Design and Construction of an Incubator

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Dedication

This project is dedicated for the cause of Allah{S.W.A}the beneficient,most merciful and prophet Muhammad {S.A.W} peace be upon Him for the knowledge bestowed on me.

Declaration

I Saidu Saidu Shafii declare that this work was done by me and has not been presented elsewhere for the award of a degree to the best of my knowledge. I also relinquish the copyright to the Federal University of Technology, Minna.

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I will first give glory to Almighty Allah worthy of all praises for sparing my life up to this stage and guiding me throughout my academic pursuit and to the success of my project. I wish to express my profound gratitude to my indefatigable supervisor MR .U.S. Dauda, whose wealth of experience was instrumental in producing this work. He has contributed immensely to the success of my project despite his tight schedule.

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Abstract

The purpose of the project is to maintain and control a specific system with a specified temperature range. The main attachment of the project is an electronic thermostat.

A linear temperature sensor which has good calibration and performance is used to actively check and monitor the particular preset temperature value to control the switching unit of the incubator. The thermostat is placed in the incubator to maintain the precise temperature range of incubation for egg of birds and other temperature related laboratory experiments, such as culturing of bacteria, fungi, determining the sex of reptiles and oven drying for proximate analysis e.t.c.

A fan is incorporated into the design to evenly distribute air in the system. Therefore, heat is reasonably distributed through concerned space for good result feedback. The heat is generated from a low – power filament also, the fan cools the incubator when temperature below the ambient temperature of the surrounding is being set.

Both the heating and cooling devices are merely controlled from the temperature signal from the sensor, through comparing the preset value. Therefore temperature is held at a particular temperature to satisfy the purpose of incubation.

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Chapter One

1.0 General Introduction

The technology incorporating science in the field of engineering has heralded the electrical computer engineering age. For example in the field of biomedical science (e.g. heart rate monitoring, human incubation etcetera), agricultural science (e.g. egg incubator), biomedical science (e.g. culturing of bacterial, fungi and reptile in order to identify their sex, and so on). Incubator is an electrical operated machine meant to manage fertile eggs to ensure the satisfactory development of the embryo into chick by the application of heat, usually created synthetically. The broad range of incubators available can be divided into three major classes namely; plywood incubator, cardboard incubator and still- air incubator. Individual incubator has a specimen tray that hold the specimen some few distance between the heat source (heating coil) which produces the desire temperature for achieving the purpose of incubation.

This heating source is regulated by means of thermostatic principle, i.e. immediately above the highest temperature, heat supply Cuts off automatically and below the threshold temperature it start up again. In addition the incubator has two ventilation holes near it's base through which oxygen is supplied to specimen as well as an exhaust hole through which carbon-dioxide escapes, while incubating. To operate an incubator successfully, it is important to have knowledge of the environmental conditions necessary for incubating satisfactorily. These conditions are the operating temperature, humidity, ventilation, turning of specimen and air velocity.

1.1 Aims And Objectives

The objectives of the project includes:-

1. To develop a simple cost effective device for incubation aimed at easing the prevailing financial difficulties faced by users .
2. To use the incubator in all regions irrespective of the different climatic weather conditions in Nigeria by farmers, scientist, students, medical practitioners, researcher. Etc.

3. To create awareness and also make fellow students appreciate the versatility of electrical and computer engineering in relation to other fields of engineering and science disciplines. Also to stimulate the interest of upcoming students to take-up research topics, not only on their field of study but to other fields.

4. To develop an incubator with high reliability and maintainability. Due to an easy visual and physical accessibility to component parts to ease carrying out maintainance routine on it in a short time and at low cost.

1.2 Methodology

The design of incubator, certain factors must be considered in designing the system and selecting the components to use. These includes:-

i. Minimum circuit complexity

ii. Circuit efficiency

iii. Cost effectiveness

iv. Power dissipation

v. Noise immunity

vi. Availability of components

These factors are not given in any particular order of priority. The requirement for this project work is:

i. Some means of providing power to the circuit

ii. A variable resistor which regulates the voltage to correspond to the temperature based on the temperature – voltage relationship of the sensor.

iii. A linear integrated circuit (IC) temperature sensor (LM35) that produced 10MV for every 1^0c.

iv. Two comparators which outputs serves as input to the switching unit

v. A means of triggering the switches.

vi. A means of controlling the power supply to the heater and fan.

1.3 Scope and Limitation

As the title implies, this project work has specification of regulating the temperature of incubation to a given point within the range of 0^0c to 100^0c for achieving the different purposes of incubation for different types.

1.4 Problem Definition

The general problem associated with the incubator is automatic cooling. It is quite obvious that whenever a temperature rang far lower than the room temperature is required, a good cooling mechanism is also required. This is out of the scope of the project because of the complexity involved in such cooling operation. Also, the calibration of the involved comparator circuit was not much a challenge due to the use of the already – calibrated temperature senior (Lm35)

Chapter Two

2.0 Literature Review

A thermostat is a device for regulating the temperature of a system within a particular or specified range by systematic control of heat generation or flow into or out of the system. Thermostats are indeed specialized thermometers in term of temperature sensing and control .In general term; thermostats have a lot to do with thermometers. This fact brings their history to the same point.

In fact, a thermometer is a device that measures the temperature of any thing. The name is made up of two smaller words: "Thermo" means heat and "meter" means to measure. One of the earliest inventors of a thermometer was probably Galileo. Galileo is said to have used a device called a "thermo scope" around 1600 .That is about 400 years ago.

The thermometers we use today are different than the ones Galileo may have used. There is usually a bulb at the base of the thermometer with a long glass tube stretching out to the top. Early thermometers used water, but because water freezes there was no way to measure temperatures less than the freezing point of water. So, alcohol, which freezes at temperature below the point where water freezes, was used.

. The thermometer measures temperatures in Fahrenheit, Celsius and another scale called Kelvin. Fahrenheit is used mostly in the United States, and most of the rest of the world uses Celsius. Kelvin is used by scientists. Fahrenheit is named after the German physicist Gabriel D. Fahrenheit who developed his scale in 1724. Ice freezes at 32 degrees Fahrenheit (F), and water boils at 212 degrees Fahrenheit (F). He arbitrarily decided that the difference between the freezing point and boiling point of water should be 180 degrees Fahrenheit (F).

The Celsius scale is named after Anders Celsius. The Celsius scale used to be called the "centigrade" scale. Centigrade means "divided into 100 degrees." Anders Celsius developed his scale in 1742. He started with the freezing point of water and said that was 0 degrees Celsius (C) . At the point where water boils, he marked that at 100 degrees C. This scale is much more scientific because the measurement is broken down into an even 100 degrees. This is similar to the scientific system of measuring distance and weight called the metric system.

Kelvin is named after Sir William Thomson, Baron Kelvin of Largs, and Lord Kelvin of Scotland. His scale starts at 0 degrees Kelvin, which is called absolute temperature. Lord Kelvin took the idea of temperature one step further with his invention of the Kelvin scale in 1848. The Kelvin scale measures the coldest temperature there can be. He said there was no upper limit of how hot things can get, but he said there was a limit as to how cold things can get. Kelvin developed the idea of Absolute Zero. This is at minus 273.15 degrees Celsius (or -523.67 F)! At this temperature, everything, including the movement of electrons in an atom, stops completely.[2].

2.1 Theoretical Background of a Thermostat.

2.1.1. The principle of operation of a thermostat

In a typical thermostat, there are two main parts. They are the temperature measuring sensor or thermometer and a heating control switch. The switch responses to the output from the temperature sensor and with reference to a particular input temperature value or range. The switch allows heating whenever the temperature of the concerned system is below the specified range or value. The heating is automatically triggered off through the switch in response to the input temperature measuring technique. That is, whenever the temperature is about going beyond the specified range. The result is a cooling effect on the system. After some time, the heating automatically starts to prevent the temperature of the system from dropping below the specified range. The operation is merely in a circle. It involves switching on and off of the heating element of the concerned system so as to maintain a particular temperature range. This is the basic operating principle of every thermostat.[1].

2.1.2 Types of thermostat

Every thermostat is mechanical, electrical or electronic in nature. In some cases, a thermostat can be attributed to both mechanical and electrical features. Such is called electromechanical thermostat. All types have one and the same basic operation.

2.1.2.1. Mechanical thermostat

A typical example of mechanical thermostat is used in automobiles using an internal combustion engine to regulate the flow of coolant. When the thermostat is open, coolant passes through the cylinder head where it gets hot. It is then led from the engine into the radiator where it looses the heat to the air flowing through it. A "water pump" driven from the engine propels the coolant around the system. When the thermostat is closed the flow is prevented and so the engine is allowed to heat up to its optimum operating temperature.

Most engines' thermostat usually makes use of a wax pellet inside a sealed chamber. The wax is solid at low temperatures but as the engine heats up the wax melts and expands. The sealed chamber has an expansion provision that operates a rod which opens a valve when the operating temperature is exceeded. The operating temperature is fixed, but is determined by the specific composition of the wax, so thermostats of this type are available to maintain different temperatures, typically in the range of 70 to 90 °C. Modern engines are run hot, that is, over 80 °C, in order to run more efficiently and to reduce the emission of pollutants. Most thermostats have a small bypass hole to vent any gas that might get into the system (e.g., air introduced during coolant replacement). Modern cooling systems contain a relief valve in the form of a spring-loaded radiator pressure cap, with a tube leading to a partially filled expansion reservoir. Owing to the high temperature, the cooling system will become pressurized to a maximum set by the relief valve. The additional pressure increases the boiling point of the coolant above that which it would be at atmospheric pressure. Another good example of mechanical thermostats is in domestic pressing iron. Its main part is a bi-metallic element.

2.1.2.2. Electrical/electronic thermostats

This project focuses on the electrical/electronic thermostat type. Most modern thermostats are digital, with thermistors or solid-state temperature sensor rather than a bimetallic strip and a transistor switch instead of a mercury switch. They are more quite precise in operation. Most came with either LED or LCD temperature display feature. The concerned temperatures can be watched or monitored on the display. Older types use electromechanical relays for switching concerned heating elements. But in this present world of advanced solid-state electronics, such operation is performed through triac-diac control\circuits. In most advanced countries, the electronic thermostats are used for sensing the temperature of the room and shut the fan on and off automatically, at the level of comfort wanted by the user. Most of them turn on the heating mechanism whenever the temperature gets below a certain temperature and level turns it off whenever the temperature rises above another level. The two temperatures are separated slightly so the heating mechanism doesn't turn on and off too quickly, and are usually set a few degrees from the desired temperature. For example, if the thermostat is set to 30 degree Celsius, it does not stay at that exact temperature. The temperature will rise and fall between about 29 degrees Celsius , which is when the thermostat turns the heating device on, and 32 degrees Celsius,which is when it turns the heater off. More complicated electronic thermostats can also control cooling devices like an air conditioner to cool the room down faster, and turning it off when the air reaches the temperature that is wanted .Some work with time and they embody both clock and timer features for special operations and performances. The application of electronic thermostats is quite evident in microwave ovens and air conditioning devices.[1].

2.1.3 Concept of Control System Design for an Incubator

Control engineering is primarily concerned with understanding and controlling natural resources and forces of nature purposefully for the benefit of mankind. That is, it is concerned with the design and development of machines and equipments for human utilization.

In modern usage, control systems are defined as an arrangement of physical component connected or related in such a manner as to command, direct or regulate itself or another system (ZADEH B. Y. 1981).

Control system absunds in man's environment and its design is a function of its input and output. The input is the stimulus or excitation applied to the control system from external energy source, usually in order to produce specific response from the control system while the output is the actual response obtained from control.

The purpose of a control system usually defines the input and output. If the input and output are given, it is possible to identify or define the nature of system's component.[7].

An open loop control system formed the basic building block for this incubator control circuit. Advantages are taken of the efficient ability of open loop system to measure the temperature with a good margin of accuracy and have an effective calibration with the temperature bracket. Their ability to withstand the prevalent problem of instability which is the commonest short coming of most amplifiers makes the open loop system to be one of the best design options.

The system under consideration is an incubator which could be regulated to a specified range of desired temperature within the temperature range of $0^{o}c$ to $100^{o}c$.[7].

Chapter Three

3.0 Circuit Design Analysis

3.1 Components Choice and Description

The project is attributed to limited number of components. It is designed for simplicity and economic reason. One of the compatibility of the involved parts, the manufactures data sheets are of great importance to the realization of the design. The performance of the overall design is quite reasonable due to the feature of the involved attachments.

The project incredibly holds seven main parts. They are given below:

i. Lm 35 (Linear temperature sensor)

ii. Lm 339 (comparator)

iii. 2sc945 (switching NPN transistor)

iv. 12v relay switch (external switching device)

v. 1N 4001 (diode)

vi. 7805 and 7812 (voltage regulator)

3.1.1. LM35

The Lm35 temperature sensor is a unique product of national semiconductors. The sensor is common and well-known for its accuracy. It provides precision temperature measuring technique for wide purposes. The device has three terminals. Two of the terminals serves power supply. The other is an output which possesses a temperature-voltage relationship. The device produces 10mv for every 1^0C temperature sensed. For instance, if the sensor is subjected to like a temperature of 500mv, the output is 50^0c in accordance with the leading relationship.

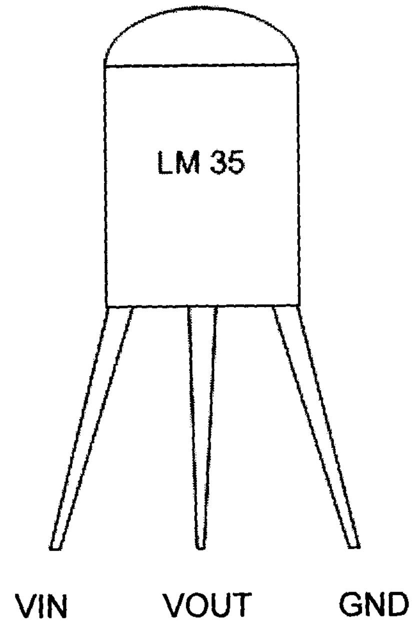


FIG. 3.1. THE PIN ARRANGEMENT FOR THE LM 35

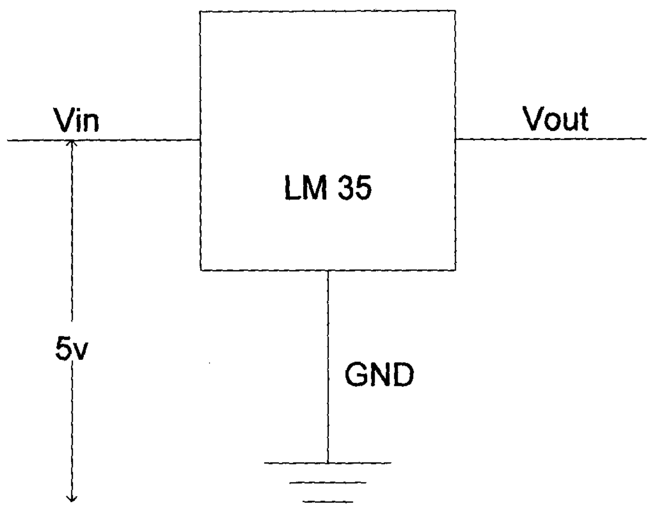


FIG.3.2. TYPICAL CONNECTION OF THE LM35.

Normally, the Lm35 is powered by 5v. Although, it is designed for 3-35v power supply. The temperature – voltage relationship is very linear and precision over 0 -100^{0}C. This allows the Lm35 to be quite useful for wide range of application.

The use of Lm35 temperature sensor in this project is justified by its linearity. Some incubators hold thermistors circuit for temperature measurement; enjoying the wide temperature range of such setup. The more important feature, reading accuracy is ignored. The result is assumed or inaccurate control.

The project is concerned with an incubator within a wide range of temperature regulation. Therefore, a Lm 35 temperature sensor is suitable of such narrow temperature regulation.

3.1.2. LM 339

A very common comparator device is the Lm339 integrated circuit. The integrated circuit holds four of such unit in built. Each of the comparator works independently. They follow one and the same operational principle of normal or conventional comparator. A comparator is attributing to two inputs and an output. The output is digital in nature. It is either logical 1 or 0. The inputs are the inverting input vin (-) and non-inverting input Vin (+). The output responses to the situation at the inputs. Sometimes, a comparator is called a digital operational amplifier.

A comparator has a generally relationship. Whenever, the voltage at the non-inverting input Vin (+) is greater than the inverting output Vin (-) is logical 1. But, the output is always logic 0 or low whenever the voltage at the inverting input Vin (-) is equal to or greater than that of the non-inverting input Vin (+). This basic relationship is considered for any design that involves the leading device.

The relationships

Vin (+) > Vin (-) ....output is logical 1

Vin (-) $\geq$ Vin (+)....................output is logical 0.

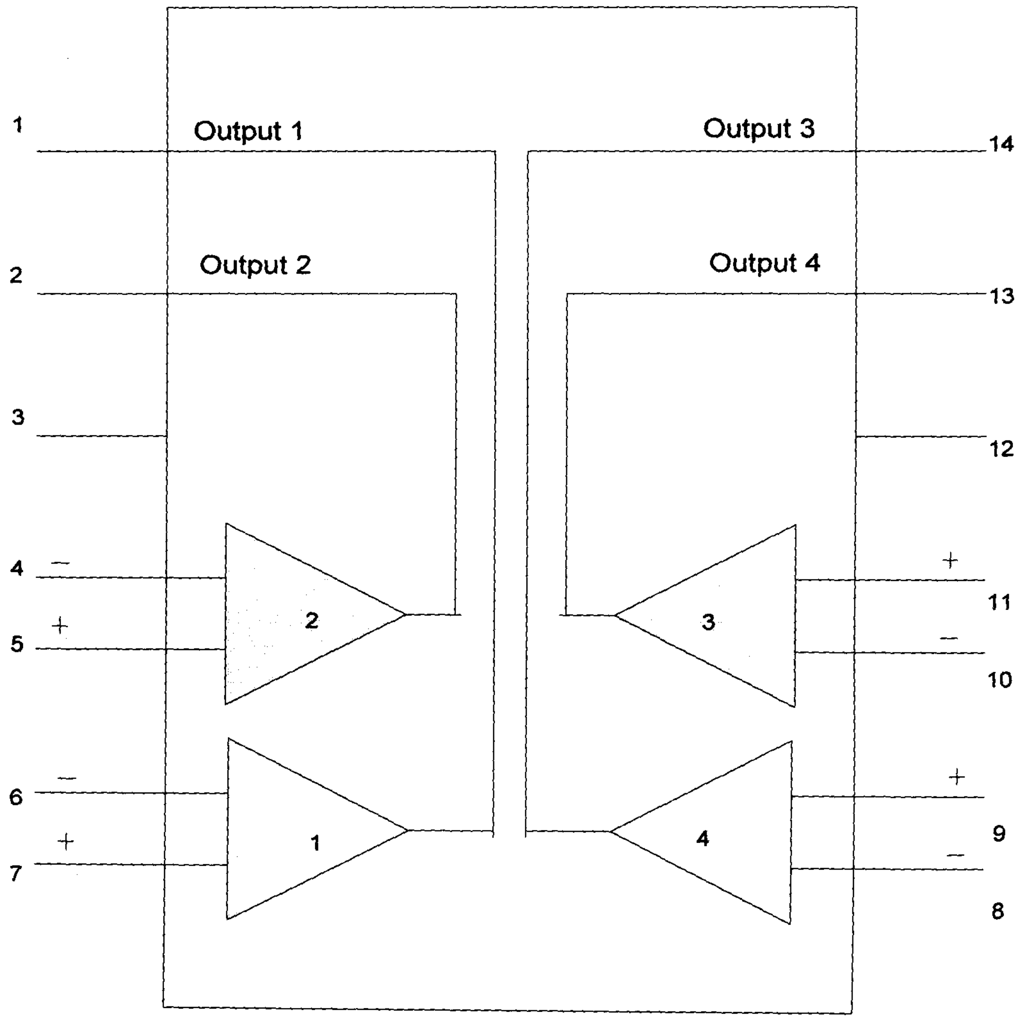


FIG.3.3. THE PIN ASSINGEMENT OF THE LM339

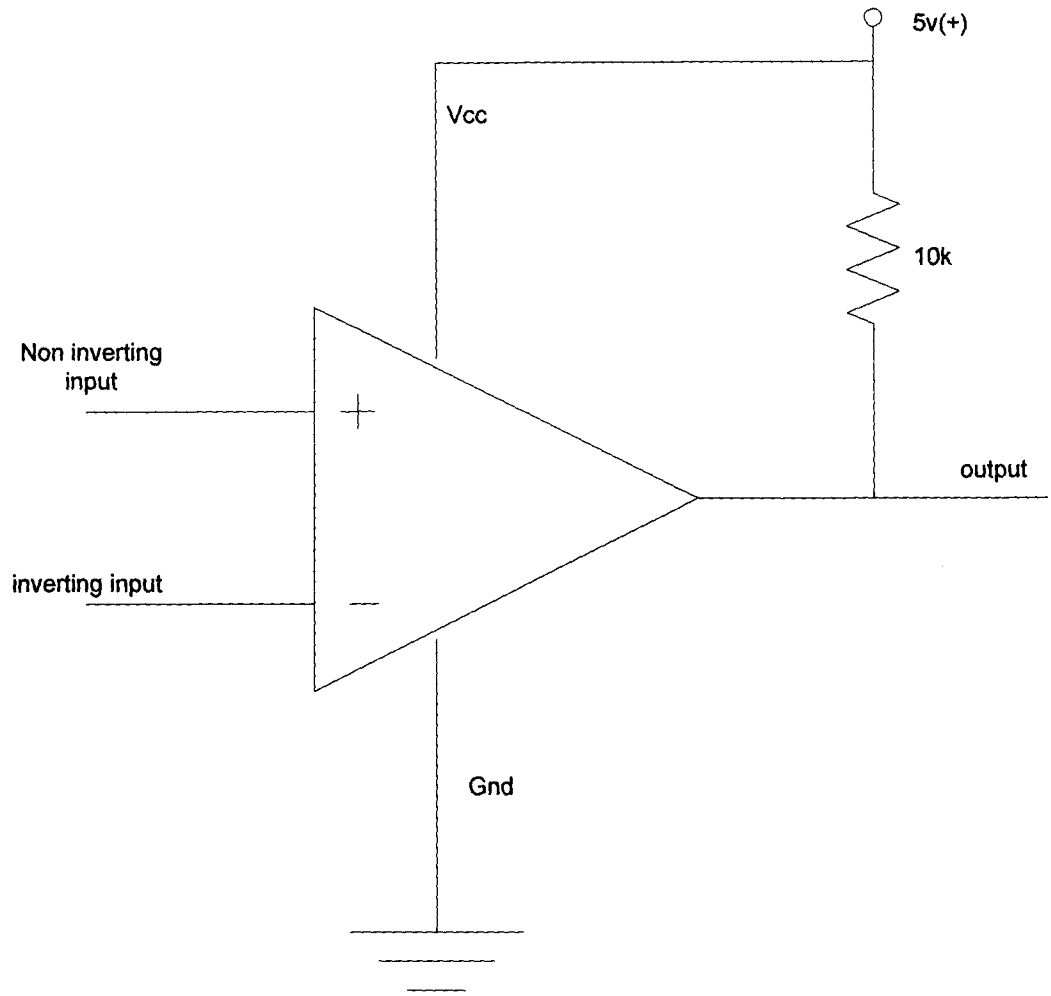


FIG.3.4. A TYPICAL CONNECTION OF THE LM339 INTEGRATED CIRCUIT COMPARATOR

Based on the manufacturer's data sheet, a typical connection of a unit comparator involves a 10kΩ resistor between the Vcc and output. Normally, 5v power supply is used in most application. The resistor is required is due to the open collector nature of the comparator's output.

The LM339 is used for referencing the output or signal from the LM35 for a particular switching response or control. Therefore, as associated with the project, the LM339 is heart of the incubator altogether.

3.1.3. 2sc945

The 2sc945 is a npn bipolar transistor. It is designed for low audio frequency amplification and low speed switching. The transistor has a typical current gain (hfe) of 100. It is usually enclosed in a T0-92 casing.

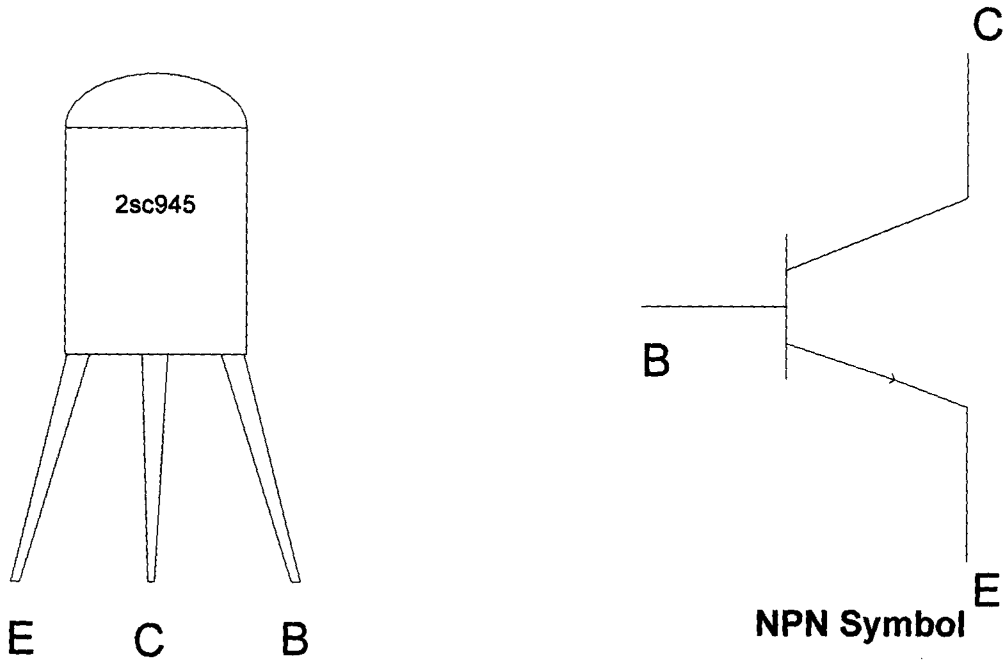


FIG.3.5. THE PIN LAYOUT OF THE 2SC945

E= Emitter

B = Base

C = Collector

The device is used for the output section of the circuit. It is used for switching a relay switch in response to the input temperature sensor. The comparator operates the transistor device.

3.1.4. 12v relay switch

A relay switch is normally used for switching heavy load in A.C. the load rating depends on the current specification of the device. The type in this circuit is rated 12 v and 10A. Therefore, if the voltage involved in switching is 220v A.C, the maximum power loading is around 2kw. A normal relay has five terminals. Three of them serve the switching connection. The other two are used for inductive switching of the relay.

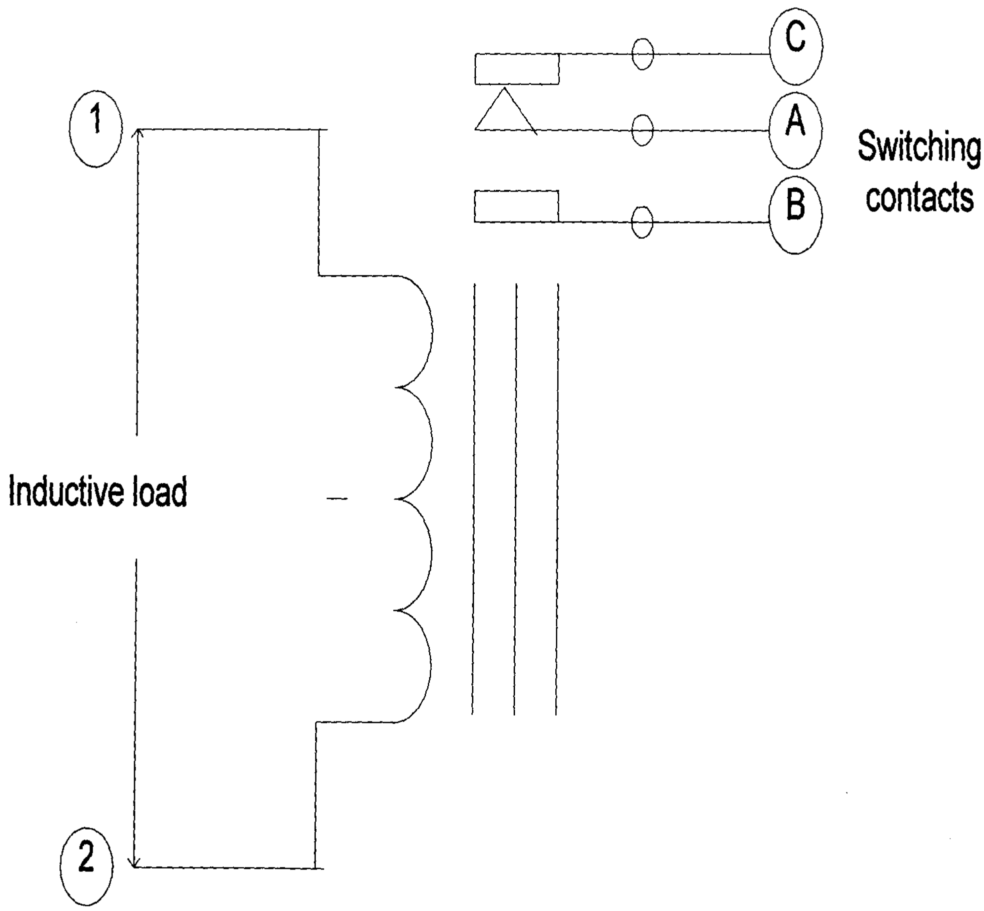


FIG.3.6. THE SYMBOL OF A RELAY

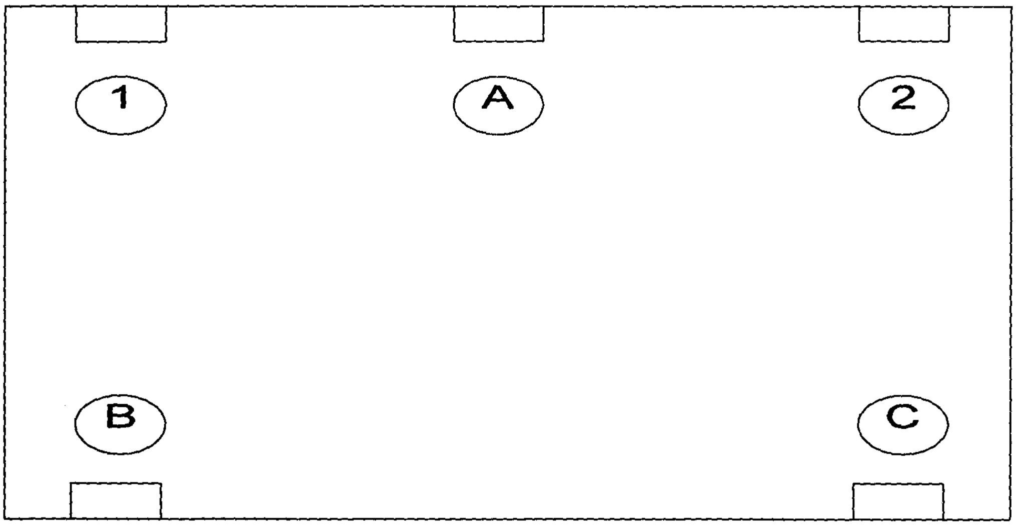


FIG.3.7. THE PIN LAYOUT OF THE RELAY.

A relay is incorporated into the circuit for switching the heating load. It is controlled by a 2sc945 transistor which responses to signal from the comparator to temperature sensor circuit.

3.1.5. 1N4001

The 1N 4001 is a Pn diode. It is quite common for general purpose circuit design below 1A and 50 V current/Voltage rating.

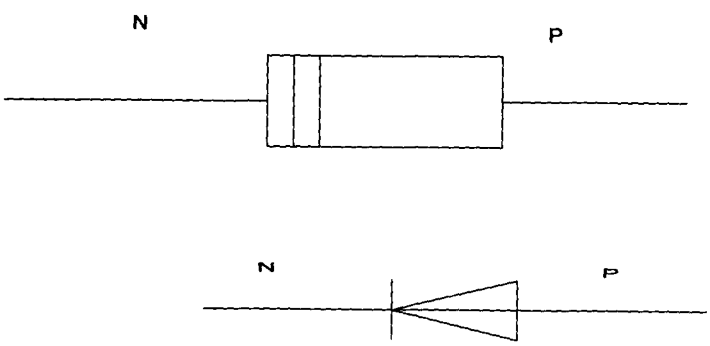


FIG.3.8 THE PIN CONNECTION AND SYMBOL OF THE 1N4001

N = Cathode

P = Anode

The component is mainly used for bridge rectifier application in the circuit. Also, it is used for protecting the involved relay for back - e.m.f destruction.

3.1.6. 7805 and 7812

The 7805 and 7812 are both positive voltage regulators. They are rated 1A and 35V. The 7805 and 7812 provide 5V and 12V voltage regulation respectively. They are used in power supplies.

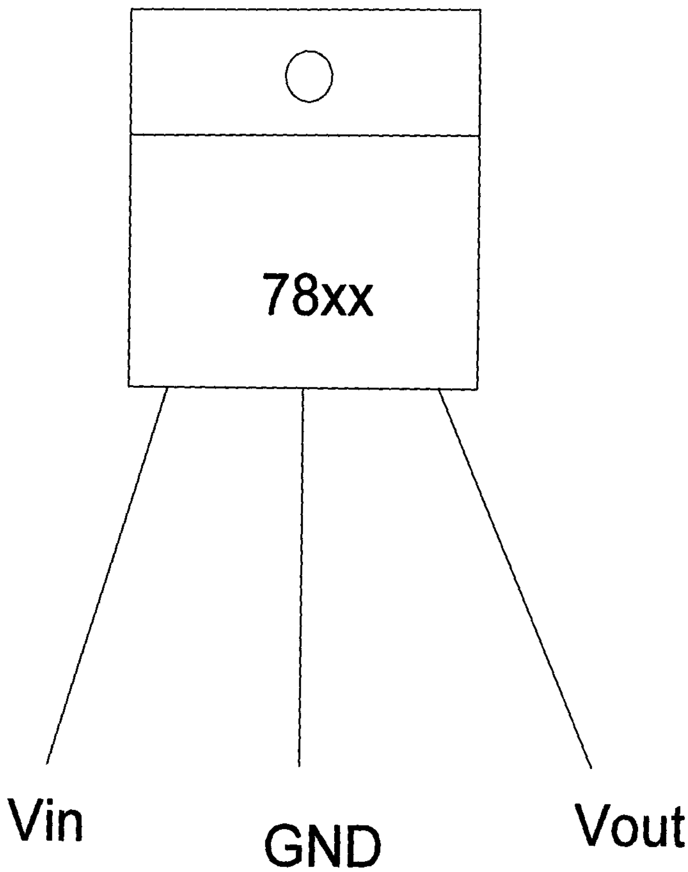


FIG.3.9. THE PIN ASSIGNMENT OF THE 78XX (BOTH 7805 and 7812)

3.2 Circuit Block Diagram Analysis

The circuit is quite simple. It is divided into five main units.

They are: -

i. Power unit

ii. Input unit

iii. Comparator/control unit

iv. Output switch unit

v. Output load

These units are quite compactable and work together to meet the possible aim of the project.

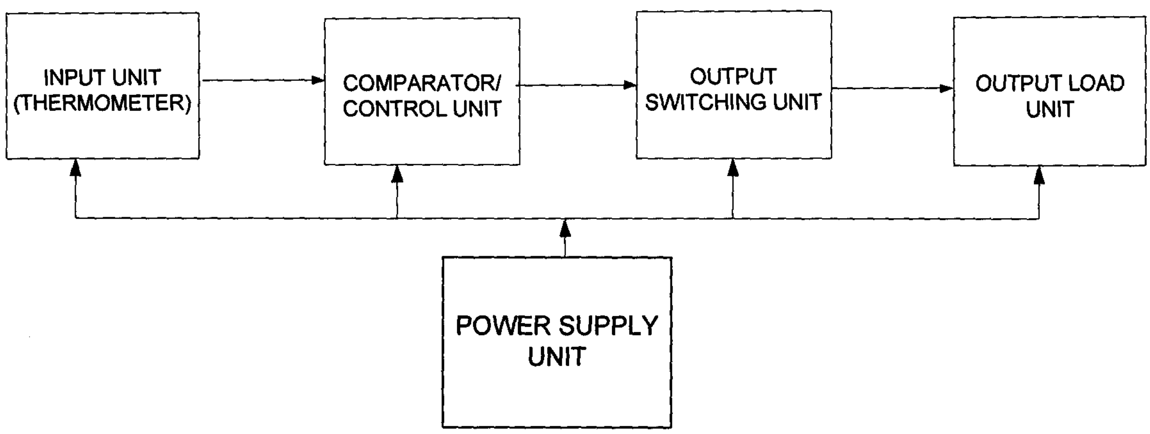


FIG.3.10. A SIMPLE BLOCK DIAGRAM OF THE CIRCUIT

3.2.0 Power Units

The power unit is designed to provide regulated 5v and 12v supply to the circuit. The power supply is based on a 24v A.C output step down transformer. The device steps down the 220v A.C main supply to roughly 24v. This relative or usual high voltage is incorporated to increase the reliability of the project in time of usual low or high mains

Power supply. The regulators maintain concerned voltages with reasonable level of the input voltage from the mains.

The 12v regulator supplies both the 12v blower (fan) and 12v relay switch. The 5v regulator maintains a steady at the input/comparators section of the circuit.

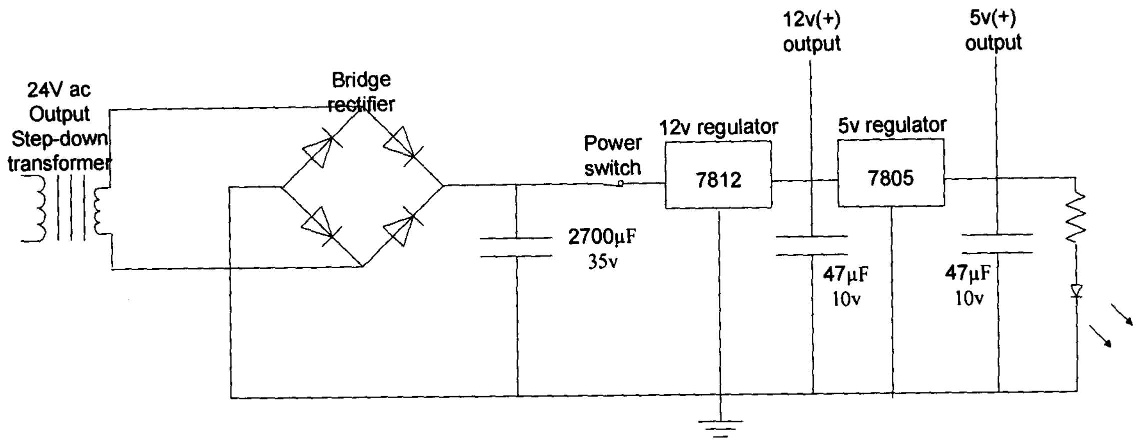


FIG.3.11. THE POWER SUPPLY UNIT.

The common bridge rectifier comprising of four rectifying diode which is the base of the power supply unit. The diodes serve in converting the 24v AC into corresponding 24v D.C. The leading connection allows only two of the diodes to be active or forward biased at a particular half-cycle of the alternating voltage. The devices direct the negative and positive components of the alternating current to separate terminals or points. Therefore, a polarized output is given from the configuration.

The output from the rectifier is expected to be fully D.C. But, this is not always true. The voltage is attributed to ripple, a signal of small component of the A.C input. The frequent way of removing the unwanted feature is the use of a polarized or electrolytic capacitor with a range of 1000-3300µF. A 2700µF of 35v capacitor is the choice for the project. The voltage rating of 35v is required because the maximum voltage of the circuit is around 24V.

The difference in voltage is for safety in situation of usual increase in power supply from the mains. Moreover, a power switch is used for opening and closing the complete circuit.

Both 7812 and 7805 are connected in parallel to the rectified and filtered D.C voltage. The connection is based on the data sheets of the devices. A 47μF of 10v capacitor might be connected between their outputs are ground for more filtration of the current in the circuit.

A power indicator circuit is for indicating the presence of electric current in the circuit. The circuit involves a resistor and light emitting diode (LED). The resistor allows a voltage drop of around 2.7v across the light indicator.

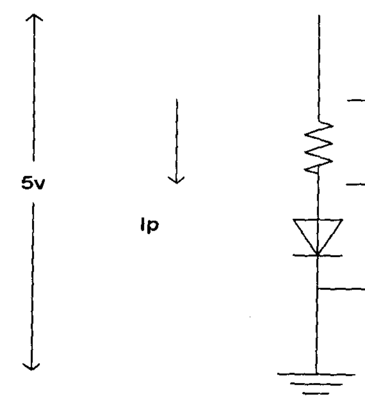


FIG.3.12. THE POWER INDICATOR CIRCUIT

A typical current (Ip) of 3mA is expected to flow in the series connection.

Therefore, the likely value of Rp is given below: -

$$Rp = \frac{2.3}{3 \times 10^{-3}}$$

Rp = 766.651 0hms

A 100Ohmns resistor is used in the circuit. It is quite a practical value. The use results into little or no difference in the circuit, only the light coming out of the LED is dimmer.

The power supply unit provides a maximum current of 500mA, as related to the involved transformer, to the unit.

3.2.1 Input Unit

The input unit is the mere Lm35 integrated circuit temperature sensor. Its output terminal is connected to the comparator. The sensor feeds back the temperature condition inside the incubator to the control unit of the circuit. The Lm35 temperature sensor operates on the basic temperature – voltage relationship for temperature regulation over a wide range.

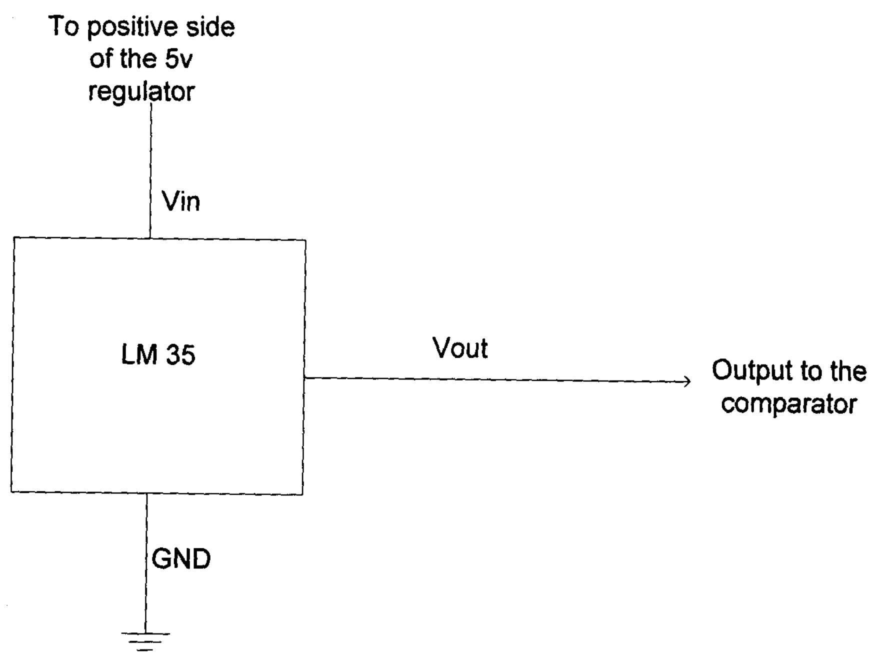


FIG.3.13. THE INPUT UNIT

3.2.3. Comparator/Control Unit

One of the comparators of a Lm339 serves this part of the circuit. Its non-inverting input VIN (+) is connected to the signal form the Lm35 temperature sensor. The other terminal, inverting input VIN (-) is referenced to 0.365V through a resistor circuit.

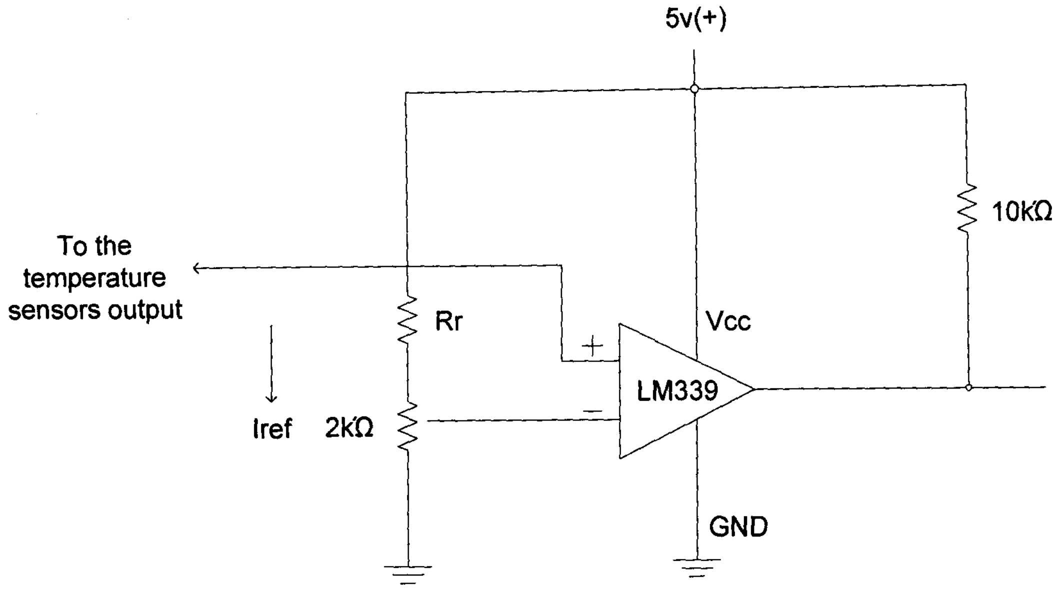


FIG.3.14. THE COMPARATOR/CONTROL UNIT

The current flowing in the series resistors is given below:

$$Iref = \frac{Vcc}{(2 + Rr) X 10^3} = \frac{5}{(2 + Rr) x 10^3}$$

$$Iref = \frac{5}{(2 + Rr)\ X 10^3}$$

The variable resistor is made 2kΩ therefore a suitable value of Rr is calculated.

The Variable resistor (2 kΩ) is used for referencing the non-inverting Vin (+) input of the comparator. Due to the temperature voltage relations of the temperature sensor, the variable resistor must cover a temperature range of 0 – 100^{0}c or voltage range of 0 – 100mv.

Therefore, a volt age of 100mv or Iv is expected across the variable resistor. The remaining 4v is expected across Rr.

So that,

$$4 = \frac{5}{(2 + Rr) \times 10^3} \times Rr$$

Rr = 8 kΩ

Therefore, by adjusting the 2 kΩ a voltage within 0 – 1v is connected to the non – inverting Vin (-) of the comparator. The initial condition of the output of the comparator is low. This keeps the output heating element operational. At this moment, when the inverting input Vin (-) is at a referenced voltage corresponding to a particular temperature, the non–inverting side must be below the referenced temperature dot. Sometime the initial temperature is high and the fan is required to cool the incubator while the heating is switched off.

The result is fit gradually fed back in the device as increase in voltage from the temperature sensor. It gets to a time that voltage from the sensor, which is corresponding to the temperature, is about going beyond the referenced voltage, the output of the comparator changes from low to high logical level. The result is the switching off of power supply to the heater.

Moreover, a cycle switching operation is developed when the temperature is about beyond or below the referenced one. This keeps the incubator at the required temperature range.

3.2.4. The Output Switching Unit

The output switching unit is designed to respond to the raise and fall of logical levels form the comparator. It comprises of a NPN bipolar transistor and a relay switch.

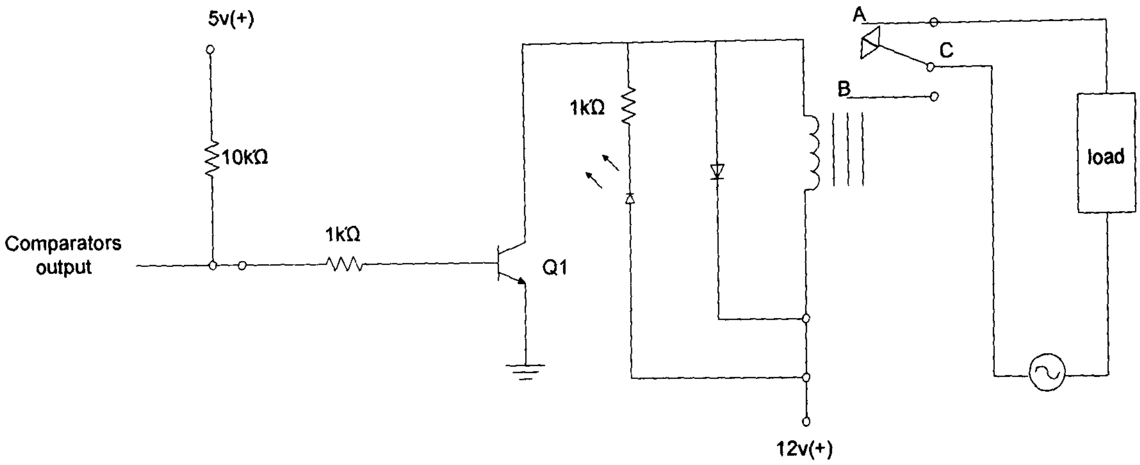


FIG.3.15. THE OUTPUT SWITCHING UNIT

The base of the involved common emitter transistor circuit is connected directly to the output of the comparator. Therefore, the voltage level at the output of the comparator determines the switching position of the relay switch.

The inductive component of the relay has a resistance of 400Ω. The relay is rated 12v.

Therefore the rely requires a current as given below:

$$Ic = \frac{12}{400} = 0.03A$$

$$Ic = 30mA.$$

The transistor has a typical current gain of 100.

Therefore,

$$I_B = \frac{Ic}{100} =$$

$$I_B = \frac{3mA}{100}$$

$$I_B = 0.03mA$$

The base resistance is given by: -

$$\frac{5 - 0.7}{I_B} = \frac{4.3}{0.03 \times 10^{-3}} = 14333\Omega \text{ or } 14.33 \text{ k}\Omega$$

A base resistance of 11kΩ is used in the circuit taking the loading resistance of the comparator into consideration. The difference compensates for inaccuracy of the involved equation and inductive property of the relay.

The relay is connected to a reversed biased diode. The diode protect the transistor form back -e.m.f. of due to switching off end on. The induced voltage flows in opposite direction of the original current flow thereby short or cancels out by the diode.

When the transistor is cut off, the condition of the comparator's output is low. The relay contacts allow current to flow through the load (heating element). But, whenever the comparator's output is high level logic, the transistor is saturated, whereby dropping the contact (C)of the relay to B. this opens the circuit of the load (heating filament) and the heating effect is off. This result into cycles of switching operations. The main aim is to attain a steady temperature in the incubator.

An additional feature to the switching unit is a LED indicator to show the switching effect of the circuit. It's configuration is similar to the power indicator.

3.2.6. Output Load Unit

The output load is merely a server of parallel connected heating filament of overall power of 180 watts. Therefore, a current of roughly 120/220 = 0.55A is flowing through the relay switching contacts. Another load, but connected across the 12v power supply line, is a 12v blower (fan). It helps in circulating a steady flow of temperature in the cavity of the incubator and lowers its temperature whenever the temperature is initially higher than the referenced temperature.

3.3 **Mode Of Operation**

The Lm35 is the input of the whole device. It is a precision temperature sensor. It is designed with a temperature-voltage relationship of 1^0c to 10mv. The Lm35 monitors the temperature of the incubator. It's connected to the non-inverting input Vin (+) of a comparator. The inverting input Vin (-) of the comparator is referenced with a particular temperature corresponding to voltage. Assuming, when the incubator is aimed to work at temperature limit of 50^0c, the inverting input Vin (-) to the comparator is set at 500mv due to the temperature-voltage relationship of the temperature sensor.

Initially, the output of the comparator is logical 0. This signal allows the normal operation of the involved heating filament. As the temperature of the incubator increases, the voltage of the non-inverting Vin (-) of the comparator also increases. When the temperature in the incubator is about going beyond the preset 50^0mv or the non-inverting input Vin (+) is about going beyond 500mv, the output of the comparator changes from logical 0 to logical 1. The result is the switching off of the output heating filament. This allows the temperature in the incubator to be at the edge of to the preset temperature level.

When the incubator cools, the temperature is about dropping below the preset temperature level. The heating starts again to maintain the preset temperature level. When the incubator is about going above the preset temperature level, the heating is cut-off one again.

The result is a cycle of switching on and off of the involved heating filament. This allows the temperature of the incubator to be regulated or maintained within a narrow temperature range.

Moreover, a fan is incorporated into the design for a fast response of heating and cooling. The air from the fan to merely circulate heat uniformly through the cavity of the incubator.

Conclusively, the preset temperature of the incubator covers a temperature range of 0-100^{0}c. Although, the lower temperature levels are not really practical.

Chapter Four

4.0 Construction Testing and Discussion of Results

4.1 Circuit Construction

This part of the project involved practical exercise on making the circuit diagram on the paper into a real working hardware. The specified components in the circuit's design were carefully connected together under the guide of the circuit diagram. The breaking of the complete circuit that was involved during the design analysis was of great important of the construction. Each unit was executed one after the other. After which the units were joined together as a single working construction.

The circuit's construction involves simple tools which are stated below:-

i) Soldering iron

ii) Knife

iii) Razor blade

iv) Pliers

v) Scissor

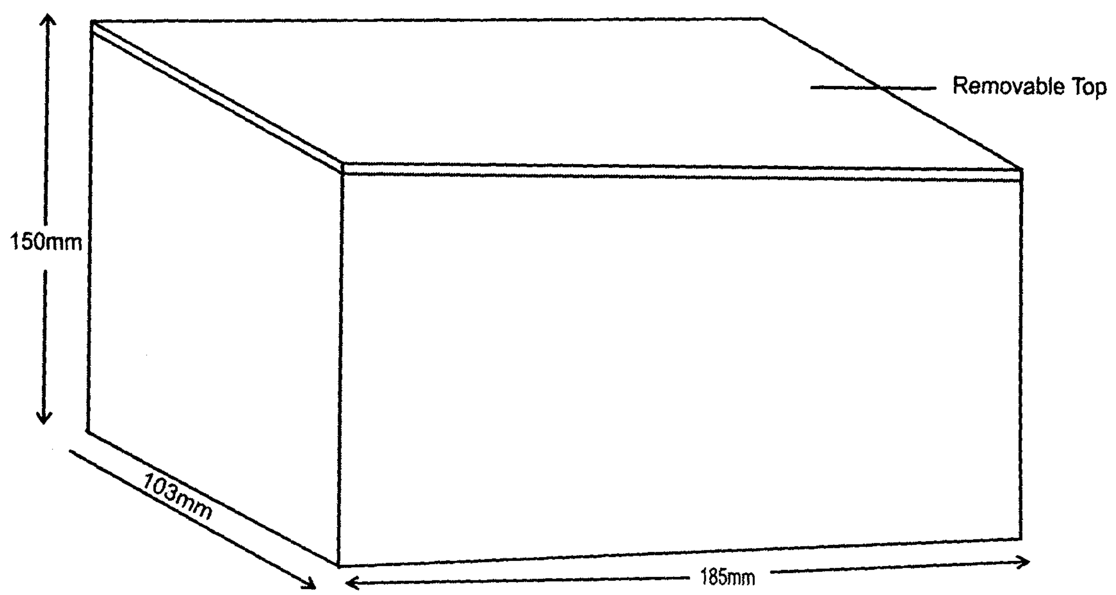
vi) Digital Multimeter.

The power supply unit was quite delicate during the construction which was made with great care. After the complete construction, the power unit was properly checked for short circuit and unwanted bridges.

4.2 Case Construction

The casing of the constructed circuit was done through the use of wooden, plastic and rubber materials. The materials were carefully selected for different parts of the circuit.

A wooden box was the base of the incubator's casing. The circuit was enclosed in a rubber casing modified from motor cycle's head light casing. The modified casing really suited the project work. The plastic material in use was transparent for the purpose of the temperature regulated incubator's cavity, the material is not really proper for the application at high temperature inference. But it is better than mere glass which could break apart in expansion to critical temperature level.



The Dimension of the transparent plastics covering

FIG.4.1.THE TRANSPARENT PLASTIC COVERING OFCASING.

The parts were connected together through bolts and nuts.

4.3 Testing

Tests were performed on the completed construction so as to check its response and performance with the aim of the project. The testing basically depends on the temperature regulation of the involved incubator's cavity.

Firstly, it involved plugging of the device to the A.C mains supply and powering it 'ON' by the use of the power knob. The preset temperature was adjusted to a particular desired temperature value by using the adjustment knob and digital meter was used for the setting. The device operates at the temperature value which corresponds to the voltage displayed by the digital multimeter. The relationship was that of Lm35 temperature sensor which was 1^0C to 10mv. The digital multimeter provided an easy manner of knowing the operating temperature of the device and, even in a situation whereby there was no digital operating temperature value displayed by the digital multimeter, the adjustment knob is well labeled for easy visual access to the preset temperature ranges on the rubber casing. Also, digital multimeter was used particularly to monitor both the reading and preset temperatures of the device. The responses or results of the two temperatures (Reading and preset temperature) getting quite close or the same were properly monitored during the course of the testing.

Numerous preset temperatures, within 0^0C-100^0C, were involved in the test. The lower temperatures were really considered during the test for preventing the set-up from heat related damages.

4.3 Result Discussion

The table below shows some outcome from the test. The result mainly showed that the associated heating of the sealed incubator's cavity was stopped whenever the two involved temperatures passed for the same situation. Heating resumed whenever the temperature sensor detected dropping temperature in the cavity about below the preset temperature. The incorporated blowing fan circulates hot air evenly through cavity.

Table 4.1 Temperature Regulation Analysis For Specified Inputs

Serial no	Preset temperature (^{0}C)	Heat switching off temperature (^{0}C)	Minimum temperature during related regulation (^{0}C)	Maximum temperature during related regulation (^{0}C)
1	37	38	36	38.4
2	45	46.5	43.9	46.9
3	58	59.9	57.3	61.2
4	65	67.1	64.3	68.3

The above table shows slight inaccuracy of the involved circuit especially the Lm35 temperature sensor. It is quite evident that at higher temperature the accuracy of the temperature sensor drops. In fact, the sealing of the involved cavity influences the efficiency of the related temperature regulation of the device.

The switching effect of the related circuit was evident at the relay. It went on and off with visible sparks during temperature control. An output light indicator (LED) indicates whenever heating was in process or not through off on states respectively.

4.4 Source Of Errors In the Design

Errors may occur in the Lm35 temperature sensor bridge due to self heating of the sensor or due to temperature or noise effect in long lead which may be used to connect a remote sensor to the bridge. Self heating errors are caused by heating of the Lm35 temperature sensor above its ambient temperature because of power dissipation in the Lm35 temperature sensor due to the bridge currents. The effect can obviously be reduced by decreasing the bridge supply voltage, but this also reduces the overall sensitivity of the circuit.

Chapter Five

5.0 Conclusion and Recommendation

5.1 Conclusion

The project merely shows the importance of digital electronic in control applications. Modern electronic components, or transducers to the particular, have extremely flexible features and attachments for numerous purposes. A device Lm35 temperature sensor (a linear temperature shows) provides a precise technique for measuring temperature, a physical quality. The device demonstrated how easily its output. Signal can be manipulated into heat control or regulation.

The attributed simplicity of the circuit corresponded to limited number of problems during the circuit's design and construction. In fact, relevant information was acquired on the involved components during the course of the project.

The project provided a real practical experience in electronics and it is economically valuable when the cost of the entire construction is weighed with its usefulness on the same balance scale.

5.2 Recommendation

i) The project could be incorporated with a digital temperature display panel to show the two involved temperatures.

ii) Wide temperature ranges could be incorporated into the design.

iii) The temperature regulating cavity of the incubator could be expanded for more practical importance in relation to size.

iv) More advanced integrated circuit temperature sensors could be used for the project for better temperature regulation.

v) Features such as alarm could be incorporated into the design for warning feature.

vi) Better temperature monitoring could be achieved through computer interfacing to the incubator which also gives precise determination of the number of eggs hatched and spoiled ones, including records of activities carried out during incubation processes.

vii) The transparent parts of the casing could be made using high heat resisting materials i.e. glass used for the door of heating devices such as electric oven etc due to their ability to withstand high heat without cracking or breaking.

Apart from the application of this control system in an incubator, it can be applied to other areas by mere adjusting the design depending on the specified range of temperature needed. Some areas of application other than incubator are:-

i) Environmental control of temperature in green house animal nursery, reptile ponds and tropical fish aquarium etc.

ii) The control of central heating system

iii) Cooling system control

iv) Automobile engine temperature control.

References

[1] http://en.wikipedia.org/wiki/thermostat

[2] http://earlythermometerhistory.us/sec001.htm

[3] P. Horowitz and W. Hill, The Art of Electronics, 2nd Ed, Cambridge University Press, New York, 2003, pp. 428-445

[4] L. Warnes, Electronic and Electrical Engineering: Principles and Practice, 2nd Ed, McGraw-Hill, New York, 1998, pp. 483-500

[5] S. Gibilisco, Teach Yourself Electricity and Electronics, 3rd Ed, McGraw-Hill, New York, 2003, pp. 583-619

[6] B.L. Theraja and A.K. Theraja, A Textbook of Electrical Technology, 22nd Ed., S. Chand & Company Ltd, New Delhi, 2001, pp. 1961-1987

[7] Zadeh B.Y., Basic Control Engineering, 1981, pp. 15-53

[8] Bell E.C.,Basic Electrical Engineering and Instrumentation for Engineers 1st Ed, Crosby Lock Wood Staples Publishers, Great Britain, 1977, pp. 122-141

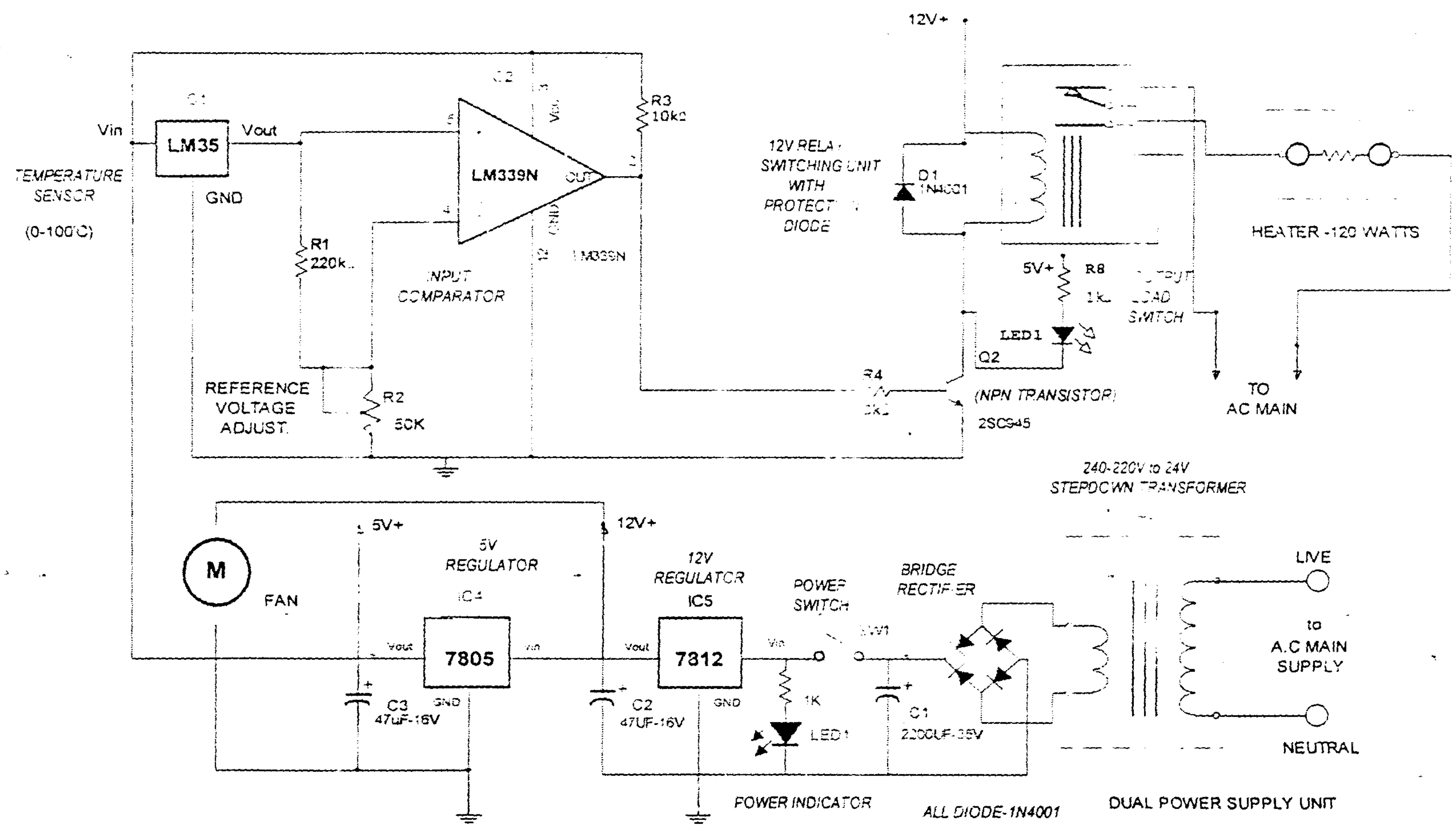
[9] G. Rizzoni, Principles and Applications of Electrical Engineering, 3rd Ed., McGraw-Hill, New York, 2000, pp. 337-377

[10] P.E. Gray and C.L. Searle, Electronic Principles, Physics, Models, and Circuits, Wiley, New York, 1969, pp. 78-92

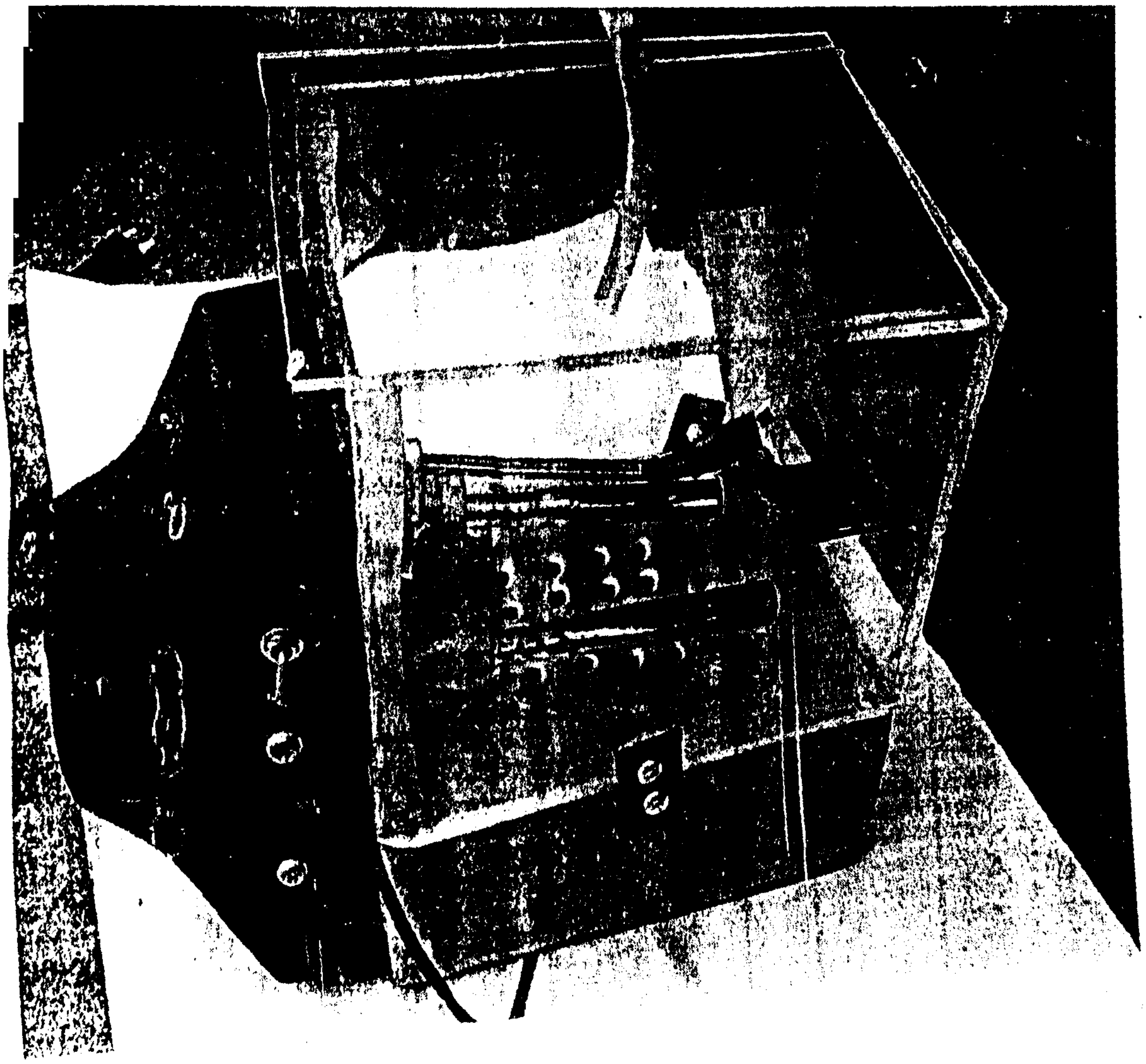
[11] E.C. Lister, Electric Circuits and Machines, 5th Ed., McGraw-Hill, New York, 1960, pp. 112-133

[14] R.G. Smith and R.C. Dorf, Circuits, Devices, & Systems, 5th Ed., Wiley, New York, 1966, pp. 171-198

[16] Mal Con Plant, Basic Electronics,2nd Ed,Holders and Stroughton, pp. 286-297.



APPENDIX I: COMPLETE CIRCIUT DIAGRAM OF A TEMPERATURE CONTROL MODULE



APPENDIX 2 THE PICTURE PROTOTYPE MODEL OF THE INCUBATOR