DESIGN AND CONSTRUCTION OF A SIMPLE AUTOMATIC ROOM HEATER

A PROJECT SUBMITTED TO THE DEPARTMENT OF

ELECTRICAL AND COMPUTER ENGINEERING

BY

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CERTIFICATION

I CERTIFY THAT THIS STUDY WAS CONDUCTED BY MALLAM MUSA ABDULRAZAQ DANJUMA, OF THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING UNDER MY SUPERVISION

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DEDICATION

This project is dedicated to my parents, Alhaji Musa Ibrahim and Hajiya Hajara Musa, for their parental care and affections they have shown to me, which enable me to come this far in my endeavors. My supervisor, Mr. rumala, my friends, my brothers and sisters, Engr. I. B Musa, Hajiya Hawa Dauda, mallama Hadiza Idris, to my sister Aishat Musa, Isah Musa.

Ramatu and Marriam Musa, whose prayers support and encouragements has been of tremendous, help to me. Above all, I will like to dedicate this project to ALMIGHTY ALLAH for his guidance, grace, and faithfulness.

DECLARATION

I MUSA ABDULRAZAQ DANJUMA, hereby declare that this project was written by me and that the contents are result of my own design and calculation. Information obtained from published and unpublished works of other have been well acknowledged by means of reference.

Signed...:...............

Date:.....................

ACKNOWLEDGEMENT

Thanks and praise be to Allah (S.A.W) who has created me and gave me the strength and protection to successfully complete my course in this institution. I, am greatly indebted to my supervisor, Mr Rumala for his attention, helpful advice and encouragement throughout the duration of the project. My sincere thanks also goes to the technical staff of the department. I am grateful to my father, Alhaji Musa Ibrahim, and my mother, Hajiya Hajara Musa for their parental love and understanding throughout my stay in this school. My gratitude goes to other members of the family whose support also enjoined. My final gratitude goes to my lecturers and other persons that might have contributed to the success of this work in one way or the other. I thank you all.

ABSTRACT

The design and construction of automatic room heating system described in this project. The project is intended to heat being regulated at a specified critical temperature. The switching depends on the geographical spread of the temperature range. This project report is intended to produce outputs which solely on the temperature of the sensor device (thermistor) according to the resistance change of the device. As the temperature of the surrounding changes from the set up temperature to the critical temperature of the thermistor. The thermistor here is fully immersed in water (hot water). As the temperature increases, its resistance decreases thereby causing it to approach the set trip value of the variable resistor. When the thermistor resistance become less than the set value of the variable resistor, the comparator output switches to a high output state and use to drive the transistor. The is used to switch ON and OFF the relay which in turn switch on or off the heating element of the circuit. The project writing is divided into four chapters. Chapter one is the introductory aspect of the various method adopted in the automatic room heater. Chapter two described the general design analysis and operation. Chapter three deals with the constructions, details and testing. Chapter four draw the conclusion regarding the project, which outlines the performance evaluation and gives recommendation for further improvement on the work.

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CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

In many developing countries the desire for warmth and comfort may well have motivated the people first use of fire. Evidence shows that man used wood and charcoal in open fires to produce warmth, as well as to prepare food in his cave or shelter. Such simple open fires were used as late as the 19th century where hurts and tepees were built allowing the smoke to escape through an opening.

The uses of stoves provide a new way to heat rooms as an alternative to open fire as earlier used. The fire was contained in a combustion chamber usually made of ceramic or iron sections. It heated the stove walls, which in turn heated the room, mainly by convection of the room air over the hot surface. As technology advanced, individual room stoves were superseded by central heating for the entire building. The general public expects public and commercial buildings to be maintained at a comfortable temperature and humidity year- round and to be free from objectionable drafts, dust, pollen, and noise. In such building complex heating and summer conditioning system must be designed to satisfy the comfort requirements of the average person. Unfortunately there is considerable variation in the physiological response of people to their atmospheric environment, and many people develop a feeling of frustration in public buildings and works space where conditions are not to their liking but still are beyond their control. To complicate the problem further, snow- melting system and other building services often are tired into the heating system.

The heating system demanded by architects and building owners vary widely, depending on building types. Multistory office buildings and hotels have complex design problems in heating control for different zones in the building. Restaurants and cafeteria's have different environment problem than sport arenas and convention halls. Libraries and museums present the problem of protecting sensitive and valuable inventories while TV studios, mosques, churches and music halls have the problem of preserving high acoustic standards. Hospitals and nursing homes must have heating systems that will not spread pathogenic bacteria among the patients, while public garages and supermarkets require heating systems that respond quickly to loads impose by frequent opening of large doors.

1.1.1 HOME HEATING SYSTEMS

In a home, the individual has a heating under his direct control, consequently he should be familiar with the type of system that are available. Most home heating system obtains their heat by burning coal, gas or oil. When any of this fuel is burnt with a deficiency of combustion air or with an improperly adjusted burners, it can produce carbon monoxide, a deadly gas that is unsafe to breathe in any concentrations greater than 1(one) part in 10,000 parts of air. For this reasons, one should recognize the used of electricity as the source of energy for the heating element. Electricity is a high grade energy source that can be used for heating by sending current through resistance elements located in the room or building. Electric heat can be provided in many different ways in system for the home. The operation and control of these systems are very simple. In selecting a heating system, many factors should be considered before one select the type of heating system for the home. There are considerable variance in fuel availability, comparative cost and the competence of contractors in installing the equipment. The efficiency in using an energy source is 80% for gas and 100% for electricity.

To meet the challenges presented by these applications, engineers design complex systems with sophisticated control systems and special heating units provided for commercial or industrial use. All of these units, however, are supplied with warm air, hot water, or steam. For instance, isolated building such as rural schools sometimes find electric heat the answer to difficult fuel supply problems. As a result of the heating system being in isolated location, there was a great improvement in comfort, convenience and cleanliness in the home.

One of the best devices for preventing excessive cold discomfort, and inconveniencing to human being is by the use of "Automatic Room Heater" (temperature monitoring equipment) that will switch ON automatically as the critical temperature is approached and switch OFF when it is far below it is needed to help in monitoring the temperature (t_c) variation in the room. The block diagram is as shown in figure one.

The critical temperature (t_c) varies from one geographical area to another; hence these temperature is best provided by engineers, design architect and metrologies. As far as Minna is concerned, 30 ^{o}c is being used as a room temperature.

1.2 LITERATURE REVIEW

Basically, their are other temperature monitoring devices that uses almost the same type of principle but different types of input and output units, though there are some, whose principle is drastically different from that used in this system. Some are designed based on the principle of thermocouple-a device that uses the voltage developed by the junction of the two dissimilar metals to measure temperature difference. One junction called the sensing junction is placed at the point of interest (room), while the other called "the reference junction" is maintained at a known reference temperature. The voltage developed across the two junctions is proportional to the difference between the including a suitable voltmeter in the circuit.

Other system uses analog to digital converters to convert the sensed analog voltage produced by the transducer (say a thermistor or a semiconductor temperature sensor) into it's digital equivalence which is then fed into a display unit from where the temperature variation may be read. But finding an analog to digital (A/D) converter in the market may be very difficult.

Hence, the system used in this project is very simple and efficient. It is also cheap and automated, once there is power supply.

The circuit used in this project is made up of three main units, namely; the temperature transducer unit, the comparator unit and the heating resistance element unit. The transducer unit is placed in an oven to the equivalent electrical signal which is then fed and compared with a fixed signal at the comparator. The comparators output is then used to control the heating element resistance element circuit.

When the temperature in the room is below the critical temperature (t_c) the comparator output is zero and hence cannot power the comparator output heating resistance element circuit. But when it is above t_c the comparator output is above zero and hence can power the heater resistance element.

CHAPTER TWO

GENERAL DESIGN ANALYSIS AND OPERATION

2.1 INTRODUCTION

This project is designed based on the availability of their components, cost and effectiveness. Hence, the design method is limited to a prototype system so as to demonstrate a room heater by the use temperature detection in a room (a small oven). The detection is then indicated using a coil-heating element. The block diagram in Figure 2.0 gives a clear picture of the whole design structure. The details of the block diagram the design are expantiated as follow:

The temperature monitoring system (temperature transducer unit) is the main unit with their individual sensor. The sensor that comprises of a negative or positive coefficient thermistor whose resistance varies with temperature. This implies that for a constant current, the voltage variation across the thermistor is directly proportional to the resistance and hence temperature variation. The thermistor is place in a wheat stone bridge circuit and its voltage drop variation due to temperature is fed into a comparator.

An LM324 operational amplifier (op amp) is connected as a comparator. One input terminal is placed at a fixed voltage with the help of a potentiometer while the other is place at a varying voltage, which depends on the voltage from the thermistor. The output from the comparator is then passed onto a transistor switch.

Detail design for each unit is described below;

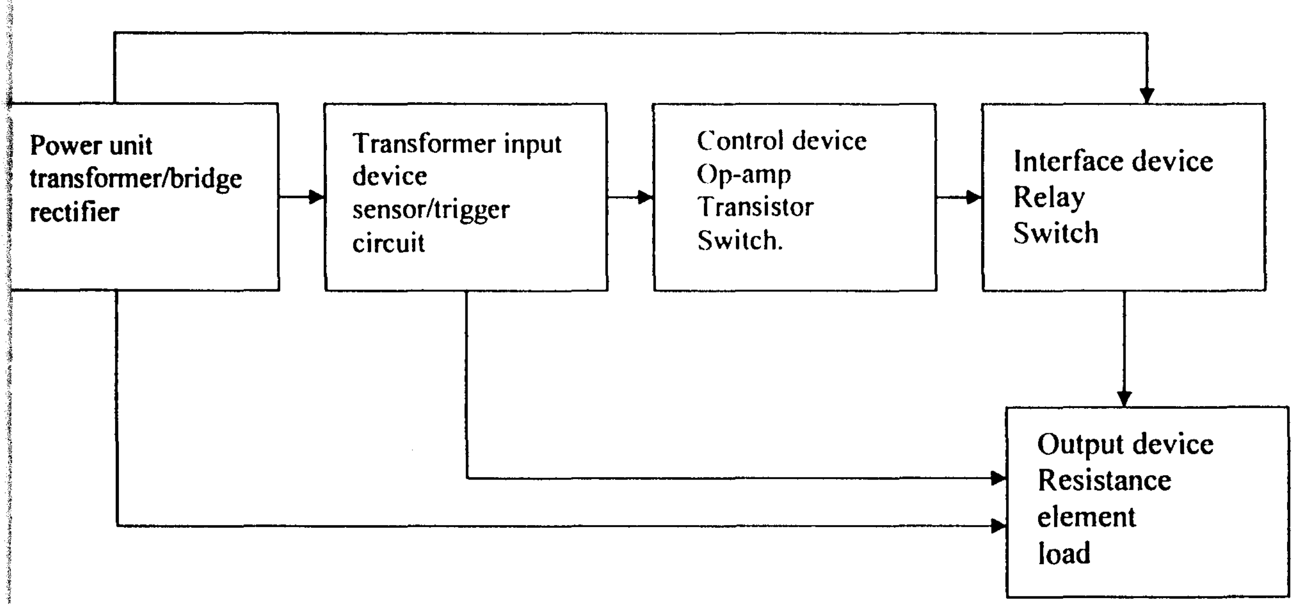


FIG 2.0 Block Diagram of the Automatic Room Heater

2.2 CIRCUIT OPERATION

TRANSDUCER

A transducer is any device which converts energy from one form into another such as magnetic energy into electrical energy, heat energy into electrical energy, electrical energy into sound energy etc. It is a device that converts a non-electrical quantity into an electrical quantity. For instance, a photo resistance converts a change in light intensity into a change in resistance and a thermistor convert a change in temperature into a change in resistance. Typical input transducers are thermocouples, thermistor, and photocells. There is also the output transducer, a device that converts an electrical quantity into a non- electrical quantity. For instance, an LED converts current into a light and a loudspeaker convert ac voltage into sound wave, and typical output transducers are loudspeakers, motor solenoid e.t.c. they are very important in electronic, as the success of any control system depends on the quality, sensitivity and stability of the input transducer.

2.2.2 TEMPERATURE CONSIDERATION IN BRIDGE BALANCING

Temperature sensors or transducer is a device that senses the temperature variation in an environment to give useful electrical signal. Different sensors are made from different materials, but generally, their properties changes with rise or fall in temperature and it is by experiencing these very changes in the electrical properties of the devices that it has been possible to create a wide variety of useful temperature sensors. Some of the useful temperature range for this project is between 15^0 to 30^0 C; hence most temperature sensor may be used. Some of the useful popular types are listed in table 2.1. But semiconductor types of sensors are not easily obtainable while the thermocouple and platinum resistance are relatively expensive. On the other hand, based on the availability, reliability and its low cost, the thermistor is used as the temperature sensor for this project.

2.2.3 THERMISTOR CHARACTERISTICS

A thermistor made basically of sintered oxides of nickel and manganese, is a device that undergoes a very large change of resistance with temperature. Most of the type has a negative temperature coefficient (NTC), i.e their resistance falls with an increase in the temperature of their surrounding; but some positive temperature coefficient (PTC) varieties exist whose resistance increase with an increase in temperature.

TABLE 2.1...

TEMPERATURE SENSORS (POPULAR TYPES)

SENSOR	FEATURES	TYPICAL USEFUL TEMPERATURE RANGE
1. THERMISTOR		
(Negative coefficient)	Resistance falls with temperature	-80°C to +300°C
(Positive coefficient)	Resistance rise with temperature	0°C to 100°C
2. THERMOCOUPLE	Voltage output rise with temperature	-50°C to +500°C
3. PLATINIUM	Resistance rises with temperature	-50°C to +150°C
4. SEMICONDUCTOR TYPES	Voltage for Pn junction falls by 2Mv/°C -Current output rises with temperature.	

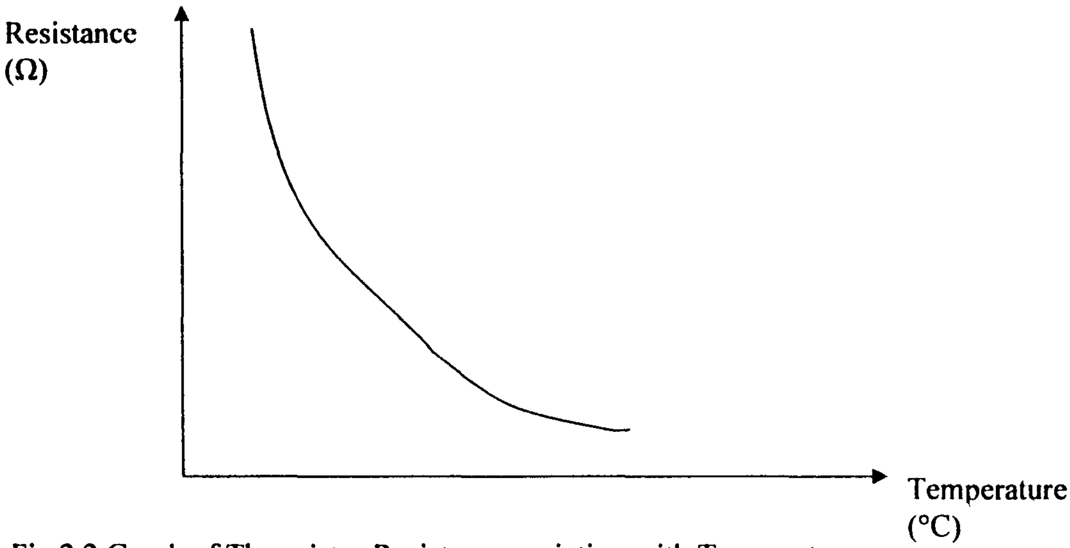


Fig 2.2 Graph of Thermistor Resistance variation with Temperature

The graph of fig 2.2 shows the resistance-temperature characteristic of a typical thermistor. The general form of the thermistor resistance characteristics is given by;

$R_T = R_o e^{(B/T - B/T_O)}$ 2.2

Where R_T = thermistor resistance (in ohm)

Ro = Thermistor resistance at a base temperature (r_o) in degree Kelvin (°K)

B = Thermistor constant (°K) which is a characteristic of the particular material.

Typical value ranges from 2000 to 5400.

e = 2.7183

And its effective temperature coefficient is

α_{eff} = -B / T ohm / ohm / °C. ....(2.3)

In temperature sensing application thermistor are commonly used in whetstones bridge circuit fig 2.3a.

Voltage equation for the above circuit is given as

$-V = Ia\ (R_1+R_2) + I_B R_1 + I_C R_3$

$0 = Ia R_1 - I_b (R_1 + R_2 + R_5) + Ic R_5$..(2.2.1)

$0=-I_a R_3 - I_b R_5 + (R_3 + R_4 + R_5)$

The individual arrangement is calculated using determinants, such as I_b, by forming a ratio in the denominator is the determinant with coefficient of the unknown current replaced by the right side of the equation.

$$I_b = \frac{\begin{pmatrix} (-R1+R3) & -V & R3 \\ R1 & 0 & R5 \\ R3 & 0 & (R3+R4+R5) \end{pmatrix}}{\begin{pmatrix} (-R1+R3) & R1 & R3 \\ -R3 & (R1+R2+R5\ ) & (R3+R4+R5) \end{pmatrix}}$$

When the lower determinant is denoted as

$\triangle$ = denominator

Means $I_b = \dfrac{[V\ R5\ R3 + V\ R1\ (R3 + R4 + R5)]}{\triangle}$..................................(2.2.2)

$$I_C = \begin{pmatrix} (-R1 + R3 + R1) & R1 & -V \\ -R1 & (R1+R2+R5) & 0 \\ -R3 & R5 & 0 \end{pmatrix}$$

$$I_C = \frac{[V\ R1\ R5\ V\ R3\ (R1 + 2 + R5)]}{\triangle}$$

Current through Rr (which is the load connected to the bridge output i.e LM324 op. amp) is given to be;

$I5 = I_b - I_c$

$= V/\triangle \quad [(R5\ R3 + R3\ R1 + R1R4 + R1R5)-(R1R5-R2R3-R5R3)] \ldots\ldots(2.2.3)$

$= V/\triangle \quad (R1\ R4 + R2\ R3) \ldots\ldots (2.2.4)$

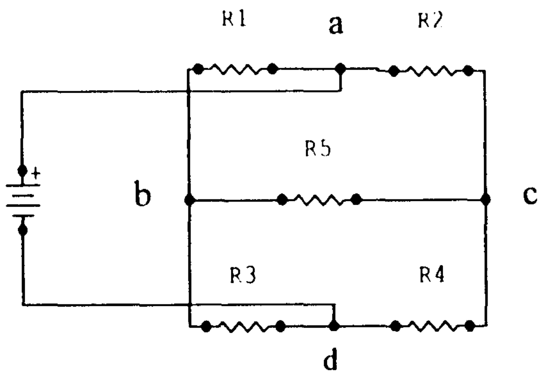


Fig. 2.3a. Wheatstone Bridge Circuit with Load Resistor R_5

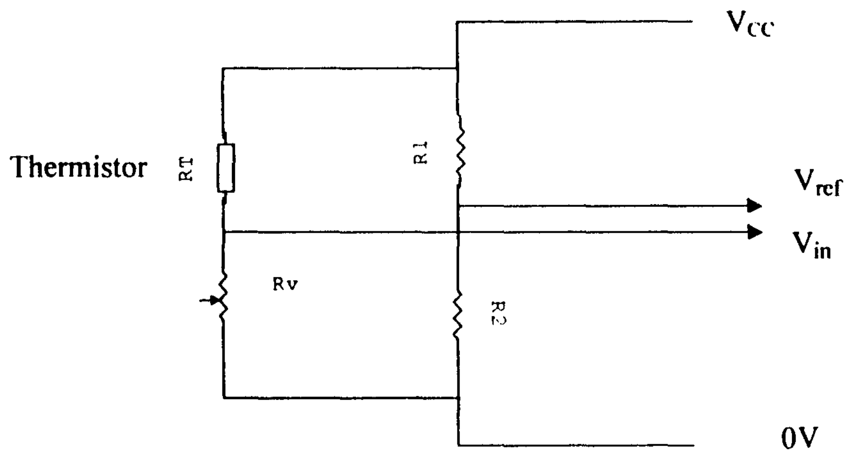
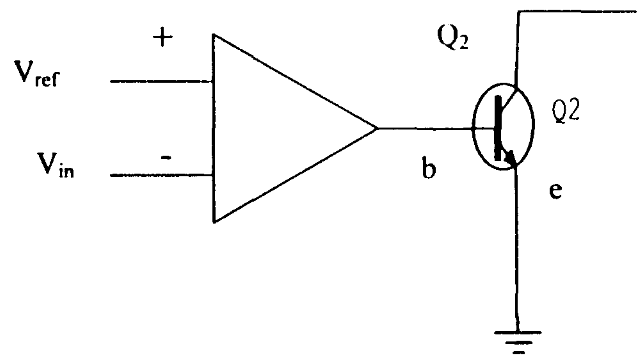


Fig. 2.3b Wheatstone Bridge mounting of a Thermistor (R_T)



Fiq 2.3c BC 337 AP Transistor switch.

Note that if

R1 R4 = R2 R3 ....2.2.5

or R2 / R4 = R3 / R4

Then I_5= 0 independent of applied voltage. For ease of design the resistance R_2 and R_4 are of the same value. Therefore for voltage drop across them will be the same.

i.e R_4 Vcc = R

Voltage-drop across them is fixed or denoted V_{ref}

V_{ref} = R_4 Vcc / (R_2 + R_4) = R Vcc / R + R = Vcc R / 2R =Vcc / 2..........2.2.6

The thermistor (R_T) is placed between point b and the supply while the variable resistor R_v is place by point b and ground such that is placed by positioning R_1 and R_V in R_3. voltage drop across the thermistor for different temperature.

Therefore, the voltage at point b is

$V_b = R_V V_{CC} / R_T + R_V$..(2.2.7)

$V_b = V_C$ where $R_T = R_V$ and $R_2 = R_4$

2.3 THE LM324 VOLTAGE COMPARATOR SUB-UNIT

2.3.1 OUTPUT DRIVER CIRCUIT

The voltage comparator is a circuit which compares input signal V_{in} with a reference voltage V_R .when the input signal exceed the reference signal of the output of the comparator, V_{out} changes from its value when V_{in} is less than or equal to V_R. A comparator circuit exhibits a non-linear operational amplifier characteristic where a differential amplifier behaves linearly (fig 2.5.3.).

A comparator is therefore a two input, one output voltage comparator. Comparing twice that is accessible of high gain, high input resistance and low output resistance. While this may be taking as the definition of an operational amplifier, it should be noted that voltage comparison is just one of the case of application of operational amplifiers. A comparator thus performs the following functions

-Detect two input voltages

-Provides an output that has two discrete states. Illustrated in fig 2.4.2

The differential voltage comparator is operated with a dual power supply with a common ground, thus enabling the output to swing either positive or negative with respect to ground. The output of the circuit is proportional to the differential signal between the input and is given as;

$$V_o = A_o (V_{in} - V_R)$$

Where

A_O = the open loop gain of the op amp.

V_{in} = the input signal at the non-inverting terminal.

V_R = the reference voltage at the inverting terminal

V_O = the output voltage

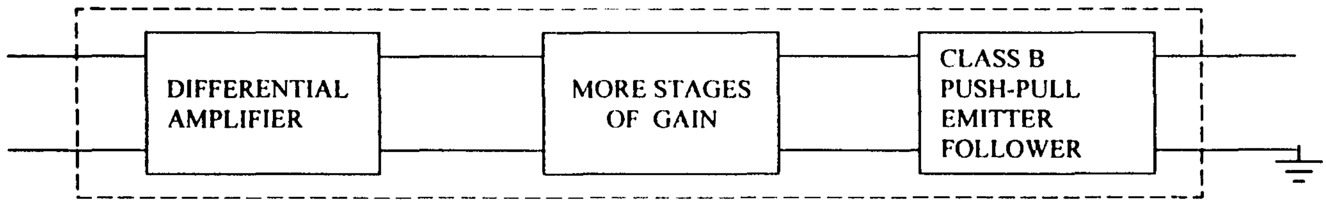


Fig. 2.4.1 Block Diagram of an Op-amp

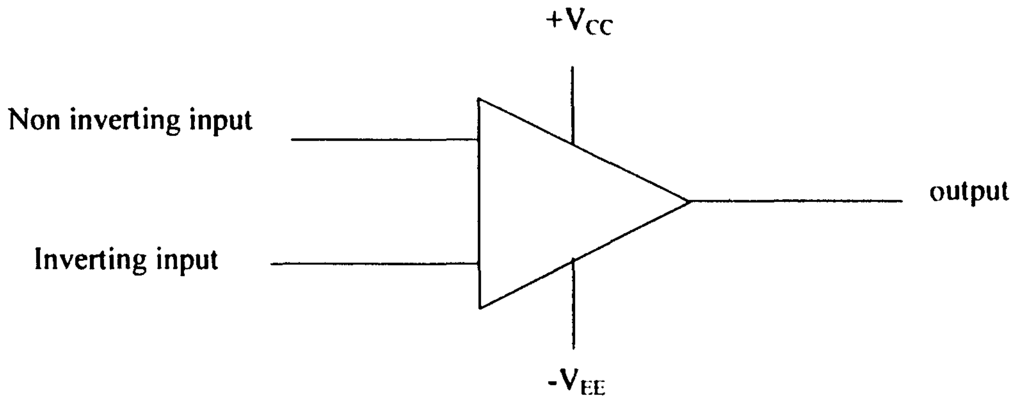


Fig. 2.4.2 Schematic Symbol for Op-amp

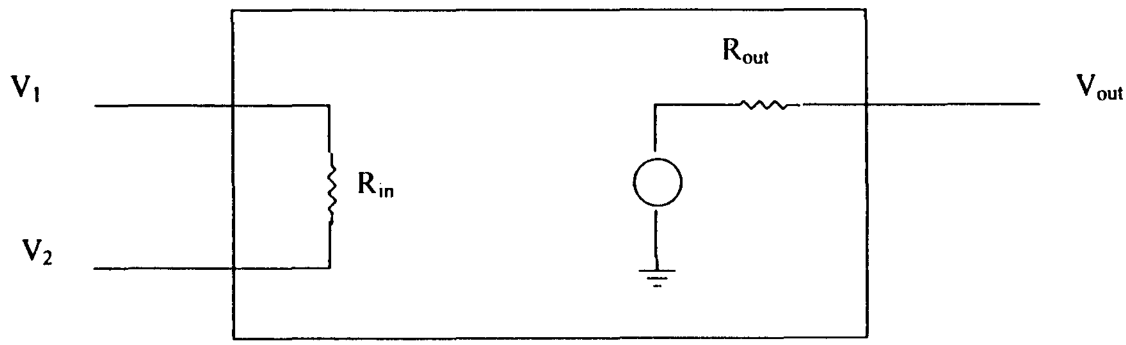


Fig. 2.4.3 Equivalent Circuit of Op-amp

Table 2.2 shows some of the operational amplifier with their various rating.

The LM324 IC op amp is used in this project as a differential voltage comparator circuit operating on whether, one of input is greater than or less than the other.

LM324 is a quad op amp that eliminates the need for dual supplies. It contains four internally compensated op amps in a single package, each with an open –loop voltage gain of 100dB, input biasing current of 45nA, input offset current of 5nA,and input offset voltage of 2mV.it runs off a single positive supply voltage that can have any value between 3 and 32V. because of this, the LM324 is convenient to use as an interface with digital circuits that run off a single positive supply of +5V. fiq 2.5.2 (a) and (b)3b shown the pin connection and logic configuration of a typical LM324 voltage comparator.

When the sample input voltage V_{in} is greater than that of reference by more than a few hundred microvolt, the output is driven into saturation positively, and when the sampled voltage is a few hundred of microvolt less than the reference voltage the output is driven to negative saturation. It is the magnitude of the differential input voltage that detects the magnitude of the output voltage, so the absolute values of input voltage are of little importance. The circuit thus functions as a precision voltage comparator or balance detector.

It is required to design a comparator circuit that will compare two signal (one from the room and the other from the main serving as reference) to give an output when the temperature is above the critical temperature and give zero output when it is below it.

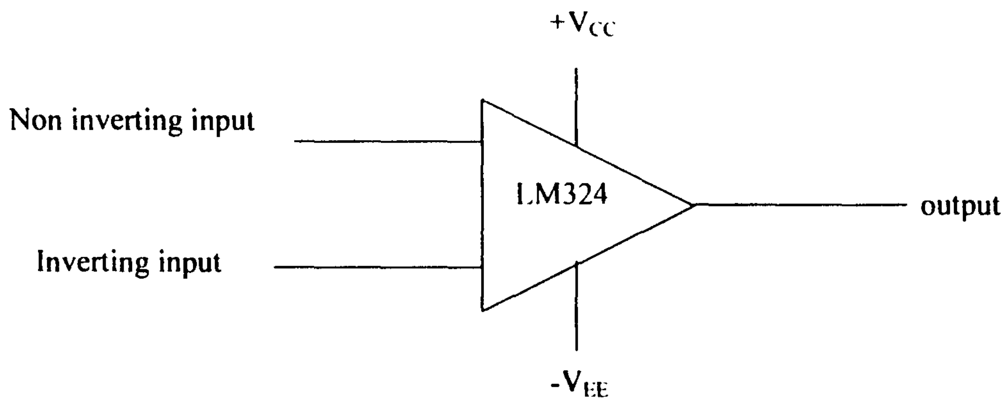


Fig 2.6 shows the complete design of LM324 IC comparator

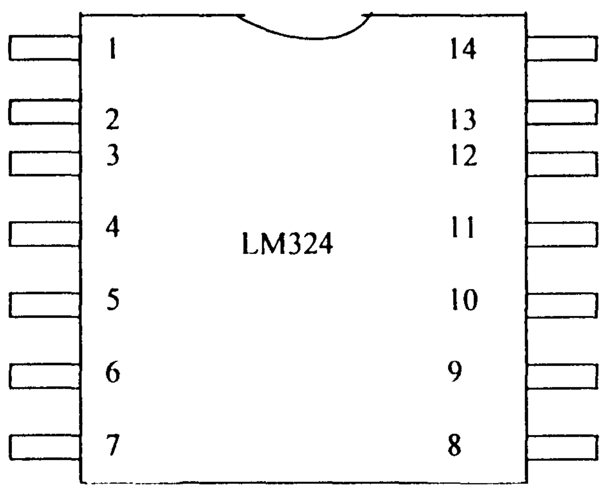


Fig. 2.5.2 LM324 IC Pin Connection

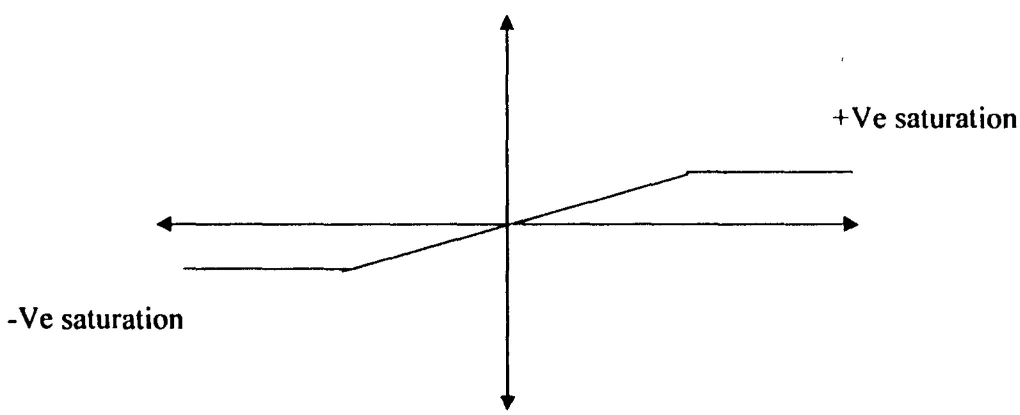


Fig. 2.5.3 Transfer Characteristic of Differential Comparator

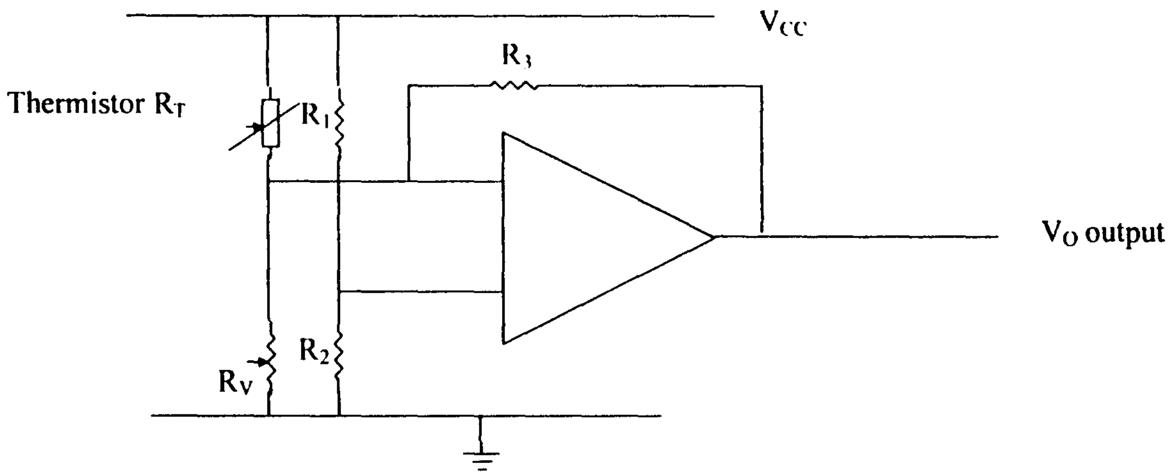


Fig. 2.6 LM324 IC Comparator Circuit

$V_{cc} = q_r$

From equation 2.2.6, Reference voltage is given to be ;

$V_{ref} = V_{CC} / 2 = 12 / 2 = 6V$

The other junction with the thermistor is then force to the non- inverting terminal and a variable resistor (R_v) is place between terminal 12 and ground.

The critical temperature is = 20°C

Since the thermistor is a negative coefficient type, it resistance decreases with temperature rise and increase with a decrease in temperature.

The resistance (R_T) of the thermistor corresponding to tc is 6.90kilo ohm.

Let thermistor resistance (R_T) at the critical temperature be denoted by RTC

Tc = critical temperature

R_T = Thermistor resistance

R_K= thermistor resistance at tc

R_V=variable resistance.

R1 = R2

V_{ref} = reference voltage

V_{in} = input voltage.

Therefore let t denote room temperature

When room temperature (t) is below tc, thermistor resistance (R_r) is greater than 6.90kilo ohm i.e at t = tc,

$R_T = R_{TC}$ = 6.90 kilo ohm

At t = tc

$R_T = R_{TC}$

Hence for $R_T = R_{TC}$ corresponding to t= tc, the comparator output (VC) should be ideally zero or negative which is its low reading after adjusting see fiq 2.6.

$V_C = 0$ if and only $V_{in} = V_{ref}$.

And V_{in}= 6v when room temperature is less than 20°C i.e for all 0°C to 30°C and for all resistance (thermistor) above R_{TC}

Hence: let variable resistance $R_T = R_V = R_{TC}$ = 6.9 kilo ohm.

i for thermistor resistance $R_T = R_V = R_{TC}$=6.90K

$V_{in} = R_v V_{cc} / R_T + R_V$ from equation 2.2.7

= (6.90 * 12) / (6.9 + 6.9) = 6V

$V_{in} = V_{ref}$

Comparator output (V_o) = V_o

I for thermistor resistance

(ii) At room temperature (t) less than critical temperature tc, the thermistor resistance (R_T) increase above

R_{TC} = 6.9

I.e at t =tc

$R_T = R_{TC} = R_V =$

Let $R_T =$

Therefore $V_{in} = V_{ref}$

Therefore comparator output $V_o = O_r$

(iii) When room temperature is increase above tc, thermistor resistance (R_T) drops below its resistance at tc (20°C)

i.e at t = tc

$R_T = R_{TC} =$

Therefore $V_{in} =$

Therefore $V_{in} = V_{ref}$

Hence the LM324 IC comparator becomes positively biased and output is obtained at pin 14.

A variable or potentiometer is used instead of a 2 kilo-ohm resistor so that the system may be used to monitor different temperature under different situations.

TRANSISTOR SWITCH

A transistor is a three terminal device that is made of three section called emitter, base and collector. A transistor is either npn or pnp. A small base current, I_b is used to control a much larger collector current Ic. A small signal superimposed on the I_b result in similar but larger variation in Ic. This is called amplification. The emitter has the largest current, this is because the emitter is the source of electrons. Since most of the emitter electrons flow to the collector, the corrent is minimal.

Consider the Transistor in the circuit of fiq 2.3c when base current $I_B = 0$, collector current Ic is a small leakage current and voltage drop V_R, across the load resistor R_V woud be negligible.

Therefore, $V_{CE} = V_{CC}$ the supply voltage.

Fig 2.4 simple transistor switch

If I_B is a small nominal amount then, $I_C = h_{FE} I_B$

And $V_R = I_C R$

$V_{CE} = Vcc - IcR_1$.

Increasing I_B would cause Ic to increase further till a point is reached when $I_C R_L = V_{CC}$, i.e Ic cannot increase further regardless of any increase of I_B hence the transistor is said to be activated and V_{CE} is called saturation output voltage V_{CE} sat.

2.4.2 DESIGN OF TRANSISTOR SWITCH

The transistor use is BD244. It is an NPN transistor. The transistor is switching 0 to A from a 12V supply, i.e. the load is heater. The base of the transistor is connected to the comparator output through the base resistor R_B. Figure ....shows the overall circuit diagram.

i) When comparator output is zero, $I_B=0$,. Therefore Ic is only a negligible current, i.e the transistor is biased off and since the collector is connected to the anode leg of 1N4002 diode connected to one leg of the relay.

ii) When the comparator output is greater than V_B (sat) =0.6 i.e the base emitter voltage, the transistor is biased ON connecting the ground. The remaining one leg of the relay is then connected to the Vcc terminal.

POWER SUPPLY UNIT

2.5 INTRODUCTION

The power supply unit comprises of the a.c rectifier circuit. It serves as the main source of power supply to the temperature monitoring circuit. The rectified a.c main is design to produce different voltage for different section of the circuit. The bridge rectifier in this circuit is similar to a full wave rectifier. Diode D_1 and D_2 conduct on the positive half cycles, D_3 and D_4 conduct on the negative half cycle. As a result, the rectified load current flows during both half cycles. As you can see D_1 and D_2 are forward biased. This produces a positive load voltage as indicated by the plus- minus polarity across the load resistor.

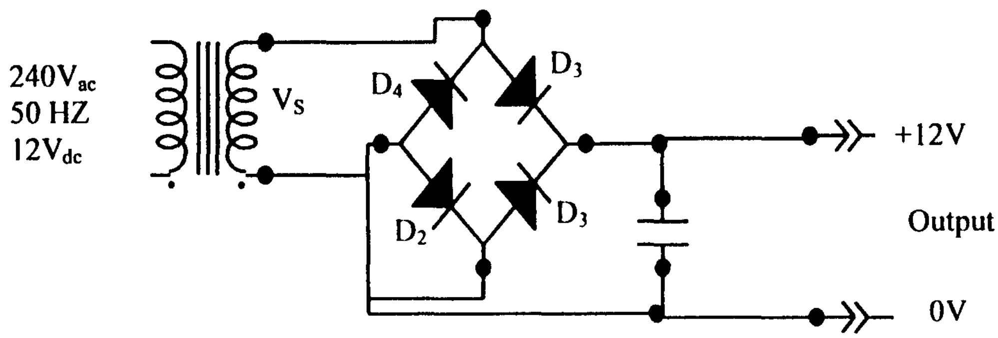


Fig 2.2 Power Supply Unit

2.2 MODE OF OPERATION

The 240V a.c mains (NEPA) was stepped down using a 240V/12V step down transformer and then rectified using four diodes mounted in the full- wave bridge rectification formation. Transformer was centre tapped so as to obtain the dual a.c polarity supplies required. The 12V output was then connected to the a.c inputs of the full- wave bridge rectifier circuit. From the output of the bridge rectifier, a 3300uF by 35V capacitor was used to smoothen these output voltages (which contains a.c ripples) by connecting the output terminals of the rectifier via the capacitor to the ground.

The r.m.s value of the induced e.m.f in the whole of primary winding = (induced e.m.f/turn) × No of primary turns

$E_1 = 4.44fN.\Phi m = 4.44fN_1BmA$............................(1)

Similarly, r.m.s value of the induced e.m.f of secondary is

$E_2 = 4.44fN_2\Phi m = 4.44fN_2BmA$................................(ii)

From equation (i) and (ii) we get;

$E_2 / E_1 = N_2 / N_1 = k$ where k is the constant called voltage transformation.

From equation (i) if $N_2 < N_1$ i.e $k < 1$, then transformer is known as step-down transformer as the case may be in this project.

Again, for an ideal transformer,

Input VA = output VA

$V_1I_1 = V_2I_2$ or $I_2/I_1 = V_1/V_2 = 1/k$

In this design, a transformer with the following characteristics was used;

Primary voltage V_p=240V

Secondary voltages = 12V

Secondary current I_s = 500mA

Using the transformer formular: $V_p / N_s = Is / Ip$

Where the I_p is the primary current, it was found that

$I_p = V_s I_s / V_p = 12 \times 500 / 240 = 25mA$

This indicate that the transformer is a step down type with ratings; 240V, 25mA/12A,500mA.

Also, $V_{peak} = \sqrt{2}\, V_{r.m.s} = \sqrt{2} \times 12V = 16.97V$

And $I_{peak} = \sqrt{2}\, I_{r.m.s} = \sqrt{2} \times 500mA = 707mA$

RECTIFICATION

A bridge rectifier with 2A rating was used in the design. It functions as an a.c to d.c converter. The d.c voltage can be calculated from;

$V_{d.c} = \sqrt{2} V_{peak} / \pi = \sqrt{2} \times 16.97 / \pi = 10.8v$

THE FILTRATION:

A high valued capacitor was chosen to eliminate the ripples. It was chosen to be 3300micro farad by 35V electrolytic capacitor. The output voltage across a capacitor is given by;

$V_L = V_{peak} = V_{diode} = 0.5 V_{ripple}$

Where V_L is the load voltage. If ripple voltage is taken to be 3.20V, then,

$V_L = 16.97 - 2(0.7) - 0.5 \times 3.20 = 13.97$

i.e $V_L = 14V$.

Since the only component powered by this transformer is the op-amp LM324 serving as the comparators with biasing voltage capability differential 30V supply, it would be wasteful incorporating a regulator into such a supply of just 14 volts and minimal ripple voltage. This approach allows the op amp to get enough current to drive the transistor switch via the relay switch.

CHAPTER THREE

CONSTRUCTION DETAILS AND TESTING

3.1 CONSTRUCTION

The construction was carried out in stages from one unit to the other using a bread board or testing board where each section of the design was built and tested to give the required signal output. The power unit provides a 12V d.c volt as the power supply.

The transducer circuit was the first to be tested on the breadboard, followed by the comparator circuit and the switching unit via the relay. The required ON and OFF state of the resistance element circuit was obtained due to temperature variation before the whole circuit was transferred from the breadboard to the Vero board using lead and soldering iron.

3.2 VERO-BOARD

Figure 3.1 shows the complete circuit diagram of how the simple automatic room heater circuit functions. The thermistor is the negative coefficient type; hence its resistance decreases with temperature rise.

Consider the first transducer circuit, resistor R_2 and R_3 are wired as fixed potential voltage divider that set ½ Vcc on the inverting terminal of the LM324 comparator. Thermistor resistance (R_1) and the control adjust potentiometer (Rv) are wired as temperature sensitive potential divider that applies variable voltage to the non-inverting terminal (pin12) of the LM324 IC. The comparator output terminal (pin14) is connected to the base of the switching transistor (BD244). The feedback is effected from the output to the inverting terminal The transistor emitter is connected to ground and its collector to the reset pin of the relay (common leg).

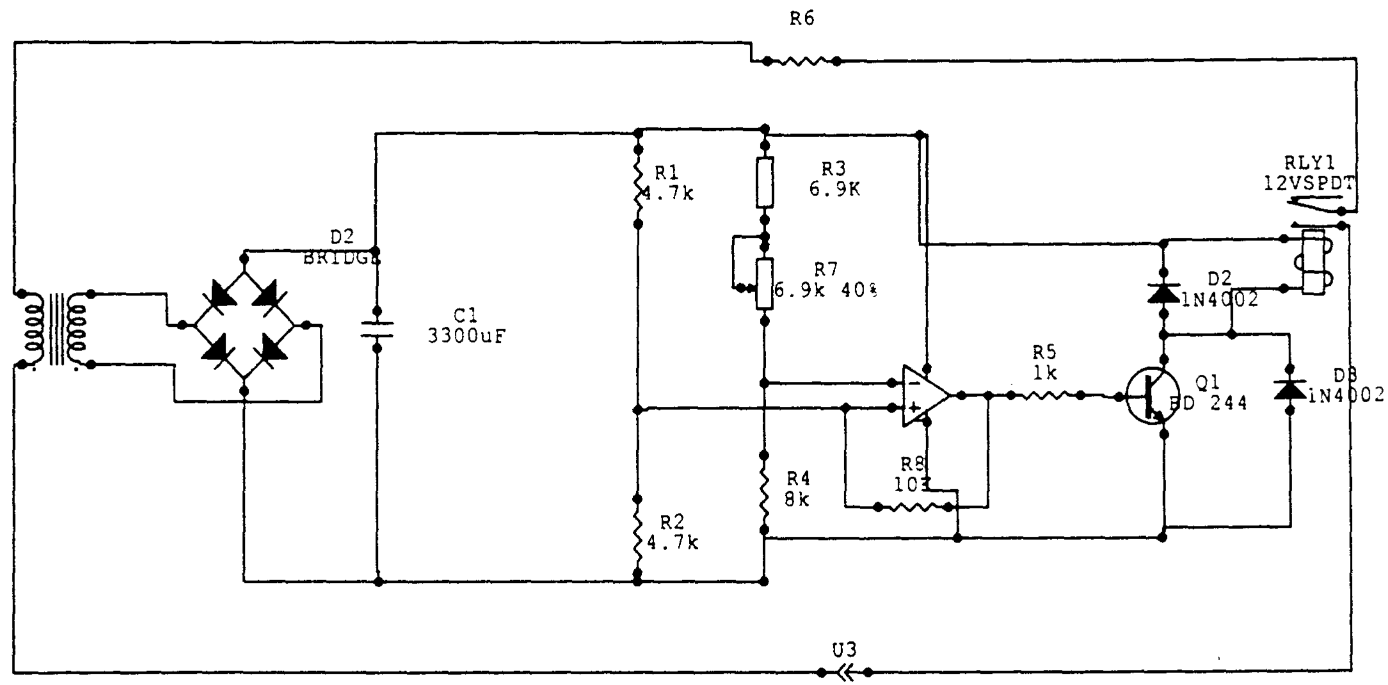


Fig. 3.1: Complete circuit diagram of a simple Automatic Room Heater.

The system is then calibrated for a particular critical temperature which is 30°C in this project. See appendix (i) on how to calibrate the system for a particular temperature.

PRINCIPLE OF OPERATION

The non-inverting terminal of the LM324 IC comparator is placed at a fixed reference voltage of 1/2Vcc. In operation, the potentiometer is adjusted till there is an output.

The thermistor is paced in the container. For temperature (t) on the container below the critical temperature (t_c) i.e. $t = t_c$.

The thermistor resistance increases and the voltage drop across it also increases. This implies a decrease in the voltage drop across the potentiometer (Vin) which is the voltage applied to pin 12 of the LM324 IC comparator. This makes the IC to be negatively biased and go into negative saturation, since Vin is less than the reference voltage. Hence the comparator output will read zero or low corresponding to its zero output. In case of any low output a resistor is placed in series with the comparator output pin 14 to drop it to the required value with zero output. In case of any low output pin 14, the switching transistor cannot be biased ON.

When the temperature surrounding the thermistor increases the voltage drop across it decreases due to the decrease in its resistance. This will cause an increase in the voltage drop across the potentiometer; hence the input voltage (Vin) to pin 13 will increase too.

When thermistor resistance falls and equals the potentiometer resistance, i.e. $R_T =$ Rv then,

$V_{in} = 1/2\ V_{cc} = V_{ref}$.

Comparator output is still reading low (i.e $Vo = 0$)

But for thermistor resistance (R_T) less than potentiometer resistance (Rv) due to thermistor temperature greater than the critical temperature (t_c), the voltage drop across the potentiometer increases sharply. Therefore, the input becomes higher than the reference voltage (V_{ref}).

i.e. for $R_T = R_v$

$V_{in} = 1/2V_{cc} = V_{ref}$

This automatically sends the LM324 IC comparator into positive saturation and an output is obtained at its output (pin14)

i.e. $Vo = 0$

Since the output voltage Vo is greater than zero, the switching transistor is biased ON, therefore the relays then triggers and it starts to function. The relay send signal to the heating resistance element. A signal of approximately 1 Hz is also fed into the LED acting as a visual signal detector. The LED signified by either dimming or brightening. Thereby drawing the attention of the user. The heat resistance element goes on heating the room (oven) till it is either switched off by turning off the power supply or by increasing the temperature of the room (oven).

3.3 TESTING OF THE CONSTRUCTED CIRCUIT.

When the thermistor was calibrated as described in appendix (i), the thermistor was placed in a container (oven). A thermistor was placed inside the container and the following observation and results were obtained. The container temperature was varied by placing it in a bowl of either hot water or cold water.

(i) When container temperature is below the chosen critical temperature 30°C, there was no output from the heat resistance element which implies that input voltage V_{in} is less than reference voltage (V_{ref}) of the LM324 comparator.

(ii) As container temperature $t = t_c = 30°C$ there was still no output.

(iii) At container temperature greater than the critical temperature, resistance element output was obtained. Below is a summary of the temperature conditions at the transducer, are the output condition at the output transducers

	INPUT(Thermistor in oven)	OUTPUT (Resistance element)
(i)	$t = t = t_c$	no output
(ii)	$t = 0 = t_c$	no output
(iii)	$t = t_c$	output was obtained

- t is the temperature inside the oven surrounding the thermistor
- tc is the chosen critical temperature which is unfavorable to the user.

From the above, it can be said that the automatic room heating device detects and gives a heat as the output for all temperatures (t) greater than the critical temperature (t_c)

CHAPTER FOUR

CONCLUSION AND RECOMMENDATION

4.1 CONCLUSION

The design and construction of a functioning simple automatic room heater for a room was successfully carried out and described. The demonstration of detection of temperature variation is via resistance element means. Hence the main aim of the design work which was to produce a system that can detect temperature variation in an oven and produce a signal at an unfavourable or critical temperature (t_c) has been fulfilled.

4.2 RECOMMENDATION

Sophisticated signal processing techniques using analogue to digital converters and microprocessor based system is recommended to bring this work toward better temperature monitoring in a large room and for monitoring temperature variation inside.

For a more sensitive and reliable system, a temperature transducer that is more sensitive than the thermistor whose resistance or factors of variation with temperature is linear should be used e.g. a diode transducer.

This design is relatively simple and to a certain extent automated, hence it can be conveniently used in many applications where overheating at particular temperature is dangerous, such as in bathroom heaters, tea kettles, boilers, automatic fan regulator e.t.c. it can be used for many application within the range of 0 to 100 degree centigrade.

Finally it can be said that the desired output at the thermistor (temperature transducer) where satisfactorily obtained.

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APPENDIX

CALIBRATION OF THE SYSTEM

Heat a container of water to the required critical temperature (t_C) and stir well. Place the thermistor in the water and together with the thermometer to take the characteristic of the thermistor. For this project the water heater to 30° C. remove it from the water for better calibration place the thermistor in another hot water that is at room temperature. If the less hot water temperature is t_1, then the accuracy of the system is a measure of how close t_1 is to t_C. The closer their values the higher the degree of accuracy.