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Solar Powered Egg Incubator Design

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Abstract: *This paper describes the design of an egg incubator which is powered from solar photovoltaic energy system. Chicken farmers at places not connected to notational grid and small households at rural settlements for them to maximize production requires egg incubators which can utilize available energy sources in absence of national electricity grid. There are critical factors which are necessary for the effectiveness of egg performance and these include correct internal temperature and relative humidity and periodic egg turning inside the incubator. The incubator designed allows for use of solar PV system as an energy source. The simulation results show that the incubator is able to maintain internal temperature and relative humidity within the required ranges. It also able to perform egg turning through electric motor actuator mechanism and is able to display number of days left before hatching. Further work will follow where the actual prototype is constructed and validated through actual egg incubation.*

Key words*: Egg incubator, photovoltaic system, performance*

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I. Introduction

Chicken rearing is one of the common farming practices for both commercial and noncommercial sector. The farming stretches for well-resourced places having amenities such as water, electricity transportation network and many more. There are however other places such as rural communities and some farms which are far away from national electricity grid. Unavailability of the services become a drawback to the farmers in these areas such as poultry farmers or chicken farmers. To maximize production and ultimately profit, egg incubators has proven to be one way of doing that because for most part of the time the hen lays eggs and does not need to spend 21 days brooding and incubating eggs and spending other weeks raising chicks. However many small scale farmers in rural areas do not have access to egg incubators due to distance and transportation problems and unavailability of electricity. Most commonly available egg incubators are powered from grid network. The purpose of this paper is therefore to come up with a design which will be powered from solar and do the incubation efficiently like other incubators found in the developed areas. Solar energy in a renewable resources which abundant and can be easily tapped. It is also anticipated to make the incubator more affordable by building it from locally available materials.

For effective and efficient operation of an incubator there are factors and parameters which need consideration. Temperature is one of such parameters because the required temperature shall range between 36 °C and 39 °C [2, 10]. Another parameter is relative humidity which should range between 50% and 65% [4]. Another factor is the periodic turning of eggs while in incubation which about two to four times per day with maximum angle of turning from pivot being 45 degrees on either side of the pivot [3].

The rest of this paper is arranged as follows: Section II principle of operation of PV system, Section III deals with main equipment used, Section IV deals with operation of proposed incubator system, Section V deals with system sizing, Section VI is on programme developed for loading into the micro controller, Section VII deals with equipment setup and the results, Section VIII is conclusion and future work.

II. Principle of Operation of Solar PV Energy System

Solar photovoltaic (PV) cells are made of a material known as semiconductors, the most common being used is silicon. Essentially, when the light strikes the cell, some of this is absorbed within the semiconductor material. and knocks the electrons loose, allowing them to flow freely hence generating flow of electrons or current as shown in figure 1 **[5].** When these PV cells are put together in series they form a PV module and a series or parallel connection of PV modules form a PV array.

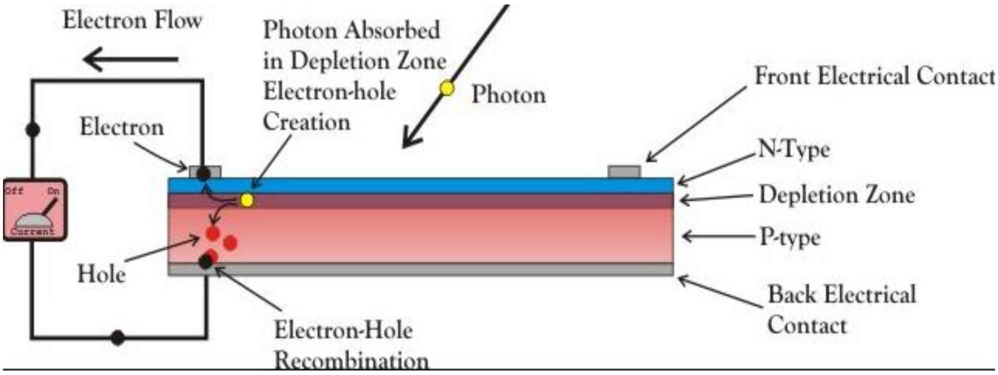


Figure 1. Generation of electric current by photovoltaic cell

Photovoltaic (PV) cells are used to absorb the sun's radiation and the energy contained in the radiation causes the photovoltaic cell to produce a voltage proportional to the intensity of such radiation. The cells are constructed using p-doped and n-doped semiconductor material, normally boron is used to dome one side and the other side doped with phosphorus [11]. Between the doped materials is what is referred to as pn-junction. As the radiation is incident on the cell it passes through p-doped upper layer towards the n-doped layer where it is absorbed by the electrons hence causing formation of conduction of electrons and hole pairs. The diffusion of electrons and hole pairs to either side of the pn-junction causes the depletion of the layer creates a potential difference across depleted layer with one side (upper layer) being positive and the lower layer being negative. So if an external circuit is connected to the layers a current will flow in the circuit to the generated potential difference

A generic PV system layout is shown in Figure 2. The PV module receives solar radiation from the sun the PV module/ generator received solar power from the sun and convert and converts such power to electrical output parameters being d.c.voltage and current. If the system is provided with energy storage and in this case being a battery, the current from the PV module is used to charge the battery which in turn would supply power to the load. Where the load to be supplied is AC, inverter is connected between the battery and the load to invert d.c. electrical parameters into a.c. Between the PV module and battery is a charge controller. Its main objective is to ensure that it monitors the state of charge of the battery. If the battery charge is low, it connects the PV module to battery for charging, and if the battery is fully charged it disconnects the battery from the MOV module. This is done to project the battery from damage and to prolong the life of the battery [6, 9].

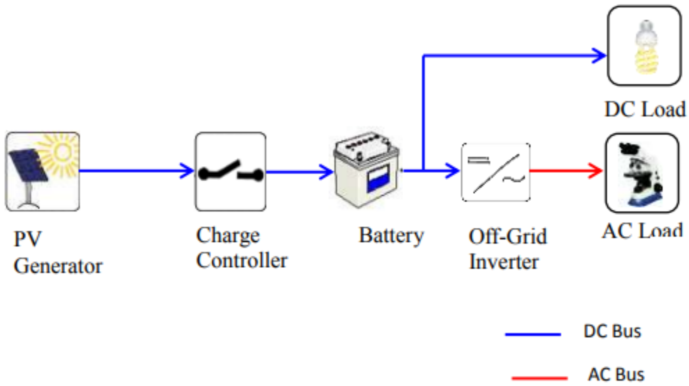


Figure 2 – Shows principle of operation of solar PV system

III. List of Main Equipment

(a) Sensors – DHT 22

A preferred sensor for the incubator is DHT 22 sensor. Figure 3 shows a picture of the DHT 22 sensor. It is a four pin sensor with the following pins and code respectively, (1) VCC – is a red wire connect to the 3.3 V – 5 V; (2) Data out – is a white wire or yellow connected to the receiver, (3) Not connected – it can be used to connect to a relay, and pin 4 GND – is a black wire connected to ground. The sensor can measure temperature and humidity [7]. It has better accuracy and has larger ranges for both humidity and temperature readings. It is used to monitor temperature and humidity readings from the incubator unit and send signals to the microcontroller for analysis. The micro controller is meant to keep the temperature between 36 degrees and 39 degress celsius and 50% to 65 % respectively. It does this by activationg relay switch to eaither switch on or off the bulb and/ or fan

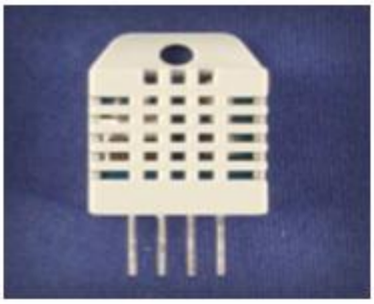


Figure 3 - Diagram of a DHT 22 sensor

(b) Arduino UNO Microcontroller

Figure 4 shows arduino UNO board micro conntroller and its main components. It has different critical components being microcontroller, analog pins, digital input/output pins, power and ground pins, USB plug, external power supply, internal programmer and reset button. Its main task is to receive and interpret signals originating from temperature and humidity sensors and communicate with actuactors to take necessary action.

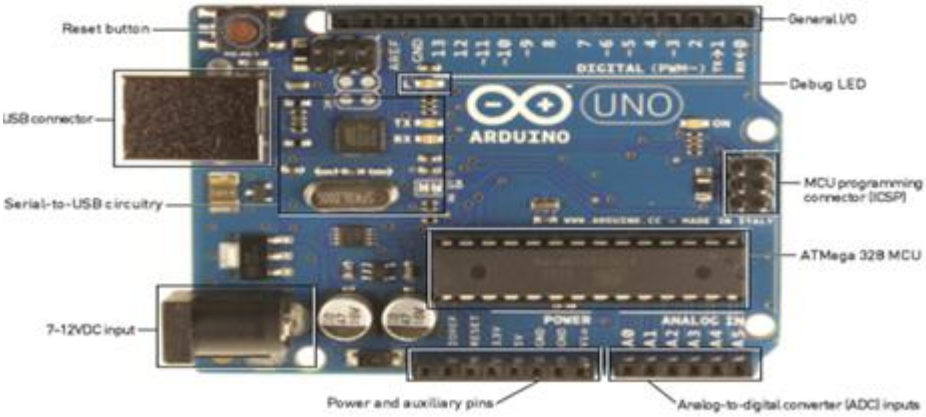


Figure 4 - Arduino UNO board and its main components

(c) Servo motor

It is used to drive the crank and rod mechanism which are used to tilt egg tray 45 degrees either side of its pivot. The motor is of a 5 V dc rating.

(d) 12 V dc circulating fan

It is used to facilitate regulation of temperature and humidity in the incubator by keepin them within required ranges of preset values.

(e) 10 W Incandescent bulb

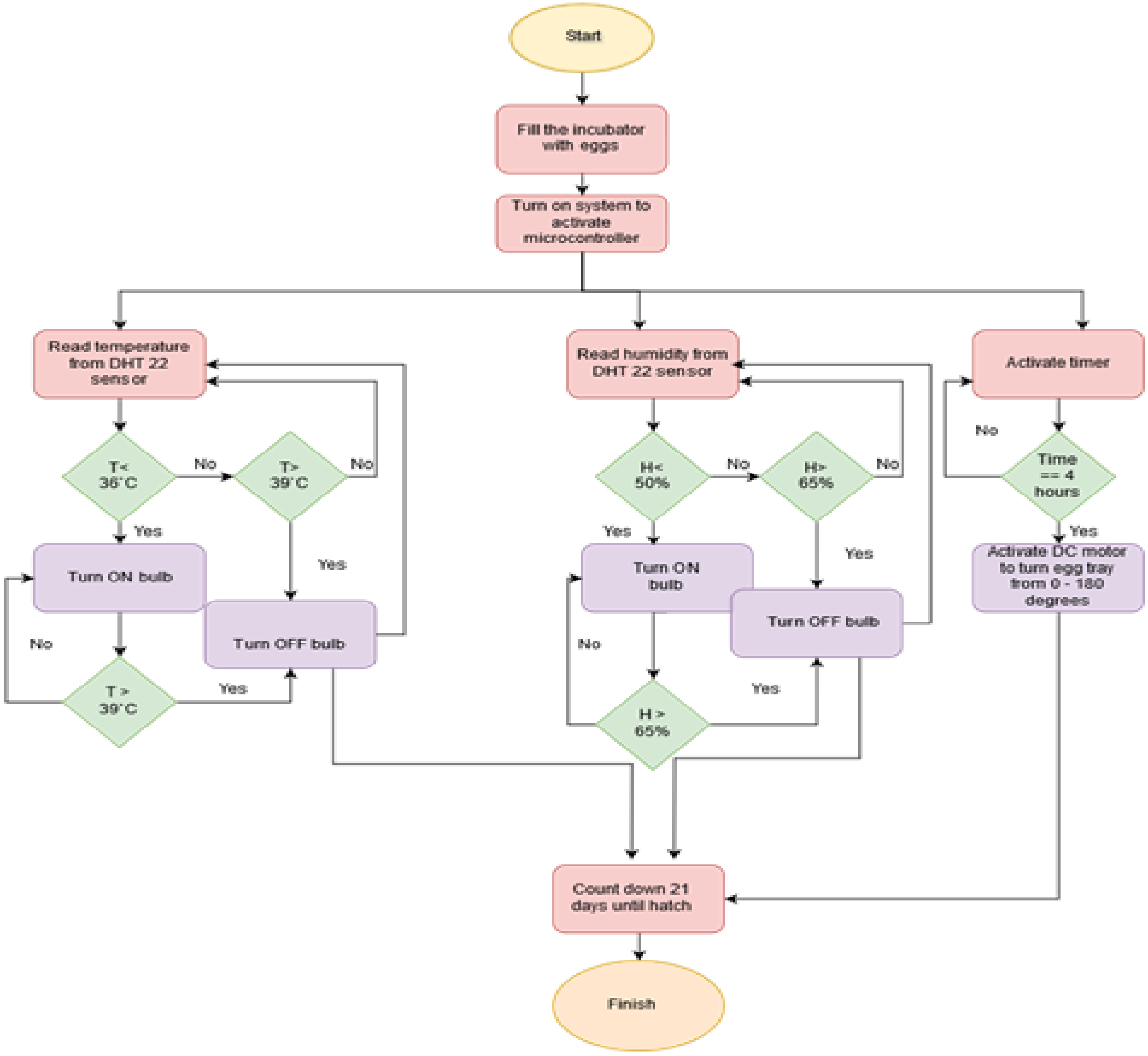
It is used to provide warmth within the incubator.

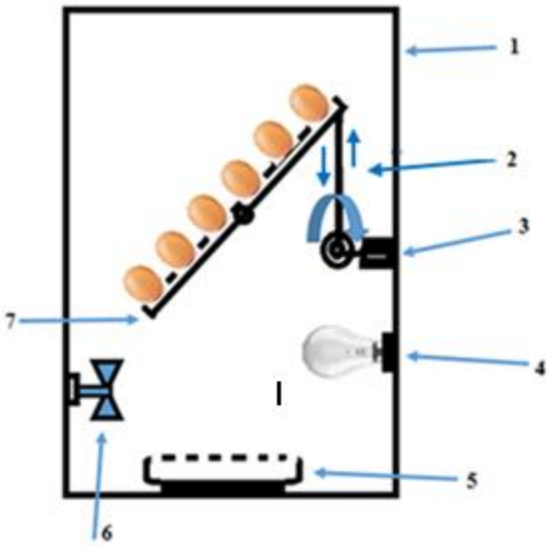
IV. System Operation

In Figure 5 the overall explanation of the operation of the incubator is given. The electrical operating system and its control circuitry ensures that the three key parameters of the incubator are maintained within normal operating range. These are temperature which is to be mantained between 36 – 39 degrees celsius, relative humidity to be maintained between 55 to 65 % and the tray turning angle to be maintained between +45 degrees and -45 degrees.The humidity and temperature are maintained by either switching on or off or both the heater and the fan. When temperature goes below 36grees the light goes on and if it goes off when it is witihn range. If temperature goes beyond 39 degrees it fan goes on until the temperarture is within ragne. On relative humidity if it is below the minimum the low fans goes on to facilitate water evaporation from the water resevoir located at the lower part of the incubator. The system is also designed such that it displays days remaining before hatching. As incubation including hatching normally takes 21 days the system counts down from 21 days until the last day of hatching.

In Figure 6 the turning of egg tray is achieved with a crank rod and connecting rod mechanism. When motor shaft rotates or cranks it causes the vertical actuating mechanisms, labeled (2) in Figure 6 to have vertical up and down movement. One end of this mechnaism is connected to the motor shaft while the other end is connected to the egg tray. With motor shaft doing having a circular rotation the direction of rotation is converted into up and down movement by the verical shaft (2) and such vertical motion converted to 45 degrees angle by the egg tray. This makes the egg tray which is pivoting at the centre to have inclination movement whereby at one instance its inclinded towards left at an angle of 45 degrees and at the other instance is inclined towards right.

Figure 5 – Process diagram for the control of temperature, humidity and tray turning





Key:

1) Incubator body; 2) Crank and connecting rod mechanism; 3) DC motor; 4) DC bulb; 5) Water resevoir; 6) DC fan 7) egg tray

Figure 6 – Cross section of an incubator

V. System Sizing

Size of incubator , it was used to determine the amount of power which will be required to turn the egg-turning mechanism, to operate the fans and for lighting puposes and also to power the arduino microcontroller. The power ratings of motors used for operating such components and for the light were determined. The duration of the operation for both winter and summer season, and day and night times were considered when determining the overall energy requirements foof the incubator. Figure 5 shows a cross section of an egg incubator. After determining total power requirements of an incubator, the number of PV modules, size of battery and charge controller were determined. The battery was necessary to provide power when there is no solar radiation available.

VI. Programme Development For Temperature And Humidity Controller

A program dealing with monitoring and regulation of internal temperature and relative humidity was developed and uploaded in the micro controller. The monitoring was to ensure that the process variables stay within the prescribed limits. When the value of the variables violates the set limits the code calls for controller to activate the relevat actuactors. Simulations were carried out to verify correctness of the design, The program code was generated using the arduino IDE software.

VII. Experimental Setup And Results

To construct or build a circuit as in Figure 7, the ISIS proteus 8 professional was used and the circuit was simulated for verification purpose..

In order to verify if the system would work,it was simulated under different conditions to find out how it would respond. Figures 8, 9 and 10 show results of simulated conditions.

Fiugre 8 – is when both the temperature and the humidity are below expected temperature ranges. On this condition the LED light is on showing that both the fans and the buld are on to increase both the humity and temperature.

Figure 9 –depicts a situation where humidity is still below the required range whereas the temperature is at the upper range. In this case the LED light is still oon indicating that the FAN is still on to improve the relative humidity in the incubator.

Figure 11 - depicts a situation when both variables, temperature and humuidity, are above the expected limits. The LED light is off indicating that both fans and the bulb are off allow temperature to cool down and humity to reduce to the required values respectively.

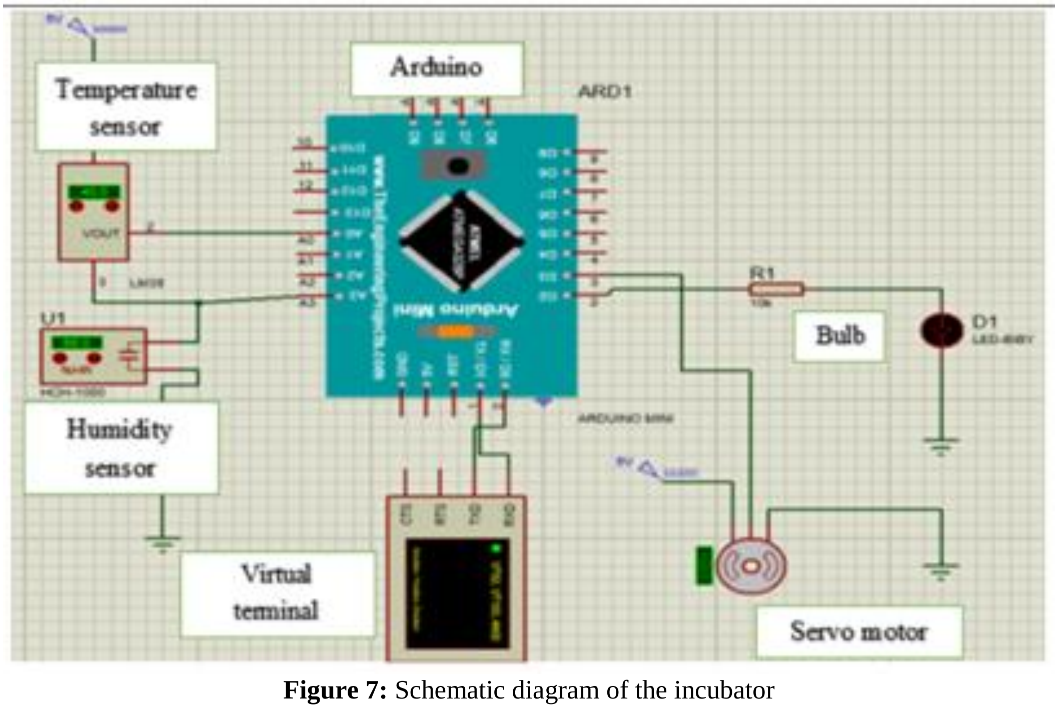


Figure 7: Schematic diagram of the incubator

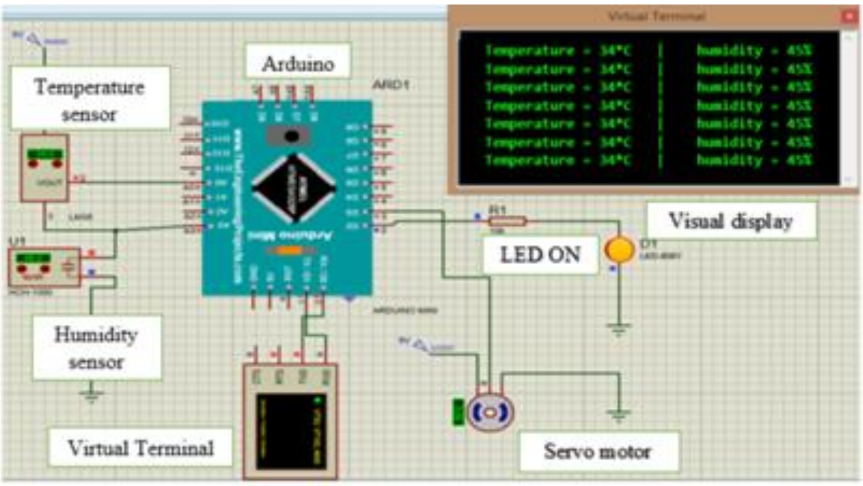


Figure 8 Simulation results when the temperature and humidity are below the setting

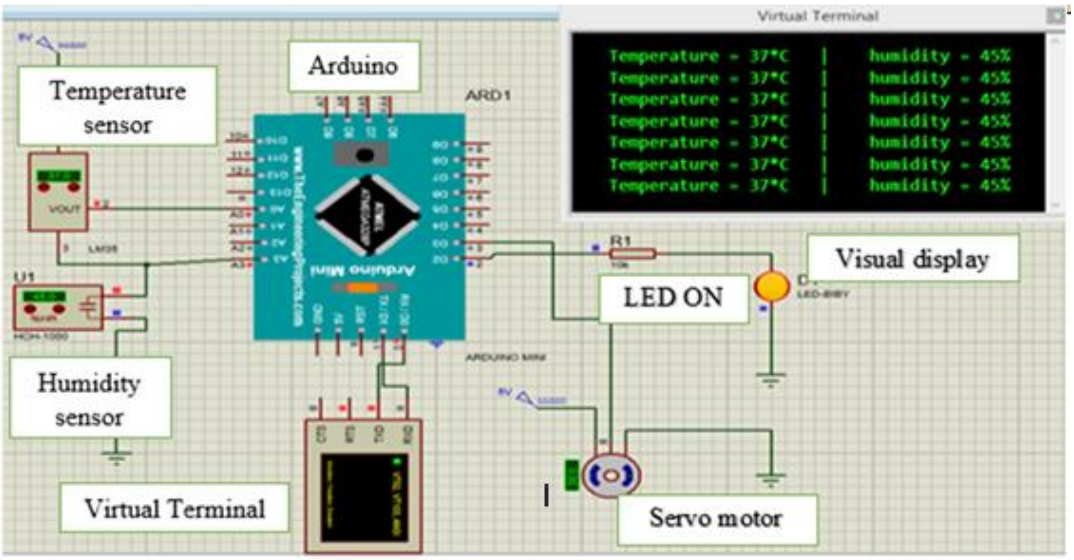


Figure 9 Simulation results when the humidity is below the setting and the temperature is at optimum

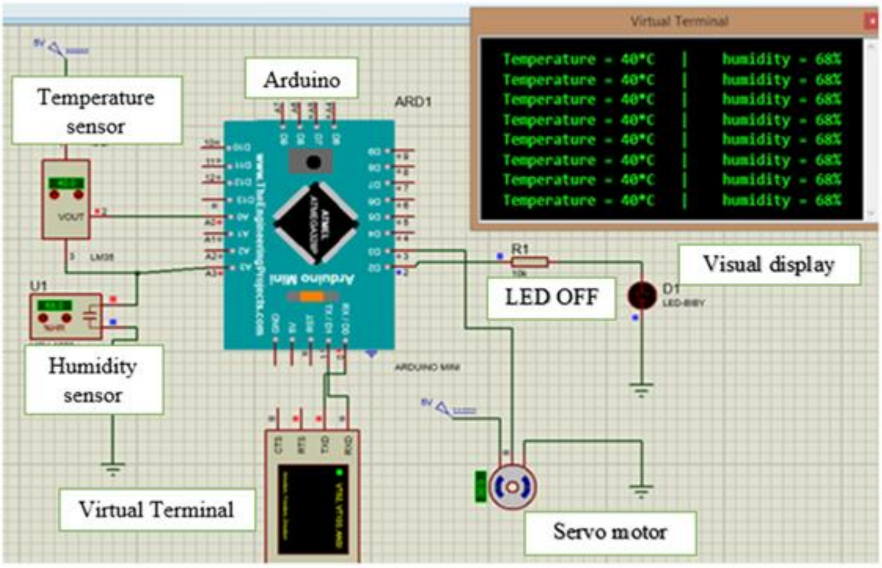


Figure 10 Simulation results when both temperature and humidity are above setting

VIII. Conclusion And Future Work

The results show that the designed egg incubator would work as expected once it is built. When simulating conditions out of range of expected values for both the temperature and the relative humidity, the system responds accordingly by activating the LED light. The light is a representation that the light bulb which act as a heat source and an electric fan, which is responsible for facilitating moisture evaporation from water reservoir, work as expected. These results confirmed the design as correct and further work would be to build the incubator as per the laid out design in this paper.

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