A Low Cost Microcontroller Based Automated Incubator System

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ABSTRACT

This presents a low cost automated incubator system which uses PIC microcontroller. The microcontroller based automated incubator is designed to keep the enclosed temperature within the band of 34-37°C which is ideal for hatching eggs (Chicken). The electric heater used switches OFF if temperature is greater than or equal to 37°C but switches ON if temperature is less than 34°C. The eggs are rotated 45 degrees clockwise and anti-clockwise every one (1) hour respectively in 24 hours. This is achieved by a stepper motor which drives the egg tray either in clockwise or anti-clockwise direction. A microcontroller (PIC16F84A) is used as the major component to realize this automated incubator. The result of the implementations of the system is low cost, and increases the hatching efficiency of the incubator.

Keywords: Automated incubator, Electric heater, Microcontroller, Stepper Motor

1.0 INTRODUCTION

Poultry is one of the most profitable agricultural businesses in Benue state, Nigeria. It provides most of the animal protein since it is relatively free from many pathological, climatic, economic, ecological, and technical constraints which affect the commercial production of other breed and classes of livestock in Nigeria [1]. In traditional poultry husbandry, the hens lay their eggs in odd corners of the house or under cover outside the house. In their free range they mate at random and hatch their fertile eggs by natural incubation, producing about 3-10 chicks per hatch. Therefore, a laying hen can produce at best between 12 and 30 chicks per year, whereas under modern methods of artificial incubation, a laying hen with no brooding disposition can produce up to 150 chicks a year [1].

Hatching involves the production of day–old chicks from parent stock through natural or artificial incubation of fertile eggs. Incubation is the process of aiding the development of a fertilized egg from the embryo inside to a live chick at appropriate time by providing such factors as heat, humidity, ventilation, and turning of eggs. Eggs can be hatched naturally by getting a hen to sit on her fertile eggs or those of other hens, or by artificial means which represent a stimulation of the necessary factors of the natural process [1]. The principles of incubation that influenced the design of an automated incubator are: environment, nutrition, position, and turning of eggs, temperature, ventilation, humidity, and condition of eggs.

2.0 Materials and Methods

The low cost microcontroller based automated incubator system consist of electrical control system includes temperature sensing, control unit, egg turning control unit and a ventilation control unit as shown in the block diagram of figure 1. In the temperature sensing circuit, the sensor is sensitive to the temperature variation and with the help of the relay; the heater is either switched ON or OFF. The detector is primarily an operational amplifier which serves two purposes; it is used as comparator and as amplifier to amplify the difference between the two output voltages from the bridge circuit. The driver circuit contains the transistor, which acts as a switch when it is turned by the detector output. The relay which forms part of the output unit switches the heater ON or OFF.

Similarly, in the egg turning control unit, the microcontroller produces pulses which count in hour. The output is fed into the output circuit which turns the egg tray either clockwise or counter clockwise. Incorporated in the ventilation unit is the driver circuit which drives the fan.

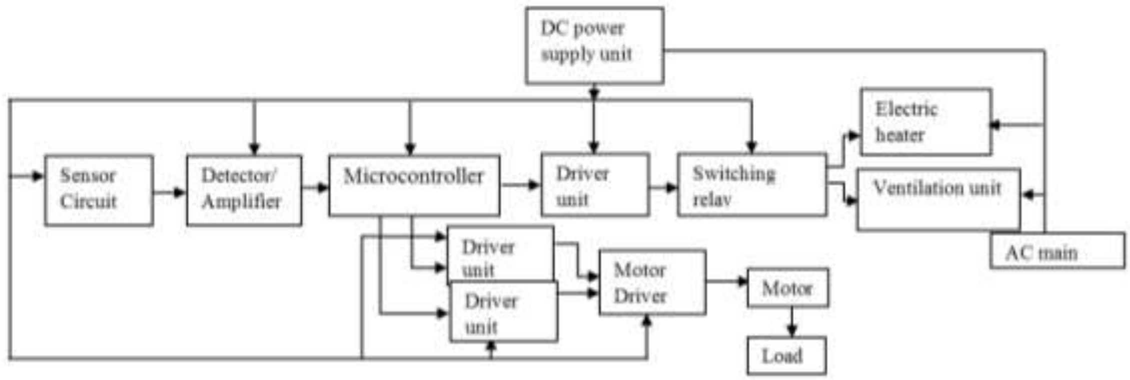

Figure 1: Block diagram of a microcontroller based automated incubator

The design of a microcontroller based automated incubator is carried out with provision of the desired temperature, ventilation, turning of eggs and conditions required to initiate and sustain the entire process of development of fertilized egg to a live chick. These stimulated conditions and assumptions were made to allow for selection of suitable components that will effectively give a reliable and efficient control of the system. These conditions are placed vis-à-vis the specification of the components to be used. The circuit diagram of the low cost microcontroller based automated incubator is shown in figure 2.

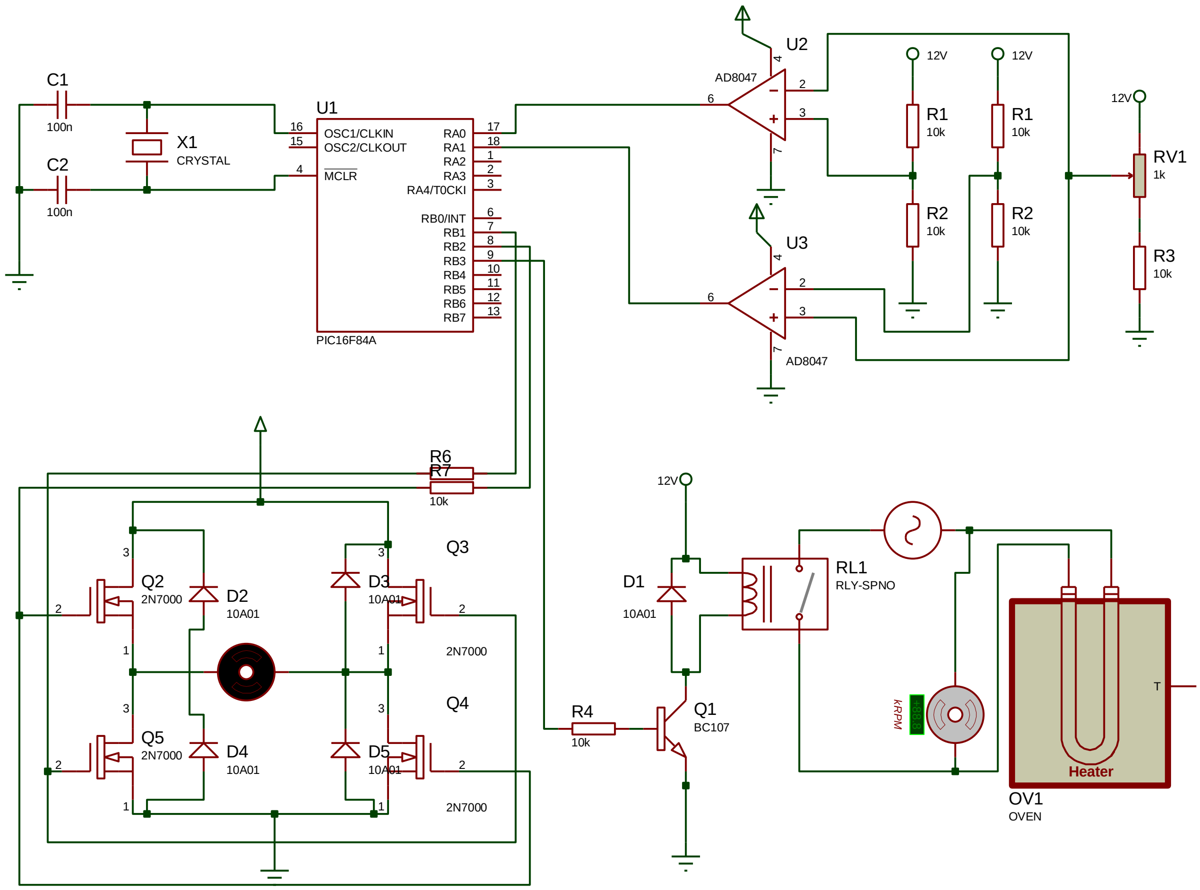

Figure 2: Circuit diagram of a microcontroller based automated incubator

2.1 ANALYSIS OF THERMISTOR TEMPERATURE CONTROL CIRCUIT

The system under design is a thermistor temperature control module for an automated incubator regulated at a temperature band of 34-37 ℃. It consists of separate units whose characteristics form the basis of the control process. The sensor and comparator unit is shown in figure 3.

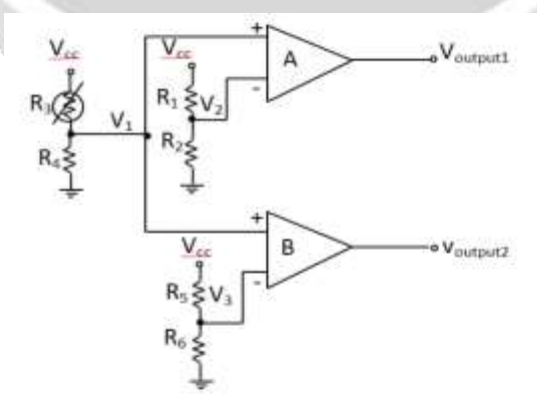

Figure 3: Diagram of Sensor and comparator circuit

From figure. 3, $V_{cc} = 5V$

Taking R1 = 2.2k and R2 = R6 =1k

At temperature, T_1 = 34ºC, thermistor's resistance R_{TH} = 1.82 $k\Omega$ and at this point $V_2 = V_1$.
Using voltage Divider Rule

$$\frac{R_2}{R_1 + R_2} \times V_{CC} = \frac{R_4}{R_3 + R_4} \times V_{CC} \quad (1)$$

Therefore R4 = 0.83K
When temperature T_1 = 37ºC, thermistor's resistance R_{TH} = 1.68kΩ and at this point $V_3 = V_1$.

$$\frac{R_6}{R_5 + R_6} \times V_{CC} = \frac{R_4}{R_3 + R_4} \times V_{CC} \quad (2)$$

Therefore R5 = 2.02K

$$V_2 = \frac{R_2}{R_1 + R_2} \times V_{CC} \quad (3)$$

$$V_3 = \frac{R_6}{R_5 + R_6} \times V_{CC} \quad (4)$$

When temperature, T_1 = 30ºC, R_{TH} = 2.14kΩ

$$V_1 = \frac{R_4}{R_3 + R_4} \times V_{CC} \quad (5)$$

The electric heater will switch ON when V2 > V1 but will switch OFF when V3 ≤ V1. Op-amp 741*u* [2] is used.

2.2 OUTPUT STAGE

The output stage consists of a relay, electric fan, heating element and the egg turning unit. The heating element emits heat energy when the relay is ON, and goes OFF when the relay switches OFF. A commutating diode (freewheeling of damping diode) of high peak inverse voltage (PIV) is connected across the relay coil to protect the transistor. The diode IN4001 [3] was selected for this purpose. The transistors are turned on depending on the state of the temperature. The temperature at the incubator determines the trigger ON or OFF of the transistor. Using the requirements for the saturation of the BJT expressed as

$$\beta_F I_B > I_C \quad (6)$$

Under the condition in equation 6, the transistor controlling the relay will turn ON. The transistor used is 2n222 [4] a general purpose transistor.
The egg turning unit consists of a bipolar stepper motor [5] controlled by mosfet H-bridge [6].
At every one hour the eggs are being rotated either 45̊ clockwise or -45̊.

2.3 FLOW CHART FOR THE TEMPERATURE CONTROL MODULE

The flow chart for the temperature control module of a microcontroller based automated incubator depicts the logical process for the programming of the microcontroller is shown in figure 3. The flow chart for the temperature control module begins with start. After that it will read high temperature, if temperature in the incubator is above 37 ºC, it will turn off the electric heater and fan. But if it is below 37 ºC, then it will go to read low temperature. From there it will proceed to the decision box where it will ask if the temperature is below 34 ºC. If the temperature is below 34 ºC, the electric heater and fan will turn ON. But if temperature is above 34 ºC, it will go to read high temperature.

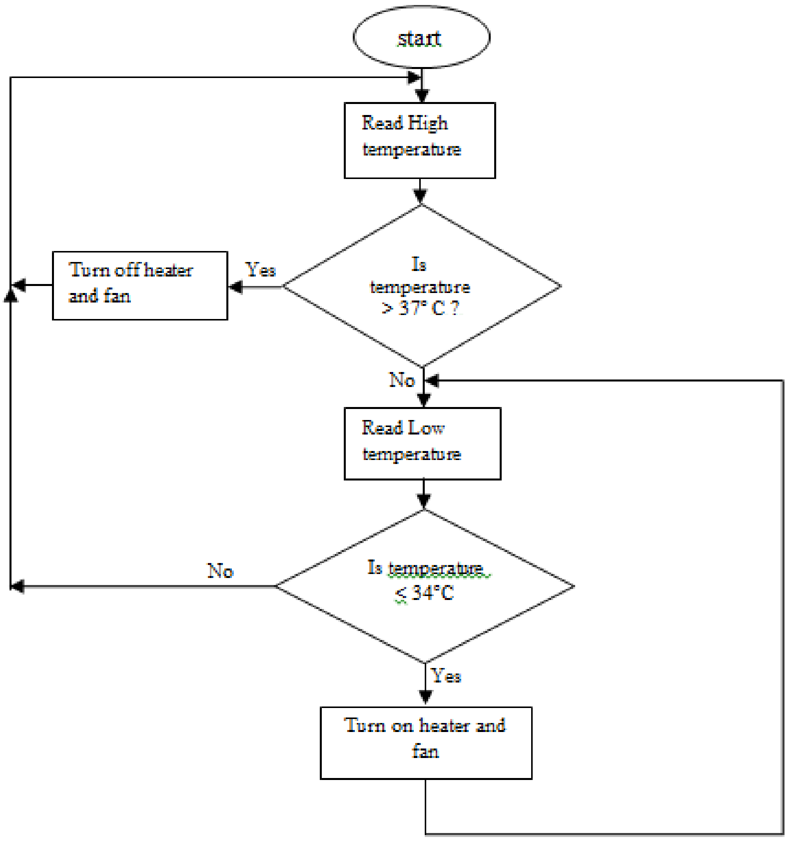

Figure 4: Flow chart for the temperature control module

3.0 CONCLUSION

The microcontroller based automated incubator was designed to achieve an accurate temperature band of 34ºC - 37 ºC and precised turning of eggs. The microcontroller is the heart of the device. Microcontroller include an integrated CPU, memory and peripherals capable of input and output. The microcontroller used in this work is PIC16F84A [7]. The program for this work was written using. This was simulated on a personal computer using software mikroC IDE[8] which enable the creation of HEX file. Thereafter, the HEX file was burned into the program memory of the microcontroller by the device using Pickit2 programmmer [9].

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