DESIGN AND CONSTRUCTION OF A TEMPERATURE ALARM CIRCUIT

(35°C – 40°C)

BY

NWEKE OBIFUNA KENECHUKWU

98/7110EE

DEPARTMENT OF ELECTRICAL / COMPUTER ENGINEERING

SCHOOL OF ENGINEERING AND ENGINEERING TECHNOLOGY

FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

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IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF A BACHELOR OF ENGINEERING (B.ENG) DEGREE

NOVEMBER, 2005

DECLARATION

I hereby declare that apart from references to works previously carried out by others and relevant journals, which have been dully credited, this project was solely carried out in its entirety by me, NWEKE OBIEFUNA KENECHUKWU, 98/7110EE of the Electrical and Computer Engineering department of Federal university of Technology Minna, under the supervision of Dr. (Mrs) Onwuka of Electrical and Computer Engineering department; School of Engineering and Engineering Technology, Federal University of Technology Minna, Niger State during the 2004 / 2005 academic session.

Signature: ______________________

Date: Dec, 2nd, 2005

CERTIFICATION

This is to certify that this project titled DESIGN AND CONSTRUCTION OF A TEMPERATURE ALARM CIRCUIT (35°C – 40°C) was carried out by NWEKE OBIEFUNA KENECHUKWU under the supervision of Dr (Mrs) Onwuka and submitted to the department of Electrical and Computer Engineering, Federal University of Technology Minna in partial fulfillment of the requirement for the award of a Bachelor of Engineering (B.ENG) Degree in Electrical and Computer Engineering.

Dr (Mrs) Onwuka	05/12/05
Project supervisor	Signature and date
Engr. M.D. Abdullahi	16/02/06
Head of Department	Signature and date
External supervisor	Signature and date

ACKNOWLEDGEMENTS

I would like to thank the Almighty God for His abundant mercies. For His guidance and protection and also for the numerous blessings He has showered on me.

He blessed me with Mr. and Mrs. A.M Nweke whom I just have to say are all I ever wanted in parents and much more. The Almighty also blessed me with the support of the following people, Late Mrs. Patience N. Nweke, Hon. And Mrs B.C.N Okeke my grandparents, Dr and Mrs Emenike Okeke. My siblings, Chimdindu, Nnaemeka and Chinazaekpele who never stopped praying for my success. Chichi, Emi Jnr, Arizechukwu, Kenechukwu and all my other cousins, uncles, aunts and numerous relatives. Thanks for all your support. Aunt J. Igwebuike, Engr. Chris Okoye, uncle Boniface Okelekwe thanks for all your support.

Having a supervisor as understanding and as meticulous as Dr. (Mrs) Onwuka I have to say is nothing short of a blessing from the Almighty. The actualization of this project would definitely have been an uphill task but for the immeasurable input of my friends Vajime Wanger C. and Agbejule O. Ayokunle both of whom worked on this project as if it belonged to them in some way. Alagbe Sanya, thank you so much. My level advisor Engr. Umar I am very grateful.

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DEDICATION

This project is dedicated to the memory of my grandmother Late Mrs. Patience N. Nweke and also to the memory of my late friends Okoroafor Amadi and Mohammed Jibril.

ABSTRACT

In the society we find ourselves in. the quest for luxury and comfort safety and a high degree of accuracy has led to large scale research into means of harnessing and controlling man's physical environmental factors and activities in order to increase productivity and efficiency in out industrial sector.

The temperature alarm circuit uses mainly a sensing bridge which has a sensor that detects a temperature range between 35°C and 40°C. The ability of the comparator to sense small signal (temperature) changes is very advantageous in the control of temperature.

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CHAPTER ONE

Introduction

1.1 TEMPERATURE:

Temperature can be defined as an inherent quality of objects expressed as degree of hotness or coldness relative to a given reference to something else. It can also be defined as the quantity of heat in a body. It is the property of a system that determines whether they are in thermal equilibrium. Two systems are said to be in thermal equilibrium if, when they are in contact through thermally conducting walls, they undergo no changes in properties. The concept of temperature stems from the idea of measuring relative hotness and coldness and from the observation that the addition of heat to a body leads to an increase in temperature as long as no melting or boiling occurs. In the case of two bodies at different temperatures, heat will flow from the hotter to the colder until their temperatures are identical and thermal equilibrium is reached.

Temperature plays an important part in determining the conditions in which living things can survive. Thus birds and mammals demand a very narrow range of body temperatures for survival and must be protected against extreme heat or cold. Aquatic species can exist only within a narrow temperature range of the water, which differs for various species. For example, an increase in the temperature of river water by only a few degrees as a result of heat discharge from power plants may cause water pollution and lead to the death of most of the native fish.

The properties of all materials are markedly affected by temperature variations. At arctic temperatures for example, steel becomes very brittle and breaks easily, liquids, solidify or becomes very viscous and offers very high frictional resistance to flow. At temperatures near absolute zero, many materials exhibit strikingly different characteristics. At high temperatures solids liquefy or become gaseous; chemical compounds may break up into their constituents.

The temperature of the atmosphere is influenced greatly by both land and sea areas. In January for instance, the great land masses of the northern hemisphere are much colder than the oceans at the same latitude and in July the reverse is mostly obtainable. At low elevations the air temperature is also determined largely by the surface temperature of the earth. The periodic temperature changes are due mainly to the sun's radiant heating of the land areas of the earth surface, which in turn heats the air lying above. As a result of this phenomenon, the temperature decreases with altitude, from a standard reference in line of 15.5°C (60°F) at sea level (in temperature latitudes) to about – 55°C (-67°F) at about 11,000m (36,000ft). About this altitude, the temperature remains nearly constant up to about 33,500m (110,000ft).[1]

Temperature changes can be of service to man in many ways. We apply changes in temperature in different activities like, cooking, drying clothes, ironing of clothing materials e.t.c. in the electronic industry semi – conductors are manufactured by heating semiconductor materials to sufficiently high temperatures and slowly cooling them down. Silicon is an example of such semiconductor materials. By taking temperature measurements, doctors get an indication of the state of health of their patients. In the agricultural industry the measurement of temperature is very important as it can be very useful in incubators for the artificial hatching of poultry, preservation and processing of agricultural products such as meat, fish and some rare plants.

1.2 MEASUREMENT OF TEMPERATURE:

The measurement of temperature is carried out mostly by the use of an instrument called THERMOMETER. This instrument is of different kinds.

The invention of the thermometer is attributed to Galileo, although the sealed thermometer did not come into existence until the middle of the 15^{th} century AD. The modern alcohol and mercury thermometers were invented by German Physicist Gabriel Fahrenheit, who also proposed the first widely adopted temperature scale, named after him, in which 32°F is the freezing point of water and 212°F is its boiling point at standard atmospheric pressure. Various temperature scales have been proposed after his time; in the centigrade or Celsius scale, devised by the Swedish astronomer Andres Celsius and used in most countries of the world, the freezing point of water is 0° and the boiling point is 100°C

1.2.1 TYPES OF THERMOMETERS: A wide variety of devices are used as thermometers. The primary requirement is that one easily measured property such as the length of the mercury column should change markedly and predictably with changes in temperature. The variation of that property should also remain fairly linear with variations in temperature. In other words, a unit change in temperature should lead to a unit change in the property to be measured at all points of the scale.

The electrical resistance of a conductor or semi conductor increases with a rise in temperature. The phenomenon is the basis of the resistance thermometer in which a constant voltage, or electric potential is applied across the thermistor or sensing element. For a thermistor of a given composition the measurement of a specific temperature will induce a specific resistance across the thermistor. This resistance can be measured by a galvanometer and becomes a measure of the temperature.

Various thermistors made of oxides of nickel, manganese or cobalt are used to sense temperatures between – 46°C and 150°C (- 50°F and 300°F). Similarly thermistors employing other metals or alloys are designed for use at higher temperatures; platinum for example can be used up to 930oC (1700oF). With proper circuitry, the current reading can be converted to a direct digital display of the temperature.

Thermocouples can be employed to make very accurate measurements of temperature in which a small voltage difference (measured in millivolts) arises when two wires of dissimilar metals are joined to form a loop, and two junctions have different temperatures. To increase the voltage signal, several thermocouples may be connected in series to form a thermocouple. Since the voltage depends on the difference of the junction temperatures one junction must be maintained at a known temperature otherwise an electronic compensation circuit must be built into the device to measure the actual temperature of the sensor. [2]

Thermistors and thermocouples often have sensing units less than 3 cm (approximately 1 in) in length, which permits them to rapidly respond to temperature changes and also makes them ideal for many biological and engineering uses.

The optical pyrometer is used to measure temperatures of solid objects at temperatures above 700°C (about 1300°F), where most other thermometers would melt. At such high temperatures, solid objects radiate sufficient energy in the usual range to permit optical measurement by exploiting the so – called glow color phenomenon. The pyrometer contains a filament that looks like that of a light bulb. This is controlled by a rheostat (dimmer switch) which is calibrated so that the color at which the filament glows corresponds to specific temperatures. The temperature of a glowing object can be measured by viewing the object through the pyrometer and adjusting the rheostat until the filament blends into the image of the object.

At this point the temperatures of the filament and the object are equal and can be read from the calibrated rheostat. [3]

1.3 NEED FOR TEMPERATURE CONTROL:

In as much as temperature measurement is important, it is the control of same that makes it a worthwhile venture. The need for the control of temperature cannot be overemphasized. In plant nursery, temperature control is very necessary. Reptile ponds, tropical fish aquarium and seed production chambers all require one form of temperature control or the other to work efficiently. The control of central heating / cooling system provides comfort for humans and increases the efficiency and productivity of industrially finished products.

In bacteriology, incubators are rectangular boxes usually kept at 19°C to 30°C (66°F to 86°F) for cultures of fungi and bacteria that do not cause diseases or at human body temperature (37°C / 98.6°F) for the growth disease causing bacteria.

In human incubators a prematurely born or unusually weak child is kept warm by keeping the child in a chamber that is usually kept at a temperature of 31° to 32°C (88° to 90°F)

In poultry raising incubators or brooders are used to keep eggs warm until they hatch and to warm young chicks immediately after hatching. Brooders are kept at about 38°C (100°C) for the first week after the eggs are laid. In most cases, the required temperature for eggs to hatch is between 35°C and 40°C (95°F – 104°F) [4]

1.4 SCOPE OF THE PROJECT

In this project we shall focus on temperature control for incubator for eggs whose requirements fall within the temperature range of the circuit we are working on.

The project, design and construction of temperature alarm circuit (between 35°C and 40°C) will trigger an alarm either when the temperature of the system falls below 35°C or goes higher than 40°C thereby ensuring the maintenance of the required temperature.

1.5 AIMS AND OBJECTIVES

The aims and objectives of this project are as stated below

i. Development of ingenuous engineering technology
ii. Development of basic project construction skills
iii. Enabling young engineers to put to practice what has been taught in the classroom
iv. To encourage creativity in young engineers.

CHAPTER TWO

2.1 SENSOR TRANSDUCERS

A transducer is a device which converts a signal of one kind into a signal of another kind. An electrical transducer is a device that converts energy from one form to electrical pulses (signal). This is achieved by abstracting energy from the source. Some common transducers include:

- Displacement transducers: this includes resistive potentiometer, inductive potentiometer, synchron element. The F – transformer, capacitive transducer
- Tachogenerator
- Temperature measurement transducers: this include resistance thermometer, thermocouple, thermistor, pyrometer e.t.c
- Strain measurement transducers: strain gauges
- Flow measurement transducers: electromagnetic flow meters. For this project however, our attention wil! be focused on the commonest and most widely used i.e. the temperature measurement transducers. Temperature sensors are grouped into five main categories:

i. Thermistors

ii. Resistance thermometers

iii. Pyrometers

iv. Thermocouples

v. Semiconductors [5]

2.1.2 THERMISTORS:

This is a thermoelectric transducer whose electric resistance changes very rapidly with small change in temperature. They are made from sintered mixture of metal oxides (semi – conductors). Their resistances change potentially with increases or decreases in temperature. Some thermistors have resistances which decrease with increase in temperature i.e. Negative temperature coefficient (N.T.C)while other have their resistances increasing with increase in temperature i.e. positive temperature co-efficient (P.T.C), N.T.C materials are however more common. They are manufactured in a variety of sizes and configuration.

Depending on the methods of fabrication and materials used, they (N.T.C thermistors) are generally used in the temperature range of – 50°C to 150°C and up to 3000°C for some glass encapsulated units. The resistance values of a thermistor are typically referenced in ohms at absolute temperature RTH is given by the formula below:

$RTH = R_o e^{(B/T - B/To)}$

Where

R_o – Thermistor resistance at base temperature

B – Thermistor constant

T – Absolute temperature

T_o – Initial temperature

The effective temperature is derived as follows:

$\alpha = 1 / R_{TH}. d / R_{TH}$

$\alpha = 1/R_o e^{(B/T - B/To)}. Roe^{(B/T - B/To)} -B/T^2$

$-B/T^2$ ohms / ohm / °C

The thermistor is the device we shall use for our project.

2.1.3 RESISTANCE THERMOMETER:

This is a group of thermoelectric devices that for its operation depends on the inherent property of metals to change in electrical resistances when they undergo a change in temperature. Pure metals are the most suitable materials for the construction of resistance thermometers. Semiconductors are also good.

The general relationship between the resistance RT (ohms) of a metal element and temperature T °C (is however a power series of the form.

$R_T = R_o (1 + aT + bT^2 + CT3)$

Where R_o = the resistance at 0°C and a, b and c are temperature coefficients of resistance. Despite the wide availability of these thermometers they have relatively low sensitivity and are susceptible to shock and vibration [6]

2.1.4 PYROMETER:

This is an instrument which measures very high temperatures typically by converting brightness, radiation into temperature readings. The working principles of the pyrometer are based on the fact that there is relationship between an objects temperature and its electromagnetic radiation emitted. When temperature is measured by a pyrometer, the temperature is not distorted because there is no direct contact between a probe (a device with a metal tip used to test the behaviour of electrical circuits) and the objects theoretically. The pyrometric method of temperature sensing has no upper limit.

The temperature of a continuous spectrum radiation source close to 6000°C will ordinarily be measured in the same manner as a temperature of 1000°C or 2000°C. Pyrometers are widely used in metal making and other industries.

In the research industry it is used in studies involving temperature from 300°C to 600°C and even higher.

2.1.5 THERMOELECTRICITY:

This is electricity generated by the application of heat to the junction of two dissimilar metals. A thermocouple is a temperature measuring device in which two wires of dissimilar metals are joined.

The potential difference between the wires is a measure of the temperature of the object they touch.

For a given combination of metals, the voltage difference varies in direct proportion to the temperature difference. At moderate temperature (up to about 260°C / 500°C) wire combinations of iron and copper, iron and constantan (a copper – nickel alloy and copper and constantan are frequently used. At high temperatures (up to 1649°C / 3000°F) wires made from platinum and platinum – rhodium are employed. Because thermocouple wires can be made very small, they also provide a means for accurate measurement of local spot temperatures.

2.1.6 SEMICONDUCTORS:

This is a material that is able to conduct electricity at room temperature more readily than an insulator, but less easily than a metal. Electrical conductivity which is the ability to conduct electric current under the application of a voltage has one of the widest ranges of values of any physical property of matter. Metals such as copper, silver and aluminum are excellent conductors but substances like diamond and glass are very poor conductors. At low temperatures, pure semiconductors behave like insulators. Under higher temperatures, or with the addition of impurities or in the presence of light, the conductivity of semiconductors can be increased dramatically.

Following advances in semiconductor technology attempts have been made to extend the applicability of semi conductors to include thermometry. One semi conductor Germanium has been used as the basis for temperature scales in the range of 4.2K and 13.8K. Mixtures of semi – conductor materials such as oxides of copper and magnesium oxides of cobalt and manganese oxides of titanium and magnesium are also used as sensors of resistance thermometer. Varying the mixed components can readily control the conductivity and temperature coefficients or resistance of such sensors. Both semi conductors and the thermometers made from them have a high negative temperature coefficient or resistance.

2.2 EFFECT OF HEAT TRANSFER IN MEASUREMENT SYSTEMS

The temperature of a sensing element at any instant depends on the rate of transfer of heat to and fro the sensor. Heat transfer can take place in three different modes – convection, conduction and radiation. Conduction is the main heat transfer mechanism involving solids. A solid may be regarded as a chain of interconnected atoms each vibrating about a fixed point. An increase in temperature at one end of a solid bar causes an increase in the vibration energy and amplitude of the atoms at the end of the chain. This energy increase is transmitted from one atom to the next along the chain, so that ultimately the temperature increase is transmitted to the other end of the bar. In the case of heat transfer between a sensing element and the fluid in which it is situated, the main heat transfer mechanism is convection. Here heat is transferred to and from the sensor by random highly disordered motion of molecules of fluid past the sensor. This random motion and corresponding heat transfer occur even when the verge velocity of the bulk fluid past the sensor is zero. This is referred to as natural convection. If bulk fluid is made to move so that the average velocity past the sensor is no longer zero, then there is a corresponding increase in rate of transfer. This is referred to as forced convection. Heat transfer by means of radiation involves the transmission of electromagnetic waves. From Newton's law of cooling, the convective heat flow wait between a sensor at T °C and fluid at T_p °C is given by

$W = \mu A\ (T - Fr)$

Where μwm-2 is the convection heat transfer coefficient and Am2 is the heat transfer area. Heat transfer coefficient is calculated using the correlation

$Nu = \varphi\ (Re, Pr)$

Between the three dimensionless numbers

Nusselt	$Nu = \mu d/k$
Reynolds	$Re = vdp/n$
Prandti	$Pr = cn / k$

dm = sensor diameter

Vms-1 = fluid velocity

Pkgm-3 = fluid density

ṅPas = fluid viscosity

cj0C $^{-1}$ = fluid heat capacity

kwm^{-1}–°C^{-1} = fluid thermal conductivity

The function φ is determined experimentally. Its form depends on the shape of the sensor, the type of convection and direction of fluid flow in relation to the sensor. For example the correlation forced convention cross flow over a cylinder is

$Nu = 0.48(Re)^{0.5} (Pr)^{0.3}$

$U = 0.48K^{0.7}P^{0.5}C^{0.3}V^{0.5} / d^{0.5}n^{0.2}$

For two – dimensional natured and forced convection from a cylinder, the approximate correlation is

$Nu = 0.24 + 0.56Re^{0.5}$

Giving $U = 0.24k/d + 0.56k\,(PV/d\eta)^{0.5}$

From the above we see that the convection heat transfer coefficient for a given sensor depends critically on the physical properties and velocity of the surrounding fluid.

2.3 DYNAMIC CHARACTERISTICS OF THERMAL SENSORS

2.3.1 A bare temperature sensor

The transfer function of a bare temperature sensor has been found to be

$\Delta Ts/\Delta T_F\,(S) = 1 / 1 + \tau s$

Where ΔTs, ΔT_F °C = deviations is sensor and fluid temperature from equilibrium

Ts = sensor time constant = mc / µA

Mkg = sensor mass

$Cjkg^{-1 0}C^{-1}$ = sensor specific heat capacity

$Mwm^{-1 0}C^{-1}$ = convection heat transfer coefficient between fluid and sensor

Am^2 = sensor heat transfer area

Since s, depends on u, the time constant of a given sensor will depend critically on the nature and velocity of the fluid surrounding the sensor.

Temperature sensor enclosed in a thermo well or sheath

A temperature sensor e.g. thermocouple or resistance thermometer is usually enclosed in a sheath or thermo well to give chemical and mechanical protection. The figure (a) below shows a typical thermocouple installation and figure (b) is a simplified model where sensor and thermo well are represented by single "lamped" masses Ms, and Mw respectively

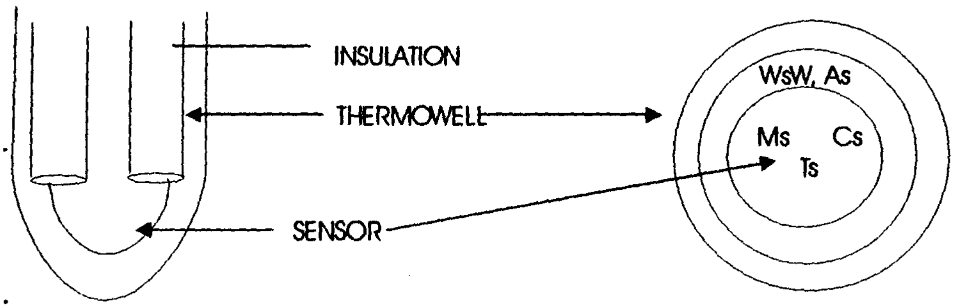

Fig. 2.1 Sensor in thermowell

a) Typical thermo well insulation

b) Simplified model

Ignoring the thermal capacity of the space between sensor and well the heat balance equations are:

Sensor: MsCs dT/dt = Usw Asw (T_{10} – Ts)

Well: MwCw dTw/ dt = -Usw Asw (T10 – Ts) + U_{WF} A_W (T_F – T_W)

This becomes:

τ_1 dTs / dt = (Tw – Ts)

τ_2 dTw / dt = - S(Tw – Ts) + (T_E – Tw)

where T2 = MwCw / Uw_F Aw

= UswAs/Uw_FAw

And AsAw = sensor, thermowell heat transfer areas.

CsCw = sensor thermowell specific heats

Usw = sensor thermowell heat transfer coefficient

Uw_F = fluid thermowell hat transfer coefficient

Defining $\square T_F$, $\square Tw$, $\square Ts$ to be deviations from initial steady condition; their laplace transforms are

$[1 + T_1 s]\ \square Ts = \square Tw$

$[(1 + \square) + T_2 S]\square Tw = \square T_F + \square\square Ts$

Eliminating Tw between these equations given the overall transfer function

$\Delta Ts/\Delta T_F = 1\ / \tau_1 \tau_2 S^2 + (\tau 1 + \tau_2 + \tau 1)\ S + 1$

This is the temperature transfer function for temperature sensor in a sheath. This is a second order model and is a good representation of an incorrect installation where the tip of the sensing element does not touch the sheath. The effective heat transfer coefficient Usw between the sensor and well is now very small; this means that T is very large and the system response is extremely sluggish. A correct and normal installation with the sensor tip touching the sheath has a far higher Usw and lower T, in the limit or perfect heat transfer between sensor and well, both elements are of the same temperature and the heat equation now becomes, (MsCs + MwCw) dT/dt = UswAsw (T_F – Ts)

Giving the first order transfer function

$\Delta Ts/\Delta T_F\ (S) = 1/1 + \tau s\ \tau = MsCs + MwCw/UFwAw$

This model is a good representation of installations where special steps have been taken to improve heat transfer. These steps include filling the sheath with oil or mercury or using a crimped metal sleeve to increase the heat transfer area. The table below gives a typical time constants for element in thermo well under different fluid conditions.

Table 2.1 Time constants for elements in thermowell under different fluid conditions

Fluid conditions	Typical U_{FW} Wm^{-1} $^0C^{-1}$	Typical T for sensor in Thermowell	Typical T for Mineral Insulated Thermocouple
Fast fluid	625	1.0	0.7
Slow fluid	250	1.5	1.5
Fast Gas	125	2	10
Medium Gas	63	4	20
Slow Gas	25	8	30

P_1 to D

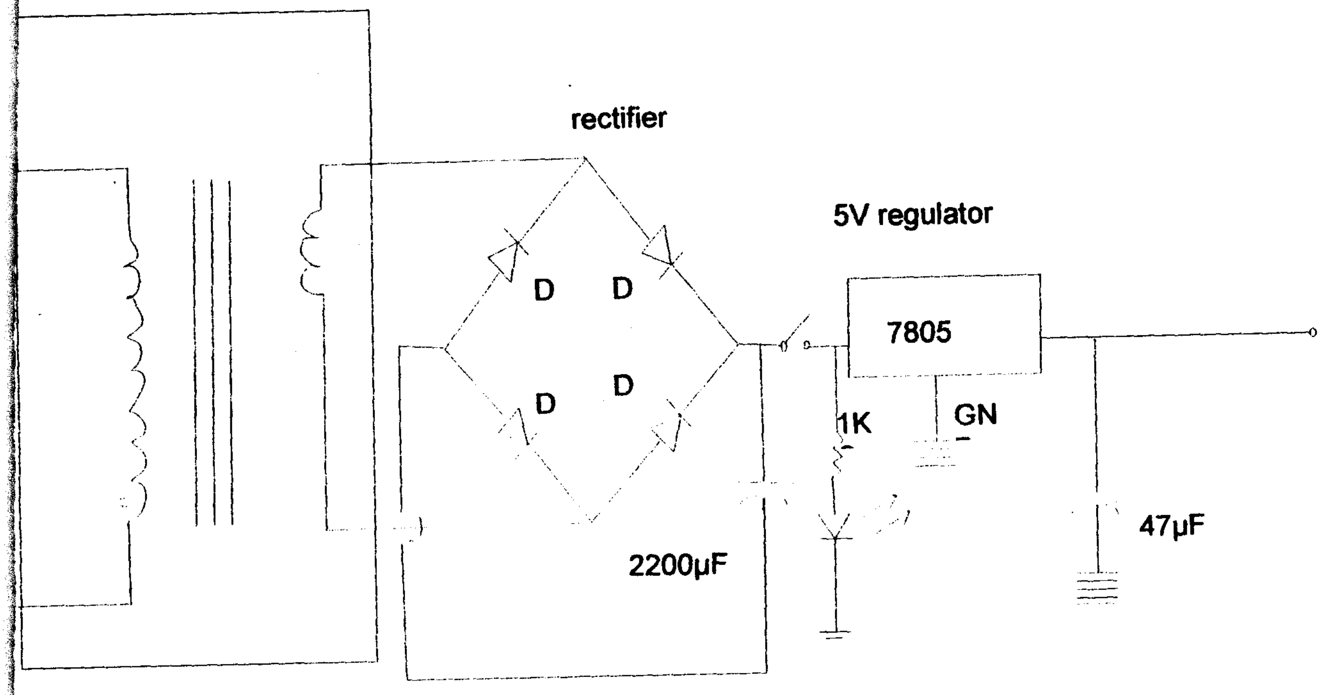

Fig.2.2 Power supply unit

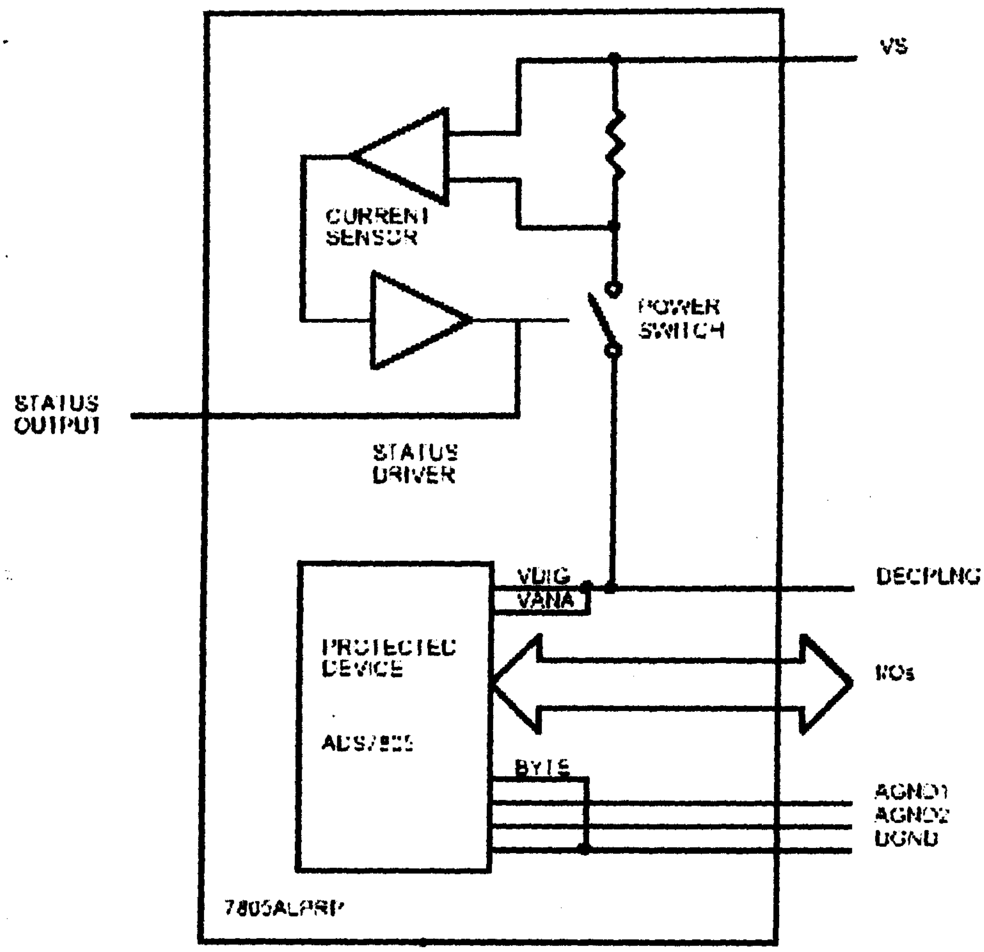

FIGURE 3. LATCHUP PROTECTION DIAGRAM

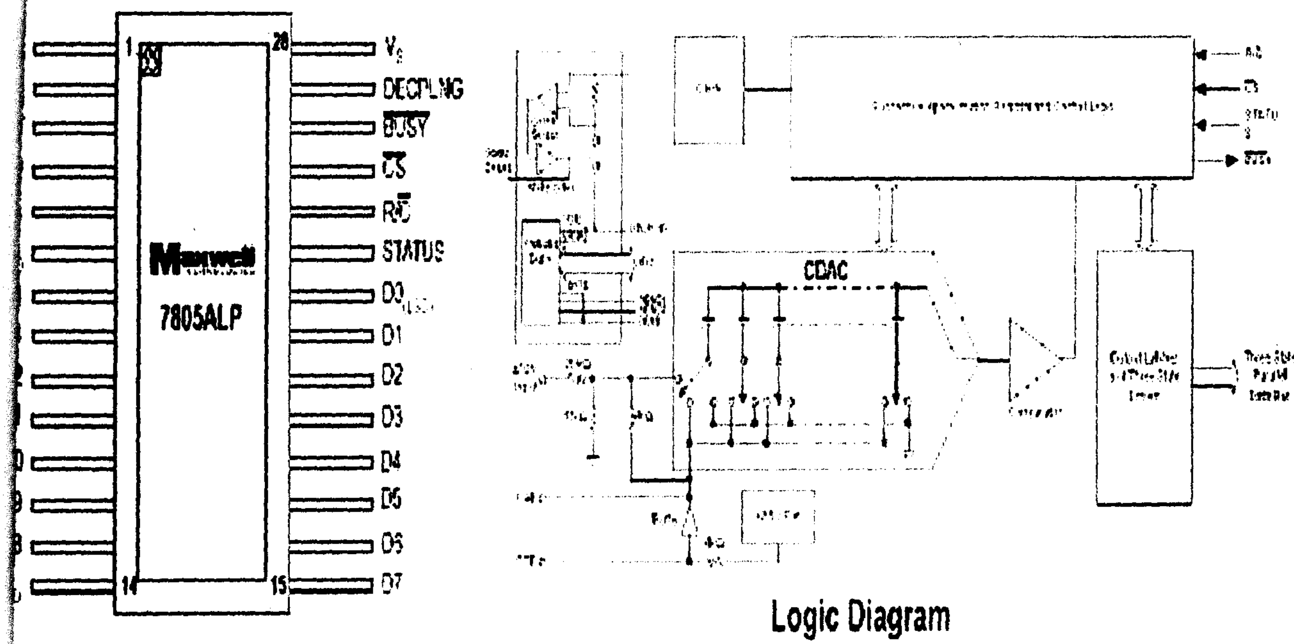

Fig. 2.4 7805ALP logic diagram [7]

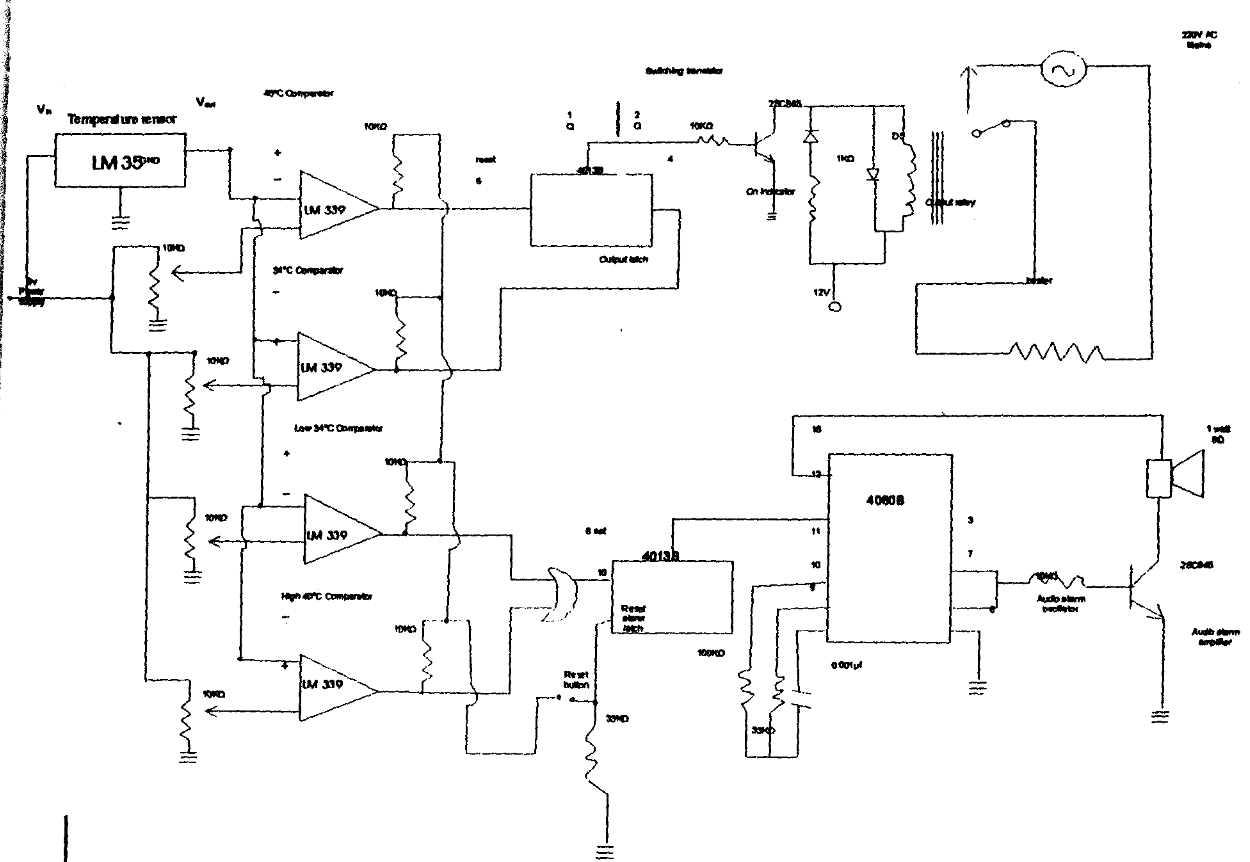

Fig. 2.5. Circuit diagram

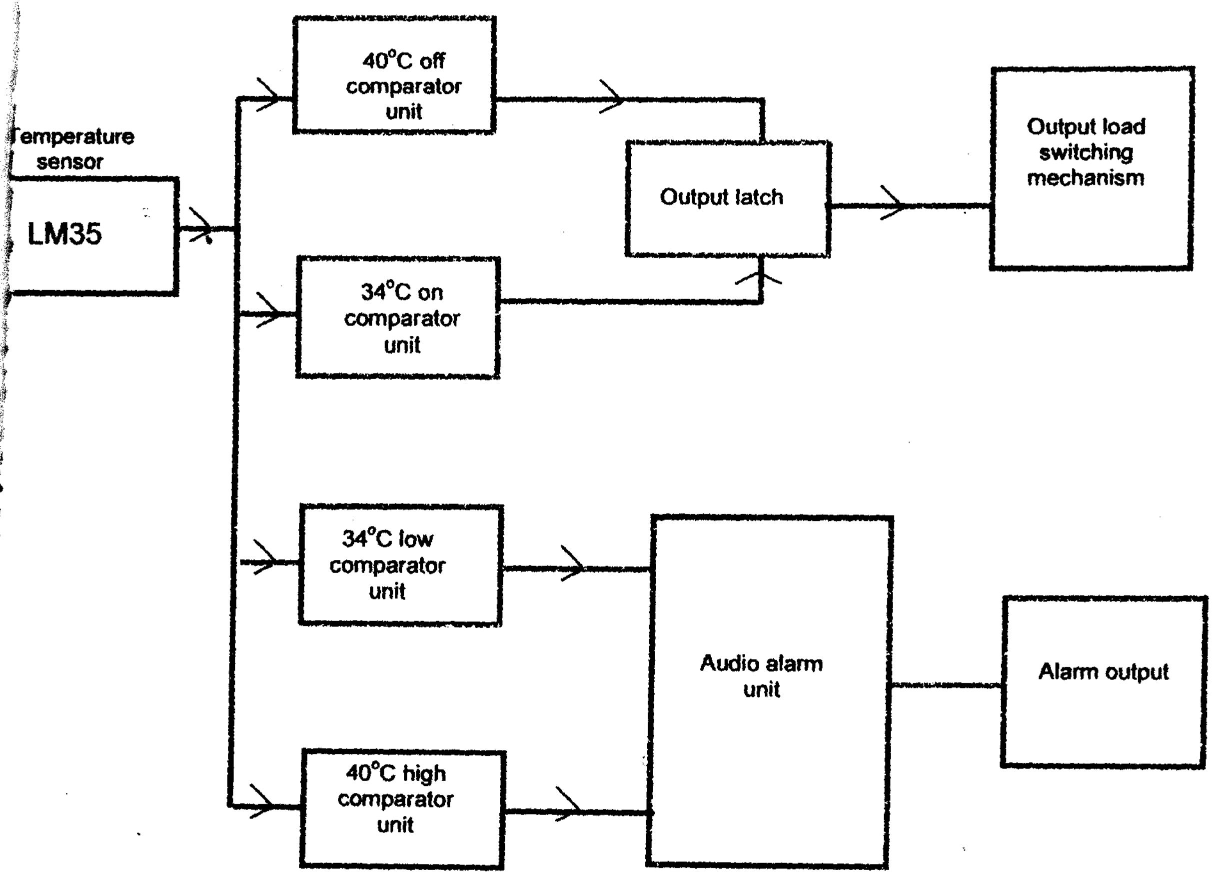

Fig 2.6. Block diagram

CHAPTER THREE

3.1 COMPONENTS USED IN THE CIRCUIT DESIGN

1. LM 35 - Temperature sensor
2. LM 339 – Quad comparator
3. 4013B – Dual D/SR latch or flip – flop
4. 4060B – oscillator / divider
5. 12 V relay
6. 2SC945 – NPN switching transistor
7. 1 watt 8Ω speaker
8. 7805 5V regulator

The circuit is designed with precision integrated devices. This makes the design not only simple but of lower power consumption. The components used in the circuit are discussed below:

3.1.1 LM 35

The LM 35 series are precision integrated circuit temperature sensors whose voltage output is linearly proportional to the centigrade (Celsius) temperature scale. The advantage this sensor has over linear temperature sensors calibrated in Kelvin is that the user is not required to subtract a large constant centigrade scaling. The LM 35 does not require any external calibration or trimming to provide typical occurrences of + 1/4°C at room temperature and + ¾ °C over a full – 55 to + 150°C temperature range. The LM 35's low output impedance, linear output and precise inherent caliberation make interfacing or control circuitry very easy. It can be used with simple power supplies or with plus or minus supplies as it draws only 60μA from its supply. It has very low self heating less than 0.1°C in still air.

The LM 35 is rated to operate over a – 55°C to + 150°C temperature range, while the LM 35c is rated for a – 40°C to 110°C range (- 10°C with improved accuracy). The LM 35 series is available packed in hermetic. To – 46 transistor packages, while the LM 35, LM35CA and LM 35D are also available in the plastic to – 92 transistor package. The LM 35D is also available in an 8 – lead surfaces mount small outline package and a plastic To – 220 package.

The LM 35 main characteristics are listed below:

1) Caliberated directly in ^{o}Celsius (Centigrade)
2) Linear + 10.0 mV/ °C scale
3) 0.5°C accuracy guaranteable (at + 25°C)
4) Rated for fill – 55 °C to 150 °C range
5) Suitable for remote application
6) Low cost due to water – level trimming
7) Operates from 4 to 30 volts
8) Less than 60μA current drain
9) Low self heating 0.08 °C in still air
10) Low impedance output, 0.1Ω for 1mA load.

3.1.1.2 TYPICAL APPLICATION

To – 92 Package

The simplicity of use of this device is such that mere reading of the output voltage tells the temperature of the surrounding. The sensitivity of the device is 10mV / °C. This shows that a voltage reading of 300mV at the Vout terminal of the device tells us that the temperature read is 30 °C.

300 / 10 = 30

In other words the sensor behaves like a thermometer of some sort and this is achieved without external help or components. [8]

3.1.2 LM 339

This integrated circuit is a quad – comparator. Put in other terms the package has four independent comparators. The package is a fourteen pin type. A comparator has two (analogue) and one digital output. The inputs are the non – inverting (+) and inverting (–.). When voltage at the non inverting input (+) is greater than that at the inverting point (–), the output of the comparator is HIGH with respect to the negative terminal of the power supply. But in a situation where the inverting point (–) is greater than or the same with the non – inverting input (+), the output of the comparator is low. [9]

3.1.3 7805 ALP

FEATURES:

• 16-bit organization

• Latch up Protection Technology™

• RAD-PAK® radiation-hardened against natural

space radiation

• Total dose hardness:

- > 50 krads (Si), depending upon space mission

• Latch up converted to reset.

- Rate based on cross section and mission.

• Package:

- 28 pin RAD-PAK® flat pack

- 28 pin RAD-PAK® DIP

• 100 kHz min sampling rate

• Standard ± 10V input range

• Advance CMOS technology

- 86 dB min SINAD with 20 kHz input

- Single 5V supply operation

- Utilizes internal or external reference

- Full parallel data output

- Power dissipation: 132 mW max

DESCRIPTION:

Maxwell Technologies' 7805ALP high-speed analog- to-digital converter features a greater than 50 krad (Si) total dose tolerance, depending upon space mission. Using Maxwell's radiation-hardened RAD-PAK® packaging technology, the 7805ALP incorporates the commercial ADS 7805 from Burr Brown. This device is latch up protected by Maxwell Technologies' LPT™ technology. The 7805ALP, 16-bit sampling A/D using state-of-the-art CMOS structure. The device contains a complete 16-bit capacitor-based SAR A/D with S/H, reference, clock, interface for microprocessor use, and three state output drivers. The 7805ALP is specified at a100 kHz sampling rate, and guaranteed over the full temperature range. Laser-trimmed scaling resistors provide an industry-standard ± 10V input range, while the innovative design allows operation from a single 5V supply, with power dissipation of under 132 mW.

Maxwell Technologies' patented RAD-PAK® packaging technology incorporates radiation shielding in the microcircuit package. It eliminates the need for box shielding while providing the required radiation shielding for a lifetime in orbit or space mission. [10]

3.2 WORKING PRINCIPLES OF THE CIRCUIT

The circuit is designed using logical techniques. The temperature sensor is a precision type and it gives the circuit a very high level of accuracy. Also the switching is done by the use of precision comparators.

3.2.1 Temperature sensing unit

As earlier stated, the temperature sensor is the Lm 35. Its interesting linear characteristics have been defined in the previous chapter. The sensor provides the source and input into the circuit. It converts heat energy into equivalent electric current. As stated earlier it produces a 10mV output for every 1°C temperature measurement. This output is connected to respective inputs at the four comparators. The comparators are connected tore pond to the input in a specific manner.

3.2.2 The comparator units

There are four comparators in all. Each is connected in a specific mode. They are the 40°C off, 34 °C on, 34 °C low and 40 °C high comparator units. The first two are connected to the output load switching mechanism through an output latch. The unit helps in switching the heating unit on and off so as to regulate the temperature of the enclosure. The other two are designed for the audio alarm unit which shows a critical temperature stage or point.

The 40 °C off comparator is designed to switch the heating element so that the temperature does not go beyond 40 °C. This is done by sending a HIGH logical level to the reset pin at the output latch from the corresponding comparator. This results into the change of the output of the latch from LOW to HIGH logical level. The input from the temperature sensors is connected to the non inverting input (+) of the comparator. The inverting input (-) is connected to a 10KΩ variable resistor. The leading resistor is designed to input a particular stable voltage to the input.

The voltage is made about 390 mV. The initial condition of the comparator is at the Low logical level whenever the signal or voltage from the sensor at the non – inverting point (+) is lower than that of the inverting point (-) or reference. When the temperature rises, the voltage at the non – inverting input (+) becomes greater than that of the inverting (-). This changes the output of the comparator from logical LOW level to HIGH. This resets the output latch and the switching transistor is off also turning off the heater through the output relay.

The 34 C is designed to trigger on the heating process whenever the temperature drops down to 34 C. This comparator is connected to the temperature sensor through the inverting input (-). The non – inverting (+) side is connected to 10KΩ resistor. A voltage of about 330mV is applied to the terminal through the resistor. So that the initial condition of the comparators output at low logical level changes to HIGH whenever the voltage from the temperature sensor goes below 330mV. At this point, the output latch is set and changes HIGH logical level from low. This supplies a relative high voltage to the base of the switching NPN transistor.

This results to the switching ON of the output relay. The ON indicator comes on. The heater is switched ON. The situation goes into a switching cycle. Whenever the temperature reaches 40°C, the heating stops. Also when the temperature drops down to below 34°C, the heating picks up again through the 34°C comparator.

3.2.3 The Audio Alarm latch

The latch is an RS flip – flop. The set is connected to the output of the OR gate. The reset is linked to a soft touch buttcn. Whenever the button is pressed, a HIGH logical level is applied to the reset terminal. The output changes from low logical level to High. The alarm latch is simply used for controlling or switching the alarm oscillator.

3.2.4 The Audio Alarm Oscillator

The unit is enabled whenever the pin 12 is at LOW logical level and disabled when the point is relative HIGH. The alarm latch provides the input to the control terminal.
The alarm oscillator generates the needed audio frequencies for the audio alarm effect. Two frequencies are generated from pin 3 and 7 of the leading integrated circuit.

3.2.5 The Low and High comparators

These comparators are designed to trigger an audio alarm whenever the temperature is critically high or low. The outputs of the comparators are up through a 2 input OR gate. The output of the gate is connected to the set input of the alarm latch. The comparator supplies a HIGH logical level to the OR gate whenever the critical condition is reached. A HIGH logical level at the latch set input, makes the output relative low logical level. The leading terminal is connected to the pin 12 of a 4060B audio oscillator integrated circuit.
The comparator works in the same manner as the early comparators. A reference voltage is made for each of the comparators to cause specified switching of the respective devices. One is relative LOW and relative HIGH. The mixed frequencies are connected to an audio alarm amplifier (2SC945). It is connected to a 1 unit 8Ω speaker.

connected to an audio alarm amplifier (2SC945). It is connected to a 1 unit 8Ω speaker. The amplifier is an NPN transistor. The base is connected to the Pin 3 and 7 of the 4060B.

Based on the frequency formula of 4060B the frequency output from pin 3 and 7 are given:

$Fi = F / 2.3 \times 33 \times 10^3 \times 0.001 \times 10^{-6} = 13175.23$ Hz

So that the frequency output from pin 3 is given by

$F_{pin3} = Fi/2^{14} = 13175.23 / 2^{14} = 0.804$Hz and for Pin 7

$F_{pin7} = F1/2^4 = 13175.23 / 2^4 = 823.45$ Hz

The lower frequency causes a switching effect on the larger one so that it results into an alarm effect.

CHAPTER 4

4.1 TESTS AND OBSERVATIONS

The circuit was built on a Vero board. The power supply unit consists of a 12V transformer, the 7805 5V regulator and the rectifying diodes (In 40011).

The temperature sensor, lm 35, provided the sourced input to the circuit. As stated earlier, it produces a 10mV output for every 1°C temperature measurement. This output signal was fed into the four comparators i.e. the 40°C off comparator unit, the 34°C ON comparator unit.

The circuit remained operational within the specified temperature range, going off only when the temperature hit the 40oC mark. An ice cup was then used as the coding agent. The circuit triggered the alarm when the temperature fed to the circuit by the sensor was below the 35°C mark. An external source of heat, in this case soldering iron, when brought close to the original heat source after the heat source had been turned off by the circuit, caused the temperature to go above 40°C. This resulted in the circuit triggering an alarm for above 40°C.

The construction was now housed in a wooden casing with holes for the speaker sound, the power switch and the power ON indicator.

4.2 PROBLEMS ENCOUNTERED

1. Sourcing for some of the components was not an easy task as many as of the readily available components even when they met the required specification were found to be of inferior quality and got easily damaged once they were tested.

2. The alarm sound was not sharp enough. This is as a result of the fact that the circuit has four (4) reference voltages which are relatively low (about 0.4 volts) and the speaker consumes a current that is relatively high. Setting the speaker to have a sharp sound would lead to the instability of the switching relay.

Table 4.1 COMPONENTS USED, DESCRIPTION, QUANTITY AND COSTS

Components	Description	Quantity	Cost (₦)
1. Lm 35	Temperature Sensor	1	120
2. 7805	5V regulator	1	50
3. In 40011	Rectifying Diode	5	5 x 5
4. 2sc 945	NPN transistor	1	10
5. 75Ω	Resistor	1	10
6. 1µF 50V	Capacitor	1	10
7. 100KΩ	Variable resistor	1	10
8. 2200µF 16V	Capacitor	1	50
9. LED	Light emitting diode	1	5
10. 10KΩ	Resistor	2	2 x 10
11. 1 KΩ	Resistor	1	10
12. 12V transformer	Power supply unit	1	50
13. Lm 339	Comparator	1	150
14. 12V relay	Switching device	1	80
15. Power Switch	Switching device	1	40
16. Vero board	Permanent Soldering board	1	150
17. 10 mΩ	Feedback resistor	1	10

4.3 CONCLUSION

The design and construction of a temperature alarm circuit has been found to be relatively simple. The variety of its functions cannot be overemphasized.

With adequate improvement on the noticed lapses, this product will predictably be not just profitable but also very marketable. This is as a result of the fact that there are so many aspects of life in which this project can be utilized.

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