DESIGN AND CONSTRUCTION OF AN ELECTRONIC CONTROL FOR HEATING SYSTEM

BY

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DECLARATION

I, EVWIEKPAMARE MOSES (2004/18726EE) hereby declare that this project was carried out by me in the Department of Electrical and Computer Engineering under the supervision of Dr. Y. A. Adediran

All information utilized and their sources have been duly acknowledged.

....16/12/09.....................

EVWIEKPAMARE MOSES DATE

CERTIFICATION

This is to certify that the project titled "Design and Construction of an Electronic Control for Heating System" was carried out by Evwiekpamare Moses, and submitted to the Electrical and Computer Engineering Department, Federal University of Technology, Minna in partial fulfillment of the requirements for the Degree of Bachelor of Engineering (honours) in Electrical and Computer Engineering.

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DEDICATION

This project is dedicated to his Excellency, the king of kings and the author of the universe, my Lord Jesus Christ for His impeccable and wondrous gifts to me and for ordering my steps. In times of indecision, He has always decided for me. To her who have humanly made me what I am in life, I lack words to express my gratitude to my ever available and loving mother, Mrs. Kupa Omokiniovo Vero for the unfailing love, moral and financial support and finally to all my brothers for their encouragement and moral supports.

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The successful completion of this work would not have been realized without assistance from great and distinguished personalities, to whom I shall forever remain grateful.

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My immeasurable gratitude goes to my dad Evwiekpamare Johnson and also to my step dad Benson Kupa and my brothers, Andrew , Emmanuel, Henry, Lawrance, I say thank you for all your support. I appreciate the efforts of my friends, Michael Ephraim, David, Mr and Mrs Abraham Ajagun, Chalitor, Benjava, Galaxy, Popsy, Gboli, Anineh, Yakubu, Obadiah, Ade, Victor, Meshach, Don Chimola, Don Panucci, Raph, Ochuko, Kadmus, Bros Solomon, As I have always said, "together we shall build that "empire" . I am also grateful to all my course and level mates for their companionship.

Finally, I cannot keep on mentioning names, but I pray that God in His infinite mercies will recognize and bless all those who have affected my life positively and wish me well.

ABSTRACT

The design and construction of an electronic control for heating system is described in this project. The project is intended to switch OFF automatically when the preset temperature is exceeded and switches ON when below. The device requires little human attention since the control is automatic.

The sensor (thermistor) detects the heating element, the comparator compares the input voltage with the reference voltage and sends the output voltage to the transistor which eventually sends the current that trips the relay at preset temperature.

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CHAPTER ONE
GENERAL INTRODUCTION

1.1 Overview

In the recent times most heating systems are determined and governed either directly or indirectly by the principle of thermostatic control, which is incorporated to maintain a desired temperature set by a thermostat that regulates the input of heat. In the days of old, the control of water temperature was done via the adjustment being made according to outside weather or room temperature [4]. As this method is liable to error, there arose the quest for a good control of heating systems by thermostat that will do the adjustment automatically. Hence, temperature monitoring device which switches off automatically as the preset temperature is exceeded and switches ON when it is below the preset temperature is needed. But the concurrent ON and OFF switching mechanism of the device further leads to power wastage. This project aims to solve this inefficiency by adding an alert system which gives warning before the heater switches OFF.

This electronic control with alert system controls heat while annulling over and under heating effects. Furthermore it buzzes so as to indicate point of maximum heat when it switches OFF and ON concurrently. Solar/external and internal heat gain may often contribute significantly to the total daily heat requirement of any heating environment, and this superimposes on the normal designed output of a heating system, which can lead to uncomfortably high internal temperature [4]. A quick response control is therefore desirable. To achieve this aim, the OFF and ON switching type of the thermostatic control with an alert system is greatly considered in this project.

The OFF and ON switching type of thermostatic control is an electronic device that triggers automatically when the temperature inside an incubator, a room, kiln, furnace, microwave oven, or any heating environment exceeds the preset temperature. Generally, the preset temperature varies from one heating system to another. This device control one or more heating sources to maintain desired temperature. Hence, this temperature is provided for any specific design of experimental observation. Temperature fluctuation is a physical event and the ability to measure the rate of temperature variation in any heating system determines the knowledge of that quality.

To execute this function of thermostatic control for heating system, a sensor (thermistor), conditioning circuit (comparator), triggering unit (relay), alert system and heating element are needed.

The sensor used in this project is a thermistor, which serves as a temperature transducer that detects the change in temperature and produce a desired result. The conditioning circuit, which is the comparator, compares the input signal with the references voltage; and when input signal exceeds or lower than the references signal, the output of the comparator changes its value.

Temperature control system or thermostatic control for heating system is a feedback control system that reacts to change in temperature, since a heating element carries fairly. Large electric currents (amperes rather than mill amperes); the change in temperature affects the sensor (temperature transducer), and in turn gives back an electric signal to control the heating element in the system.

1.2 Aim and Objective

All types of modern heating system kiln, microwave oven, electric furnace(s), room heaters, water heaters, and incubators, are capable of supplying highly satisfactory heating performance when properly designed and installed. Conversely any system can be disappointing when it is improperly deigned or installed. Hence, the major objective of this project is to design and construct an electronic control for heating system that will be automatic by switching OFF and ON.

However, to achieve this objective, the features considered to incorporate the entire system design and construction are:

i Low installation cost

ii Less human attention

iii Automatic in operation

iv General control of different heating systems.

1.3 Methodology

An outline approach was employed in the realization of this project ranging from the understanding of basic electronic principles which govern the operation of the electronic components to the complete construction of the final circuit.

The main task in designing such an electric device involves getting the sensor and the comparator to work in synchronism. Two preset temperature points are required as references to the comparator. The first is the preset temperature point (62^0C) for the alarm alert system and the second is a preset temperature point (65^{o}C) where the heater and alarm are deactivated. To achieve this, the heat sensor is connected to the comparator having the two reference points. When heat exceeds the first references point (62^0C), current drives the first transistor connected to the comparator to activate the alarm system. When temperature increases and exceeds the second preset temperature point (65^0C), then the heater and alarm is deactivated.

The favourable result obtained was due to the useful input from various sources which include textbooks, previous related works done which have been cited in the course of this report.

1.4 Scope

Although this project is primarily concerned with heat change, many of the principles, techniques and approaches discussed are of basic importance and they find application in most heating system. This project examines thermostatic heat control which is useful for control of heat for basic home appliance such as microwave oven, water heater, e.t.c.

1.5 Limitation

In the course of this project, setbacks and constraints encountered were mainly due to unavailability of required components, non workable circuit design and ignorance of knowledge of electrical circuit principle. These were however within containable limits as necessary remedies were sought and implemented leading to the final completion of the desired project.

1.6 Project Layout

Chapter one: This chapter gives a general introduction to the project. Aims and objectives are also contained in this chapter.

Chapter two: This chapter covers the literature review that highlights pervious work on the subject.

Chapter three: This chapter contains the principle of operation, and the detailed circuit design and the analysis of the projects, which also shows an in-depth look at various components and sub-circuits that make up the system.

Chapter four: This chapter covers all the details of the construction and testing procedures employed to achieve the final product. It spans simulation of the circuit diagram on the computer, bread-boarding and soldering of the components on the vero board, casing construction, testing precautions taken, troubleshooting and results obtained, as well as the difficulties encountered in the course of the construction and testing.

Chapter five: This chapter contains the conclusion drawn from the results of the testing, with reference to the objectives and goals of the project. The chapter also contains the recommendations for further work on the project topic in future.

CHAPTER TWO

LITERATURE REVIEW

2.1 Theoretical Background

In inception, thermostatic control itself did not take off till 80s, when it became very important to control heating systems automatically. The desire for warmth and comfort motivated man's use of a fire. The early man used wood and charcoal in open fire to produce warmth, as well as to prepare food in his cave or shelter. American Indians, who built fires in their hurts and tepees, which had opening to allow the smoke to escape, used these open fires as late as 19^{th} century. While in 300 B.C the Europeans built crude fire places with connecting chimneys; with this arrangement, combustion efficiency and ventilation were much improved [1].

By the first century B.C, the Romans had developed the hypocaust, which provided a better way to heat a room. The hypocaust was a basement with a low arched vault furnace made of brick or stone. The hot air from the furnace passed through tile flues in the room above the furnace, heating the room. The first bimetal temperature responsive device was a "grid iron" pendulum built in England in 1726 to improve the accuracy of a clock operating under varying temperature conditions [1].

In 1743, Benjamin Franklin invented the iron Franklin stove and it gained a reputation of high efficiency in the American colonies. The use of stoves provided a new way to heat rooms. 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 convention of the room air over the hot surface [1]. However steam boiler was developed for the steam engine in England, but engineers soon learnt to adapt it for central steam heating system.

Steam heating systems are particularly suitable for serving large public building because large quantities of heat can be carried in long distance by small pipes [1].

As technology advanced, the word "thermostatic" was introduced in 1830 by Andrew Ure, a Scottish professor of chemistry, who issued a patent on what he called "a heat-responsive element consisting of a bar of steel united to zinc by numerous rivets" [1]. This bimetallic bar bends with temperature change because of the different expansion rates of the metal strips, and the bending can be used to actuate valves or dampers to control heating systems [2].

Bimetallic – strip thermostats of improved designs have been developed. One type has a low expansion rod contained in high expansion tube. For example, a steel rod and nickel tube are sealed together at one end. Construction of the tubes at one end of the rod, actuates a valve or electric switch. Thermostats used at homes or small buildings are usually low-voltage electric control that turn a burner ON or OFF as required [2].

Other thermostats exist, that basically use almost the same type of principles but different type of input and output units, though there are some heating controlling device with principle of operation quite different from the one used in this project. Some systems are based on the principle of analog to digital converter. The analogue voltage produced by the thermal transducer is converted into its digital equivalent, which is fed into the 7-segment display unit from where the temperature variation may be read out [4,7].

After careful consideration of past projects related to thermostatic operations it was seen that all the designs, controls and heating were done without an output notification when the temperature exceeds its preset value. Also the concurrent ON and OFF switching mechanism of the device further leads to power wastage. This therefore necessitates the construction and design of alert system that would indicate when the system is about to reach its preset temperature, as encapsulated in this project.

CHAPTER THREE

SYSTEM DESIGN AND ANALYSIS

3.1 Introduction

This project is based on feedback-(closed loop) system that aids the detection of heat in an environment it is designed for. The components used in this project are based on their cost, availability and effectiveness.

The design procedure is limited to a prototype system so as to demonstrate temperature control in heating systems. The main units in the temperature controlling system are: the temperature transducer unit with their individual sensors (a negative temperature co-efficient thermistor whose resistance varies with temperature). This implies that for a constant current (I), the voltage (V), variation across the thermistor is directly proportional to the resistance (R) and hence temperature (t) variations.

$V \propto R$

$V = IR$ (I = constant of proportionality)..(1)

The thermistor is placed in series with a resistor to create a voltage divider network. The comparator used in this project is the LM 324 which contains four Op-amps. Two of the op-amps are used in this project.

This device is capable of high resistance, high gain and low output. One input terminal is placed at a fixed voltage with the help of potentiometer while the other is placed at a varying voltage, which depends on this voltage from the thermistor. The output from the comparator is then passed into a transistor switch. The NPN transistor is used to switch ON and OFF the heating element via the relay that does the switching [6,2].

3.2 General Heating System Principles and Design

Certain design principles, are common to all types of heating systems, such as incubator, kiln, microwave oven, and room. First, the heat loss of the heating system and its room temperature must be determined for a design calculated data to suit it. Second, the type of heating system must be selected to match the calculated heat loss.

Finally, the correct location of air registers, convectors (apparatus for heating by convection), heating panels, and other equipment must be determined to ensure even temperature distribution and air movement throughout the system. The automatic control system is worked out, and auxiliary components are determined.

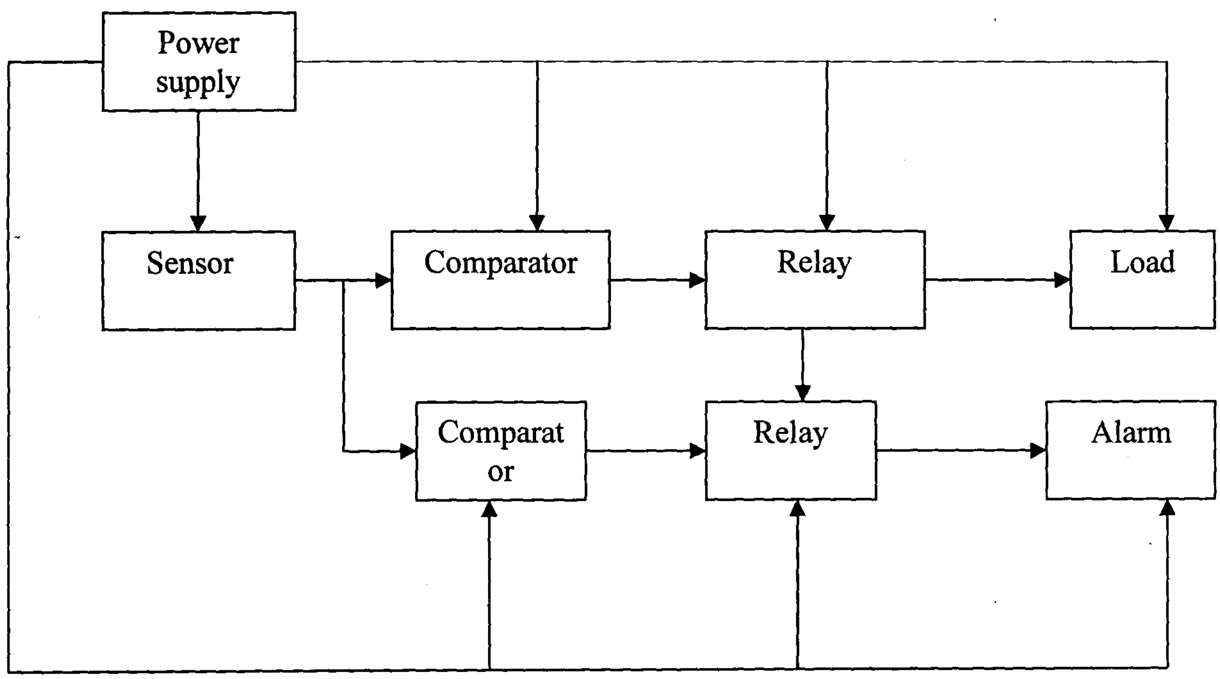


Figure 3.1 Block diagram of electronic control for heating system.

3.3 POWER SUPPLY UNIT

All electronic devices utilize a direct current (DC) voltage source for operation. The mains electricity supply is an alternating current (AC) at a voltage of 220V-240V and have to be converted to D.C supply of the required value.

The use of batteries should have been alternative power supply to the rectification process. However, it has some disadvantages which include; limited life span. This results from the manner in which the internal resistance increases with age, thereby deteriorating the battery. It cannot satisfy the amount of current drawn by most electronic devices for a long time as the battery is quickly drained and this becomes inefficient; hence, an AC-to-DC conversion is done by the power supply unit to avoid these inadequacies of the battery.

The power supply unit consists of the transformer, a bridge rectifier, a filter and a voltage regulator which all function together to transform the AC voltage supply from the mains into a regulated DC supply as the output of the power supply unit. The block diagram of the power supply unit is shown in the figure 3.2 [7].

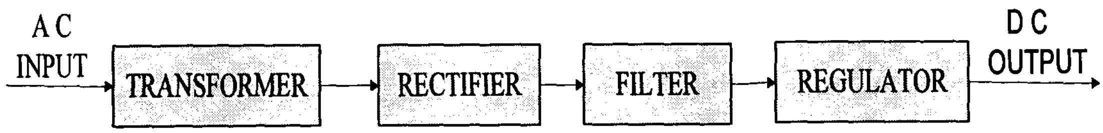


Fig 3.2 Block diagram of the power supply unit

The input ac supply voltage is a single phase voltage obtained from the mains supply of PHCN with a value of 240V, 50Hz.

3.3.1 THE TRANSFORMER SPECIFICATIONS

This is the stage of the power supply unit that involves the reduction of the AC voltage value to a lower value of 18V AC with the aid of 240V/18V transformer. The current rating is about 500mA which is enough to drive the entire circuit .A transformer is an electrical device that provides physical relation between the 240V A.C main and the rest part of the circuit [7]. The only link is by means of magnetic flux, thus eliminating the risk of electric shock.

There are basically two types of transformer, namely; step-up and step-down transformer. The step-down transformer is used and consists of two windings (coils), the primary winding and the secondary winding. Figure 3.3 shows the circuit symbol of a transformer.

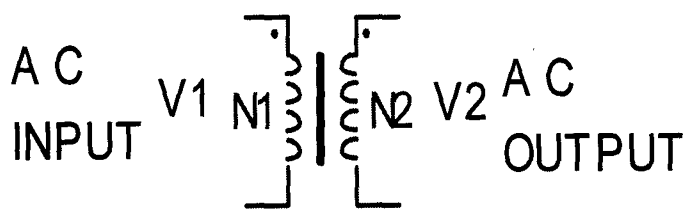


Figure 3.3 Transformer circuit symbol

The transformer data is given as V_1 (input) =240V, V_2 (output) =18V, I_2 =500mA=0.5A, frequency f =50Hz.

The ratio of the primary voltage V_1 to the secondary voltage V_2 is equal l to the turns ratio or number of turns of the primary winding N_1 to that of the secondary winding N_2 of the transformer.

The primary and the secondary voltages of an ideal transformer are related as follows.

$V_1/V_2 = N_1/N_2$

$= 240V/18V = 13$

Turns ratio $N_1:N_2 = 13:1$

Magneto motive force (mmf) =NI

$N_1 \times I_1 = N_2 \times I_2$

$N_1/N_2 = I_2/I_1 = 13$

$I_2 = 500mA = 0.5A$

$I_1 = I_2/13 = 0.5/13 = 38mA$

Also, power input = power output

$P_1 = P_2$

$I_1 \times V_1 = I_2 \times V_2$

$50mA \times 240 = 12W$

3.3.2 THE RECTIFIER SPECIFICATIONS

The output of the transformer (secondary terminal) which is an AC signal is converted to DC signal with the aid of a rectifier circuit but the full wave bridge rectifier circuit is used for this project. It consists of four KBP 208 diodes arranged as shown in figure 3.4 below.

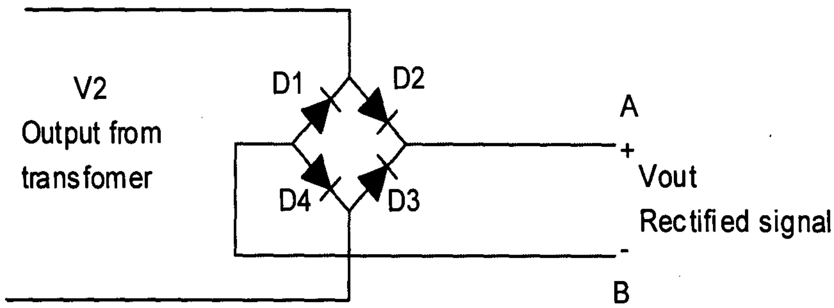


Fig 3.4 Full-wave rectifier circuit diagram

During the positive half cycle of the secondary voltage, diodes D_2 and D_4 are forward biased, current flow through diode D_2, terminal A, terminal B,(through a load connected at the output terminals),diode D_4 During the negative half cycle of the input voltage V2, diodes D1 and D_3 are forward biased and therefore, conducts current flowing through a load connected across the terminals AB in the same direction as above (i.e. from point A to B)

This circuit achieves the aim of making current flow in one direction only (DC) irrespective of the positive and negative half-cycles of the input signal [1,2].

The peak secondary voltage of transformer $V_{ps} = \sqrt{2}\ V_{rms}$

$V_{rms} = 18V$

$V_{ps} = 18\sqrt{2} = 25.45V$

The average DC voltage V_{dc} across terminal AB

$V_{dc} = 2V_{ps}/\Pi$

$V_{dc} = (2 \times 25.45)/3.142$

$= 16.2V$

By standard, the acceptable PIV (Peak inverse voltage) = 4 x V_{ps} for a full wave bridge rectifier.

$4 \times V_{ps} = 4 \times 25.45V = 101.8V$

Thus, the diode KBP208 with PIV greater than 101.8V is chosen.

3.3.3 THE FILTER SPECIFICATIONS

The filter circuit forms a part of the power supply unit to minimize the ripple content of the rectifier output. The output voltage waveform of a rectifier is pulsating because it has both DC component and some AC components called ripple and this type of output signal is not suitable for driving electronic circuits. The filter circuit receives DC signal as input and filters out or smoothens out the pulsations in the input [1].

There are various types of filtering circuits but the simple capacitive filtering is adopted in the design; where a large electrolytic capacitor (2200μF) is connected to the rectifier output. The shunt capacitor "bypasses" AC signal present (ripples) and this effect makes the output to almost assume a pure DC level. The capacitor charges during the diode connection period to the peak value and when the input voltage falls below the value, the capacitor discharges through the load so that the load receives almost steady voltage [7]. Figure 3.5 below shows the ripple gradient of the supply.

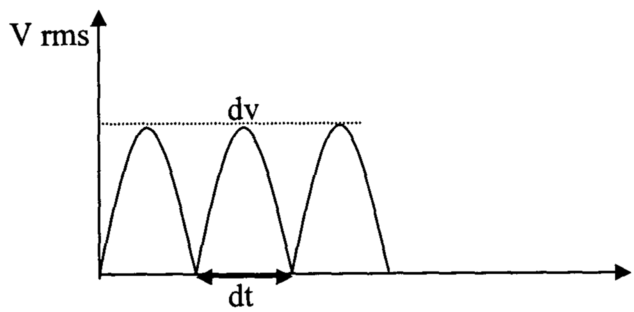


Fig.3.5 ripple gradient waveform

dv is the ripple voltage for time dt, and dt depends on power supply frequency.

For a rms voltage of 18volts (from transformer)

V_{peak} = 18v x √2 (i.e. rms x √2)

= 25.45V

But Q=It=Cdv

But t=1/2f =1/100 =0.01

Hence, let dv=15% of ripple voltage

15/100 x 25.45=3.817

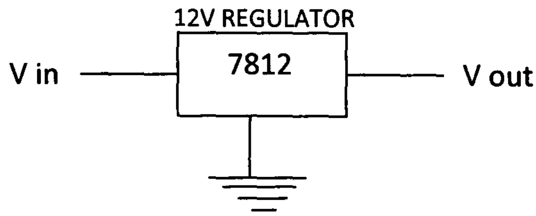
C=1 x0.01/3.817=2200μF

A preferred value of 2200μF was employed for the rectification aspects of the power supply stage. C_1 act as filter capacitor and filters out or smoothens out the pulsations

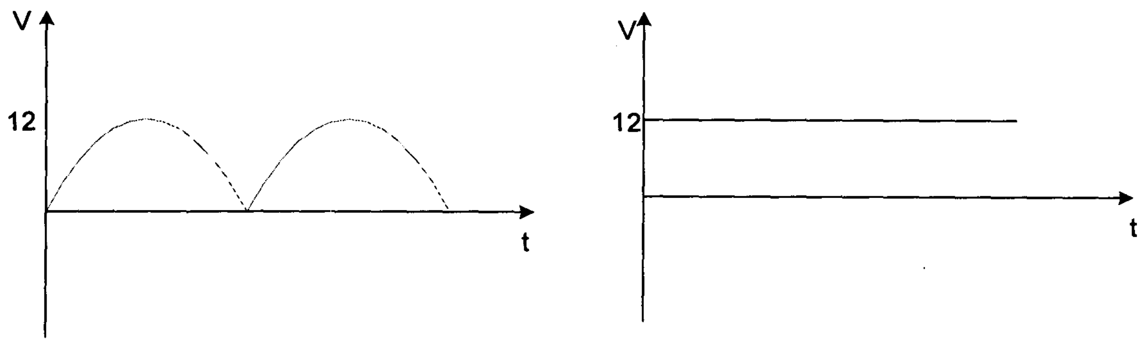
3.3.4 THE VOLTAGE REGULATOR

The introduction of voltage regulator in the power supply unit is necessary to maintain a constant voltage supply of 12V regardless of the varying voltage of input or load change which can cause irregular supply. In other words, a voltage regulator is a circuit that holds an output voltage at a predetermined value regardless of the change in normal input or changes in load impedance [7].

Voltage regulators mostly come in a three terminal package; one input terminal, one output terminal, and a ground terminal. The monolithic voltage regulator IC chip 7812 is used to supply steady 12V DC to drive the system circuit. The 7812 chip supplies the rated voltage of 12V with a wide range of voltage input and variations in load current. Figure 3.6a, b & c shows regulator circuit, input and output waveforms respectively.



(a)



(b) (c)

Fig 3.6 (a) Regulator circuit

(b) Input signal

(c) Output signal (regulated)

LED Indicator

The LED indicates power ON, and it is connected in series with a current limiting resistor.

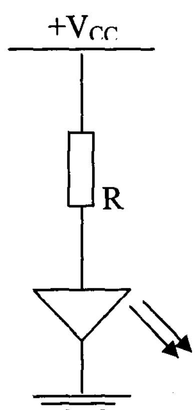


Fig 3.3 LED circuit

By standard, the current consumption of an LED is 10mA and the voltage rating is from 1.2volts to 2volts [8].

To determine the resistor R, let $V_{LED} = 1.5$ volts

$$\frac{V_{CC} - V_{LED}}{I_{LED}} = R$$

$$\frac{18-1.5}{10\times10^{-3}} = R$$

$$\therefore R = 1650 \approx 1K\ \Omega$$

3.4 Temperature Sensing Circuit (Thermistor)

The thermistor used in this project, is a $15\text{k}\Omega$ negative temperature coefficient (NTC). This device varies in resistance with varying temperature. There are two types of thermistor, the negative temperature coefficient (NTC) and the positive temperature coefficient (PTC). The resistance of the NTC thermistors decreased with increase in temperature. A factor considered in its implementation in the design circuiting. Note, the PTC thermistor does otherwise.

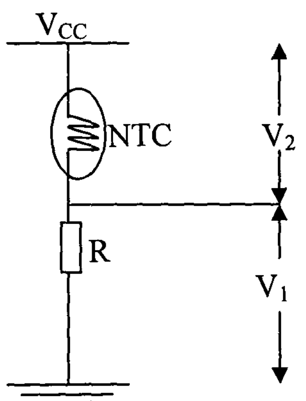


Figure 3.7 Temperature sensing unit

Experiment shows that at room temperature (i.e. 28^0C) the resistance of the thermistor is 11kΩ. Assuming at room temperature a divider network is needed to divide the voltage into two, that means $V_1 = 6$V.

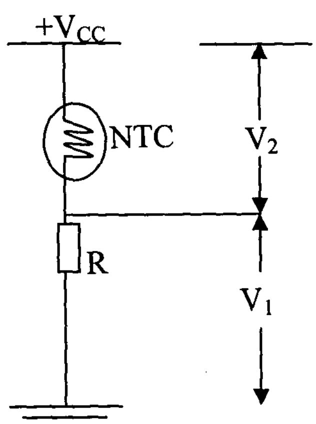
$$\frac{R}{R+TH} \times V_{CC} = V_1$$

$$\frac{R}{R+11K} \times 12 = 6$$

$$6R + 66k = 12R$$
$$66k = 12R - 6R$$
$$66k = 6R$$
$$R = 11k \approx 15\text{k}$$

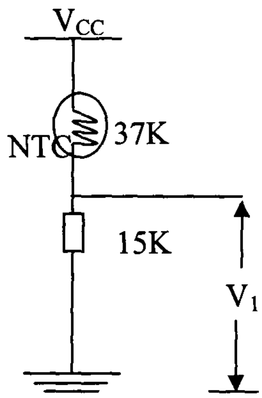
3.5 Temperature Control

The arrangement shown below is used to preset the temperature at which the alarm will alert and when the heater should cut off.



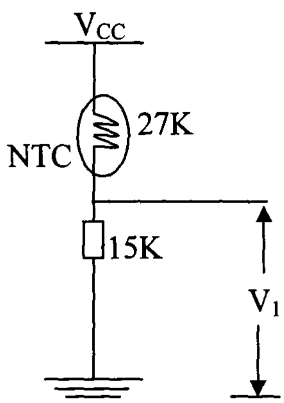
At room temperature V_1 = 6v is expected. During the experiment, at 0^oC the resistance of the thermistor is 37kΩ and at 100^oC the resistance is 2.7kΩ.

At 0°C



$$V_1 = \left(\frac{15k}{37k+15k}\right) \times 12v = 3.5V$$

At 100°C

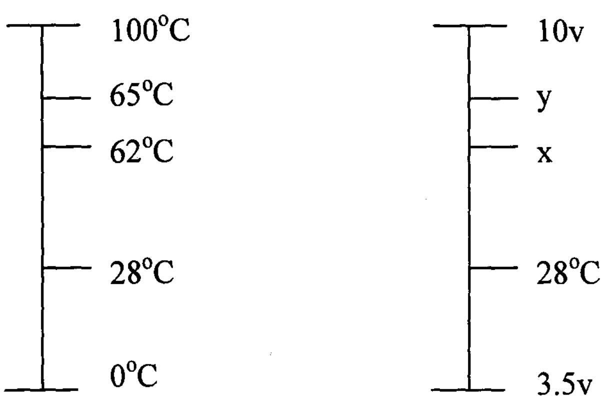


$$V_1 = \left(\frac{15k}{15k+2.7k}\right) \times 12v = 10V$$

Calibration

Since the alert system is at 62°C and the cut off point is at 65°C

At 62°C



$$\therefore \frac{62-0}{100-0} = \frac{x-3.5}{10-3.5}$$
$$= \frac{62}{100} = \frac{x-3.5}{6.5}$$
$$403 = 100x - 350$$
$$100x = 753$$
$$\therefore x = 7.5V$$

At 65°C

$$\therefore \frac{65-0}{100-0} = \frac{y-3.5}{10-3.5}$$
$$= \frac{65}{100} = \frac{y-3.5}{6.5}$$
$$422.5 = 100y - 350$$
$$100y = 772.5$$
$$y = 7.7V$$

Therefore, for the first comparator the non-inverting terminal is set to be 7.7v at 65°C. While for the second comparator the inverting terminal is set to be 7.5v at 62°C.

3.6 Comparator

The comparator is connected in differential mode. It rectifiers the difference of the input voltages [9].

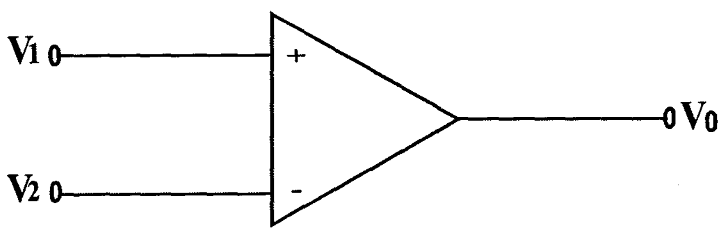


Figure 3.8 (a) Comparator

The output of the comparator depends on the difference between the input voltages. For there to be an output the non-inverting terminal must be greater than the inverting terminal.

3.7 Transistor Switching

Modern transistors are invariably silicon types and are available in either NPN or PNP forms. Transistors are three terminal devices that comprises of emitter, collector and the base. The common emitter mode is commonly used for most designs because of its high stability [10]. Transistor tends to have diverse applications such as;"

Linear: Transistor designed for linear applications (such as Low-Level Voltage Amplification).

Switching: Transistor designed for switching applications.

Radio Frequency: Transistors deigned for high frequency applications.

High Voltage: Transistors designed specifically to handle high voltages.

For this project, the NPN type of transistor BC108 is used for current amplification, and provides the switching effect for the 12v relay.

Table 3.1: Typical Characteristic of BC108 Transistor

Type	BC 108L
Material	Silicon
Construction	N – P – N
Maximum collector power dissipated	300mW
Maximum collector current	100mA
Maximum collector-emitter voltage	20v
Current gain	300

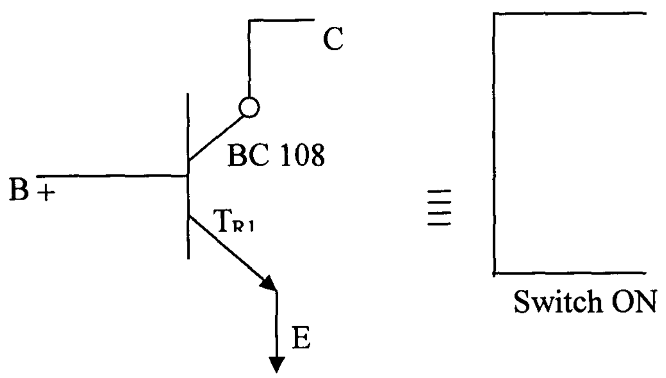


Fig 3.9 Transistor conducting

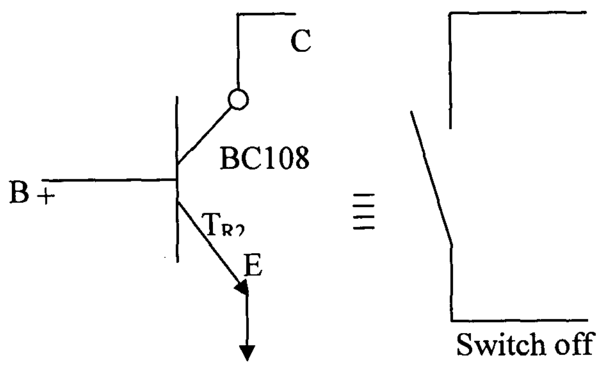


Fig 3.10 Transistor Non-Conducting Conducting

A conducting transistor is equivalent to a switch in the 'ON' state while a non-conducting transistor is equivalent to a switch in the 'OFF' state. The transistor is operated under saturated switching conditions; in the conducting state, sufficient base current must be applied for the collector voltage to fall to approximately 0v, provided the transistor is operated under saturation conditions, dissipation within the transistor is kept relatively low level. The output of the comparator is fed into the base of the transistor. When this transistor is saturated a current flow through the collector to the coil of the relay, when it is energized it switches are close and the heating element is triggered.

Reasons for choosing the biasing Resistor 22kΩ for the first comparator and 100kΩ for the second comparator

For the first comparator.

$V_{CC}=I_C R_C$

But RC = 200Ω

$V_{CC} = 12v$

$12 = Ic \times 200$

$Ic = 12/200$

$= 0.06 = 60mA$

But $hfe = \frac{I_c}{I_b}$

let hfe = 160

$$I_b = \frac{I_c}{hfe} = 3.75\times10^{-4}$$
$$V_B = I_B\, R_B$$
$$V_B = 2/3 \text{ of } V_{CC} = 8v$$
$$8/I_B = R_B$$
$$\therefore R_B = 22K$$

For the second comparator

$$V_{cc} = I_C\, R_C$$

$$R_C = 400\Omega$$

$$I_C = 12/400 = 0.03A$$
$$hfe = \frac{I_C}{I_B}$$

Let hfe = 300

$$I_B = 1\ \times10^{-4}$$

$$\therefore V_B = I_B\, R_B$$

$$V_B = 2/3 \text{ of } V_{CC} = 8v$$

$$8/I_B = R_B$$

$$R_B = 80{,}000 \approx 100K\Omega$$

3.8 Relay Switch

The method of switching current through a load, which required isolation from this controlling circuit, involves the use of an electromechanical relay [12]. This device offers a simple, low-cost solution to the problem of maintaining adequate isolation between the controlling circuit and the potentially lethal voltages associate with an AC mains supply.

However, when the coil energized, a flux is set up in the relay core and the air gap. The relay function in this project is to operates as a switch. Due to its energized nature, the armature is altered and the contact points open to close by responding to the change in physical quantities such as current, voltage, frequency, temperature, etc. A relay is normally open position but closed when energized. When the energizing force is removed, the spring action returns the armature to its original state normally [11].

Before the coil is powered the common is always on the contact called normally open. However, when power is fed into the coil, the common is then moved to the normally closed – contact.

3.9 Alarm alert system

In the circuit designed a buzzer of 12 to 24 DC volts was used as an alert sound, to notify the system user that the heater is tending to preset temperature, in order to avoid the concurrent ON and OFF switching mechanism of the device which further leads to power wastage.

3.10 General Circuit Mode Operation

The general circuit is set – up when the mains supply is switched ON, then the 12volts DC power supply is applied to the control circuit, the heating element is switch ON. The 22kΩ variable resistor, acting as a temperature control for the second comparator is used to upset the voltage V_{ref} to be 7.5V at 62°C, so that the comparator output voltage V_o, cannot bias the transistor T_{R2}. Thus, at this point V_{ref} is greater than Vin. Also the 22kΩ variable resistor, acting as the temperature control for the first comparator is used to upset the reference voltage v_{ref} to be 7.7V at 65°C, so that the comparator output voltage $V_{o,}$ cannot bias the transistor T_{R1}. Thus, at this point V_{ref} is also greater than Vin.

However, the Vin is fed to the input of the second comparator. As temperature increases due to heating, the resistance of thermistor is also decreasing causing a rise in the input voltage Vin, when Vin has risen to a value, which corresponds with the preset value 7.5V at 62°C, the alert system will be trigger ON.

Also, Vin is fed to the input of the first comparator. As temperature increases due to heating, the resistance of thermistor is also decreasing causing a rise in the input voltage Vin, when Vin has risen to a value, which corresponds with the preset value 7.7V at 65°C, the alert system and the heater will be cut OFF. At initial Vref is greater than Vin, the rise in V_{ref} causes the comparator to rise high and the voltage V_o is just adequate to bias the transistor T_{R1}, then the collector current Ic will flows into the relay coil to energize it. But when Vin is greater than Vref the system will be cut OFF. Since the relay switch is normally opened type becomes close thereby switching OFF the heating element. Also, as temperature decreases below the preset temperature, the resistance of the thermistor R^{th} increases. This assesses a rise in V_o at this point Vref is greater than Vin, and the output voltage of the comparator V_o becomes high; which is adequate to bias the transistor thereby switching ON the transistor $T_{r1.}$

Finally, as the temperature decreases; the resistance R_{th} of the thermistor will begin to rise until its resistance is equal to 15kΩ, the relay coil becomes energizes and the heating element is triggered ON again.

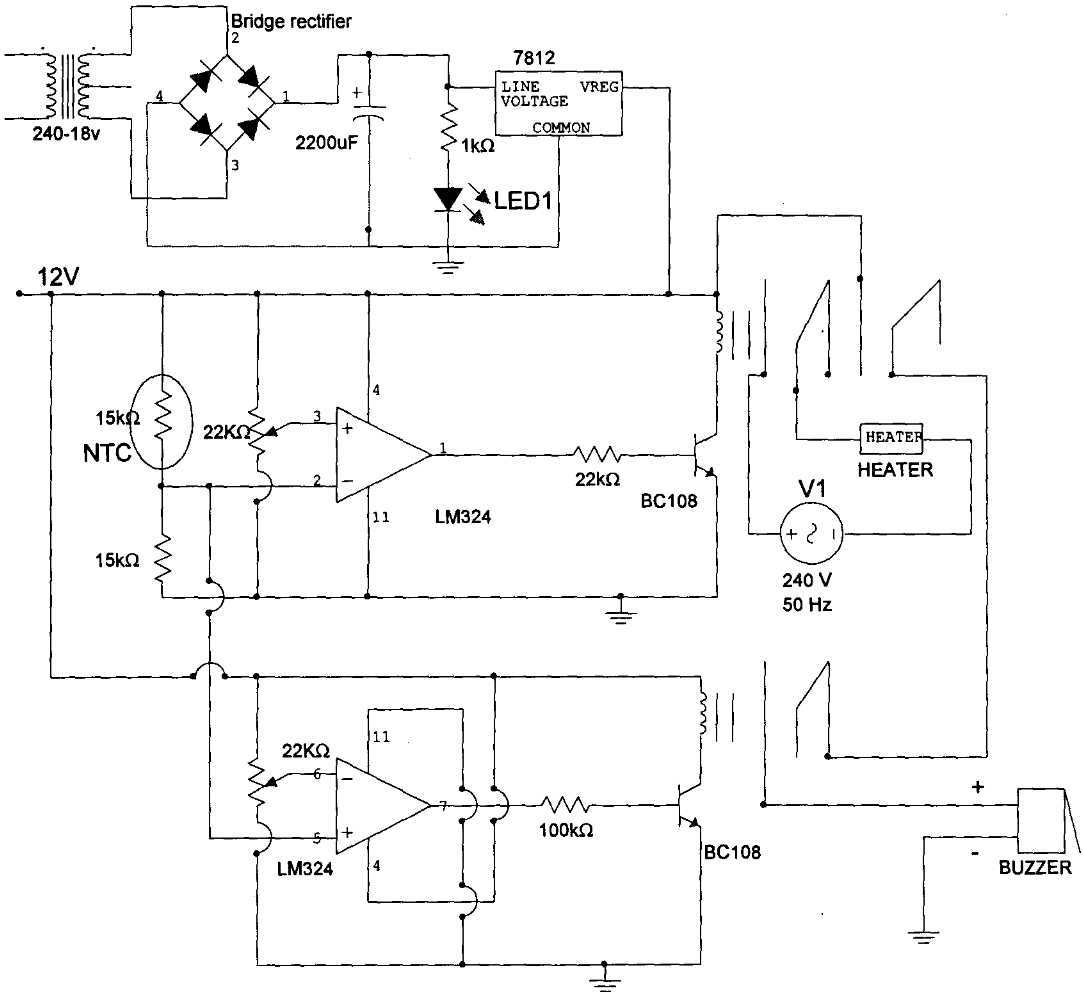


Fig 3.11 Circuit diagram of an electronic control for heating system.

CHAPTER FOUR

4.1 CONSTRUCTION

In the course of the construction of this electronic control for heating system, some tools and materials were used .These include:

i. Breadboard: This is a board with connectivity along its horizontal lines and vertical lines (In some cases). It was used primarily for temporal setting up of the design and to ascertain its working condition and hence further modification.

ii. Vero board: This is a perforated plastic board where the working circuit was finally mounted and soldered permanently.

iii. Soldering lead: This is a metal with low melting point. It was used to hold components and connecting wires in place in the vero board.

iv. Soldering iron: This is a low power heating element typically 40 watts. It provides the heat needed to melt the lead, so that it can be used for the connection of the components permanently on the vero board. It is usually connected to the AC mains.

v. Lead sucker: This used to suck up excess molten lead from the vero board to prevent short circuiting (bridging) or undesirable electrical connections.

vi. Multimeter: This is a multi-functional device used for testing of continuity and measurement of voltages, currents and resistances in the course of the construction.

vii. Wires and connections: Wires were used during the testing stage of the project on the breadboard to connect the component together as well as during the soldering of the components on the Vero board. Aluminum wires were used.

viii. Wire cutters/strippers: These tools were used to cut the wires to the desired size required before use, as well as to strip off insulation of the wire in other to expose the conductor for proper and neat soldering.

The circuit was first laid- out on the bread-board to observe its operational response and ensure that it is in line with the required objectives. Then it was dismantled.

The circuit was finally constructed on the vero board starting with the power supply unit. The components were inserted into the holes on the board properly to ensure that it is out on the other side where the copper tracks are. All components and jumpers (connecting wires) were inserted in place before soldering. This was to permit better judgment on connection linkages between the components. The connection between the components on different horizontal lines (potential) was carried out with the use of aluminum wires and a hole was made to break the horizontal lines continuity where it was needed or necessary.

To obtain a good soldering joint which is very important, it was ensured that the tip of the wire was in contact with the copper track, the wire to be soldered and the soldering lead. This soldering operation was carried out for a period of five seconds or less to prevent the components from getting overheated thereby damaging the components. The integrated circuits are very sensitive to this heat, so they were protected by the use of IC sockets. These sockets were soldered to the board while the ICs were inserted into place.

The entire circuit board and the transformer were housed in a wooden casing. This type of casing was chosen because of its poor conductivity, readily available and relatively cheaper. The appropriate holes for the LEDs, sensors wires and power cable were drilled at various positions. Holes were also drilled to allow air flow for ventilation.

Various precautions were taken during the construction which includes—

i. All soldered joints were tested for continuity so as to avoid unnecessary open circuits.

ii. Any the excess lead were removed to avoid "short circuits" on the boards.

iii. Polarities of the electrolytic capacitors and LEDS were properly checked to be correctly positioned before soldering on the vero board.

iv. IC sockets were used for the ICs to avoid overheating caused by soldering.

4.2 TESTING AND RESULTS

After all the components were arranged on the breadboard, they were tested to ensure the required output. The components and connecting wires which were soldered were tested for continuity using the continuity alarm tester of the multi-meter. The soldering joints were properly checked and errors detected were corrected by appropriate soldering and de-soldering actions. At the end of the soldering operation, each unit was tested at every stage and the results obtained were adequate.

The calibration was done using a multi –meter. The 22kΩ variable resistor for the second comparator was varied until we have a preset value of 7.5V at 62°C for the alarm to triggers ON. Also the 22kΩ variable resistor for the first comparator was varied until we have 7.7V at 65°C for the heater and the alarm to switches OFF.

CHAPTER FIVE

5.1 CONCLUSION

Electronic control for heating systems with an alarm was designed and constructed successfully and the aim of this project was achieved from the satisfactory results obtained form testing. The project has not only exposed me to proper comprehensive of electronic circuits, but also increased my knowledge to understand and recognize identical components made from different companies and how they are connected especially the integrated circuit.

The design is relatively simple and automated; the detection in the heating environment of the sensor is through themionic emission. Hence, it can be conveniently used in many applications where overheating at a particular temperature is dangerous, such as in rooms, incubators, water heaters, etc.

Finally, the desired output at the relay is due to temperature variation at the thermistor, was obtained satisfactorily.

5.2 RECOMMENDATIONS

Sophisticated signal processing techniques, in order to have a digital readout based system are recommended to bring this work toward limelight of better temperature monitoring in many applications.

Finally, for a more sensitive and reliable system, a temperature transducer that is more sensitive then the thermistor whose resistance or factor of variation with temperature is linear should be used e.g. Silicon diode transducers.

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APPENDIX

LIST OF COMPONENTS

LM324 linear dot, bar driver [1]

BC108 NPN transistor [1]

78L12 12V regulator [1]

KBP208 Diodes [4]

Relay 12volts [3]

Capacitors:

- 2200μF Electrolytic

Resistors:

- 1.0 KΩ [1]
- 15 KΩ [1]
- 22 KΩ [1]
- 100 KΩ [1]

Variable Resistors

- 22 KΩ [2]