A Microcontroller-Based Egg Candling System

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***Abstract*—This paper presents a new microcontroller-based egg candling system. The system, which is integrated to a complete automated hatching machine, utilizes an IR transmitter and a highly sensitive TSOP receiver. A 40 KHz signal is passed through a partially incubated egg and received at the other end. Distortion in the frequency of the received signal indicates the presence of a live embryo indicating that the process of hatching should continue. An undistorted signal indicates the absence of life in the egg and the process of hatching is terminated. Two sets of stepper motors are used for the mechanism of the Candler. The system was tested using chick and quail eggs and performance is excellent.**

***Index Terms*—Candling, egg, incubation, microcontroller.**

I. Introduction

Candling refers to the process of transluminating an egg with light to determine the presence or absence of a viable embryo or to look for shell defects [1]. Candling of eggs during incubation a useful tool for quality assurance and determination of poor hatches. Other important parameters during the incubation process are incubator temperature, humidity, shell quality and egg moisture loss.

The arteries of the extraembryonic circulation are uniformly distributed throughout the incubating egg structure. This provides the means for detecting change in blood flow photoelectrically, thus providing a means through which the embryonic heartbeat can be detected..To determine life in an incubating embryo, relatively intense white light is passed through the partially incubated eggs. This process is called candling and the time it is done depends on the type of egg under incubation. For example, chicken, pheasant, partridge and quail eggs should be candled after 5 to 7 days of incubation. Turkey, duck and goose eggs should be candled after 8 to 10 days of incubation due to their longer incubation periods [1]. The embryo at this stage of incubation is about the size of a dime and appears as a small bubble floating on the surface of the yolk.

Candling, as the name implies, was originally done with a candle to provide the transluminating light. Later, more powerful light sources like the electric bulb were used. Recently, a number of new methods for determining egg fertility have been reported. For example, Das and Evens [2] used a combination of machine vision and artificial neural network to identify fertile eggs with accuracy of 93.9 % at day 4, 93.5 % at day 3 and 67.6 % at day 2. In [3], machine vision and modified PSO was used with impressive results. Bamiles *et al*. [4] successfully used a combination of two light wavelengths (577 and 610 nm) to determine the fertility of an egg after 4.5 to 5 days of development. Other reported methods for determining egg fertility include machine vision and LS estimation [5], magnetic resonance imaging [6], acoustic resonant analysis [7] high frequency ultrasound imaging [8], hyperspectral imaging [9], [10] and acoustic impulse response and supervised pattern recognition [11].

The candling system presented in this paper is part of a complete microcontroller-based multicompartment hatching system whose block diagram is shown in Fig. 1. Each of the four compartments is designed to hold different type of egg. Three compartments labelled A, B and C are for chicken eggs, while the other compartment labelled D is for quail eggs .

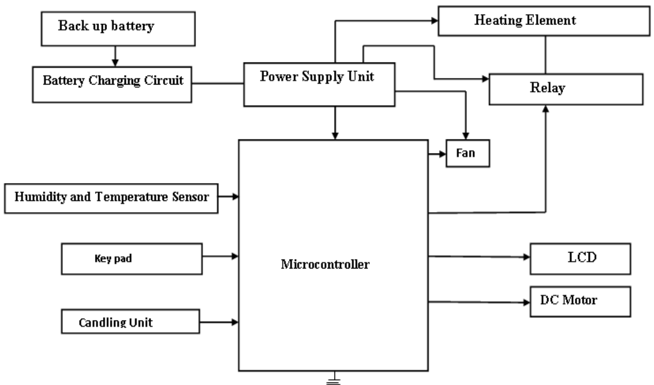

Fig. 1. Block diagram of a complete hatching machine.

II. Design of the Candling Unit

Fig. 2 shows the circuit diagram of the proposed candling system. On the fifth day of incubation (specifically, after exactly 120 hours), a 5V, 40 kHz signal is generated by pin A0 of the 16F877A microcontroller [12]. The signal is sent to the infrared transmitter in compartment one. The transmitter causes the signal to pulsate; the pulsating signal at 40 kHz is passed through the egg placed between the IR transmitter and the receiver. The receiver circuit consists of TSOP11240 [13] from Vishay Instruments. The output signal at the receiver biases transistor Q61 and amplified by transistor Q62 due to its low magnitude. Whenever the frequency of the transmitted signal is below what is received due to distortion of the signal by the breathing of the life embryo in the incubated egg, the ouput of TSOP11240 is low and the transistor Q61 is switched off. This means the collector is at high potential, thus turning transistor Q62 on. This makes pin C4 low because it is attached to the collector of Q62 which is at low potential. Thus low at pin C4 signifies that the egg is fertile. Whenever pin C4 goes high, it means that the transmitted signal is received at the same frequency as transmitted, because there is no life embryo in the egg whose breathing will distort the signal. The egg is therefore non-fertile. A 'BAD EGG' is then displayed on the

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LCD. This subcircuit is repeated for each of the three other compartments as shown. Circuit components were carefully selected using standard circuit design procedure.

Fig. 3 shows an abridged flowchart for apartment A containing chicken eggs. The algorithm is only a portion of the larger algorithm for the automated hatching machine.

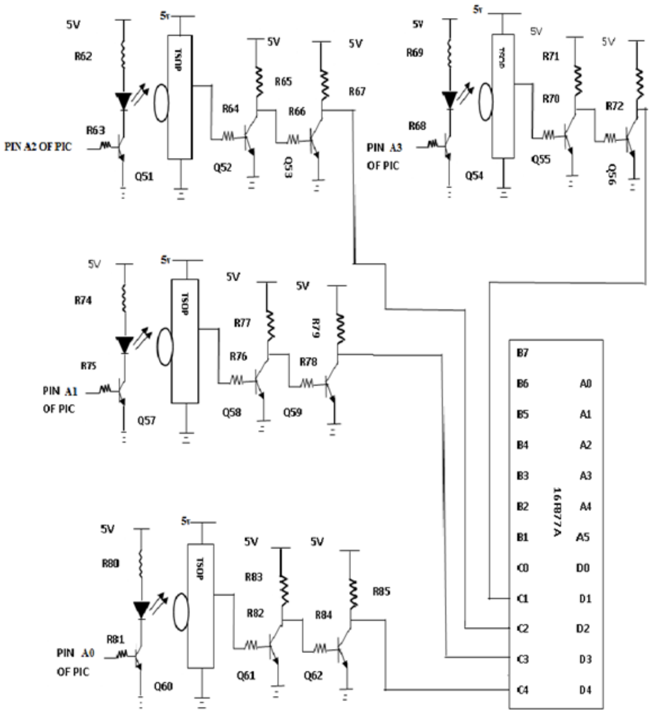

Fig. 2. Diagram showing microcontroller interfaced with candling unit.

The mechanism of the candling unit consists of two stepper motors; one moves the candling unit laterally and stops at a given targeted egg while the other moves downwards clamping the transmitter unit to the egg for the candling test. Fig. 4 and Fig. 5 show the motors C1 to C4 and P1 to P4 respectively interfaced with the microcontroller.

Building an egg-hatching system involves lots of concern in terms of temperature, humidity and movement in order to change the position of the eggs. Temperature, humidity and turning requirements for various egg types are summarized in Table I.

TABLE I: CONDITION OF INCUBATION FOR VARIOUS EGG TYPES [14]

Species	Incubation Period	Temperature (°F)	Temperature (°C)	Humidity (°F)^2	Do not turn after
Chicken	21	100	37.8	85-87	18th day
Duck	28	100	37.8	85-86	25th day
Turkey	28	99	37.2	84-86	25th day
Goose	28-34	99	37.2	86-88	25th day
Guinea Fowl	28	100	37.8	85-87	25th day
Pheasant	3-28	100	37.8	86-88	21st day
Bobwhite Quail	23-24	100	37.8	84-87	20th day
Muscovy Duck	35-37	100	37.8	85-86	31th day

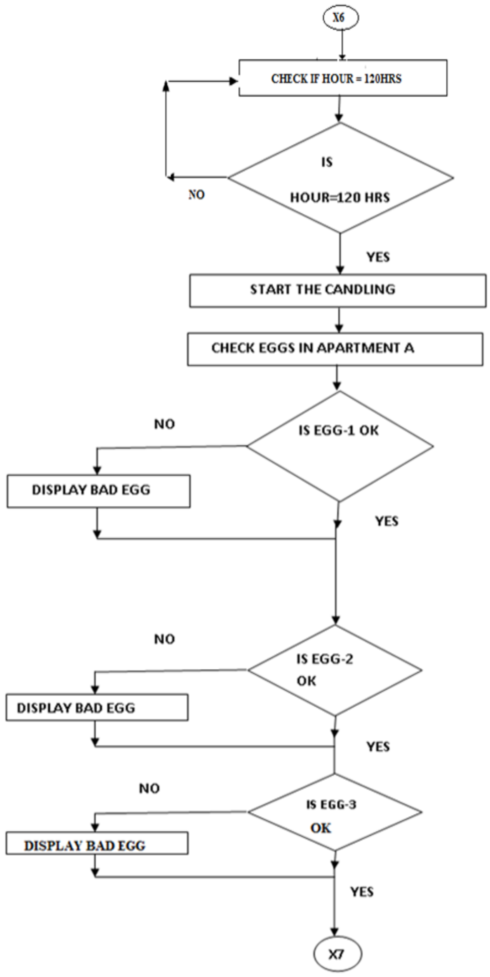

Fig. 3. Flow chart for the egg candling unit.

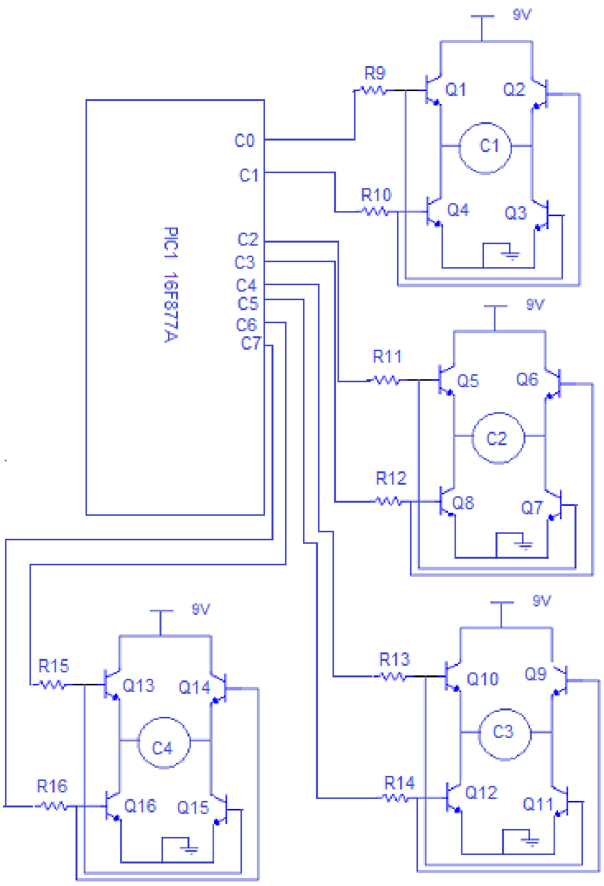

Fig. 4. Microcontroller interfaced with motor for lateral motion of candling unit.

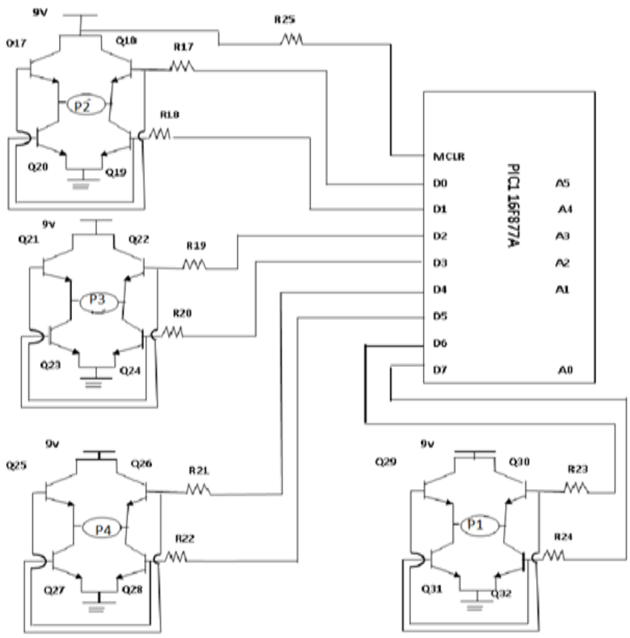

Fig. 5. Microcontroller interfaced with motors for up and down motion of candling unit.

The position of the egg must be changed two times every day until hatching. In the first twelve hours the egg turner is rotated from 180^0 to 45^0 and from 45^0 to 180^0 in the second twelve hours. The eggs need to be shifted slowly and smoothly since jostling would disturb development of the chicks. The egg shifting is done using a rectangular piece of softwood in which circular holes are evenly drilled to accommodate the eggs; the turner is driven by a programmed stepper motor.

To maintain a constant temperature in the incubator throughout the incubation period, microcontroller is interfaced with LM35 temperature sensor which senses the temperature of the incubator. Whenever the temperature goes beyond the required value, the heat source is switched OFF and a fan is turned ON to evacuate excess heat. The fan remains switched on until the required temperature is maintained. The temperature control arrangement is shown in Fig. 6.

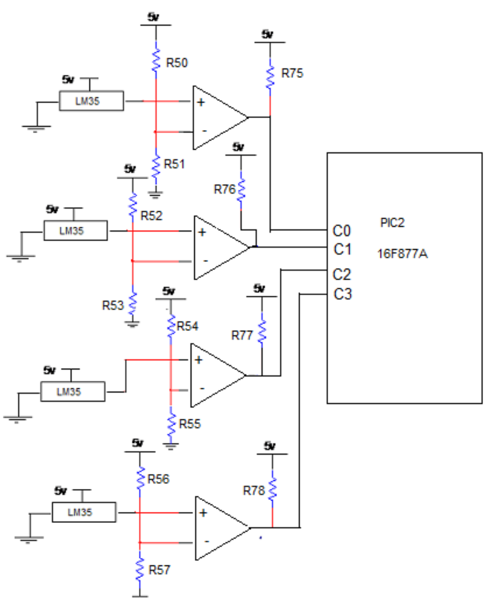

Fig. 6. Microcontroller interfaced with temperature sensors.

To achieve humidity control the circuit of Fig. 7 was used.

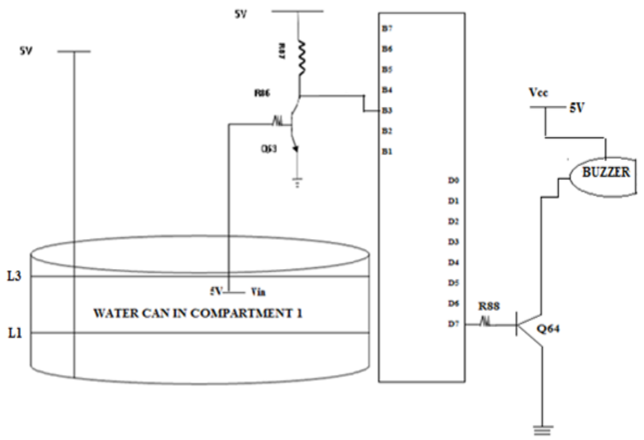

Fig. 7. Microcontroller interfaced with humidity controller.

A water pan is filled with water up to the L3 level. Water being a good conductor is at the potential of 5 V. This voltage biases transistor Q63. Whenever the level of water falls to L1 (critical level) due to evaporation from the can, transistor Q63 is not biased causing pin B3 of the microcontroller to go high. This action leads to the activation of a buzzer which produces a continuous sound and display of no water by the LCD.

Wood is chosen for the incubator casing because it is a readily available natural insulation material, cheap and has a low thermal conductivity of $0.13Wm^{-1}K^{-1}$. Like most natural insulation materials, it is breathable, i.e. it absorbs moisture in periods of high humidity and releases it when the conditions are dry. This reduces the risk of condensation and moisture, thus protecting the timber [15]. A good quality hardwood was used for the incubator casing. The hardwood was chosen because it is preferable to softwood which is susceptible to warp during the incubation process.

III. Results

The candler algorithm was coded in assembly language in an MPLAB environment. It was thereafter loaded on the microcontroller.

60 eggs (40 chicken and 20 quail) were used for the test and the results are as shown in Tables II and III.

Out of the 40 chicken eggs used, 28 were fertile while 12 are nonfertile. When the eggs were tested using the developed candler, 33 tested fertile (among them the truly fertile 28) while seven tested nonfertile. This indicates that the probability of a chicken egg returned as fertile being exactly so is 85 %. However, the probability of a nonfertile egg being returned as nonfertile is 100 %.

Out of the 20 quail eggs used in this analysis, nine are fertile and 11 are nonfertile. However, 14 eggs tested fertile among them the truly fertile nine. This shows that the level of confidence that a fertile quail egg will be returned as fertile is only 64 %. On the other hand, a user of the proposed candler can be 100 % confident that it will return a nonfertile quail egg as nonfertile.

Although the above result is encouraging, there is still room for improvement for the proposed candler. This is moreso if its performance is compared to previous methods like MS and SVM [5]. Factors responsible for nonperformance may include the fact that the candler was switched to public power supply, standby generator and car battery at different times during the test.

TABLE II: RESULTS OF FERTILITY TEST FOR CHICKEN EGGS

No. of chicken eggs	Fertile	Nonfertile	Total
Tested fertile	28 (true positive)	5 (false positive)	33
Tested nonfertile	0 (false negative)	7 (true negative)	7
Total	28	12	40

TABLE III: RESULTS OF FERTILITY TEST FOR QUAIL EGGS

No. of quail eggs	Fertile	Nonfertile	Total
Tested fertile	9 (true positive)	5 (false positive)	14
Tested nonfertile	0 (false negative)	6 (true negative)	6
Total	9	11	20

IV. CONCLUSION

A microcontroller-based egg-fertility testing unit has been presented. The unit, which is better for the candling of chicken eggs, may also be used to test the fertility of quail eggs. By appropriate adjustment in the algorithm the unit can be used to test the fertility of other egg types like turkey eggs. The system is important for poultry managers and has been used as a unit of a complete automated hatching machine.

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