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Proposed Development of a Solar Powered Automated Incubator for Chickens

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Abstract:

The number of chick produced through natural incubation is very low due to irregular environmental parameters like temperature, humidity, etc and the death of hen can lead to the total collapse of this incubation process. A solar powered automated incubator system was designed to operate in place where there are no source of electricity (in very remote areas). The solar energy is used in two forms; to provide solar electric energy and also to provide solar heat energy. The solar reflector was used captured heat energy during the day and to supply this regulated heat at temperature band of 36-37°C to the incubator via a valve controlled by a PIC18f4550 microcontroller, while the solar PV was used to charge the battery and to supply power to the system during the day. At night or poor weather when battery is used to power the system, if the temperature goes below 36°C an electric heater will be used to increase the temperature band to 36-37°C and the heat of the heater will be decrease if temperature is getting greater than 37°C. The turning of the eggs is done twelve times daily and is achieved by the use of stepper motor which drives the egg tray either in clockwise or counter clockwise direction. The advantages of this system are numerous, especially that it uses only solar energy.

Keywords — **Solar PV, solar reflector, charge controller, boost converter, PIC18f4550 microcontroller, automated incubator**

I. INTRODUCTION

Human have used the eggs of animals as a source of food, weather they were the eggs of birds, reptiles, amphibians or fish. But human's abilities to survive resulted in an explosion of population around the globe that requires the resources and facilities to feed them. Egg incubator is a device that keeps the eggs in a good temperature and lightness until they hatch. It helps farmers to hatch eggs automatically without the need of human intervention by keeping the eggs warm, allowing the fetuses inside them to grow and hatch without the mother present.

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. Condition of egg: Extreme conditions such as porosity of the eggs shell allows microorganism to enter the eggs and destroy the eggs content including the embryo, and allows excessive loss of moisture from the egg.

Furthermore, egg incubator will not only improve poultry production considerably, but it will also allow regularity in income making, enabling subsistence farmers' transition into possible rural entrepreneurs. There are two types of incubator: Still-air incubator and Forced air incubator. **i. Still Air Incubators:** Still air incubators are the most basic form of incubator. A still air incubator is basically an insulated box consisting of:

- A Heating element
- A Thermostat or temperature controller to control temperature
- Egg tray
- A thermometer to measure the air temperature
- A tray for water
- Some machines may have a hygrometer for humidity measurement
- Some machines may have turning mechanism for automatic turning of eggs

The air inside a still air incubator is circulated by convection. As the air is heated it expands and rises to the top of the incubator. The amount of airflow achieved in a still air machine is therefore determined by the ratio of air temperature inside the box to outside. The lower the air temperature outside the box the greater the airflow inside. To achieve good air circulation, air inlets are usually positioned in the base and top of the incubator. Inside a still air incubator, the warm air moves towards the top so different temperatures will be recorded at different levels. It is therefore important that a still air incubator is kept on a level surface and that eggs are all of similar size.

ii. Forced Draft Incubator: The forced draft machine was developed to overcome temperature gradient problems throughout the incubator. In a forced draft incubator a fan is used to circulate the air, which gives a uniform temperature throughout the machine. The air temperature surrounding the egg is therefore constant and positioning of the thermometer and temperature sensor is less critical. Eggs, too, can be of differing size and set in trays at different levels. Using a forced draft incubator also allows the use of a Wet Bulb Thermometer, which can be used for the accurate reading of humidity. It is of more importance to control humidity in a forced air machine to prevent the higher airflow drying the eggs. Table 1 shows the advantages and disadvantages between the two types of incubators.

Table 1: Advantages and Disadvantages of the two type of Incubators

Option	Advantages	Disadvantages
Still Air incubator	• Simple • Cheap	• All eggs should be similar sizes • Only one level of hatching is available • Temperature distribution isn't uniform
Forced draft incubator	• Different egg sizes can be hatched at different levels • Gives a uniform temperature distribution • allows the use of a Wet Bulb Thermometer	• More complex • More cost • Reliable

A. Design Specifications and Factors to be considered in Incubation Process

i. Temperature: The fertile egg will resume development when it is placed in an incubator, and the recommended temperature for the incubation varies that is from 36-37°C with no harmful effects.

If the temperature stays at either extreme for several days, the hatch may be reduced [2].
ii. Humidity: Humidity is of great importance for the development of chicken that is from their embryonic stage. During incubation moisture is lost from the egg through the tiny holes on the shell, this increases the size of the air cell, which after 19 days of incubation occupies about one-third of the egg [2].Although a variation of 5 to 10% is acceptable, the relative humidity of air within an incubator for the first 18days should be about 60% during the last 3days (matching period) should be nearer 70%. When the humidity is lower than the recommended it causes excess evaporation of water, while high humidity prevents the evaporation of sufficient amount of water from the egg. In both cases, hatchability is reduced [3].
iii. Turning of eggs: When eggs are put in an incubator, lay them on their sides and turn them at least three times a day. Turning prevents the embryo from sticking to the shell membranes, as it will if it is left in one position too long. Continue to turn the eggs day 2 through day 17, but do not turn them after day 17 [4].
iv. Ventilation: When the embryo develops, it uses oxygen and gives off carbon dioxide. Thus, sufficient ventilation within the incubator is required to ensure an adequate supply of oxygen and the proper removal of carbon dioxide. The best hatching results are obtained within 21% oxygen in the air the normal oxygen level in the atmosphere. The embryo will tolerate a carbon dioxide level of 5% [3].
v. Fertile Egg Quality: From the smallest canary eggs to the largest ostrich eggs, high quality fertile eggs should always be considered rare and fragile. To successfully hatch eggs, begin with fresh, clean, fertile eggs [5].

B. Literature Review

Siriluk S. et al (2011) [6] designed an automatic incubator which consists of three main parts. The first part is a mathematical model of an incubator. Thermo-physical properties of selected materials were substituted to investigate its heat transfer characteristics. The second part is the consideration of equipment used to measure and control temperature and humidity. The last part is to select the controller for an inclined egg tray.

Benjamin and Oye, (2012) [7] worked on modification of the design of poultry incubator that will be user friendly, portable, affordable and easy to maintain. Evaluation and test was carried out, thus having result for days of the testing, an average value of temperature was gotten to be 37°C, average percent humidity value of 56.15% and an average angle turn of 46.58°. It was recommended that solar energy should be used as heat source because of the untimely failure of electricity to enhance the efficiency of the system and a two way power source should be used.

Radhakrishnan K. et al (2014) [8] designed and implementation of a fully automated egg incubator using ATmega16 microcontroller to automatically maintain the environment which is optimum for embryo growth. The system has a temperature sensor which is able to monitor the temperature inside and outside the incubator and this data is sent to AV microcontroller, which controls the relays that controls an incandescent lamp and an air circulating fan to maintain the egg temperature from 37 to 38.5°C, with all the temperature readings being displayed on LCD.

An Electrically-Operated Egg Incubator was implemented by Umar A. B. et al (2016) [9]. The electrically operated incubator with the capacity of 60 eggs was constructed and tested. It was constructed using locally available materials and it is a still air incubator. Also when tested the temperature was between the range of 37°C- 38°C, the relative humidity was also 55%-60% and turning of egg was done 3 times daily; however the egg did not hatch due to unavailability of a stable power supply. Thus, the power supply to the incubator can be improved using an alternative source of power supply.

II. MATERIALS AND METHODS

The Block diagram of the solar powered automated incubator system is shown in Fig. 1.

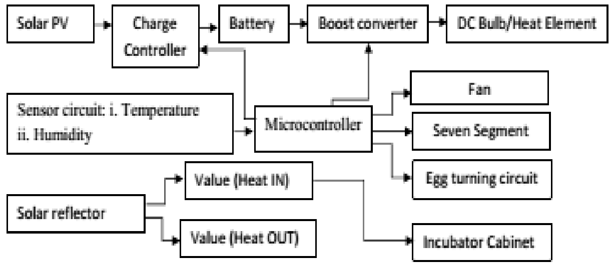
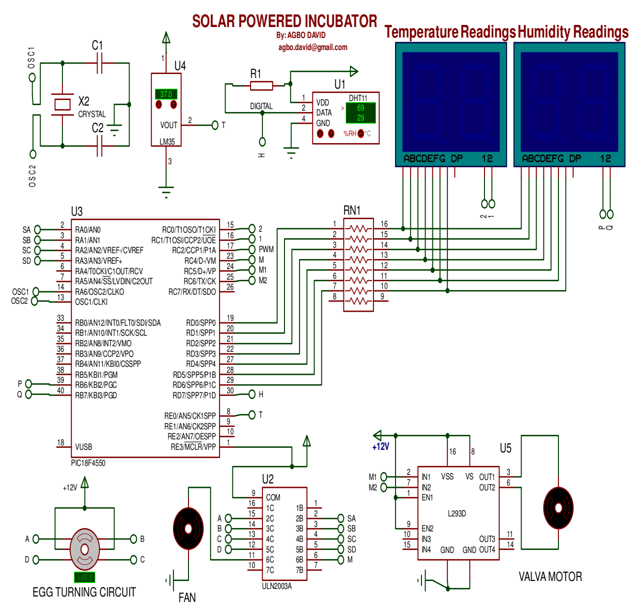


Fig. 1: Block diagram of a solar powered automated incubator for chickens

The circuit shown in the Fig. 2 is the solar based incubator system consists of solar PV which is used to charge the battery, the voltage of the battery is step up using boost converter to power a 240Vdc bulb or heat element. The solar energy is also captured using a solar reflector which is included in the design. The solar reflector is used to supply heat energy to the incubator unit via pipes controlled by valves. This heat is captured during the day and supplied to the incubator and during the night or bad weather the charge battery supply voltage to system and for the dc bulb or heat element to provide heat for the incubator. On sunny days, if the temperature inside the incubator is getting above the rated range of temperature (36-37ºC) the valve supplying the heat to the incubator will be gradually closed while the another valve will be gradually open for the heat to escape to the environment. But if the incubator temperature is lower than the rated temperature (36-37ºC), even when the reflector is providing heat, the heating element will gradually be powered to compensate for the fall in temperature. The bulb or heat element is controlled using PWM to control the IRF540 mosfet [10] of the boost converter via mosfet driver IR2112 [11], thereby either decreasing the temperature or increasing the temperature so that the temperature will always be at a fix temperature. This pwm is achieved by either increasing or decreasing the duty cycle of the pwm feeding the mosfet controlling the boost converter. Lm35 [12] is used to measure the temperature and dht11 [13] is used to measure the humidity. The two set of double seven segment is used to display the temperature and humidity values. The fan is used to exchange air of the incubator and the environment and to blow the air across the water pan to control humidity. The stepper motor is used in the egg turning circuit to turn egg trays either clockwise (+45º) or counter clockwise (-45º) for every 2hrs. The design makes use of PIC18f4550 microcontroller [14] which is the heart of the system. PIC18f4550 controls all the processes in this design. From the opening and closing of the valve to sensing of the temperature and humidity, to displays of the temperature and humidity values on seven segment, to the turning of the egg tray, to the powering of the fan and the control of the pwm of the boost converter. One of the dc motor and the unipolar stepper motor are connected to the PIC18f4550 microcontroller via UNL2003A [15], which serve as driver to the dc motor and the stepper motor. The second dc motor is connected to a L293D [16] dc motor that controls the opening and closing of the valve that allows heat energy to flow into the incubator. This system is a stand-alone device that depend solely solar energy for all its source of power.



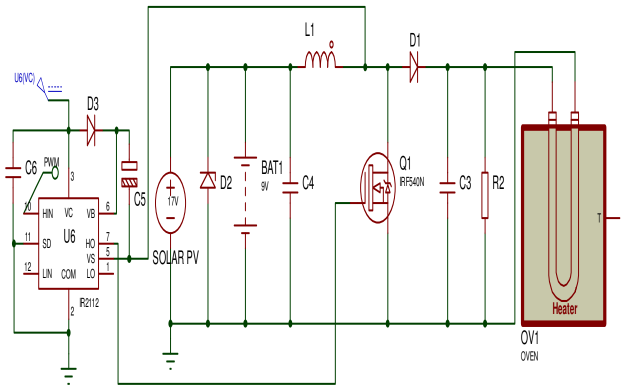
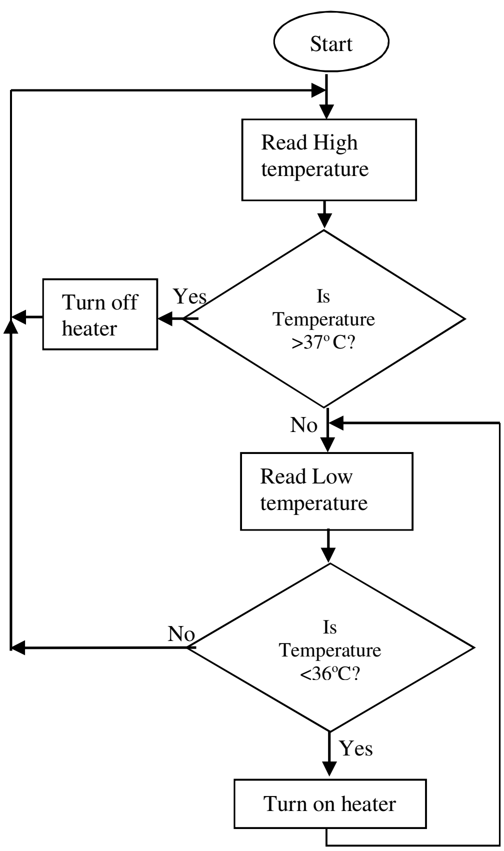
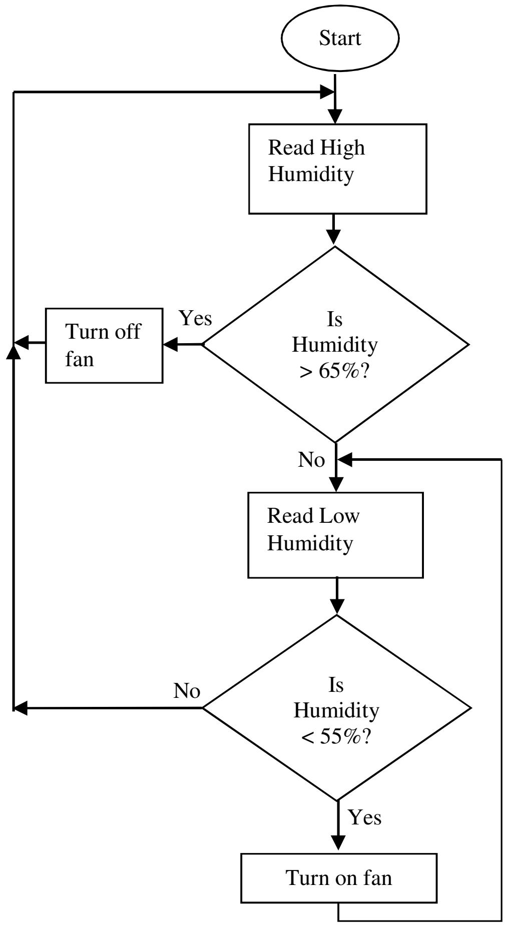


Fig. 2: Circuit diagram of a microcontroller based automated incubator

The flowchart of the program for the system is shown in Fig. 3. Using this flowchart, a program was written and simulated in mikroC integrated development environment (IDE) [17]. Proteus 8.4 [18] was used to simulate the hardware of the system.



(a) Temperature Flow Chart



(b) Humidity Flow Chart

Fig. 3: Flow chart for the temperature and humidity control module

Fig. 3a show the flow chart for the temperature control module that 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. 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 36 ºC. If the temperature is below 36 ºC, the electric heater will turn ON. But if temperature is above 36 ºC, it will go to read high temperature. Fig. 3b show the flow chart for the humidity control module that begins with start. After that it will read high humidity, if humidity in the incubator is above 65%, it will turn off the fan. But if it is below 55%, then it will go to read low temperature. From there it will proceed to the decision box where it will ask if the humidity is below 55%. If the temperature is below 55%, the fan will turn ON. But if humidity is above 55%, it will go to read high humidity.

III. RESULTS AND DISCUSSION

The program for the microcontroller was written in C language and was then compiled into an executable file using the mickroC IDE. The executable file was next imported into the Proteus Design Suite IDE where the hardware circuit was designed and simulated as shown in Fig. 3. Fig. 4 to 6 show the proteus simulation of the solar powered automated incubator. Fig. 4 shows when the temperature inside the incubator is above 37ºC, Fig. 5 shows when the temperature inside the incubator is below 36ºC and Fig. 6 shows when the temperature inside the incubator is within the band of 36-37ºC. Fig. 7 shows when the humidity is less than 55%, Fig. 8 shows when the humidity is within the humidity band of 55-65% while Fig. 9 shows when the humidity is above 65%.

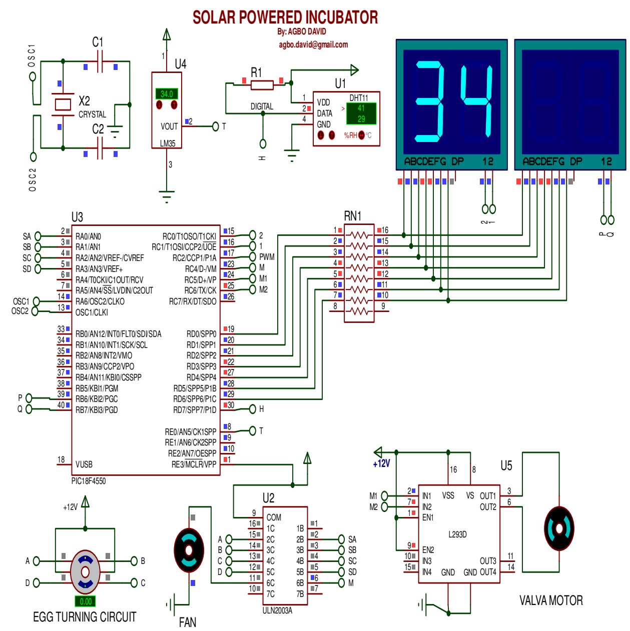


Fig. 5: When Temperature is below 34ºC.

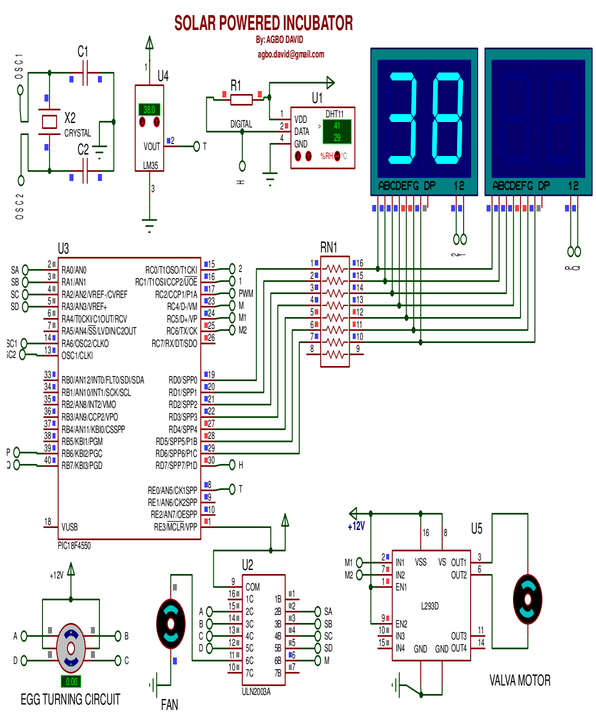


Fig. 4: When Temperature is above 37ºC.

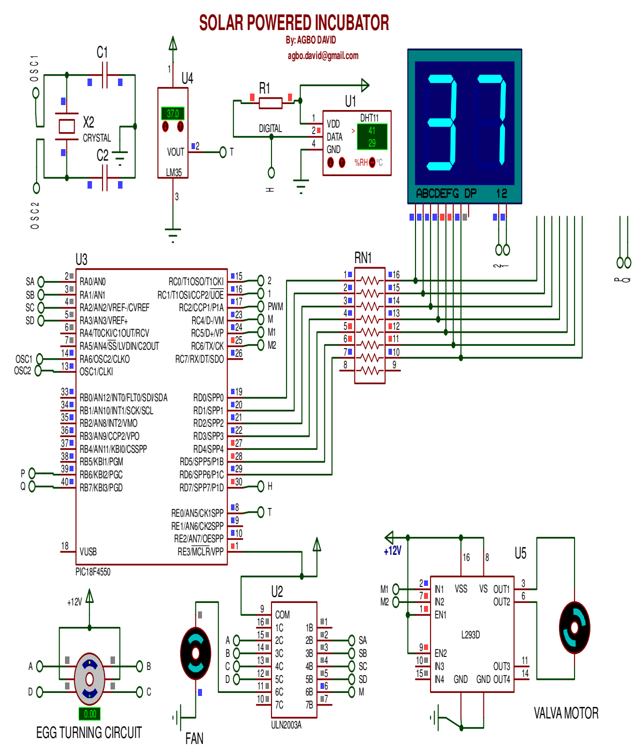


Fig. 6: When Temperature is within the range 34-37ºC.

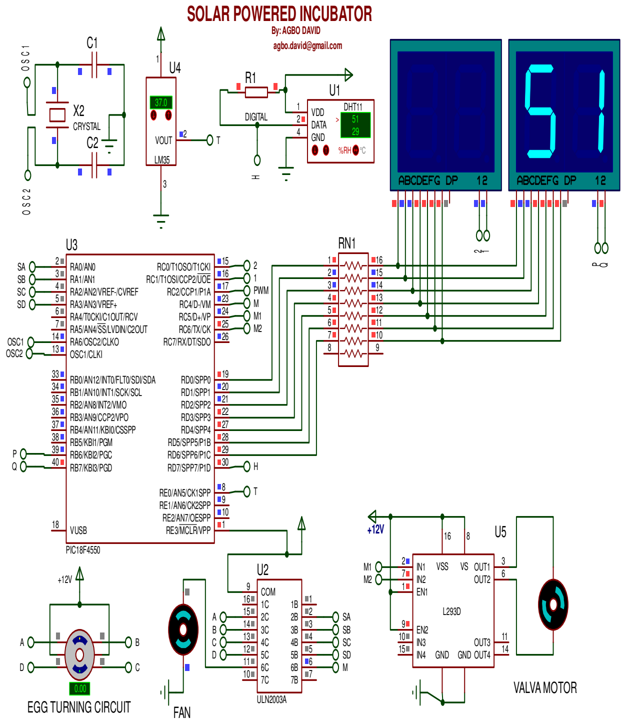


Fig. 7: When Humidity is below 51%.

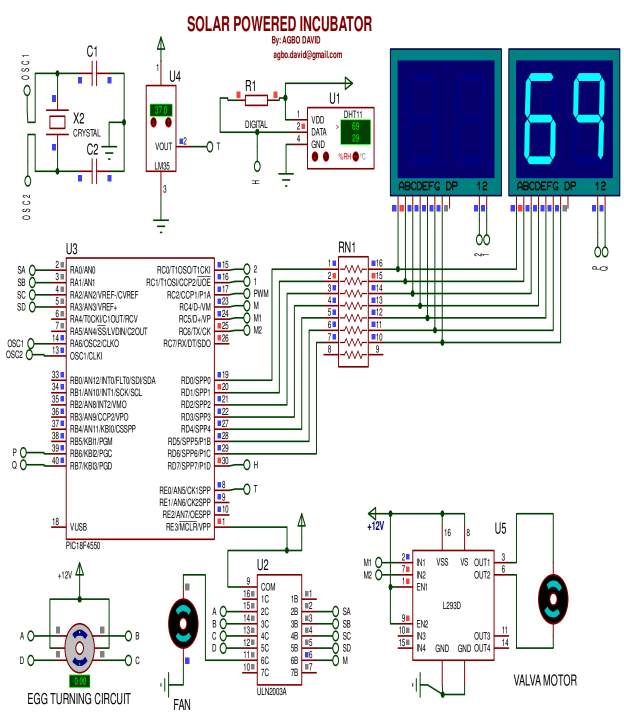


Fig. 8: When Hunidity is above 69%.

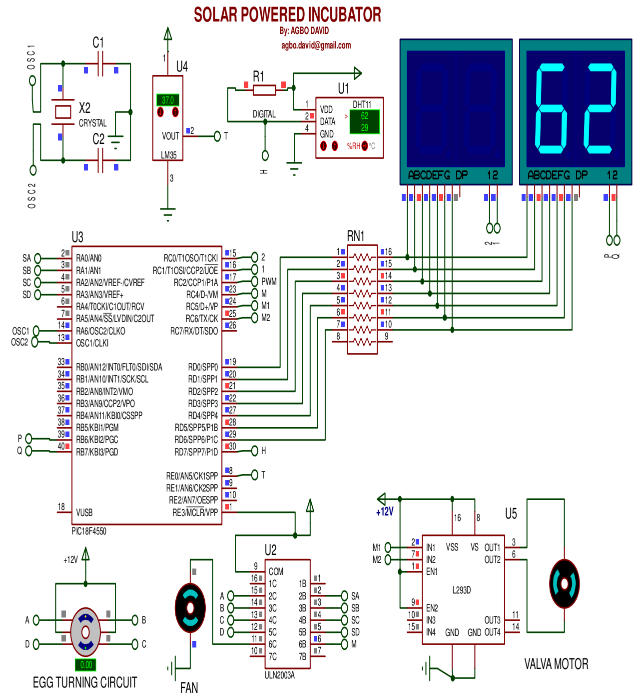


Fig. 9: When Humidity is within the range 55-65%.

VI. Conclusion

The solar powered automated incubator was designed to achieve an accurate temperature band of 36ºC- 37 ºC, humidity of 55% to 65% and precise turning of eggs twelve times daily. Lm35 and DHT11 sensors were used to sense the temperature and humidity respectively. The stepper motor was used to drive the egg tray either clockwise or anti-clockwise direction. The Pic18f4550 microcontroller is the heart of the device is used to control all the process.

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