural pattern of the embryo and eggshell temperature shows an increase towards the end of incubation. In the incubator we must differentiate between the temperature set point at which the incubator operates and the temperature of the air at the level of the eggs, which determines the temperature of the egg and embryo.

At the start of incubation the embryo produces little heat and eggs must be warmed. This means that the air temperature must be higher than the egg temperature. As the embryo grows, metabolic heat production increases, the air surrounding the eggs must be cooled such that heat is removed from the eggs by so doing overheating can be prevented [1].

2.2. Microcontroller

The microcontroller is an entire computer on a single chip. The advantage of designing around microcontroller is that a large amount of electronics needed for certain applications can be eliminated. This makes it the ideal device for use with large system and other applications where computing power is needed. The AT89S52 microcontroller unit (MCU) is a 40-pin and 44-pin packages. The special feature of microcontroller is that, it can be used until 100,000 erase/write cycle using enhanced flash program memory and can also be used to 1,000,000 erase/write cycle data EEPROM memory typical. Self-reprogrammable under software control single-supply 5V In-Circuit Serial Programming, Watchdog Timer (WDT) with its own on-chip RC oscillator for reliable operation, programmable code protection, Power saving Sleep mode, Selectable oscillator options, In-Circuit Debug (ICD) via two pins can be done for the microcontroller.

The microcontroller is popular because the chip can be programmed easily to perform different functions and is not expensive. The microcontroller contains all the basic components that make up a computer. It contain a central processing unit (CPU), read-only memory, random-access memory (RAM), arithmetic logic unit, input and output lines, timers, serial and parallel ports, digital-to-analog converter, and analog-to-digital converters. There many kind of microcontroller in market such as Motorola, PIC, Basic Stamp and etc. Intel Corporation presented an 8 bits Microcontroller called the 8051 [2]. But, in this project, the AT89S52 is chosen because of the functionality, lower in cost, robustness, easy to program and troubleshoot.

The AT89S52 is a low-power, high-performance CMOS 8-bit microcontroller with 8Kbytes of in-system programmable Flash memory. The device is manufactured using Atmel's high-density nonvolatile memory technology and is compatible with the industry-standard 80C51 instruction set and pin out. Currently of the leading 8-bit microcontrollers, the 8051 family has the largest number of diversified suppliers [3]. The on-chip Flash allows the program memory to be reprogrammed in-system or by a conventional nonvolatile memory programmer. By combining a versatile 8-bit CPU with in-system programmable Flash on a monolithic chip, the Atmel AT89S52 is a powerful microcontroller which provides a highly-flexible and cost-effective solution to many embedded control applications.

In addition, the AT89S52 is designed with static logic for operation down to zero frequency and supports two software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, serial port, and interrupt system to continue functioning. The Power-down mode saves the RAM contents but freezes the oscillator, disabling all other chip functions until the next interrupt or hardware reset.

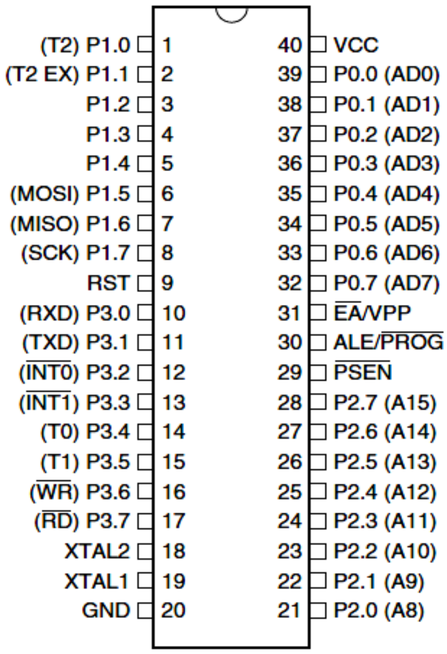

Figure 2.1: AT89S52 pin configuration

2.3 Analog-to-Digital Converter (A/D) Module

Analog-to-Digital converter converts a physical quantity (usually voltage) to a digital numeric values that characterizes the quantity's amplitude [4]. ADC (Analog to Digital Converter) module is available with a number of Atmel MCU models. The Analog-to-Digital (A/D) Converter module has five inputs for the 28-pin devices and eight for the 40/44-pin devices. The conversion of an analog input signal results in a corresponding 10-bit digital number. The A/D module has high and low voltage reference input that is software selectable to some combination of VDD, VSS, RA2 or RA3.

The A/D converter has a unique feature of being able to operate while the device is in Sleep mode. To operate in Sleep, the A/D clock must be derived from the A/D's internal RC oscillator. The A/D module has four registers. These registers are:

- A/D Result High Register (ADRESH)
- A/D Result Low Register (ADRESL)
- A/D Control Register 0 (ADCON0)
- A/D Control Register 1 (ADCON1)

ADC0804 is an 8 bit successive approximation analogue to digital converter from National semiconductors. The features of ADC0804 are differential analogue voltage inputs, 0-5V input voltage range, no zero adjustment, built in clock generator, reference voltage can be externally adjusted to convert smaller analogue voltage span to 8 bit resolution etc.

The voltage at Vref/2 (pin9) of ADC0804 can be externally adjusted to convert smaller input voltage spans to full 8 bit resolution. Vref/2 (pin9) left open means input voltage span is 0-5V and step size is 5/255=19.6V

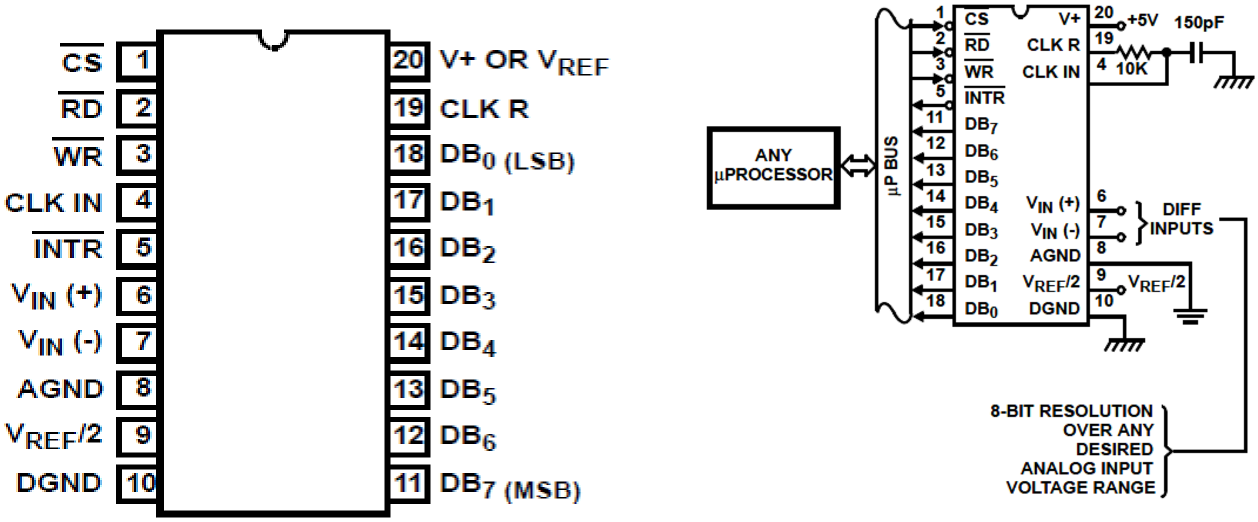

Figure 2.2: Pin Configuration of ADC0804

3. Materials and Methods

3.1. Materials

The following materials were used for the construction of this project.

3.1.1. Hardwood: Wood is chosen for the incubator casing because it is a readily available natural insulation material, cheap and has allow thermal conductivity of $0.13Wm^{-1}K^{-1}$. Like most natural insulation materials, it is breathable

3.1.2. Nails and Top Bond Glue: These are used to fasten the partitions of the incubator together in order to form a box.

3.1.3. LM35 Temperature Sensor: This sensor is used to measure the surrounding temperature and then send the measured values to the microcontroller. LM35 was chosen because its voltage output is linearly proportional to the Celsius (Centigrade) temperature. It has wide temperature range and low power dissipation. The reasons why I use LM35 to measure the Temperature are:

- It can measure temperature more accurately than a using a thermistor.
- The sensor circuitry is sealed and not subject to oxidation.

- The LM35 generates a higher output voltage than thermocouples and may not require that the output voltage be amplified.

The following features also made it possible for the choice of this sensor:

- Calibrated directly in ° Celsius (Centigrade)
- Linear + 10.0 mV/°C scale factor
- 0.5°C accuracy guarantee able (at +25°C)
- Rated for full −55° to +150°C range
- Suitable for remote applications
- Low cost due to wafer-level trimming
- Operates from 4 to 30 volts
- Less than 60 µA current drain
- Low self-heating, 0.08°C in still air

3.1.4. Relay–5 Volts: The relay is used for switching the incandescent lamp to a 230 V supply and a circulating fan to a 12 V supply.

3.1.5. Transistor: The 2N2222 transistor is an NPN Transistor. The 2N2222 transistor is a general-purpose transistor. It is used in general-purpose of switching and amplification.

3.1.6. ADC0804: ADC0804 is an 8 bit successive approximation analogue to digital converter from National semiconductors. It is to convert the analogue temperature values from temperature sensor LM35 to digital values. ADC0804 was chosen based on the following features: differential analogue voltage inputs, 0-5V input voltage range, no zero adjustment, built in clock generator, reference voltage can be externally adjusted to convert smaller analogue voltage span to 8 bit resolution etc.

3.1.7. Cooling Fan: It is used for the purpose of cooling the chamber when the temperature exceeds the required temperature.

3.1.8. Light Bulb: This device is needed to provide artificial heat when the temperature of the incubator is below the specified temperature. This module includes a relay to switch the light-bulb on and off, and a transistor to power the relay. A diode is used to prevent the Microcontroller from getting damaged by current flowing back into it. The rating the light bulb is 60W and it was chosen because it heats up faster than other heating elements.

3.1.9. Microcontroller: The microcontroller controls, schedule and directs all the activities and behaviors of this design based on the control program written for it. The following basic criteria were considered in selecting a microcontroller for the system: Ability to handle the task at hand efficiently and cost effectiveness; Maximum operating speed the microcontroller can support:low Power consumption; the timer on the chip and the number of I/O pins and the easy of developing products around the chip. AT89S52 was chosen for this work because it is a low-power, high-performance CMOS 8-bit microcontroller with 8K bytes of in-system programmable Flash memory.

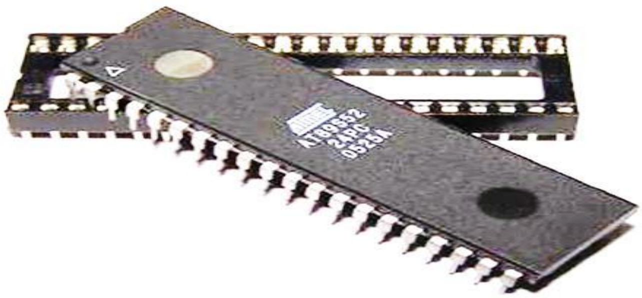

Figure 3.1: AT89S52 Microcontroller

3.1.10. LCD (Liquid Crystal Display): LCD is an electronic display system. A 16x2 LCD display is a very basic system and commonly used in various devices and circuits. A 16x2 LCD means it can display 16 characters per line and 2 such lines are there. In this LCD every character is displayed in 5x7 pixel matrix.

LCD's are preferred over seven segments and other multi segment LEDs. The advantages of LCD's are as follows:

- LCDs are economical.
- They are easily programmable.
- A number of characters can be displayed.
- Very compact and light.
- Low power consumption

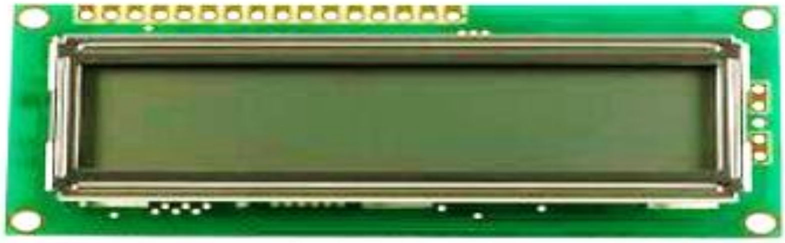

Figure 3.2: LCD Display

3.1.11. Voltage Regulator: LM7805 voltage Regulator was chosen to lower the voltage of the power supply from 12V to 5V in order to supply to the Microcontroller, ADC0804, LM35 temperature sensor and LCD.

3.2. Methods

The method employed in the development of this project consists of three parts namely: Mechanical, software and Electronic (Hardware).The project flow chart is shown below:

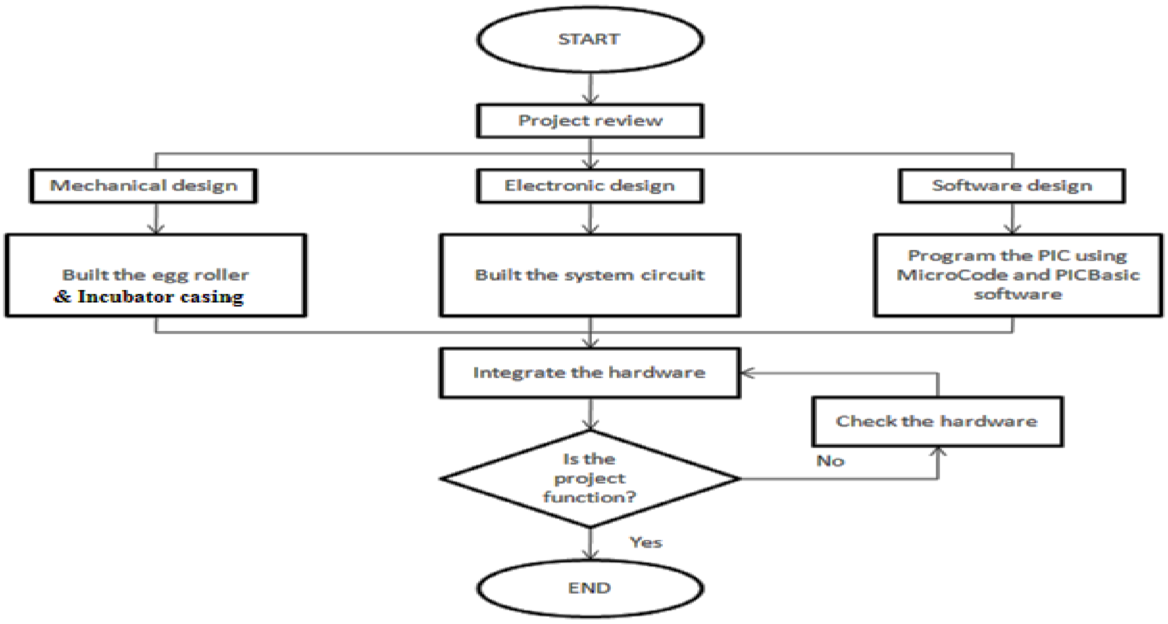

Figure 3.3: Project Development Flow Chart

3.3. Mechanical Design

The project development was started with the mechanical design. It is consists the development of incubator casing and built an egg roller.

3.4. Software Design

In order to enable the microcontroller perform the appropriate and specified control functions, a software that models the system operation is designed and implemented with respect to the flow chart shown below:

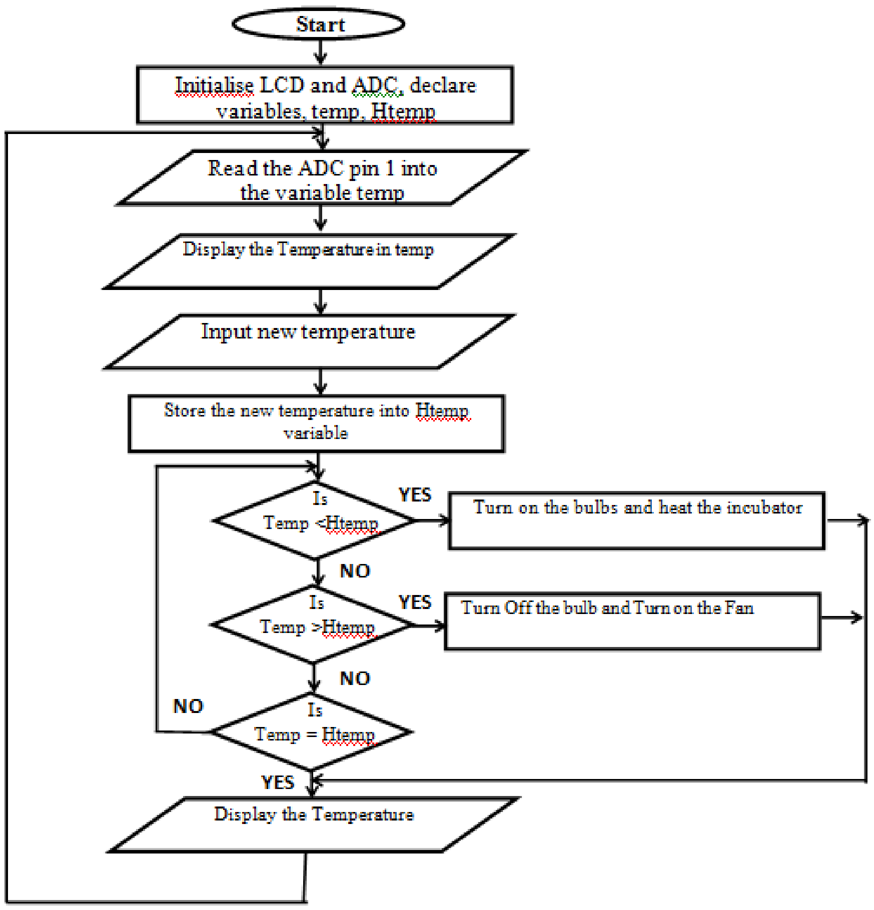

Figure 3.4: software Design flow chart

The source codes were developed in assembly language. The program is assembled using the ASM51 assembler to translate the source code into object code. The microcontroller based egg incubator displays numerically the change in temperature, however, when a temperature value is set from the keypad, the control program causes the relay to switch ON the power until the set temperature is attained and then hatching starts. After which the reset button is operated to reinitialize the system for the next reading.

3.5. Hardware Design

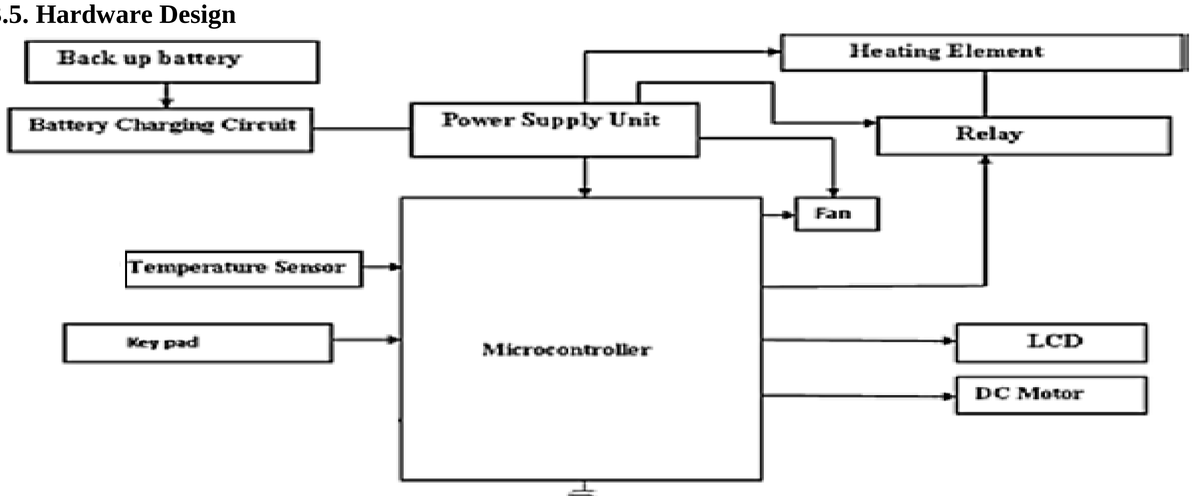

Figure 3.5: Block diagram of hardware design

Block diagram in figure 3.8 shows the connection of all part of the system. They consist of input, CPU and output. The inputs of the system are keypad, temperature sensor and power supply. The AT89S52 will operate as a CPU which is the main controlling system. For the output element consist of LCD screen display, DC motor, fan and lamp.

The Hardware Circuit of the microcontroller based improved egg incubator with preset temperature is designed in seven units. The units are connected together to derive the functional hardware. At the input is a temperature sensor LM35; a linear temperature sensor from national semiconductor. This particular unit senses the heat from the incubator chamber. The second unit is the Keypad which enables the user to enter the required temperature for egg hatching. The data from this unit is fed into Port 0 of the AT89S52 Microcontroller. The Third unit is the ADC 0804; this unit is the analog to digital converter (A/D) that converts analog signal to digital 8-bit parallel output. This data is fed into port 1 and2 respectively of the AT89S52 microcontroller. The fourth unit is the AT89S52 micro-controller designed to perform the micro-program control. The fifth unit is a transistor static switch realized with three (3) NPN bipolar junction transistors; one 2N2222 and two B458. These three transistors are used to switch the relay, Fan and DC Motor. The sixth unit is the interface card realized with the combination of a transistor switch and an electromagnetic relay. Here the heater is connected as an external device through a 13-amps socket outlet. The final and the sixth unit is the digital temperature display configured with 16x2 character LCD display with HD44780U dot-matrix liquid crystal display driver and controller.

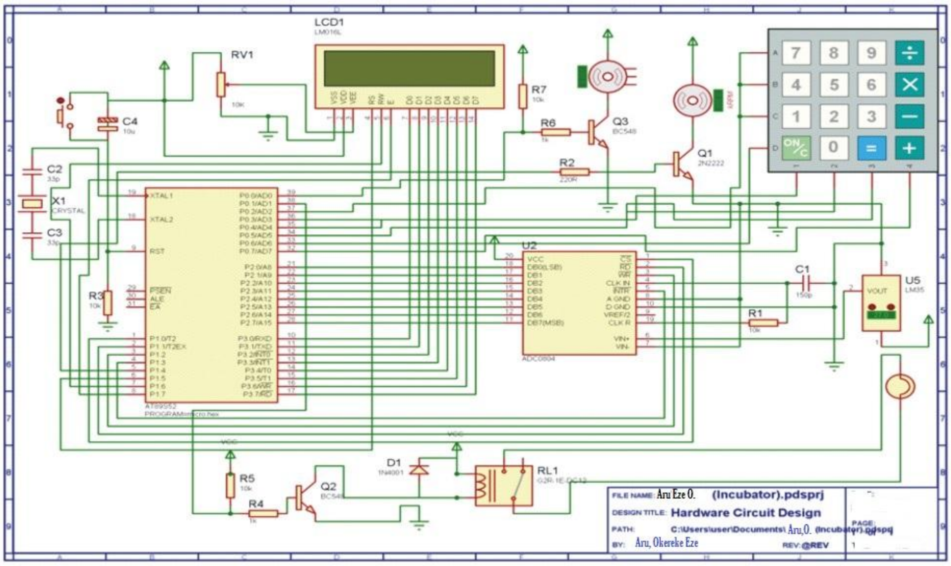

Figure 3.6: The Hardware Circuitry

3.5.1. The Power Supply

This is the power house of the system, it consists of a 12v transformer, which is a device that is mostly used to change/lower the voltage in an alternating current, and this is then connected to a rectifier. A rectifier usually consists of 4 diodes arranged in a diamond shape a type called a bridge rectifier. A diode only allows current to pass in one direction, the diamond configuration allow 2 diodes to pass the positive half of the current and the other 2 diodes to pass the negative half. The output of both sets is then connected to a 1000uf capacitor which smooth's the output voltage to the required 5 volts DC. The circuit diagram is as shown below

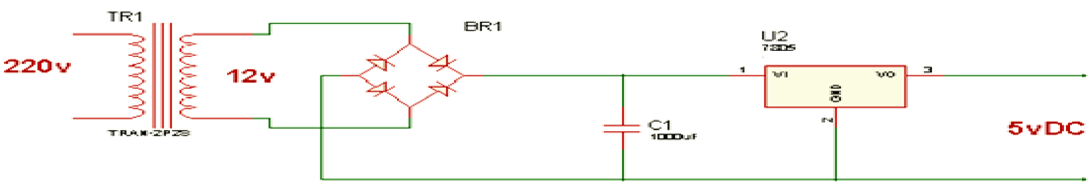

Figure 3.7: The Power supply circuit

3.6.1. Volume of Air in the Incubator

Thickness of Plywood = 10 mm

$V = L \times B \times H$

Where V = Volume of the incubator cabinet (m^3)

L = Length of the Incubator = 45cm = 0.45m

W = Breadth of the incubator = 30cm = 0.3m

H = Height of the incubator = 45cm = 0.45m

$V = 0.45 \times 0.3 \times 0.45 = 0.06075m^3$

The volume of Air in the incubator =$0.06075m^3$

3.6.2. Determination of the Mass of Air (M_a)

$\rho_a = \frac{m}{V}$, where ρa = Density of air = $1.23kg/m^3$ [6]

M_a = mass of air (kg)

V = volume of air in the incubator cabinet = $0.06075m^3$

$M_a = \rho_a \times V = 1.23kg/m^3 \times 0.0607m^3 = 0.0747225kg$

The required mass of air is 0.075kg

3.6.3. Determination of the Amount of Heat Energy in the Incubator

This calculation was done in order to determine the quantity of electric heat energy suitable to incubate the required number of eggs. This is the sum of the expected heat loss through the walls of the incubator, insulator and the actual heat required for incubation. It was based on the temperature ranges needed by the incubator (37-39 °C). It was therefore calculated by the difference between the room temperature (25 °C) and optimum temperature of the incubator 39(°C).

$$Q = M_p \times C_{pp} + M_a \times C_{pa}(T_2 - T_1)$$

Where

Q = heat required by the incubator (J)

M_p = mass of plywood =15 kg

C_{pp}= specific heat capacity of the plywood = 1210J/kgk

M_a = mass of air = 0.075 kg

C_{pa} = specific capacity of air = 1005J/kgk [5]

T_1 = room temperature = 25 °C

T_2 = Optimum temperature of the incubator = 39 °C

$$\therefore Q = 15 \times 1210 + 0.075 \times 1005 \times (39 - 25)$$

$$= 18150 + 1055.25 = 19205.25 \text{ J}$$

3.6.4. Power Requirement by the Incubator

The power supply by the heating element was determined for a period of 24 hours.

$Q = P \times t, \qquad P = \frac{Q}{t}$

Where Q = heat energy required by the incubator = 19205.25J

P = electric power to be supplied by the heating element (W)

t = time = 24 x 60 x 60 = 86400

$P = \frac{19205.25}{86400} = 0.22W$

4.1. Implementation

- The output pin of LM35 temperature sensor was connected to one of the ADC input pin of AT89S52 microcontroller.
- LCD was connected to Port 3 of the microcontroller. The LCD is wired in 8-bit mode. The data pins of the LCD are connected to PORT3 of AT89S52 microcontroller and the RS,R/W and E pins of LCD are respectively connected to P1.5, P1.6 and P1.7.

- ADC0804Intelsemiconductor that converts the analog signal from the output of the senor into 8-bit digital parallel output was activated for interfacing the temperature sensor and a program was written so that whatever temperature the sensor senses can be displayed on LCD screen.
- A normally closed relay was interfaced to Port 0 of the AT89S52 with the help of transistor to turn off the heater when temperature is above the set point. Transistor was acting as a switch to turn ON/OFF the relay. An AC bulb was interfaced with the microcontroller with the help of relay.
- A Cooling Fan was interfaced to Port 1.4 of the AT89S52 with the help of NPN 2N2222 transistor. Transistor was acting as a switch to turn ON/OFF the Fan.
- The Keypad was connected to PORT 0 so that user can set the temperature of the device accordingly.
- Code was written such that the microcontroller can switch ON/OFF bulb with respect to set temperature.
- The AT89S52 microcontroller is embedded with real time software written in assembly language. The ROM that contains the software reads the data via port0 and port 1 and the read data is written by the RAM into port2 and port 3 in the form of machine language.
- A 12MHZ quartz crystal is connected across pin18 and pin 19 of the microcontroller to avoid frequency of the micro controller's internal clock.
- The DC Motor was interfaced to Port 3 of the AT89S52 with the help of relay. Once the DC motor is turned on it moves the egg-roller on the egg tray to and fro which rotates the egg. This provides sufficient movement for the egg, to prevent solidification of the yolk.

4.2. Testing

Every component used to actualize this project was properly checked and tested using digital Multimeter before construction.

Individual components testing, continuity testing, performance testing and Thermal stability testing were performed.

This is to make sure that we remove bad/defective components, to ensure that the components are properly soldered to avoid a bridge on the copper strip board, to know the performance level of the entire circuitry i.e its ability to hatch egg at certain temperature eg. 37^0C and to ascertain if the component used are not overheated when powered which may cause excessive flow of current or bridge in the circuitry. Components such as transistors, capacitors, ICs are properly checked to know their thermal level, if stable or not. By so doing, it gives the difference between practical values and theoretical values which may be caused due to tolerance or losses as a result of soldering.

4.3. Results

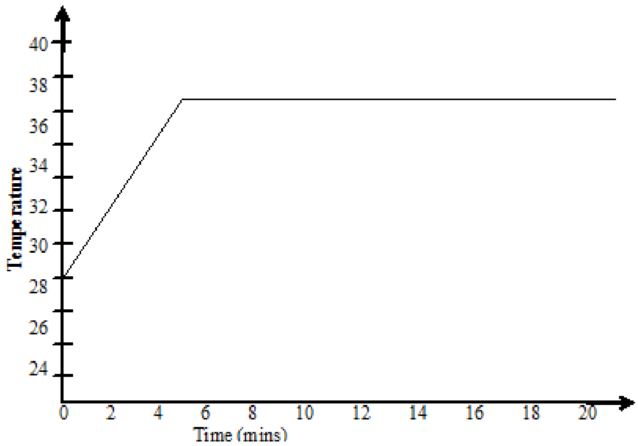

Figure 4.1: Graph of Temperature against Incubator Time

Results of this designed system with hardware Implementation are discussed below. After initialization, Programmed port is set as input. If temperature is below the specified, lights which are used as heating elements will be on until temperature reaches the desired value. If temperature is above the specified, fan which is used as cooling elements will be on until temperature reaches the desired value. If temperature is already within desired value, all elements either heating or cooling will be off. As fan is on which depicts that temperature is beyond desired value which is considered as error. In Order to overcome this error fan will be on until Temperature of livestock area is within desired Temperature range.

The incubator was run without hatching egg for about 2 days and in each day for about 8 hours. The temperature was set to 37 °C. At the first 15 minutes, temperature data were recorded1 min each. Figure 4.1 plots the relationship between temperature and incubator time calculated.

5.1. Summary

Hardware results and simulated results are nearly in agreement according to set point of low, desire range and high range of temperature. When temperature increases or decreases from normal value, control elements i.e. cooling fan or heater will operate accordingly, value of the temperature is displayed on the LCD; desired temperature has been adjusted efficiently. Thus, we are able to maintain temperature of a localized area according to desire of poultry farm. This system is not only feasible in poultry farm but can be installed in livestock career to save life of animals.

5.2. Conclusion

An attempt was made in this work to improve on the limitations of the existing Automatic egg Incubator. This work has therefore presented a microcontroller based incubator with preset temperature that will be able to accommodate different types of eggs ranging from Chicken, Duck, Turkey, Pigeon, Quail etc.

After the final development of this proposed design, this system shall be capable of hatching different types of egg at their specified temperatures. This is done by sensing the temperature of the incubator with LM35 Temperature Sensor and comparing it with that of the input temperature specified by the user. The temperature of the incubator is adjusted by the microcontroller to match that of the input. This is a feedback control system that maintains a constant temperature of the incubator for a long period of time with the help of the microcontroller and its embedded programme. This system does not require the continual presence of the operator and will boost poultry farming in the country and beyond. The incubator functioned as expected.

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