DESIGN AND CONSTRUCTION OF ELECTRONIC INCUBATOR WITH VARIABLE TEMPERATURE (35-40)^{0}C AND ALARM SYSTEM

BY

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Submitted to the

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DEDICATION

I dedicate this project to the Almighty God for giving me inspiration, strength and protection throughout my period of studies, and to my late elder Bro. Benjamin Adekunle Ayoola through whom I pick courage daily.

CERTIFICATION

This is to certify that Ayoola Sunday carried out the design and construction of an electronic incubator with variable temperature (35 -40)°C with and alarm system, under the supervision of Mr. Abraham Usman and submitted to the department of Electrical and Computer Engineering for the award of B. Eng in Electrical and Computer Engineering, Federal University of Technology, Minna, Nigeria.

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2nd Dec, 2005
DATE

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HEAD OF DEPARTMENT

16/02/06
DATE

EXTERNAL EXAMINER

DATE

ACKNOWLEDGEMENT

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I shall never forget these great men and women, ladies and gentlemen, for their wholehearted support both physically and otherwise Surveyor Momoh Aiyegbeni, Engr.

I shall never forget these great men and women, ladies and gentlemen, for their wholehearted support both physically and otherwise Surveyor Momoh Aiyegbeni, Engr. Abdulkadiri Sule, Mr. Bright O., Mr Titus Hammer, Mr. Ezekiel (aka No Face), Mr. Ameh Ameh, Mr. Yuhana Audu (aka Col. Audu), Mr Inusa (aka She Tailor), Comrade Surajjuddeen, Engr. Godwin Haruna, Solomon Solo, Miss Blessing Uluocha, Augustine Uluocha, Peaceo, "Under 16 F.K" Mr. John, Alh. Rasaq Bello, a friend indeed. Webmaster Adekunle Adeleke, Engr. Festus Kogi, Sailor Babatunde Festus Ayoola, Miss Joke Ayoola, Iya Bayo (Minna), Miss Grace Ikpi, Miss Sarah Ayoola, Miss Lizzy Ayoola, Engr. Emmanuel Ayoola, Dr. Uzu Edwin, Charles Akpoveta, Emir Chicago, Moses, mother indeed "Kaka" land lady, Shola E., Taiwo (Brother), Mr. Ben, Mama Ben "Ogoja woman" Kuye Ayodeji.

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ABSTRACT

This work discusses the design and construction of electronic incubator with variable temperature to hatch fertile egg/eggs into chicks by the application of regulated heat. The temperature monitoring circuit consist of Op-amp comparator, resistor, relay with alarm unit. However, the heat is controlled by a Schmitt trigger through a switching circuit depending on voltage divider output that rapture into the comparator. The electronic incubator so designed to maintain variable temperature between (35-40)°C. The device can house a maximum of twenty four eggs at a time.

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CHAPTER ONE

1.0 INTRODUCTION

Poultry keeping has become one of the successful age long professions. Agricultural industries provides supplementary to other sources of protein through breeding of domestic birds. The use of the brood hens to incubate the eggs has disadvantages in that the output cannot be guaranteed with a good degree of certainty as the hen can walk away abandoning the eggs or situation where reptiles eat up the eggs and the hen.

In addition to this, broody hens are not always available when they are needed particularly early in the year. Base on these aforementioned reasons man has to seek technological ways to improve on the poultry production, with a view to increasing the output and consequently ensuring steady supply of it.

That is the technology of incorporating sciences in the field of engineering with latest break through in Electrical & Computer Engineering research. For instance, in the field of biomedical sciences (e.g. heart rate monitor, human incubator etc), agricultural sciences (e.g. eggs incubator) are designed and constructed which are subject to improvement.

Artificial incubation is not a new idea, it has been used over 2000 years ago by the Chinese who hatched eggs in large clay – bricks oven heated by burning wood [6].Base on insufficiencies from Chinese artificial means an egg incubator is designed and constructed based on the technical know-how in the field of electrical and computer engineering to ease the stress that poultry farmers will be passing through when the demand for eggs increases in the market.

Artificial incubator has a capacity to handle thousands of eggs at a time, depending on the size. Incubator is an electrically operated machine meant to cause fertile eggs to hatch into chicks by the application of a controlled temperature and humidity equivalent to the temperature produced by the brooding hens, producing the same condition for incubation as the natural one.

There are major range of incubators available that can be grouped into three (3) types as follows plywood incubator, cardboard incubator and still air incubator. Every incubator has an egg tray that holds the fertile eggs some few distances below the heat source and above its base.

The heating source is regulated by means of a thermostatic principle i.e. the heat generated is regulated to the desire range by cutting off automatically the heat supply. There is ventilating holes near its base for oxygen to come into the incubator through which the eggs get oxygen via the egg shell as well as an escape hole through which carbon dioxide leaves via the egg shell.

The embryo is developing to become a chick at the end of the incubation; the yolk, white and the shell of the egg contain all of the proteins, fats, carbohydrates, minerals and vitamins necessary to the embryo during 21 days incubation period for brood hen [4] as shown below in the table.

Species	Incubation period (Days)
Chicks	20-21
Turkey	26-28
Duck	26-28
Missvory duck	33-35
Goose	33-35
Pigeon	17-19
Bad white quail	22-24

1.1 OBJECTIVES

Just as has been slightly included in the introduction, the main objectives of the project are:

I. To design and construct electronic incubator locally to improve on the poultry production with a view to boost the output and ensuring constant supply of poultry products.

II. The incubator is been designed locally in such a way that it will be cheaper and affordable by most of our poultry farmers. Since the imported incubators are very expensive and most of these farmers cannot afford it, this design will give them the privilege to overcome the problem they have been facing.

III. To create an ideal and also to make fellow students bring out the creative skills in them using the knowledge gotten in the field of Electrical and Computer Engineering to extend to other fields in other to salvage the country from shortage of food and importation of frozen chicken, which will lead to boosting of the economy generally.

IV. The creative skills developed could lead to source of employment for the coming students which shows the potential of Electrical & Computer Engineering as a noble profession.

1.2 SCOPE AND LIMITATION

Artificial incubator has a capacity to handle thousands of eggs at a time, depending on the size.

For this project, we are restricting ourselves to the incubator size that is capable of handling maximum of twenty four eggs due to the financial constraint.

One of the major limitations faced in the process of carrying out the project is inability to get the actual values of the majority of the components needed; we resulted in consulting data books, electronic work bench software, looking for the equivalent values of these components.

In addition, most of these components are not readily available here, we have to embark on a journey to Abuja for the procurement of these components.

It should also be noted that prolong power outage by PHCN will render the incubation process useless. This work thus assumes that there is efficient power supply by PHCN.

1.3 ADVANTAGES OF ARTIFICIAL INCUBATOR

Artificial incubator is very useful in the poultry industries where the need for mass production of chicks is required, thus increasing production rate.

It is also very useful in hospitals where premature babies are put into the incubator to complete the number of months they are supposed to stay in their mothers' womb before their birth.

Bio – medical equipment are sterilized and preserved under a precise temperature environment or condition.

CHAPTER TWO

2.0 LITERATURE REVIEW

The ancient Egyptians and Chinese both devised incubators to hatch chicks from eggs without the mother hen sitting on the eggs. This enabled hens to continue laying eggs. The Egyptian incubators were large rooms heated by fire, attendants turned the eggs at regular intervals so they would warn evenly. Some Chinese incubators were warmed by fire, other by rotting manure.

The Italian inventor Jean Baptiste Porta drew on the ancient Egyptian designs to build his 1588 egg incubator, but was forced to abandon his work by the inquisition. Dutch inventor Cornelius Drebbel also invented an incubator to hatch eggs. Knowledge about egg incubation was revived and introduced throughout Europe by the inventive Frenchman Rene Antoine Ferchault de Reaumur (1683-1757) around 1750 [6].

Reaumur's device was warmed by a wood store; temperature was controlled by a thermometer, also invented by Reaumur which gave rise to the temperature scale named after the inventor. The success of Reaumur, which gave rise to the temperature scale named after the inventor. The success of Reaumur's incubator – Louis XV (1710 – 1774) enjoyed helping the chicks hatch helped boost commercial production of foodstuffs at the beginning of the industrial era. After Reaumur's death, the incubator was further developed by Abbe Jean Antoine Nollet (1700 – 1770) and later by Abbe's Copineau, who used alcohol lamps as a source of heat.

Today's incubators are electrically heated and turn the eggs automatically, large ones may hold up to 75,000 eggs [3]

The temperature in the hen's body approximately 100^0F (38^0C) and if development of the fertilized egg is to continue, this temperature must be maintained. The completion of embryo development requires (21) twenty one days of incubation, plus or minus few hours for brood hen. [4].

CHAPTER THREE

3.0 DESIGN ANALYSIS

INTRODUCTION

The invention of egg incubator has provided the poultry farmers high productivity, lesser time, cost reduction, low risk bearing, safety in the production of poultry birds.

This chapter provides the complete description of the various elements or units of the egg incubator. The theoretical background of each element is extremely dealt with, the block diagram of an egg incubator circuit is shown

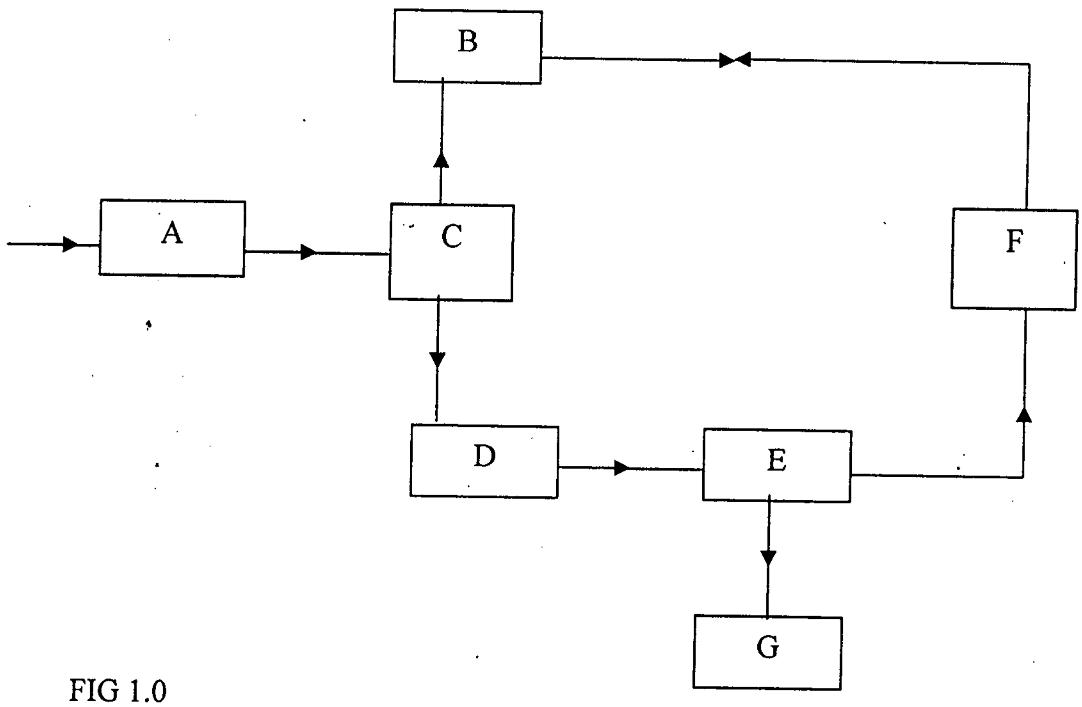


FIG 1.0

Block diagram of an egg incubator circuit

A – Power supply unit

B – Sensor unit

C – Voltage comparator OP-amp unit

D – Relay unit

E – Switching unit

F – Heat unit

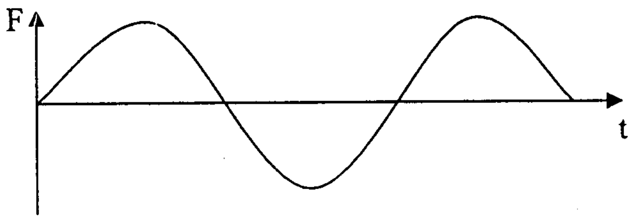
G – Alarm unit

The block shows the process leading to hatching of the poultry fertilized egg into chick. The power supply unit is the power house of the entire circuit of the egg incubator. Its output voltage (normally after rectification) is fed into the egg incubator circuit and subsequently converted into energy. This happened as the temperature sensor, the thermistor (a transducer) converts the heat into voltage signal that drives the comparator unit meant to compare at the inverting and the non inverting input with respect to the reference voltage obtained by adjusting the potentiometer of the comparator unit.

The output from the comparator unit drives the switching unit through a voltage divider network of R_1 and R_2. The switching comprises of a transistor and relay to which the heat source is connected as the induced heat equals the desired temperature of the egg incubator, the alarm unit will trigger and once its temperature falls below desired range the alarm unit will switch on in a positive response to the switching unit which switches off the electric bulb and after a few seconds the temperature sensor senses through the comparator unit relates the signal to the switching unit once more, hence the process is repeated again and again, thus, the desired temperature for hatching is steady.

3.1 POWER SUPPLY UNIT

Majority of electric circuit uses direct current supply for operation and the conversion of alternating voltage (usually 240 V_{rms}) to the desired 12Volts dc voltage is achieved through the following lay down procedure.



A. C Input

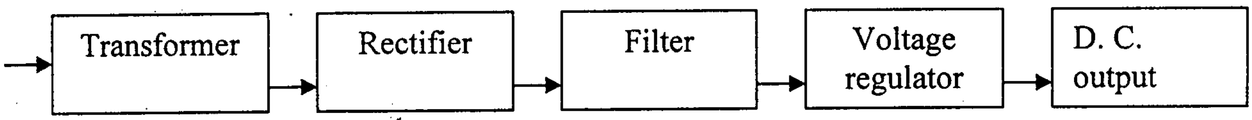


Fig 1.1 The block diagram of the power supply unit.

3.2 THE TRANSFORMER STAGE

The transformer steps the domestic ac supply of about 240V_{rms} to the required voltage suitable for electronic drives. It consist of two closely coupled coils identified as the primary (V_p) appears at the secondary (V_s) as a voltage multiplication inversely proportional to the turns ratio (k)

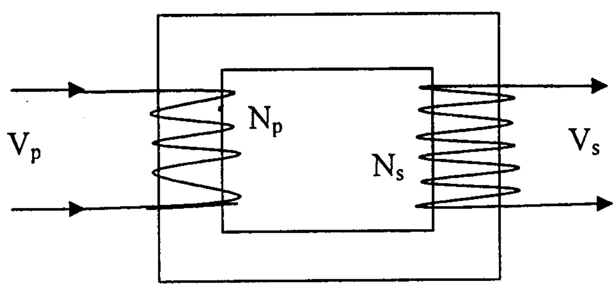


Fig 1.2 The Transformer

$$K = \frac{Vs}{Vp} = \frac{Ns}{Np}$$

When K>1, the transformer is a step-up transformer, and when K<1, the transformer is a step-down type.

K = voltage transformer ratio

V_s = voltage applied at the secondary coil

V_p = voltage applied a the primary coil

N_s = number of turns in the secondary

N_p = number of turns in the primary winding

A 15V step-down transformer was used for this project to meet the twelve volts (12V) required for the incubator.

3.3 RECTIFICATION UNIT

The term rectification is defined as the process of changing pulsating ac voltage into dc voltage by eliminating the negative half cycle of the alternating voltage. This project adopts the use of a full wave bridge rectifier because of its ability to produce the approximate varying and reference voltage.

The maximum instantaneous voltages between the terminals are:

$$V_{max} = V_{rms}\sqrt{2} \qquad (1)$$

The four diode in fig 1.2 below are arranged in a diamond configuration called full-wave bridge rectifier

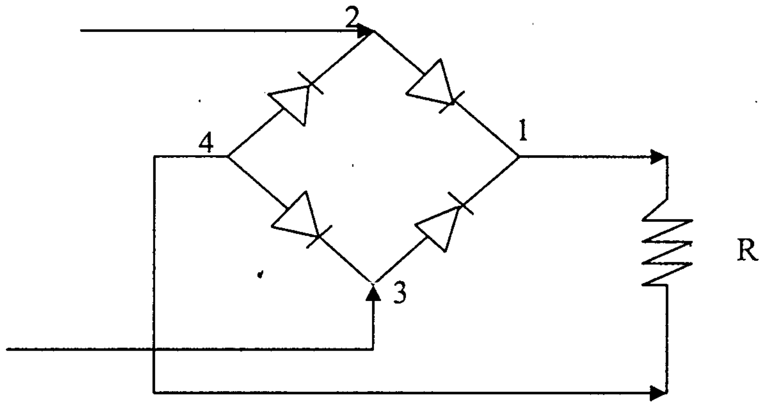


Fig 1.3 Circuit of bridge rectifier

DESIGN/CALCULATION

The direct current voltage V_{dc} is given by

$$Vdc = \frac{2V\max}{\pi} = 0.636V\max \qquad (2)$$

It must be noted that the PIV (peak inverse voltage) be greater than the $V_{max.}$

Also note that $V_{rms} = 12V$

From the expression,

$$V_{max} / \sqrt{2} = V_{rms} \qquad (3)$$

$$V_{max} / \sqrt{2} = V_{rms} \times \sqrt{2}$$

$$= 12 \times \sqrt{2}$$

$$= 16.968V \qquad (4)$$

Allowing a safety margin of 1.5, hence PIV = 1.5 x 16.968 = 25.5V. The value of the PIV 25.5V, prompted the need of selecting a 2A bridge rectifier with a maximum peak inverse voltage of 100V

3.4 SMOOTHING AND FILTERING

The main function of a filter is to maximize the ripple content at the full-wave bridge rectifier output. The input and output waveform of the filtering circuit is shown in fig 1.4 below

(a)

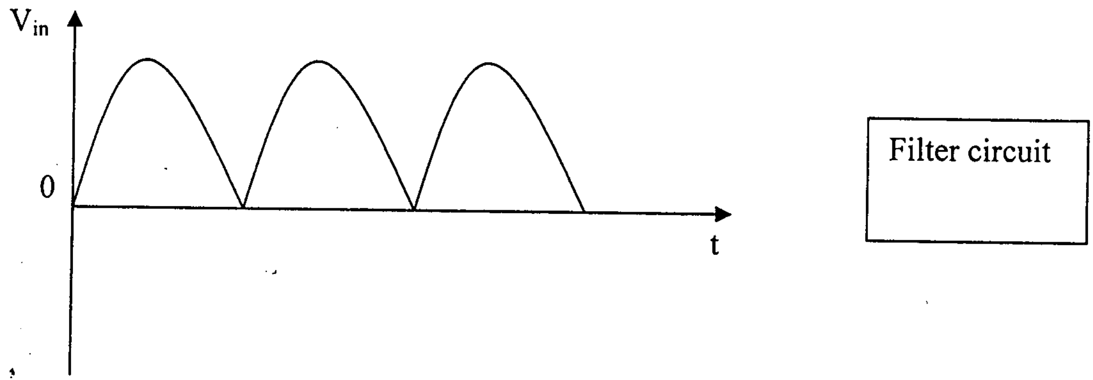


Fig 1.4 a

Pulsating D. C.

(b)

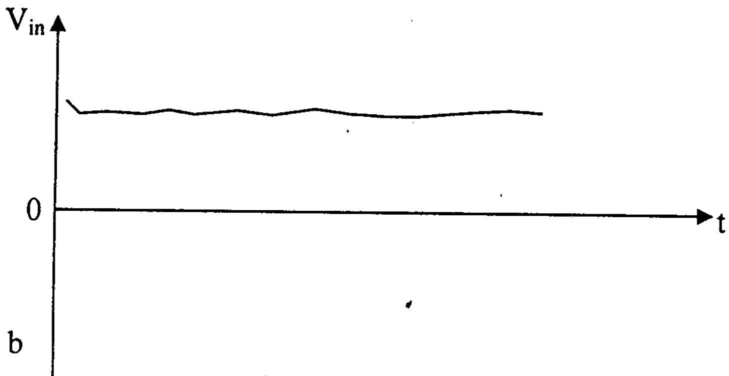


Fig 1.4 b

Filtered D. C.

The electrolytic capacity depends on its operation, the property of the device to charge up, i.e. store charge, during the conducting half cycle and discharge during the non conducting half-cycle

Below is the input and output waveform to the shunt capacitor and the approximated ripple voltage

Fig 1.5 INPUT WAVEFORM TO THE SHUNT CAPACITOR

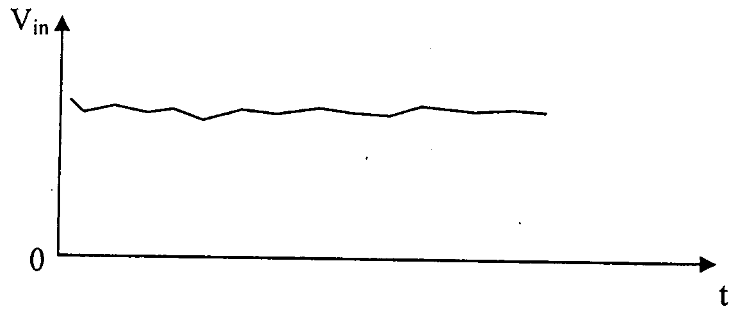


Fig 1.6 OUTPUT WAVEFORM OF THE SHUNT CAPACITOR

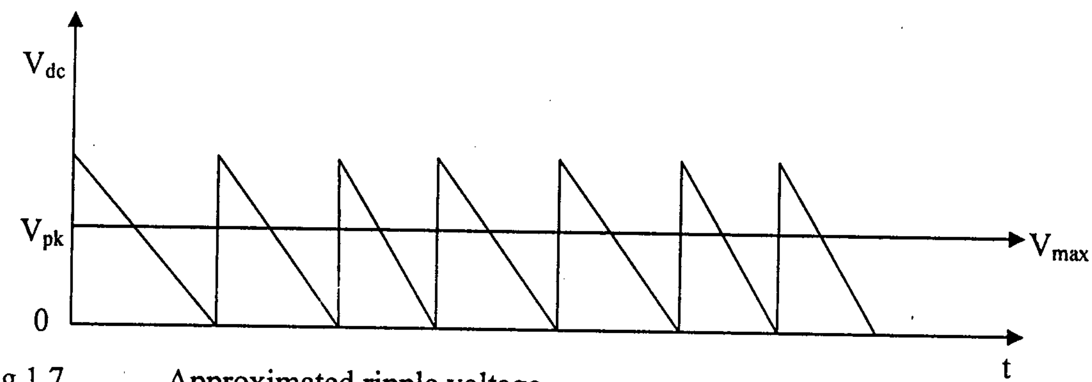


Fig 1.7 Approximated ripple voltage

3.5 DESIGN OF RIPPLES VOLTAGE/POWER

The ripple voltage can be approximated by a triangular waveform, which has a peak-to-peak ripple voltage and a period of time (Tr) as in fig 1.6 above.

Considering the charge during the capacitor discharge as dq in time is I_{dc} x T_r.

$V_r(P - P) = dq / C$

$$= (I_{dc} \times T_r) / C \qquad (5)$$

But,

$$I_{dc} = \frac{V_{dc}}{R_L} \qquad (6)$$

$$T_r = \frac{1}{F_r} \qquad (7)$$

Substituting equation (4) into equation (5) becomes

$$V_r(P-P) = \frac{V_{dc}}{R_L} x \frac{\frac{1}{F_r}}{C} \qquad (8)$$

$$V_r(P-P) = \frac{V_{dc}}{R_L} x \frac{1}{F_r C}$$

$$V_r = \frac{V_{dc}}{R_L F_r C} \qquad (9)$$

But $V_{rms} = V_r(P\text{-}P)/2\sqrt{3}$ (10)

Equation (9) can be written as

$$\frac{V_{dc}}{F_r R_L C} = V_{rms}\, x \sqrt[2]{3}$$

$$V_{rms} = \frac{V_{dc}}{\sqrt[2]{3} F_r R_L C} \qquad (11)$$

It must be noted that for a bridge rectifier F_r=2f where F_r is the ripple frequency and F is the normalize frequencies.

$$V_{rms} = \frac{V_{dc}}{2\sqrt{3}\,x\,2FR_LC}$$

$$V_{rms} = \frac{V_{dc}}{4\sqrt{3}\,x\,FR_LC}$$

$$\frac{V_{rms}}{V_{dc}} = \frac{1}{4\sqrt{3}\,x\,FR_LC} = \gamma \qquad whwre\ \gamma = \frac{V_{rms}}{V_{dc}} = 0.0386$$

F = 50hz, C =? V_{max} =16.968V

V= 12V, R_L= 215Ω (Asume load value)

But $V_{max} = I_{dc}R_L$, :. $R_L = V_{max}/I_{dc}$

Hence

$$\gamma = \frac{1}{4\sqrt{3}FC}\left[\frac{V_{max}}{I_{dc}}\right] = \frac{I_{dc}}{4\sqrt{3}FCV_{max}}$$

$$\gamma = \frac{I_{dc}}{4\sqrt{3}FC}V_{max}$$

But $V_{dc} = 0.636V_{max}$=0.636 x 16.968V = 10.792V

:. $I_{dc} = V_{dc}/R_L$ = 10.792/215 = 0.05A

$$\gamma = \frac{0.05}{4\sqrt{3}x50xCx16.968}$$

$$0.0386 = \frac{0.05}{4\sqrt{3}x50xCx16.968}$$

$$C = \frac{0.05}{0.0386x4\sqrt{3}x50xCx16.968} = \frac{0.05}{226.8865} = 2.2037x10^{-4}F$$

Hence, 1uF = 10^{-6}F

Therefore, 10^6 =1F thus, $2.2x10^{-4}$ x 10^6uF = $2.2x10^2$uF= 220uF.

Here, 220uF, 25V rating was selected for the design.

3.6 VOLTAGE REGULATOR

In order to obtain the desired d.c. voltage for the circuit operation, voltage regulator IC's are employed. In this project the voltage regulator used here is a 12V regulator IC (7812A)

3.7 ANTI – SURGE

Due to the over head high tension cable, power supply from the generating station is susceptible to surge. This may be attributed to the falling of big trees on the high tension power line during storm, bird perching on the power line, which eventually result in short circuit fault, hence the supply of abnormal voltage. In most cases, the consumer is affected in an area where the step down transformer has no fuse and as such, the fault current flows through the conductor (put in place of the fused).

This faulty current was designed and constructed in order that, the voltage regulator and the appliance (load) be protected from any surge occurrence. The figure below shows an anti – surge for the 12V power supply circuit and the incubator circuit.

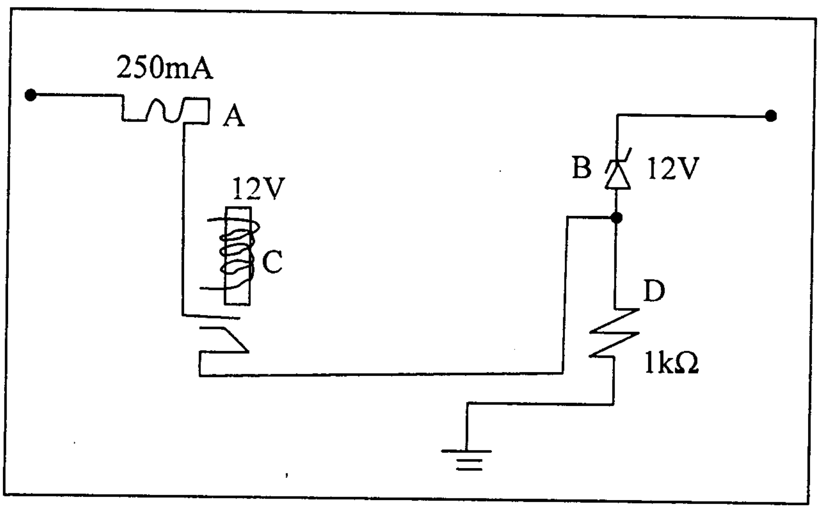


Fig 1.8 Anti Surge Circuit

A – Anti surge fuse

B – Zener diode

C – Relay

D – Resistor

3.8 TRANSDUCER (TEMPERATURE SENSOR)

The term "transducer" has been applied to variety of devices, including measuring instruments, acoustic energy transmitters, signal converters and photographer cartridges. With the recent vast increase in the development and use of electronic measuring systems, instrumentation engineers find it necessary to device a more limited definition of transducer as a device for measuring purposes.

The "measurand" is a physical quantity, property or condition, which is measured, and the output is the electrical quantity (voltage signal) produced by a transducer, which is a function of the applied measurand.

Considering the function or the role of the thermistor in this project, in relation to the above definition, it measures the surface temperature induced by the electric bulb, while its output is the voltage signal to the comparator circuit (pin 3 of 741IC), which is a function of the applied surface temperature. In other words, the thermistor can be regarded as a transducer used for measuring surface temperature to produce a suitable output electrical signal required to energize the comparator. However, its non – linear resistance versus temperature is employed where a short time constant is required.

Furthermore, the thermistor can also be regarded s an electrically conductive surface – temperature transducer and because of its size (small and flat shape) it is not influenced by convective heat transfer but only conductive heat transfer from the measured surface. The coating or covering on its surface minimize the heat loss by radiation.

3.9 VOLTAGE DIVIDER UNIT

Voltage divider principle is very useful to determine the voltage drop across any two or more resistor in series. It can be defined in such a case; the voltage drop across a resistor with others is directly proportional to the value of that resistor.

In this project a transistorized sensor and resistor of resistance R_1 and R_2 ohm accordingly was connected such that the point between was connected to the oscillator via the switching transistor Q_1. The transistorized sensor on sensing heat causes the supply sources voltage to multiply by half the source voltage 6V.

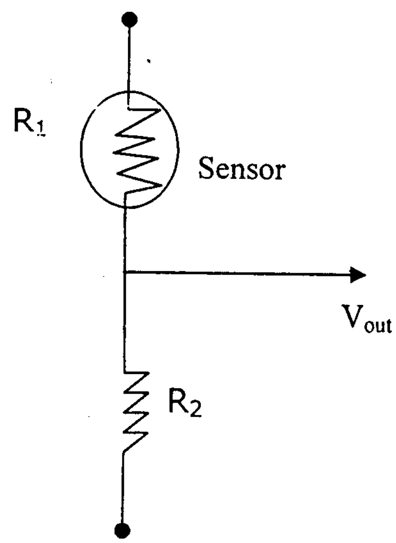


Fig 1.9 Voltage Divider Unit

R_2 = 10kΩ (Transistorized sensor resistance when there is heat).

$$V_{out} = \left(\frac{V_m x R_2}{R_1 + R_2} \right)$$

Where $V_{in} = 12V$

Hence, $V_{out} = \frac{12V x 10K\Omega}{10K\Omega + 10K\Omega} = \frac{120000}{20000} = 6V$

The V_{out} 9output voltage) is the required voltage necessary to drive the voltage comparator unit.

3.10 VOLTAGE COMPARATOR UNIT

Voltage comparator as the name implies, is a circuit that compares the magnitude of the two analogue signals (usually voltage) between the inverting and non – inverting and a logic output. It is similar to a differential amplifier operating in an open loop mode.

However, because of its high gain, the output is normally saturated in either high or low state depending upon the relative amplitude of the two input voltages with this condition the computer provides a logic state output which is indicative of the amplitude relationship between two analogue signals.

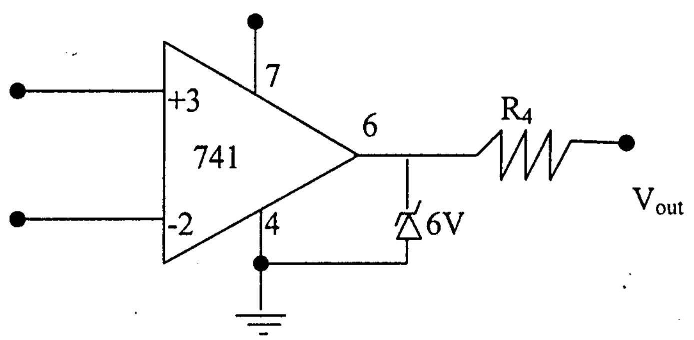


Fig 1.10 The comparator circuit of the egg incubator.

3.11 SWITCHING UNIT

Switch means making, braking or changing the connector in an electrical circuit. The switching unit interfaces the entire system with load. The comparator 6V energizes the switching circuit through a parallel combination of R_4 and R_5 the switching unit on receiving signal, energizes the load connected to the socket outlet of the system.

For this design, a transistor and relay was used for the switching unit. The choice of the transistor was based on its reliability, durability, responsiveness and its snap action.

Thus with the aid of the transistor (2N222) silicon type was used and was connected in common emitter configuration with its collector output connected to the relay coil. The small signal from the logic circuit (comparator unit) will produce a higher switched output voltage current at the collector output required to drive the relay coil, which in turn energizes the load at the socket outlet. Below is the switching unit of the incubator.

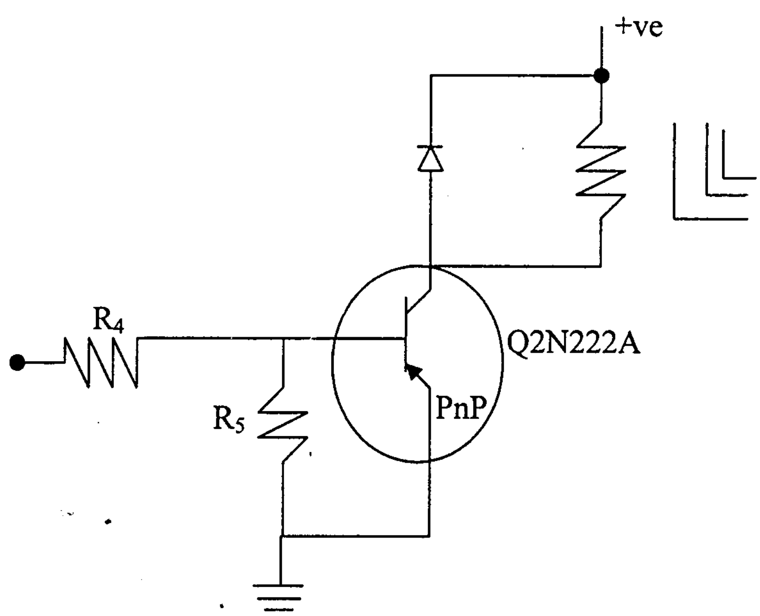


Fig 1.11 The switching circuit of the egg incubator.

3.12 CHARACTERISTICS OF 2N222 (TRANSISTOR)

$I_B max = 0.02A$

$I_c max = 0.8A$

$V_{BE} = 0.6V$

$V_{cc} = 12V$

$V_{in} = 6V$

$R_4 = ?$

$R_5 = ?$

$V_{BB} = 2V$

From the switching unit shown in fig 1.10 above ohm's law

$I_c R_c = V_{cc}$ (1)

Where R_c is the collector resistance (i.e. the relay load resistance usually given as 410Ω)

From equation (1)

$$I_C = \frac{V_{CC}}{R_C} \qquad (II)$$

$$I_C = \frac{12V}{410\Omega} = 0.029A$$

Ignoring any leakage current I_{cBO}

$I_B min = I_c/\beta$

$= 0.029A/40$

$= 0.000725A$

The current through R_4 necessary to ensure cut – off for an over – driven switch (by thumb rule) equal to $2I_B min$.

Therefore $I_b = 2 \times 0.000725A = 0.00145A$

$$I_b R_5 = V_{BB} - V_{BE}$$

$$R_5 = \frac{(V_{BB} - V_{BE})}{I_b} \quad (III)$$

$$R_5 = \frac{2V - 0.6V}{0.00145} = 962.5\Omega$$

thus

$$I_a R_5 = V_{in} - V_{BE} \quad (IV)$$

$$:.V_{out} = \frac{120}{20} = 6V$$

From eqn (IV)

$$R_4 = \frac{V_{in} - V_{BE}}{I_a}$$

Where $I_a = I_B min$

$$R_4 = \frac{8 - 0.6}{0.000725} = 10206.89\Omega$$

$$= 10K\Omega$$

Hence $R_4 = 10K\Omega$, $R_5 = 1\ K\Omega$.

3.13 ALARM UNIT

The alarm circuit is triggered as soon as the circuit is powered on and as temperature of the incubator gets to the desire saturated range and it switch – off and thereafter as the temperature reduces below expected temperature of the incubator the alarm triggers on again. This will continue until desire saturated incubator temperature is maintained.

This was achieved by the use of an inverter and thyristor. The output of the inverter triggers the thyristor that power the alarm circuit and the relay. The alarm circuit is made up of two Integrated Circuit (IC) timer that the connection includes [7];

I. Astable mode

II. Monostable mode

The timer generates oscillation that is producing voltages that vary in a regular fashion; the waveforms of the voltages are repeated exactly in equal successive intervals of time. The instruments that produce repetitive waveform that are square, triangular or saw tooth in shape are called relaxation oscillators.

The term "relaxation" is used because during the generation of the waveform there is a period of activity in which there is a sharp transition from one state to another. This period is then followed by a relatively quiescent one after which the whole cycle is repeated.
Oscillators can be constructed as to operate at frequencies as low as one or two cycles an hour or as high as hundreds of megahertz. The selection of a suitable frequency or range of frequencies depends upon the function that the oscillator is required to perform.

The square – wave is rich in harmonics and so it was used in this project to generate the pulses used in alarm circuit. The pulse is thus generated by 555 timer Integrated Circuit (IC) connected in Astable mode. While the second 555 timer Integrated Circuit is connected in monostable mode as Fig 1.12.

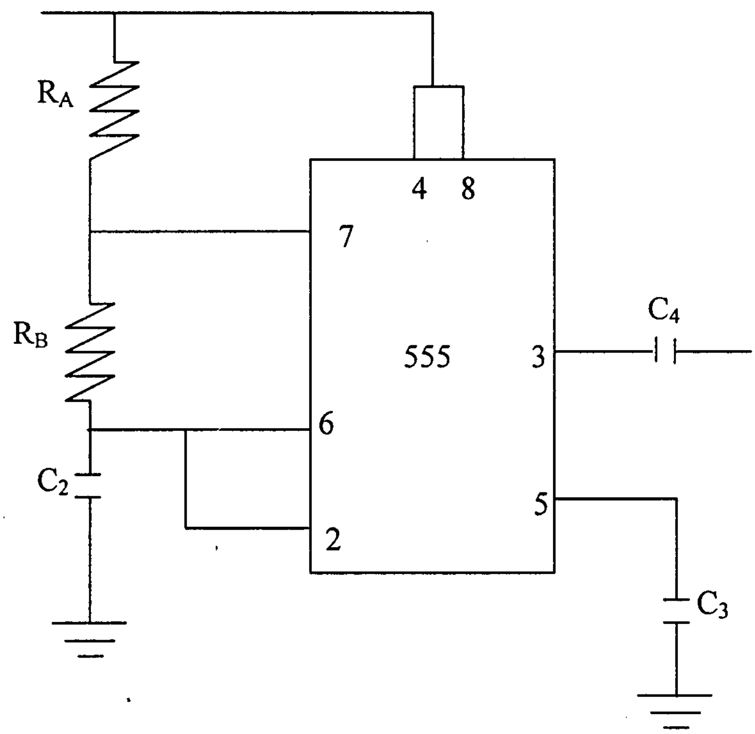


Fig 1.12 A Stable Mode Circuit

The monostable depends on the output of the astable IC. A coupling capacitor was used at the output of astable to the input of monostable and the function is the block dc voltage to allow A.C. voltage to drop across the monostable IC.

The monostable is a two tone generator with its output (pin 3) conne..ted to a speaker that converts electrical energy to sound. Such sound produced could easily cut through commercial or industrial noise as traffic office or factory noises.

3.14 MODE OF OPERATION

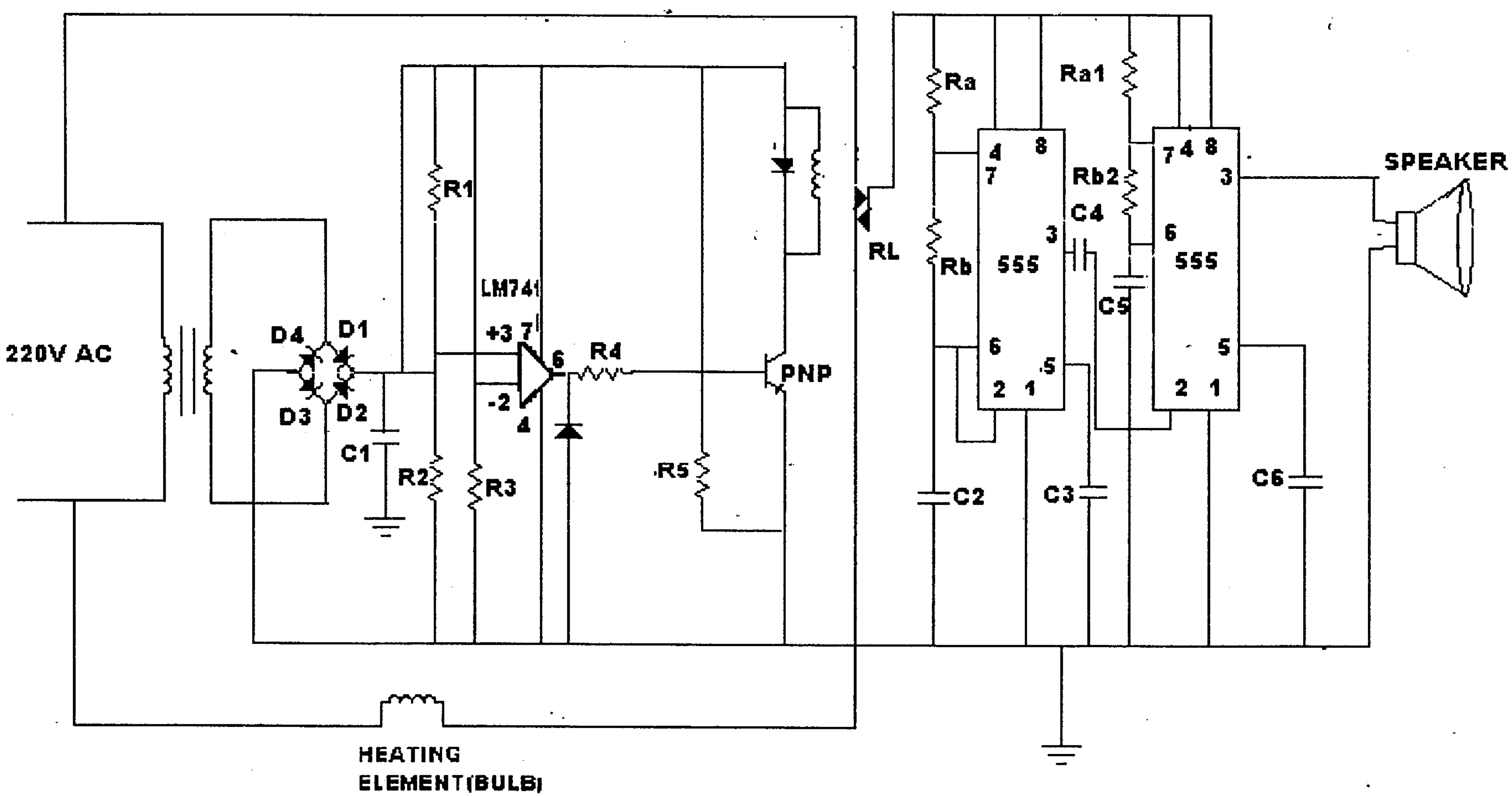
As the circuit is powered on as shown from the circuit diagram of an egg incubator in fig 1.11 from the main supply and the sensor is heated through the electric bulb a resistance is developed across the two terminals of the heat sensor, this leads to voltage drop across the sensor through the voltage divider network. The voltage drop at pin 2 of the 741 comparator is compared with the reference threshold voltage set by R_3 the variable resistor, at the comparator. [1]

If the voltage drop is greater than the reference threshold voltage, then the output of comparator at pin 6 will be highly negative. The voltage is applied to the base of the PnP relay. As long as the comparator output is negative, the transistor is ON, and the relay contact is closed which keeps the heating element (electric bulb) energized.

However, the voltage drop across the sensor will drop suddenly to give desired temperature range. This new voltage drop is comparator switch to a positive output of the comparator 741 pin 6. (its inverting input is now negative with respect to its non inverting input) and the relay will open and the alarm circuit will trigger automatically which will produce sound at its output; if the temperature falls below the desired temperature range of the incubator, before the alarm signal will go high [1]

Contrarily, when the incubator temperature decreases the thermistor resistance increases causing pin 3 of the comparator to rise which inturn causes the comparator output voltage at pin 6 to high (swing towards the supply voltage). Consequently, causing the transistor to switch from its cut – off region to saturation region.

Hence the relay coil is energized (activated) and the light bulb on receiving signal from the energized relay turn on to balance the drop in the incubator temperature. When this is achieved the alarm system will be switch of, it will produce no sound.



THE ELECTRONIC INCUBATOR CIRCUIT

LIST OF COMPONENET USED

COMPONENT	VALUE	QUANTITY
R_1	300 Ω	1
R_2, R_4	10K Ω	2
R_3	50K Ω	1
R_5, R_B	1K Ω	2
R_A, R_{B1}	33K Ω	2
C_1	100μF	1
C_2	42μF	1
C_3,C_5	1000nF	2
C_6	47μF	1
D_1,D_2,D_3,D_4	IN4001	4
BULB	60W	2
TIMER IC	NE 555	2
COMPARATOR	LM741	1
RELAY	12V	1
THYMISTOR		1

CHAPTER FOUR

4.0 CONSTRUCTION, TESTING & TROUBLESHOOTING

In the hardware construction, the whole system was divided into sections for easy construction, testing and troubleshooting of the incubator.

- Power supply unit
- Voltage divider
- Voltage comparator unit
- Switching unit
- Heat source unit (elastic bulb)
- Plywood incubator
- Wooden Candler

4.1 POWER SUPPLY UNIT

SECTION 1

The section 1 was constructed with bridge rectifier as the first component on the vero board. The bridge rectifier has four terminals denoted by the following symbols, + ~ - where the positive terminal (+ve) was connected to the supply line, V_{cc}, while the negative terminal (-ve) was grounded, that is zero volt line.

However, two center terminal denoted by the symbol (~) was connected to the transformer output/secondary terminal, as well, the capacitor (100uF) was connected across the rectified output as a filter. Meanwhile, a voltage regulator (7812 A) with its pin configuration identified was also connected across the resulting D.C. output to regulate the voltage.

In order to reduce high voltage spike, another 220uF capacitor was connected across the regulator's output. With the transformer terminals identified terminal with low as primary (the terminal with high resistance value) and secondary (the resistance value), the primary was then connected to the main supply (240V_{rms}) and the secondary was connected to circuit through the bridge rectifier.

4.2 VOLTAGE DIVIDER UNIT

SECTION 2

This section was built on the vero board after the power supply unit. It is made up of resistor and thermistor as sensor. The thermistor senses the temperature/heat generated by the heat element (electric bulb) and converts it to voltage signal. It has two terminals with one connected to the ground and the other connected to the supply line through a resistor, a voltage divider network result. The thermistor was mounted about 4.0cm away from the heating element without any electrical contact between them.

4.3 VOLTAGE COMPARATOR UNIT

SECTION 3

This section involves UA 741C IC (Integrated Circuit) with a negative feedback resistor. The UA 741C was mounted on an IC socket soldered on the vero board after identifying various pin configurations the IC output pin was connected through a voltage divider network.

Meanwhile, the inverting and non – inverting input was connected to the voltage divider source (made up by the thermistor and the resistor) as well as the reference voltage the resistor that stabilizes the output voltage requires to drive the switching circuit. On the non - inverting input a potentiometer was connected to it through a combine resistors meant to hold the reference voltage at the desired voltage value so as to trigger the switching circuit.

4.4 SWITCHING UNIT

SECTION 4

This section comprises a relay and a transistor. With the aid of digital multimeter the emitter, base and the collector of the transistor were identified, hence soldered on the vero board this was accompanied with the identification of the relay pin configuration as ON, OFF and the relay coil was also checked to ensure efficient switching of the relay.

Across the relay coil terminal a diode (free wheeling diode) was connected in order to eliminate the sparking of the relay coil as well as avoiding back e. m. f which may be induced when the relay turns off. With the aid of this section the control of the heating unit and hence the entire system is controlled.

4.5 HEATING UNIT

SECTION 5

This section uses a 60 watt electric bulb meant to induce heat inside the incubator thus causing the fertile eggs to hatch into chicks. At the set temperature 38^0C the electric bulb goes off when it is above 38^0C and comes on automatically and this was achieved with the aid of the switching unit, thus the temperature of the entire system is regulated.

4.6 PLYWOOD INCUBATOR

SECTION 6

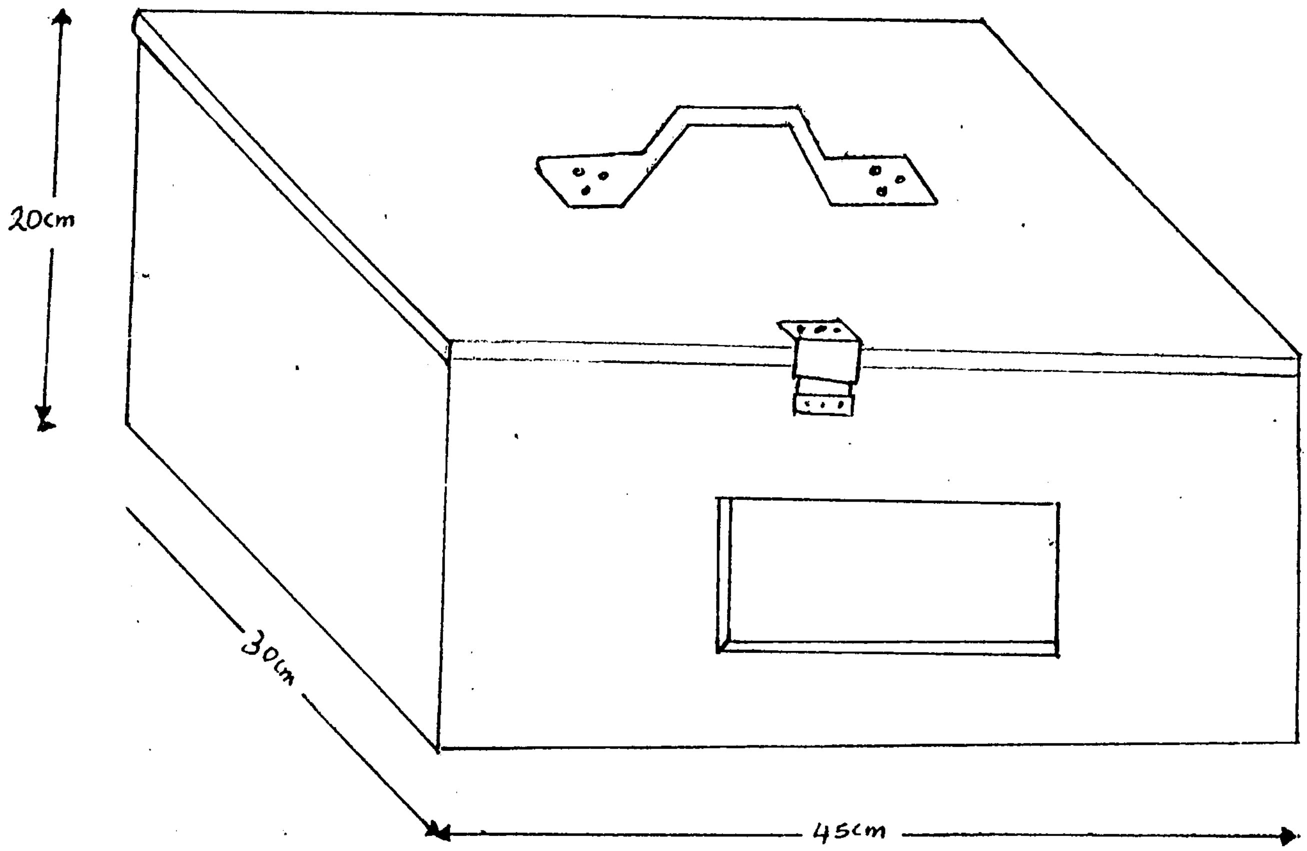
This was constructed with the following materials

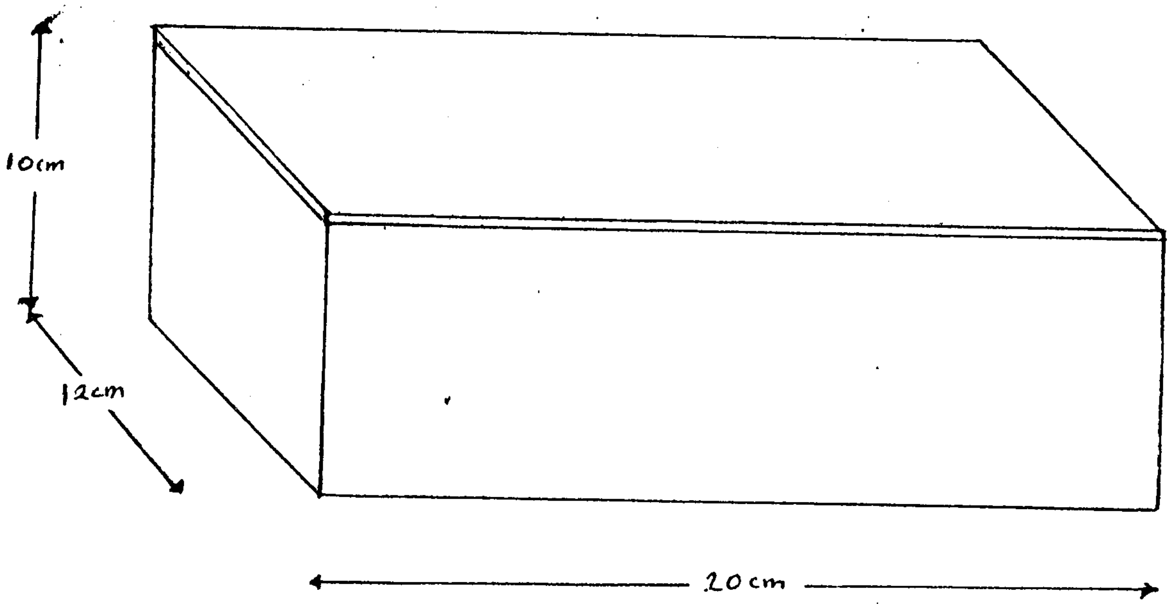
1. Plywood
2. Glass
3. Particle crate
4. Measuring tape
5. Nail & hinges
6. Hacksaw
7. Sand paper
8. Evostic gum.

4.7 CONSTRUCTION STEPS OF THE INCUBATOR

- ✓ With the hacksaw and measuring tape, the require length, breadth, and width of the incubator was cut to their sizes accordingly.
- ✓ Measuring tape was used to take the dimension of height (7 inches), width (12 inches) length (15 inches) for the incubator box and height (2.3inches) width (4 inches) and the length (5.6inches) for the circuit box and sawed with hacksaw
- ✓ Plywood was assembled to form a rectangular shape.
- ✓ Hammer and nail were used to join the assembled above in order to give it rigid structure physically.
- ✓ Having form the rigid structure, using nails, two small piece of plywood 91.5mm thick diameter) and a hammer, fix the small piece of plywood. This was done inside the rigid structure.

- ✓ Using the measuring tape, the required dimension of the egg tray was also measured, and assembled.
- ✓ The assembly above, a wire gauge was fixed permanently using nails at its base (egg tray)
- ✓ The assembly above was then placed in the egg – tray holder constructed above, thus the plywood incubator assumed the required shape.
- ✓ The glass after being measured to required size, it was cut with glass cutter (diamond cutter)
- ✓ The glass diamond cutter was dragged slightly and gently along the mark.
- ✓ The glass was then fixed on the assembly obtained above thus a complete plywood incubator was constructed.
- ✓ The figure below shows the constructed incubator.


20cm
30cm
45cm


10cm
12cm
20cm

4.8 WOODEN CANDLER

SECTION 7

This was constructed with the aid of a plywood cut to the desired dimension and finally assembled to form a square shape device. At the upper portion an egg sized hole was drilled. This hole is meant to hold the egg/eggs while the ray from the electric bulb (usually on) installed inside the enclosure directly strikes the egg/eggs from underneath.

With the help of this wooden Candler, one is able to identify and separate the fertile egg/eggs from the non fertile egg/eggs, hence hatching is accomplished. This is usually done on the 6^{th} and 18^{th} day of the egg/eggs stay inside the incubator. The process is called CANDLING

4.9 CALIBRATION

SECTION 8

The choice of a thermometer for a particular purpose depend on the temperature range to be covered, the precision required, the nature of the substance whose temperature is to be measured, the space available as well as the type of reading desired.

In this project, due to the small temperature range 99^0F to 103^0F, the mercury – in – glass thermometer because of its temperature range was employed for the calibration of the incubator temperature, thus proper calibration at the desired temperature range. It must be noted that the potentiometer is the major component that plays the calibration role.

4.10 COMPONENT LAYOUT

The following was observed and carried out while constructing the hardware system.

✓ The IC was mounted and soldered to the vero board.

✓ Interconnection was made through earthen of the vero board and the use of insulated copper wise connected at the bottom of the vero – board and then soldered underneath, thus giving the component good layout and space to give room for troubleshooting and replacement of faulty components.

✓ The long leads or legs of various components such as transistor, resistors and capacitors were reduce so as to prevent short circuit.

✓ Having made necessary connections and soldering on the vero board, proper care was taken to avoid bridging/short circuit by examination of the connection hole (line) and non – connecting hole (line). This was to ensure that the required current was supplied and proper connection between components.

4.11 CONSTRUCTION TOOLS USED

These are the construction tools used during the modeling and hardware construction;

1. Project – board and insulated copper wires (used as jumpers). These components were used for building part of the prototype model for test before the circuit was finally transferred to the vero board permanently.
2. Soldering iron and lead: A 60watt soldering iron and lead was used in the soldering of all components on the vero board.
3. Digital multi – meter: This electronic device was used to carry out test on continuity between two lines. It was also employed in measuring voltage, resistor value and in determining the base, collector and emitter of the transistor as well as the N/O

(normally open) and N/C (normally close) terminal of the relay in checking the relay coil during construction of the hardware.

4. Precision screw diver: Because of the various shape and size of this set of screw drivers, it was employed in regulating the variable resistor (potentiometer) so as to ensure the desired switching required.
5. Lead sucker: This was employed to remove molten lead while desoldering components from the vero board.

4.12 INCUBATOR PROTECTION AND TESTING

GENERAL TESTING

A single phase 240v supply is needed for testing and continuous use of the incubator. After the connection of the incubator is well verified, the connection to the main supply is made through a 13Amp fuse plug. The indicating lamp glows to show that there is supply to the system.

A 2A fuse is used for protection in case there is excess current or over voltage. The fuse will melt indicating that the current required is exceeded. The fault is cleared later and the fuse is repaired or replaced with another one.

As the voltage is supplied to the incubator current flows through the circuit which is indicated by the LED. The relay is closed so current passes through heating element (electric bulb). This current is converted to heat energy needed to raise the temperature in the incubator.

The green indicator is ON and remain ON as long as the heating elements is ON (working). Whenever the sensor senses a higher temperature above the required setting, the relay switches to off position thereby switching off the heating element and the indicator.

As soon as the temperature falls below the potentiometer setting the relay contact closes again and current flows and heating element commences another cycle of heating.

On testing the power supply unit the output from the filtering unit was fed into an oscilloscope and the corresponding waveform were observed as shown in Fig 4.0 below.

D. C. Output of the rectifier

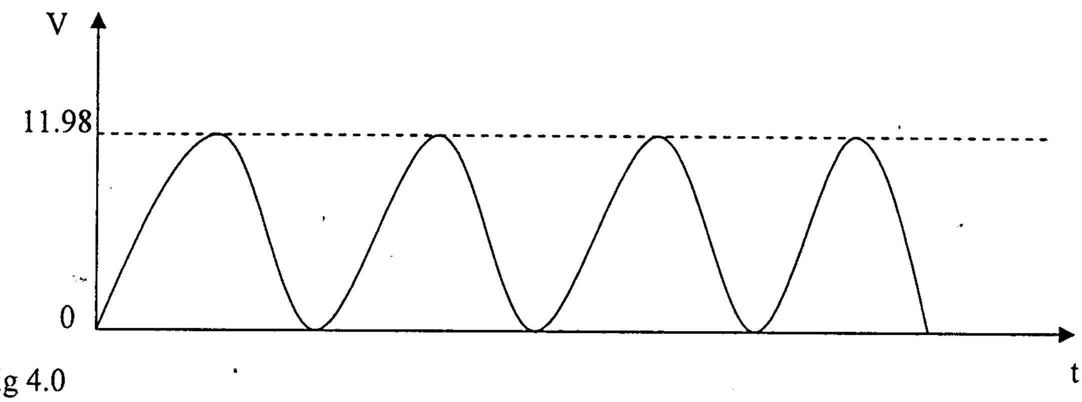


Fig 4.0

A connection is made from a bell set to one end of the cable and along head is run to the other end. This long head is in turn connected to the ends of the cable until the bell rings indicating continuity of the particular cable.

This test is carried out to ensure there is continuity of all the cable use for connection of the incubator.

4.13 MAINTENANCE

Since the casing of the incubator is constructed with a cheap material (plywood). It should be kept away from where rain can touch it.

Also the casing should be fumigated frequently to keep termites away from attacking the wooden casing.

There should also be critical inspection of component used in the designed work to minimize cost due to component failures.

4.14 TROUBLESHOOTING OF THE INCUBATOR

Troubleshooting has actually led to good maintenance culture with the following benefits:

a) Prolong the useful working life of equipment.

b) Reduce cost rate in protection and maintenance.

c) Increase the design levels and reliability deficiency in these levels as recognized during equipment operation.

d) Prevent deterioration of the reliability and safety of the equipment.

e) If there is power failure into the incubator check 13A fuse at the plug. Then if it is in order check the control switch and transformer.

f) Then if it is in order check the operational amplifier and the relay.

g) If the relay refuse to OFF at the set temperature and excess heat is observed as a result of continuous sound of alarm, check the sensing element.

CHAPTER FIVE

1.0 OBSERVATION, DISCUSSION OF RESULT, CONCLUSION AND RECOMMENDATION

1.1 OBSERVATION

Having successfully carried out the execution of this project, the OP Amplifier comparator was used to compare the regulated voltages which makes relay to contact and the required temperature range between $35^0C - 40^0C$ was observed.

1.2 DISCUSSION OF RESULT

From the simulation of circuit the result shows that the system (egg incubator), operates based on thermostatic principle. The system on receiving heat from the heat source (electric bulb) through its thermistor which in turn drives a relay to activate the load (electric bulb) within a predetermine time interval thus maintaining a steady temperature ($99^0F - 103^0F$) inside the incubator with subsequent successful hatching of the fertile egg.

The heat inside the incubator was measured based on the changes in the pulses at the comparator output. The interface between the incubator circuit and the heat/temperature source was performed here.

1.3 CONCLUSION

The design and construction of electronic incubator has been an interesting project indeed. An "Egg incubator" was constructed locally from the basic thermostatic principle, by the use of comparator circuit, switching, circuit, voltage divider circuit.

The low operating voltage, $12V_{dc}$, and low power consumption of the system allows for low temperature ($99^0C - 103^0F$) of the incubator, longer life, better maintenance, low overall cost in construction and operation thus resulting in high reliability of the system in egg hatching to produce chick.

Control process is very important in engineering and the design and construction of any equipment for use without proper control method is a deficient engineering exercise. This project work provides the use of switch, comparator, relay and for this purpose. Although, I wish to go beyond this scope, but I could not due to the limited time, financial and material resources.

Indeed, I need to emphasize that the project provides me with additional technical and practical engineering skills.

5.4 RECOMMENDATION

My hopeful desire as an Electrical & Computer Engineer is to fully integrate the profession into other field such as: hospitals where premature babies can be kept, bio – chemical equipment are sterilized and preserved under a precise temperature environment, agricultural sciences as other engineering profession.

This project can be call up to suite various purposes, a model or prototype has been left for student coming behind who might be interested in continuation of the project.

The control panel housing and switch may be separated from the box containing the heating element prevents direct heating.

The upcoming students should try to incorporate a digital display temperature read out screen of the incubator temperature. The future expansion work on this project must include minimizing of loss at minimum cost.

Above all, this project promises to provide job opportunity for the designer especially in self employment.

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