DESIGN AND CONSTRUCTION OF AN AUTOMATIC ROOM HEATER

BY

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2003/15419EE

A THESIS SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER-STATE, NIGERIA.

NOVEMBER, 2008.

DEDICATION

I hereby dedicate this project to the Almighty God , my father above, the creator of Heaven and Earth, the one who moulds and shapes the destines of men; it is him that deserves all thanks and praise. Also to my lovely dearest parents, Mr. and Mrs. Chris Obidike, for the solid foundation they given to me and to my lovely siblings.

DECLARATION

I, Obidike Uchenna Tochukwu, declare that this work was done by me and has never been presented elsewhere for the award of a degree. I also hereby relinquish the copyright to the Federal University of Technology, Minna.

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ACKNOWLEDGEMENT

To my father in heaven, the creator of Heaven and Earth, the one who moulds and shapes the destinies of men; it is you that deserve all the praise and glory, for the favor, protection and honor you have bestowed upon me at this point in my life...God, I bless your name. Jesus, I thank you.

My parents; Mr. & Mrs. Obidike, words are definitely not enough to appreciate and thank you for your prayers, support and the trust you both have given to me. I look at both of you and you give me every reason to want to excel in life, you both undoubtedly are the best. I love you both. My prayer; that I continue to be a source of joy to you.

What can I do without my siblings; Ugochukwu, Ofodile, Ifeoma, Chinenye and Emeka, the five of you are my source of inspiration, my joy and my hope. I love you guys eternally. Together, the six of us are going to affect our generation positively and we are definitely bound to be at the top.

To my amiable, principled and incorruptible Head of Department, Dr. Yunusa Adediran, you are one in a million, I thank you sir for the discipline and sense of responsibility you have instilled in my colleagues and I. God bless you and your family sir.

My project supervisor, Mr. Nathaniel Salawu, meeting you has taken me step closer to my destiny; you are a friend and a brother. I thank you for your assistance, support and encouragement throughout the course of executing this project. God bless you sir.

To the class of 2008 graduates of Electrical and Computer Engineering; the top is where all of us belong; I will definitely miss you all.

Mrs. A. Caroline, my best lecturer in the department, I pray that God bless you and all other lecturers in the department and Mr. and Mrs. Leonard Okpala, God bless you.

Bright, Gozzy, Zizzu, Seun, and Paul (Right wingers crew), Debo, Kaffy, Bola, Abey, Gordons, Efizzy, Femi, Bianca and Anita : we remain friends for life.

ABSTRACT

This thesis: design and construction of automatic room heater was built under the following: LM35, microcontroller, 0804ADC and a relay. This was used to achieve the regulation of the temperature in a room to aid user to live in the normal temperature of human beings.

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CHAPTER ONE

INTRODUCTION

The design and construction of an Automatic Room heater is a device used to provide a simple modern way for human comfort and warmth required in a room with low power consumption and at an affordable price. This model is designed in such a way that any individual can employ its services because it is user-friendly during the cold weather. As it is known that during harmattan and rainy seasons, the room temperature always fall below the normal for human comfort. Therefore, the need for warmth for effectiveness and good health has necessitated the design of this unit. Also, change of environment may require having the device of this nature that is moving from a hot weather to a cold weather [1].

Obviously being one of the people usually affected by the cold weather that actually leads to the development of this idea that is, the design and construction of an Automatic Room Heater at this level. In the same manner, it has been established that human bodies need to be maintained at a certain temperature world wide that is, certain quantity of heat need to be maintained in the body system for it to work properly. This quantity of heat helps to develop ones mental stability especially in a weather friendly environment.

The model converts electrical current into heat by means of heating element that emits radiant energy. The heating element might compose of metal alloy wire embedded in refractory insulation and encased in protective metal. The heating element maintains the room temperature based on the principle of heat transfer that is, a situation where a heated substance will give off heat to another substance at low temperature. The three ways by which heat can be transferred are: Conduction, Convection and Radiation.

Convection method of a heat transfer is the most effective way by which room heater is achieved. Convection can be described as the constant flow of air upward a cross-heated element, the heated air in contact with the heated element expands and raises, cool air flowing in to take its place. However, for this project work, a small fan motor is used to fasten this process of convection, and corresponding gives an effective and balance distribution of heat within the various parts of the room in which the heater is connected.

If it is purposed for industrial use, a blower may be incorporated to convey the heat produced out of the unit, and fan's blades are to increase even distribution of heat in the room [2, 4].

The model has a sensing unit comprising of an LM35 temperature sensor that senses the temperature of the room and automatically trigger the heating element, however current continues or ceases to flow through the heating element whenever the room temperature is below or above the preset temperature respectively. This sensing part of the project is interfaced with and analog-to-digital converter that converts the analog signal to digital. Seven segment displays is incorporated to display the upper and lower preset temperature respectively and the temperature read-out.

1.1 Historical background

Houses that are planned and built, taking into consideration the local climate will be warm and comfortable on cold weather [3].

Generally, people find some conducive more than the other which prompted the early man to look for diverse means of controlling temperature to having the desired temperature in their dwellings. In other words, the warmth and comfort needed were sought by different methods. In early centuries, Man was motivated and found a solution by the use of wood and charcoal in an open fire to provide warmth for his body system as well as his early meal. This simple open fire method was provided with an escape opening for smoke to pass through during the process and this method lasted up till late 19^{th} century world over [3].

Man was also able to develop the use of STOVE and BRAZIER [3] for heating of dwelling places by the ancient Romans which are still in use in some part of the world today through a convection current of the hot air which in turn heats up the room [3].

However, as a result of limitation in the above methods, engineers came together and reasoned about the solution to pollution that are caused by these means therefore chimney was employed to control the smoke and discharge it from our home to our environment through clay bricks. But this combustion gas (CO) is deadly to humans, plants and animals. Also depletion of the ozone layer which is causing hazardous effect that is direct ultra violet rays upon the earth surface [3, 5].

Also this limitation made engineers to sit down further to find a pollution free way of heating a room to the warmth and comfort desired by man and the first generation of heaters were developed though not an invention but to serve as an improvement of its clone.

1.2 Objectives

The main objective of this project is to design and construct an automatic room heating system that is capable of automatically controlling and maintaining the temperature of a room at a particular preset range (upper and lower limit) which can be altered or changed using a switch to a desired range. To reduce the effect of condensation and uncomfortable draughts that can cause structural damage to our property and human physic during this harsh condition, to show how efficient an idea could be achieved using very cheap discrete electronic components to solve a problem to humanity.

Finally, there are many other components that can be use to achieve these objectives listed but however, I preferred and took up this design based on the availability of components, portability, simplicity and this particular design have a very high reliability.

1.3 Methodology

The design and construction of automatic room heater indeed called for severe search for relevant materials and information. These useful information and important facts proffered solution to this particular problem as it affected some specifications of the targeted design.

As a project that entailed putting into functional structure, where it performs function of regulating the desired temperature of a particular environment. The automatic room heater needed to be realized by a simple pattern of design which led to the choice of components available.

The design took off properly, by first designing the block diagram which was achievable for the project design. The circuit diagram of each block was able to be realized followed by the calculations involved at each stage. In line with this, was the implementation of the design on breadboard which entailed several components like (ADC0804) Analogue-to-Digitalconverter, 89S51 microcontroller and LM35 temperature sensor. Preamble tests were not left out which helped to ascertain the workability of the design. Errors were detected and corrected on the breadboard which aided to the final decision taken on the values of the components used.

Followed with this, was the layout and positioning of the components on the veroboard which ensured good space management and wiring. Soldering was subsequently done on the veroboard as well.

Testing was carried out again at the end of the implementation to reassure the efficient and effective functionality of the designed project. The testing corresponded to the various functions of the project like RESET and TURNS ON/OFF of the heater.

1.4 Scope of study

The project work is going to be limited to hot regions in the country and world wide. This design work is targeted at providing a device that could be presented as a final year project. However, a well finished design with a temperature display can profitably be marketed to the general public.

This study is centralized on the area of heat transfer, conversion of one form of energy to another and displayed for the human eye to see.

1.5 Sources of Material

Datasheet of all the IC's used in the project was of good help because it gave a good insight about the property of the IC's and the requirement for good working condition. Studies of textbooks, past project from the departmental and school libraries was very necessary in the design of the power supply and the relay as a power-switching device that controls the operation of the heating element. Journals, magazines and materials from the internet were also employed to make the project a good reference material for people in the department, school and other schools who want to improve on this particular project or simpler ones for the benefit of man in his environment. My colleagues were also good source during times of sharing ideas.

CHAPTER TWO

Literature Review/ Theoretical Background

2.1 Evolution of Room Heaters

The Sauna and the first Sauna heaters where invented in Finland over 2000 years ago, when the Fins discovered the many health benefits of saunas [6]. It was so much a part of their culture that Finnish emigrants took the sauna tradition with them wherever they went in the world, introducing it to other countries and cultures. Since that time, it has become extremely popular all over the globe, while remaining an integral part of life in Finland itself.

The sauna experience is revered and honored in Finland because it provides a number of health benefits, including;

- Relief of muscle soreness
- Cleaning of respiratory system
- Relaxation and stress relief
- Easing of discomfort from arthritis

So how does sauna generate the heat and moisture necessary to make it such an enjoyable experience? [6]

2.1.2 The first sauna heaters

The key to any sauna is the heater, which has evolved tremendously since the first saunas were built into embankments in the ground. Written records dating back to 1112 describe the first saunas as using stones for heaters, with the stones first being heated using a wood fire in a stone store [6]. This method continued to be used as the Finns progressed to above ground saunas built with large logs.

The wood fire method of heating a sauna was a slow, smoky process. It took up to 12 hours to bring the room up to the proper temperature and smoke from the wood fire remained in the sauna itself, turning the inside black with soot. The smoke was eventually vented through a small air hole located in one of the well so that bathers could at last enter the sauna and begin soaking up the benefits [6].

2.1.2 Improvement to the sauna heater

Over time, sauna heater evolved and improved as technology changed. The open wood fire eventually gave way to metal wood stoves that used a chimney to vent smoke to the outside. This type of heater still took a great deal of time to properly heat a room, though, so that the sauna did not truly surge in popularity until the advent of electric sauna heaters in the 1950's [6].

For the first time, saunas could be quickly and easily heated using the convenience of electricity instead of the traditional wood fire. This improvement made it easier to own and enjoy a sauna, helping to spread it even further into the mainstream of other cultures.

Today's sauna heaters still use stones to heat the sauna room, built they can be quite sophisticated in how they heat the sauna, regulate the temperature of the air and the stones, and use energy as efficiently as possible. They transfer heat to your body by using a combination of radiant heat, heat conductive materials and air convection to circulate both heat and moisture [6].

While basic heaters bring a sauna up to temperature fairly quickly, they struggle a bit to keep the air and the stones at the correct temperature in some circumstances.

More advanced sauna heaters have multiple phases of heating control better control the sauna temperature. Some have two sets of heating elements, one of which kicks on when extra heat is needed. Other heaters have separate temperature controls for the stones and the air within the sauna, so that both stay heated properly. There are even heaters that have special lids and fans to help adjust and control heating for a variety of common usage situations [6].

2.2 Description of other relevant works in literature.

In recent years, after the evolution of sauna heaters and the development of man and his environment in Science and Technology, room heaters fabricated nowadays are enhanced and improved from previous ones constructed either by their mode of operations, their circuitry or by their size.

In the year 2000, Ojelabi Bukola Aderemi, a student of Federal University of Technology Minna designed and constructed an automatic room heater control [4] "Unpublished" as a final year project. The mode of operation of the project was based on using a sensing unit incorporated which comprises of quad-comparator LM339 and a thermistor input transducer that senses the temperature of the room and automatically trigger the heating element by a solid state relay. A comparator circuit accepts input of linear voltages and provides a digital output that indicates with one input is less than or greater than the other [4]. The comparator circuit together with the thermistor determines the high or low of the comparator output which is a digital signal that stays at a high voltage level when the non-inverting input voltage goes below the inverting input voltage [4]. This results to the automatic triggering of the heating element by the relay. For the display of the temperature value, a code conversion unit using logic gates interfaced with a single 7 segment display is used.

After criticizing the project work and taking the limitations stated in the project, the following setbacks were realized:

- Thermistors do not have a wide range of temperature values;
- The heating element was not cased thereby making it not safe and not accurate due to the external temperature of the surrounding;
- The device is not user-friendly because the temperature range can not be varied to the user's desire during the time of hot weather.

The improvement made on these setbacks as will be discussed in description of prior work 2 is the use of an LM35 temperature sensor as a transducer instead of a thermistor because of the wide range of temperature sensitivity (-55°C to 150°C) and the wooden casing introduced for more accurate temperature reading.

Another project work, the design and construction of an Adjustable Electric Room Heater [8] "Unpublished" worked on the limitations of the above design.

The project was designed to provide an alternative to local way of room heating by the construction of the wooden casing. The power supply for the control and sensing unit was a regulated 12V D.C supply to trigger most of the major component by a 12V regulator [8]. The sensing unit is made up of an LM35 sensor which provides a precise temperature and prompt isolation of the heating element enclosed in the wooden casing. Also, the control unit is made up of a ramp generator, comparator (NE 555) and a triac instead of the solid state relay for the switching circuit. When the output of the comparator goes high, an NPN transistor is turned "ON" which also switches an opto triac “ON”, thereby switching on an external triac connected to the heating element “ON” and this makes the heating element come on.

When the temperature tends to exceed the present limit, the sensor sends signal via NPN transistor that forces another transistor “OFF” in respective of the output of the [8]. This action switches “OFF” the heating element and comes “ON” again if the temperature drops.

The limitation encountered during this project is that:

- The temperature effect on some of the components used in the control circuit;
- Temperature display was not provided;
- The device is not user-friendly because the temperature range is 23°C – 45°C which can not be altered incase of hot weather;
- Not easy to operate and big in size.

After looking into all this prior works limitations, it posed on me a challenge to work on all the limitations as possible and come out with something that tremendous improvement on the limitations. This improvement and contributions made by me through research works and studies are described below.

2.2.1 My improvement and Contributions over previous Room Heaters

The automatic electric room heater that is designed in this project is similar to previous heaters designed years before now such as Convector heaters, Radiant fires and the prior project described earlier.

Although it differs in the aspects of control and distribution of hot air within the room. The two mentioned above use natural convection current of air to circulate hot air. They also use (in most cases) thermostat control for the temperature regulation. Whereas the electric heater designed in this project is to use a fan for the distribution of the hot air produced by the heating element to the surrounding of the temperature sensor. Then the output of the LM35 is interfaced with a 0804 Analogue-to-digital converter (ADC) that converts the analogue signal from the sensor to digital output and interfaced with a microcontroller. The use of an LM35 temperature sensor, ADC and a microcontroller and are employed for an automatic temperature regulation via a relay used to turn "OFF" and "ON" the heating element connected to it. During the "OFF" state, the fan incorporated with the heating element in a metal casing (advantage over wooden one) acts as a blower which makes the project work a multipurpose one. If the temperature of the surrounding changes and the room temperature drops or rises, the preset range value (lower and upper limits) can be adjusted by the use of an upper and lower mode select via the microcontroller in the device making the project work user-friendly and easy to operate.

Also, a digital display of the present temperature in the room on a seven (7) segment display at any point in time and its simplicity of using only three (3) Integrated Circuits (ICs) to achieve the aim of the project work.

The reason why I used a microcontroller in the automation of this project work is because of the advantage it has over Comparators used in the design of previous project. That is, it is easier to accomplish the purpose and objective than comparators. Not only that, purchasing of this electronic component (Comparators) might not be favorable because most of them are not what is inscribed on them while for microcontrollers, it comes with its family grouping and what is inscribed on it is what it is.

One main disadvantage of using the microcontroller is that you must have acquired the knowledge of writing the programme of how you want it to perform a specific task and how to use a programmer to burn the written programme on the microcontroller and the cost of the programmer is very expensive.

2.3 Theoretical background

Heat is the most common form of energy and because changes of temperature have great effects on our personal comfort and on the properties of substances, such as water which we use everyday [7].

Electric heating is best explained by first understanding the concept of the term “heat”. This is because, the primary aim of an electric heating is to convert electrical energy to a certain quantity of heat for the usage of man and his environment. The heat generated is usually maintained at a particular temperature depending on the particular purpose for it at that time.

2.3.1 Heat: - Heat in physics is defined as energy in transit [4]. Generally, heat is a form of energy associated with the motion of atoms, molecules and other particles which comprises matter. Heat can be created by chemical reaction (such as burning), nuclear reaction (such as fusion taking place inside the sun), electromagnet dissipation (as in electric stores or heater), or mechanical dissipation (such as friction) [4].

The area of interest here is the thermoelectricity which is caused by the relationship between electrons, heat fluxes and electrical currents. Also heat can only be radiated as a result of the movement of atom and molecules in a material [4].

It is one of the valuable features in electricity and there is no way the concept of the term “heat” is discussed well without citing out these quantities and the aspect of heat.

2.3.2 Temperature: - is a scientific quantity which corresponds to primary sensations (hotness or coldness) [7] that is it is the measures of the quantity of heat and is recorded in the lower ranges by thermometers e.g. mercury- in- glass thermometer and Pyrometers used for higher temperature measurement [8].

In other words, heat does not flow from a lower to a higher temperature, unless another form of energy [2].

Common scales of temperature are:

Temperature in degree Celsius (^{0}C) = (^{0}F – 32) x 5/9 (2.0)

Temperature in Fahrenheit (^{0}F) = 9/5 ^{0}C + 32 (2.1)

The absolute scale of temperature = Kelvin (K).

It can be deduced, that temperature is analogous to electrical potential in electricity and heat is analogous to quantity of electricity. We can detect temperature changes, and whenever the temperature of a body rises, that body has gained heat. The converse is not always true, when a body is melting or boiling, it is absorbing heat from the flame beneath it to change its solid or liquid state but its temperature is not rising [5].

2.3.3 Heat Transfer: - is the science which seeks to predict the energy transfer (from higher temperature to lower temperature) which may take place between material bodies as a result of a temperature difference [9]. Thermodynamics teaches that the energy transfer is defined as heat. The science of heat transfer seeks not merely to explain how heat energy may be transferred, but also to predict the rate at which the exchange will take place under certain specific conditions [9]. The fact that a heat transfer rate is desired objective of an analysis points out the difference between heat transfer and thermodynamics.

The three modes by which heat can be transferred are:

1. Conduction: mostly in solids
2. Convection: in liquids or fluids e.g. air
3. Radiation: between mediums that are not physically connected by one another [9].

2.3.4 Conversion of Electricity to heat

Power can be defined as the "rate of doing work" or the "rate of expending energy" [10].

Electrical Power (P) is equal to the amount of electrical energy per unit time.

That is: $P = VIt / t = VI$ (2.2)

where V is the voltage drop in the conductor and I is the current in Amperes [10].

From ohm's law; $V = IR$ (2.3)

where R is the resistance of the conductor.

substituting equation (2.2) into (2.3)

Then, $P = I^2R$ (2.4)

This energy is converted into heat, which raises temperature of the conductor. As the conductor gets hot, it gives off some of its heat to the surrounding atmosphere or substance [11].

The design and construction of an Automatic Room Heater was divided into seven (7) modules as shown in Fig 2.1

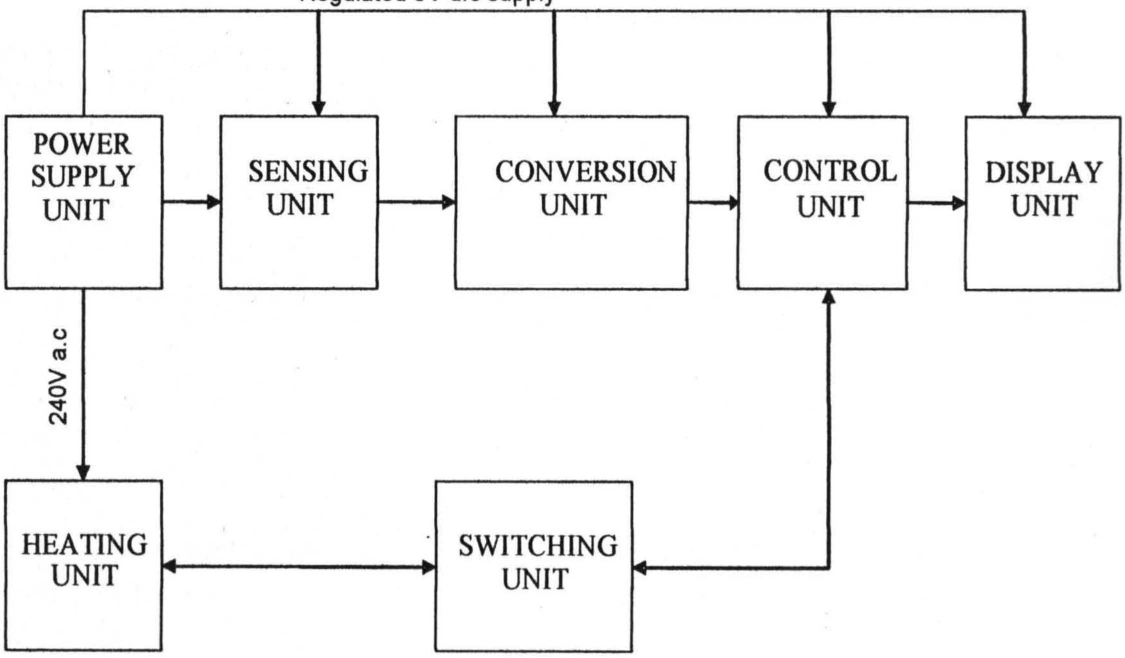

Fig 2.1: Block Diagram of an Automatic Room Heater

CHAPTER THREE

Design and Implementation

3.1 The Component Choice and Description

The design and implementation of this device were greatly influenced by the choice of component and the need to produce the device at a very low cost as possible without compromising either functionality or efficiency whilst utilizing easily available, affordable and durable components.

The circuit is designed and constructed with the following electronic components list below:

1. 12V/0.5A step down transformer
2. IN5392 Diodes
3. Capacitors
4. Resistors
5. 5V/1A 7805 regulator
6. 2SA1015GR Transistors
7. Light Emitting Diode (LED)
8. Relay Switch
9. Seven Segment Display
10. LM35DZ Temperature Sensor
11. 8-bit 0804 Analogue-to-Digital Converter (ADC)
12. 89C51 Microcontroller

3.1.1 Transformer

A transformer is a static (or stationary) piece of apparatus by means of which electric power in one circuit is transformed into electric power of the same frequency in another circuit [12]. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. The working principle of a transformer is the principle of electromagnetic induction that is if one coil is connected to a source of alternating voltage (primary winding) an alternating flux is setup in the laminated core, most of which is linked with the other coil (secondary winding) in which it produces mutually induced e.m.f . The physical basic of a transformer is mutual induction between two circuits linked by a common magnetic flux [12]. Fig 3.1 shows the symbol of a transformer

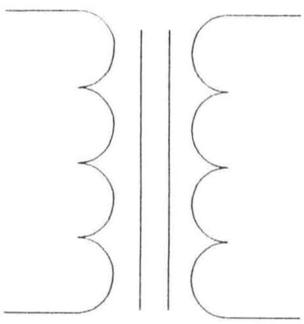

Fig 3.1 Circuit symbol of a transformer

Transformers are of two types namely;

i. Step-Up

ii. Step-Down

The transformer used in this project is a 12V/0.5A step-down transformer stepping down 220V a.c from P.H.C.N to 12V a.c output.

3.1.2 Diodes

It is a two terminal device consisting of P-N junction formed either in Ge or Si crystal [12] that allows the passage of current in only one direction. The diode most commonly used in electronic circuit today is semiconductor diodes.

The diode used in this project design is the IN5392 diodes. The symbol of a diode and its circuit symbol are shown in Fig 3.2.

Fig 3.2: Schematic symbol of a diode and its circuit symbol

3.1.3 Capacitors

Capacitor; or any electrical condenser is a device for storing an electrical charge. In its simplest form a capacitor essentially consists of two conducting surfaces separated by a layer of an insulating medium called dielectric [12]. The purpose of a capacitor is to store electrical energy by electrostatic stress in the dielectric (the word 'condenser' is a misnomer since a capacitor does not 'condense' electricity as such, it merely stores it) [12].

When one plate is charged with electricity from direct current or electrostatic source, the other plate will have induced in it a charge of the opposite sign that is, positive if the original charge is negative and negative if the charge is positive. The electric size of a capacitor is its capacitance, the amount of electric it can hold.

Capacitors are limited in the amount of electric charge they can absorb; they can conduct direct current for only an instant but function well as conductors in alternating current circuits. This property makes them useful when direct current must be prevented from entering some part of an electric circuit. Fixed-capacity and variable-capacity capacitors are used in conjunction with coils as resonant circuits in radios and other electronic equipment. Large capacitors are also employed in power line to transmit more power [13].

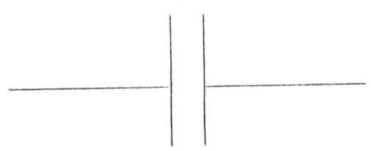

Fig 3.3: Circuit symbol of a capacitor

3.1.4 Resistors

They are component of an electric circuit that resists the flow of direct or alternating electric current. Resistors can limit or dive the current, reduce the voltage, protect an electric circuit, or provide large amount of heat or light [13].

An electric current is the movement of charged particles called electrons from one region to another. The amount of resistance to the flow of current that a resistor causes depends on the material is made of as well as its size and shape.

When a voltage or electrical potential, is applied to opposite ends of a circuit, it causes current to flow through the circuit. As the current flows, it encounters a certain amount of resistance from the conductor and any resistor in the circuit. In any electric circuit, the current in the entire circuit is equal to the voltage across that circuit divided by the resistance of the circuit. Resistors are often made to have a specific value of resistance so that the characteristics of the circuit can be accurately calculated [13]. The symbol circuit of resistor is shown in Fig3.4

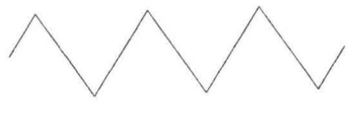

Fig 3.4: A circuit symbol of a resistor

3.1.5 Regulators

A regulator is a controller designed to maintain the state of the controlled variable despite fluctuation of the load [14]. It is also used to remove the last of the ripples in the output from the rectifier.

In this design, the voltage regulator used is a 7805 regulator which keeps the terminal voltage of the d.c supply at 5V even when a.c input to the transformer varies.

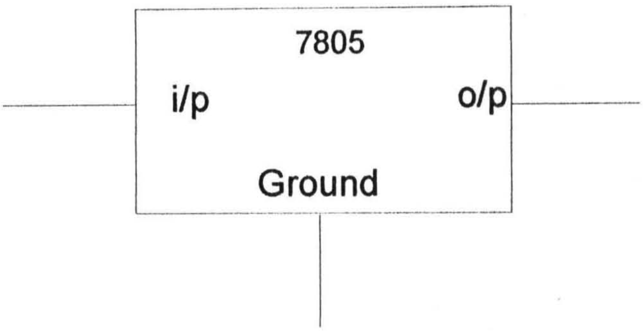

Fig 3.5: A schematic symbol of a 5V regulator

3.1.6 Transistors

The transistor is a three terminal semiconductor device usually manufactured from either Silicon (Si) or Germanium (Ge). Transistors are typically used in amplifying electrical signals and in circuit switching. There are two main categories of transistors;

- Bipolar Junction Transistors (BJT)
- Field Effect Transistors

The BJT is combination of two junction diodes and is available in two conventions; NPN and the PNP [15]. They conduct by using both majority and minority carriers. Fig 3.6 shows the two types of transistors we have and their symbol.

Fig 3.6a: Schematic symbol and circuit symbol of a PNP transistor

Fig 3.6b: Schematic symbol and circuit symbol of an NPN transistor

3.1.7 Light Emitting Diode (LED)

This is a type of diode that has a forward biased PN-junction which emits visible light when energized. The LED in this design is used to indicate when the heating element is ON. Anytime it is ON, the heating element connected to the switch has been turned ON and when it is OFF the heating element is not functioning. Fig.7 shows a typical circuit symbol of an LED.

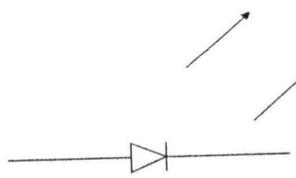

Fig 3.7: A circuit symbol of an LED

3.1.8 Relay Switch

In the electrical world, relays are elect mechanical device that use electromagnets to operate other switches and circuit. The relay was invented by Joseph Henry in 1835 [16]. Since relay can control output circuits that are of higher power than the input circuits, they are often considered, in a broad sense, to be type of electrical amplifiers.

A relay has a coil and a spring-loaded armature in the circuit. When an electrical current is passed, a magnetic field is induced and it attacks the armature that touches the contact. When the current is stopped, the spring-loaded armature goes back to its original position. There are some latching relays that require a second coil to reset the contact position. By analogy with the functions of the electromagnetic device, solid-state relay operates a thyristor or other type of solid-state switching device with a transformer or LED to set it off.

There are three types of relay contacts namely:

- Normally-closed Contact
- Normally-open Contact
- Change-over Contact

For this design, the relay used is a change-over contact that is, it controls one normally open contact and one normally closed contact. When the relay is activated, it is normally open and deactivated when normally closed.

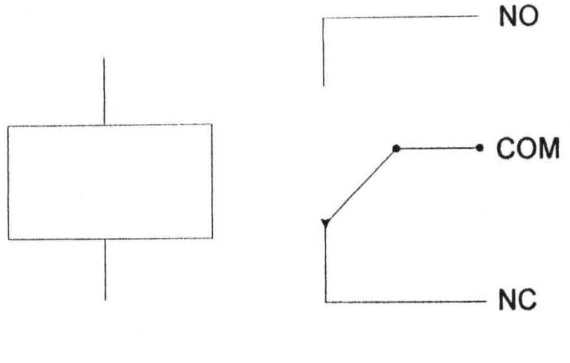

Fig 3.8: Schematic symbol of a Change Over relay

3.2 Design Analysis

The automatic room heater is made up of the following units presented below;

1) Power Supply Unit
2) Sensing Unit
3) Conversion Unit
4) Control Unit
5) Switching Unit
6) Heating Unit
7) Display Unit

3.2.1 Power Supply Unit

The power supply unit comprises of a step-down transformer, an a.c rectifier circuit that serves as the source of supply to all unit except the heating unit which takes its supply without stepping-down the a.c source that is, 240V for it to be operational. The operational voltage for all units except the heating unit is 5V d.c supply. This was derived from a 12V/0.5A step-down transformer connected to a bridge rectifier. From fig 13, D1 and D2 conduct on positive half cycle, while D3 and D4 conduct during the negative half cycle. Therefore, the rectified load current flows during both half cycles. D1 and D2 are forward biased, thus produces a positive load voltage. Fig 3.9 is the power supply of 5V used for operation of all units except for heating unit

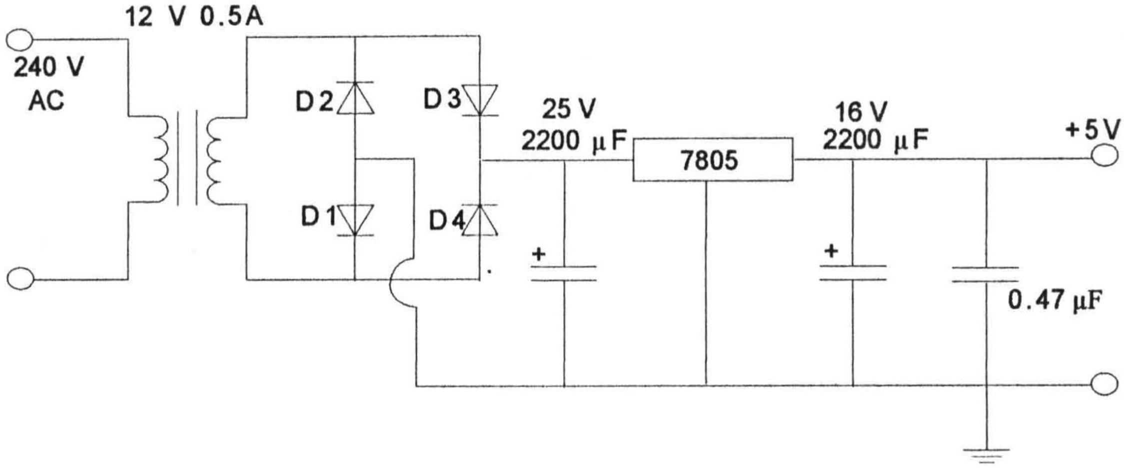

Fig 3.9: A 5V System D.C Supply

Mode of operation: - The 240V a.c main was stepped-down using 240V/12V step-down transformer and rectified with the help of a full bridge rectifier. A capacitor of 25V/2200μF was used to smooth the d.c output voltage that has a.c ripples. The rms value of the induced e.m.f in the primary wing is from the Universal law of transformer which is stated as:

$$E_1 = 4.44fN_1\theta m \quad (3.0)$$

$$E_1 = 4.44fN_1IBmA \quad (3.1)$$

Similarly, rms value of the induced e.m.f of the secondary winding is

$$E_2 = 4.44fN_2\theta m \quad (3.2)$$

$E_2 = 4.44fN_2IBmA$ (3.3)

Comparing equations (3.0) and (3.2), we have;

$E_2/E_1 = N_1/N_2 = K$ (3.4)

where K is a constant called voltage transformation ratio.

From equation (3.4), if $N_2 < N_1$ i.e. $K < 1$ then it is a step-down transformer.

Also, for and ideal transformer

Input VA = Output VA

$V_1/I_1 = V_2/I_2$ (3.5)

$V_1/V_2 = I_2/I_1 = 1/K$ (3.6)

In this design, a step-down transformer with the following characteristics was employed;

i) Primary voltage $V_p = 240V$

ii) Secondary voltage $V_s = 12V$

iii) Secondary current is = 500mA or 0.5A

Using the transformer formula;

$V_p/V_s = I_s/I_p$ (3.7)

Make I_p subject of formula (where the I_p = the primary current)

$I_p = V_s I_s/V_p$

$I_p = 12 \times 500/240$

$I_p = 25mA$

This indicates that the transformer is a step-down with rating 240V, 25mA / 12V, 500mA

Rectification: - The 12V a.c was rectified into a peak amplitude d.c voltage.

$V_{rms}\sqrt{2} - 2V_f$ (3.8)

$\sqrt{2}$ = rms – to – peak conversion factor.

V_f = Forward voltage drop in two adjacent diode pair and is as 0.7

For a 12V rms,

The peak amplitude of the d.c voltage is

$$V_{peak} = 12\sqrt{2} - 2(0.7) = 15.57V \qquad \text{(from equation (3.8))}$$

Also $I_{peak} = I_{rms}\sqrt{2}$ (3.9)

$$I_{peak} = 500\sqrt{2}$$

$$I_{peak} = 707mA$$

Filtration: - The d.c voltage was smoothened by a minimum capacitance of value deduced from:

$$C = I\,t/V \tag{4.0}$$

where I = maximum load current

t = period of the unsmoothened d.c voltage

V = maximum a.c ripple voltage superimposed on the d.c voltage

The maximum load current was computed from the summation of the current drawn by the different unit except the heating unit.

i) ADC0804 – 5mA

ii) AT89C51 – 15mA

iii) Relay – 15mA

iv) Display – 320mA

$$\sum I = 360mA$$

For a regulated system supply voltage, the minimum input into the regulator is

$$V_{d.c} - (V_{out} + 2) \tag{4.1}$$

where "2" in the equation is the minimum output – input differential voltage for the 7805 regulator used.

therefore, the maximum ripple voltage is thus:

$$15.57 - (5 + 2) = 8.57\text{V}$$

From equation 3.9,

$$C = \{0.36 \times (1/\{2 \times 50\})\}/8.57$$

$$C = 0.0036/8.57$$

$$C = 0.00042007\text{F} \approx 420.07\mu\text{F}$$

A value of 2200μF was used to improve specification at low a.c line voltages.

The smoothened d.c voltage was regulated down to +5V by a 7805 5V/1A regulator device as depicted in Fig 3.10.

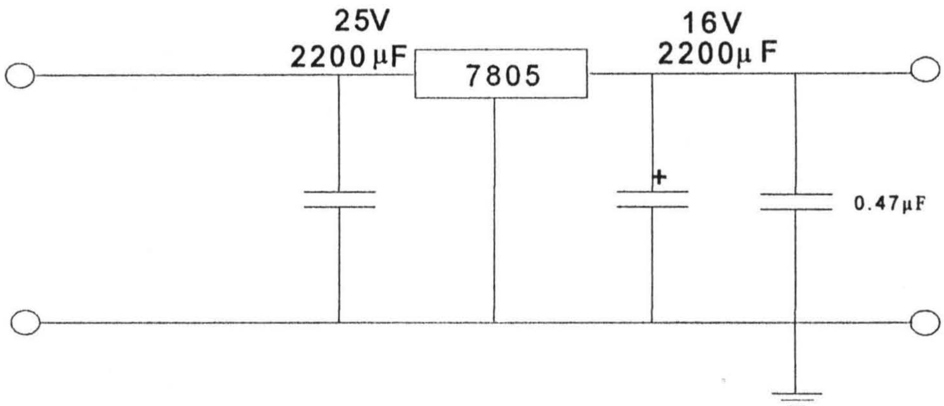

Fig 3.10: A regulated 5V circuit.

3.2.2 Sensing Unit

This unit is made up of an LM35 temperature sensor which is a precision integrated circuit temperature-to-voltage converter that gives an output of 10mV per degree centigrade. It was used as the intermediate front-end between the ambient surrounding and the digital system. The LM35DZ series was used as the temperature

Sensing device and it has a sensing range of 0°C-100°C with a typical guaranteed accuracy of 0.5°C.

The device was interfaced to an 8-bit Analog-to-digital Converter (ADC0804) that translated the analogue temperature dependent output voltage to a digital value that can be processed by the microcontroller. The sensor's output was stabilized by a 100μF capacitance in parallel with a 47KΩ resistance to prevent against too much of rapid fluctuations in the displayed temperature reading as shown in Fig 3.11.

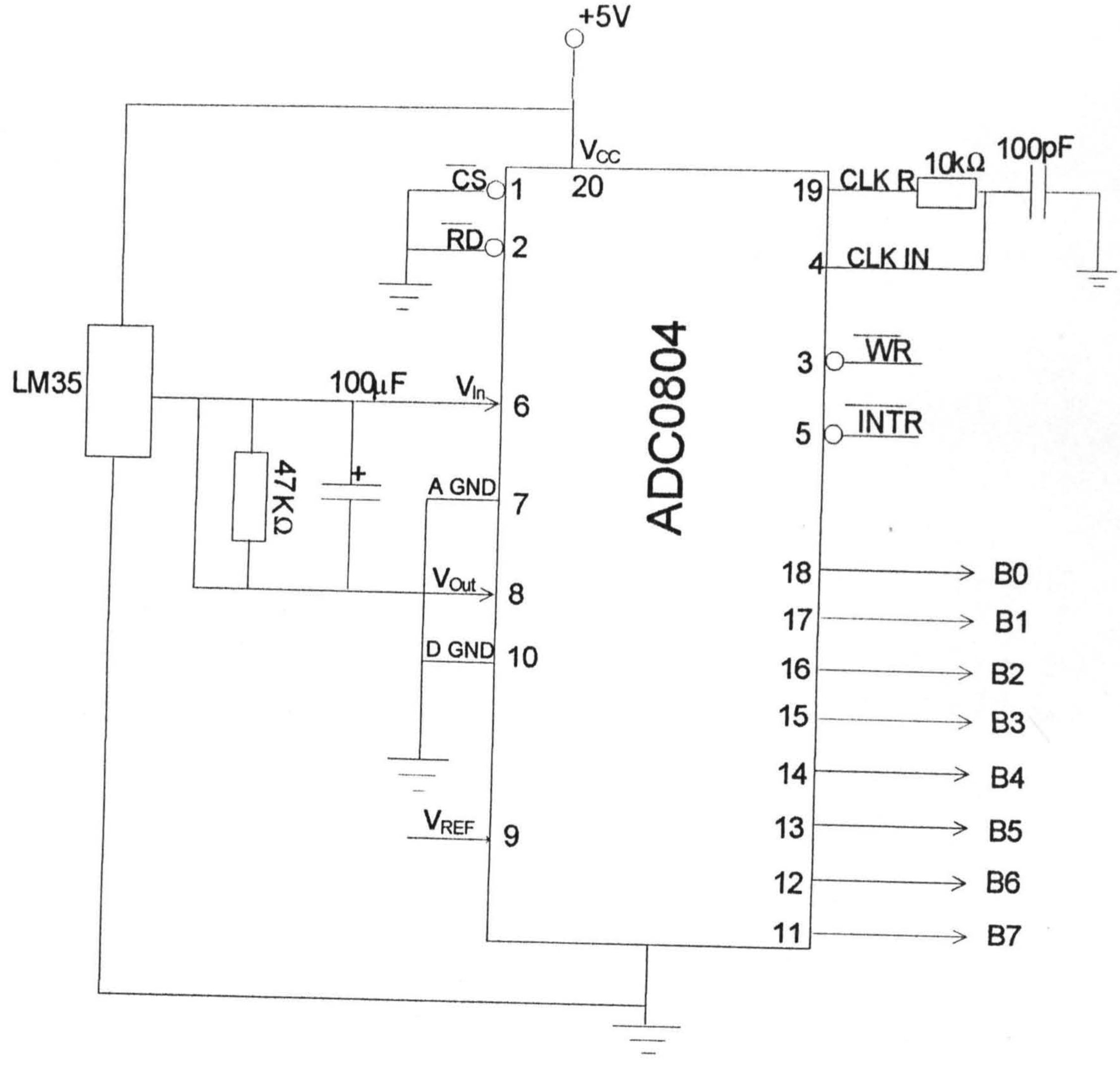

Fig 3.11: LM35 interfaced with an ADC0804 Converter

3.2.3 Conversion Unit

An 8-bit analog-to-digital converter was used for converting the sensing unit output analogue voltage to a digital value. An 8-bit device was used since the analogue voltage does not have a wide dynamic range. The device has the specification stated below.

It was run off a clock source of value deduced from the expression

$$F = 1/1.1RC \quad (4.2)$$

where R = Resistance between pin 1.9 and pin 4

C = Capacitor from pin 4 to ground.

The device has a specified minimum frequency of 100KHz and a maximum of 1.46MHz. The analogue-to-Digital Converter clock was chosen to be about 500KHz.

Make C the subject of formula in equation 4.2 then substitute the values of R and F

R is typically $10{,}000\Omega \approx 10K\Omega$, F = 500KHz

$$C = 1/1.1RF \quad (4.3)$$

$$C = 1/(1.1 \times 10 \times 10^3 \times 500 \times 10^3)$$

$$C = 1.8182 \times 10^{-10}\,F \approx 181.82pF$$

In this design, the interfacing the ADC to the microcontroller, the CS-bar line (CS – Chip Select) is connected to ground to permanently enable the Chip. The INTR- bar line goes low once a conversion is complete, therefore it is connected to port 3.1 one of the external interrupt pins on the microcontroller which will interrupt the microcontroller when a conversion is complete and hence ready for reading.

The data lines are tri-state (hence the inverted triangle symbol) which are connected to port 1 and only when the conversion is complete that RD-bar port (Read

Data line) enables the tri-state outputs at logic 0 and the analogue conversion appear on port 1 of the microcontroller. Conversion was effect by pulsing WR-bar port (Write Data line) low and then high and is complete after 100μs.

The ADC was setup for a full-scale analog input voltage of 2.56V corresponding to a maximum input of 2.56V. Although the sensor is only capable of producing 0V to 1.00V, corresponding to 0°C-100°C sensing range.

3.2.4 Control Unit

This is the main unit of this design. An 8-bit microcontroller (AT89C51) was used as the system controller. For maximum and good functionality of this AT89C51, the datasheet was adopted as a guide during the project. Also, because of its RAM space and flexible input/output characteristics, this device was adopted.

The controller was interfaced with other system components as shown in Fig 3.12

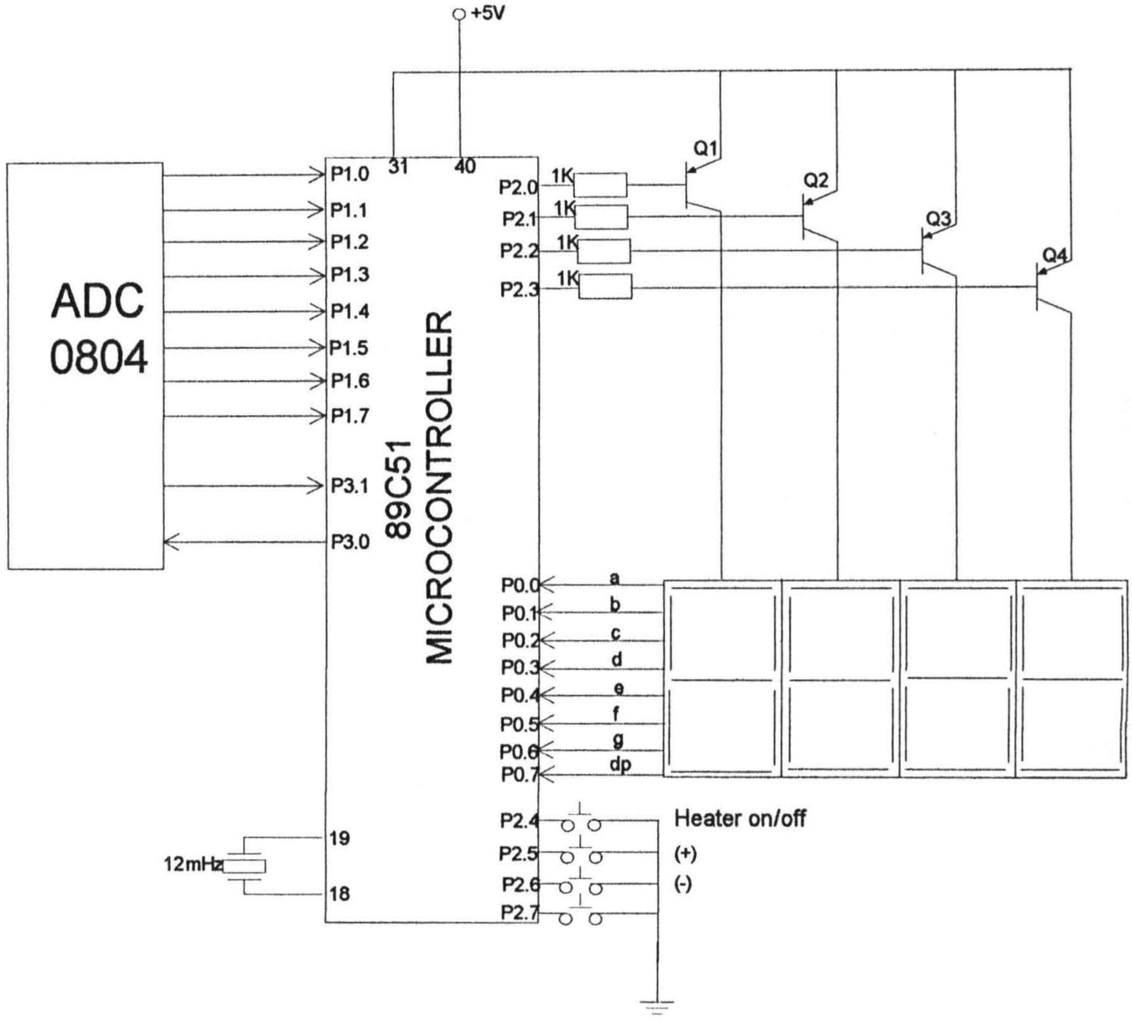

Fig 3.12: ADC0804 Converter interfaced with an 89C51 Microcontroller

The 89C51 microcontroller performed the following function

i Controlled the Analogue to Digital conversion process via the ADC0804

ii Responds to user inputs via the input keys interfaced to port 2

iii Controlled the 4-digital common anode 7-segment display on port 0 via four PNP digit drivers interfaced to port 2.

The 12MHz crystal was connected normally to the microcontroller to yield an effective instruction cycle time of 1μs. This device executed the system control software written and burnt in the 89C51 to effect the basic system functionality as stated below;

1 System initialization

2 Analogue-to-Digital conversion

3 Computation of the ambient temperature from the ADC output

4 Comparism of the ambient temperature with the high/low user set limits

5 Scanning the three input keys for inputting user settings

The control software was provided with a user interface that allowed setting of the upper and lower switching thresholds. Two buttons were provided for up/down adjustment of the either the upper or lower limit, a third button was provided for selecting either the upper or lower limit. The heater ON/OFF was provided via a fourth input key to manually control the heater state.

3.2.5 Switching Unit

A 6V/10A d.c relay was used to provide ON/OFF switch for the connected heating element. The switch was controlled by a PNP silicon transistor interfaced with Port pin 3.4 as shown in Fig 3.13

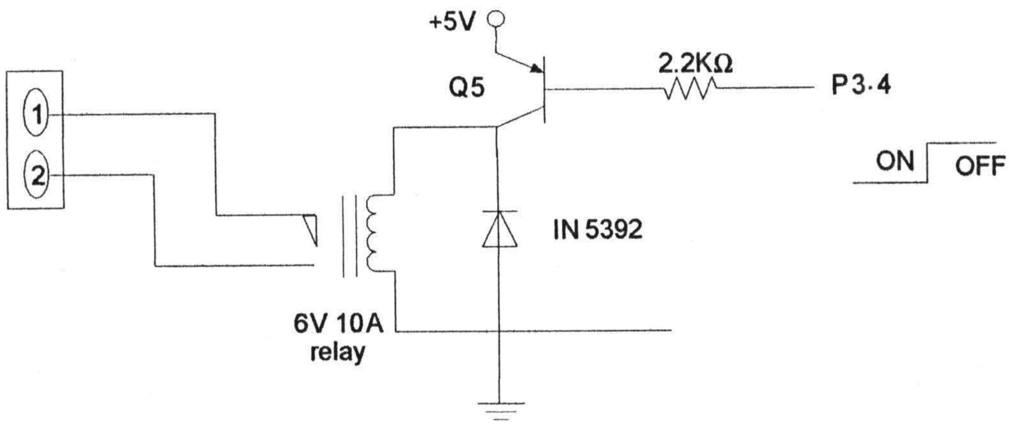

Fig 3.13: The switching unit circuit interfaced with Port 3.4

The relay was either ON/OFF depending on the logic result of the comparism made on the value of the detected ambient temperature, upper temperature limit and lower temperature limit.

The d.c relay had a coil resistance of 400Ω, requiring a coil of energizing current of;

$$V/R = I_C \text{ of } Q5 \quad (4.4)$$

$I_C = 6/400$

$I_C = 15mA$

Also, $I_{B\,(Q5)} = I_C/H_{fe}$ (4.5)

where H_{fe} Q5 has a typical value of 200

$I_B\ (Q5) = (1.5\times10^{-2})/(2\times10^{2})$

$I_B\ (Q5) = 0.75 \times10^{-4}A$

$I_B\ (Q5) = 75 \times10^{-6}A \approx 75\mu A$

then from the formula,

$$R_B = (V_{CC}-V_{BE})/I_B \quad (4.6)$$

and $V_{CC} = 5V$, V_{BE} typically $= 0.7V$, $I_B = 75 \times 10^{-6}A$

substituting the values in equation (4.6)

$$R_B = (5 - 0.7)/7.5 \times 10^{-6}$$

$$R_B = 5.6 \times 10^5 \Omega$$

The value was reduced to 2.2KΩ in the design for overdrive and guarantee reliable switching at all possible system operation states.

The measured ambient temperature was compared with the upper limit. If the ambient temperature is greater than the upper, the heater is turned OFF. The heater remains off until the detected ambient temperature falls below the lower limit at which the heater is turned back ON.

This hystersis effect prevents system instability and ensures a stable system operation.

3.2.6 Heating Unit

This unit is made up of a heating element that takes its power supply direct from a.c source of the power supply unit because of the rating of the heating element and a d.c fan that its source is a stepped down and rectified 12V.

The unit produces the heat through the heating element and the fan helps to concentrate the heat to the surrounding, to increase the temperature around the temperature sensor easily and when the heating element goes OFF, the fan will just act as a blower to the surrounding and it is controlled by the control unit that is the relay.

The software heater ON/OFF was provided via a further input key to normally control the heater state.

3.2.7 Display Unit

In this unit, a 4-digit seven segment common anode display was interfaced with the controller for visual display of the system status over P0. The display digits were controlled by software written on the microcontroller via four PNP digit drivers connected to P2.0-P2.3. The display was multiplexed to reduce the amount of wiring needed to interface the display to the controller.

The separate digits were controlled by individual PNP digit drivers as in Fig 3.14

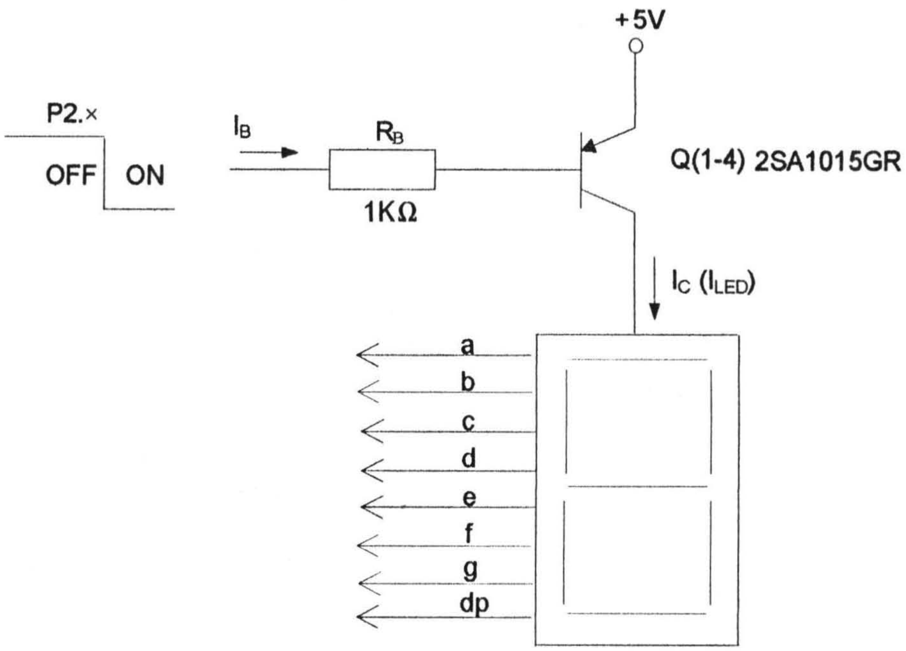

Fig 3.14: A separate digital common anode 7-segment display

The transistors used have an H_{fe} of 200 typically. For an n-digit multiplexed display, the peak forward current through each segment is $n \times I_C$ for actual brightness. I_C, for a 4-digit display with each LED operated with a steady forward current of 10mA, a 40mA peak current is required through each segment.

The total digit current is thus;

$I_C = 40mA \times 8$ (8 LED segment)

$I_C = 320mA$

Recall, equation (4.5)

$I_B = I_C/H_{fe}$

$I_B = 320/200$

$I_B = 1.6mA$

R_B, the value of the base resistance was deduced using equation (4.6)

where $V_{CC} = 5V$, $V_{BE} = 0.7$, $I_B = 0.0016A$

$R_B = (5 - 0.7)/0.0016$

$R_B = 4.3/0.0016$

$R_B = 2.7K\Omega$ (A $1K\Omega$ value was used)

No current limiting resistance was used to limit the forward current through the segment as the software was written to pulse current through the segments for only about 1ms. This allowed a greater simplicity of the design and component minimization.

A display refresh involves the following under listed sequence of software events;

1 Turn-off all digit drivers (Q1-Q4)

2 Write seven segment code value of display to the common data port (P0)

3 Turn-on the digit driver associated with the desire digit position

4 Delay for visibility

5 Turn-off the digit driver turned on

6 Repeat sequence (1-5).

The above loop was done at a high rate, such that the human eyes are not able to visualize it since the human eyes can only see changes at 32Hz. The software tuned to provide a display refresh of about 150Hz.

Though the digit are turned ON/OFF in sequence, the illusion of persistence provides an apparently continuously on display for a refresh rate greater than 50Hz.

The complete circuit diagram of An Automatic Room Heater is shown in Fig 3.15

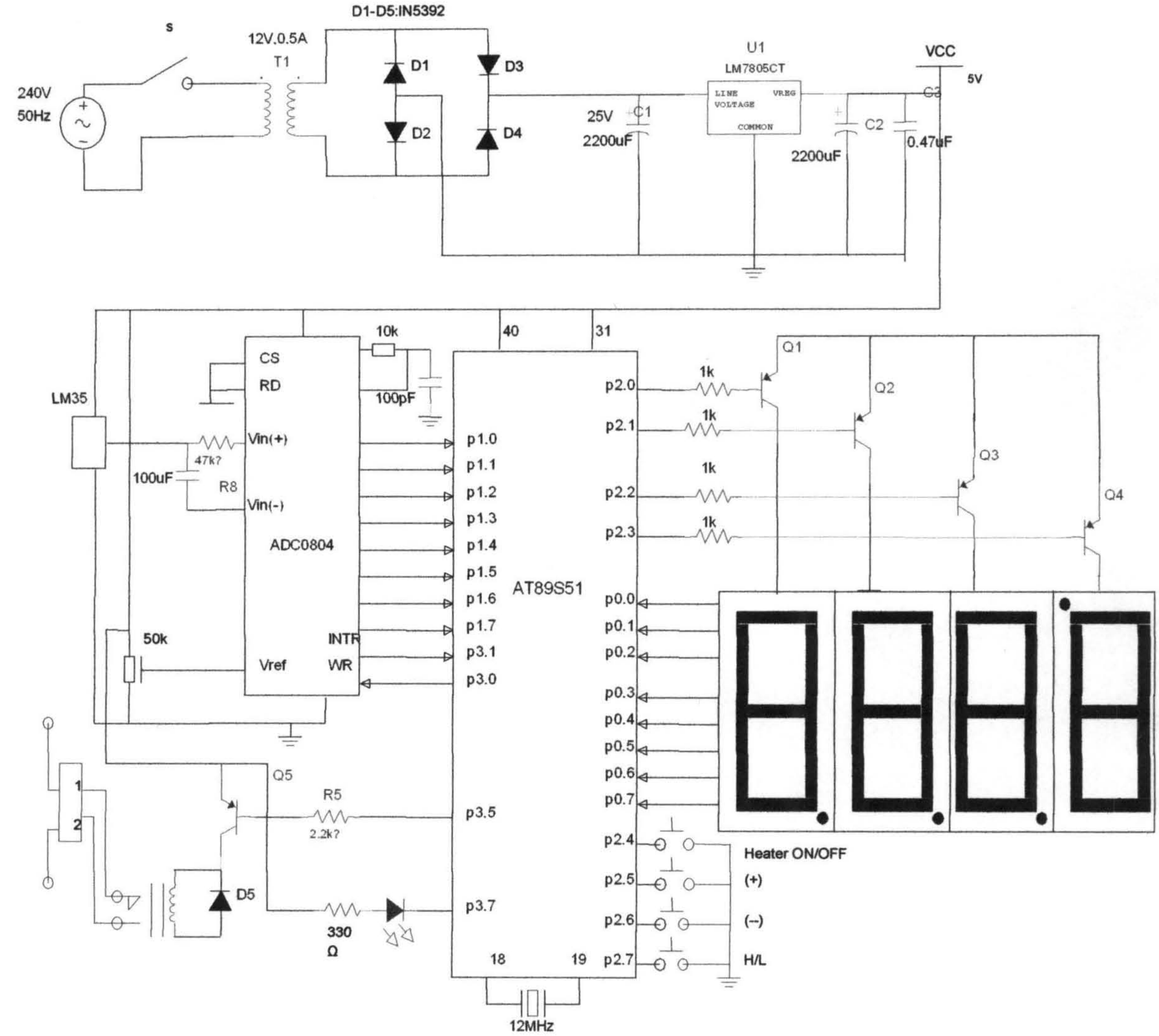

Fig 3.15: A Complete Circuit Diagram of an Automatic Room Heater.

CHAPTER FOUR

Construction, Testing and Result

4.1 Construction

This project consists of two parts in terms of construction namely:

i) Circuit Construction

ii) Heating Case Construction

4.1.1 Circuit construction

This part of the project involved practical exercise on making the circuit diagram on the paper into a real working hardware. The specified components in the circuit design were carefully connected together under the guide of the circuit diagram. The breaking of the complete circuit that was involved during the design analysis was of great important of the construction because each unit was executed one after the other. The circuit construction was made of ceramics.

Most of the equipment tools used during construction work is listed below:

1) Vero board

2) Copper Wire and a Plier

3) Soldering Iron, Lead and Suction

4) Glue and Razor blade

5) Plastic and Metal sheath

6) Digital Multimeter

During the circuit construction process before mounting any component, each component's terminals and functionality are verified. Interconnections were made through etching of the Veroboard and the use of insulation copper wire to avoid shortcircuiting. All excess wires were neatly clipped off with a plier making sure that all of soldered connections were properly made. The components were laid out on the Veroboard with enough space to give room for ventilation, troubleshooting and replacement of fault components.

The power supply unit was quite delicate during construction and was properly checked for short circuit and unwanted bridges.

Fig. 4.1 shows all the components on veroboard used in the design of this project.

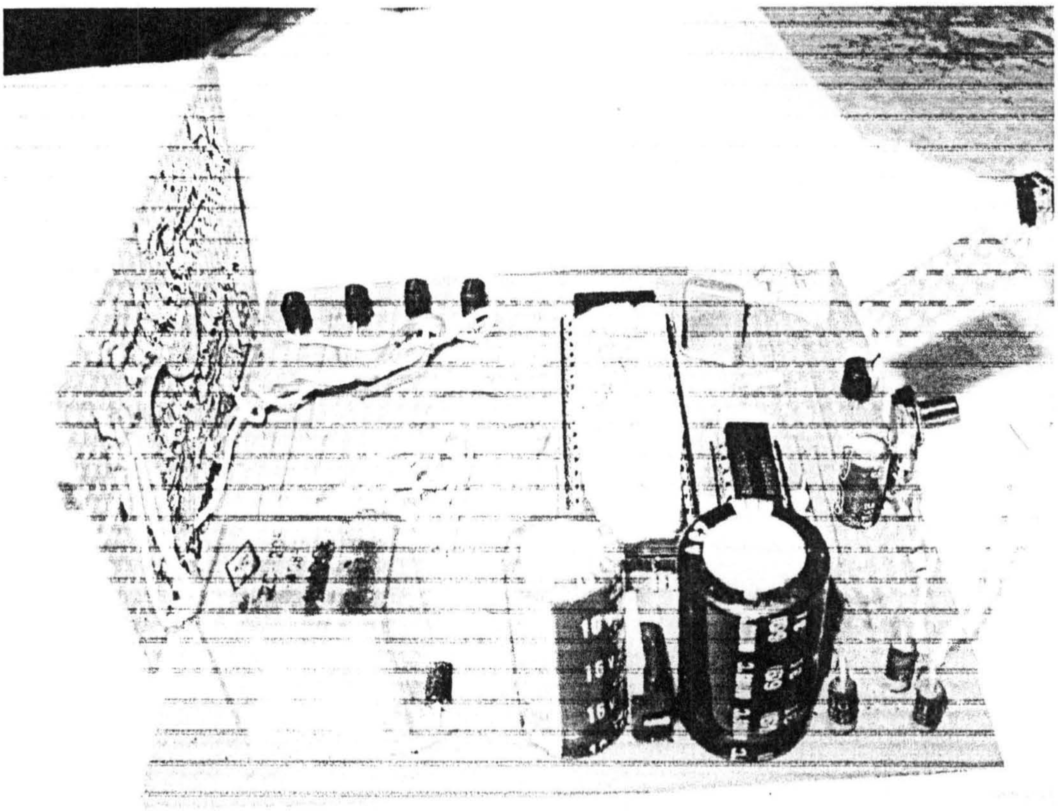

Fig 4.1 Construction work on the Vero board

4.1.2 Heating Case Construction

The case consists of a step-down transformer, 4-diodes for rectification, a d.c motor fan and a heating element.

For maximum conduction and circulation of heat from the case construction, a metal casing was employed and a d.c fan to concentrate the heat produced by the heating element directly to the LM35 respectively.

The step-down transformer steps down the a.c supply from PHCN and it is being rectified before powering the d.c motor fan. But, the heating element is powered from the circuit.

The d.c motor fan was mounted directly at the back of the heating element. It was fixed on three separate small sheath of metal and firmly tightened by copper wires. The dimension of the casing is (19.5×22×21) cm and all parts of the casing were connected together by screws. Fig 4.2 shows the stages of construction of the heating element.

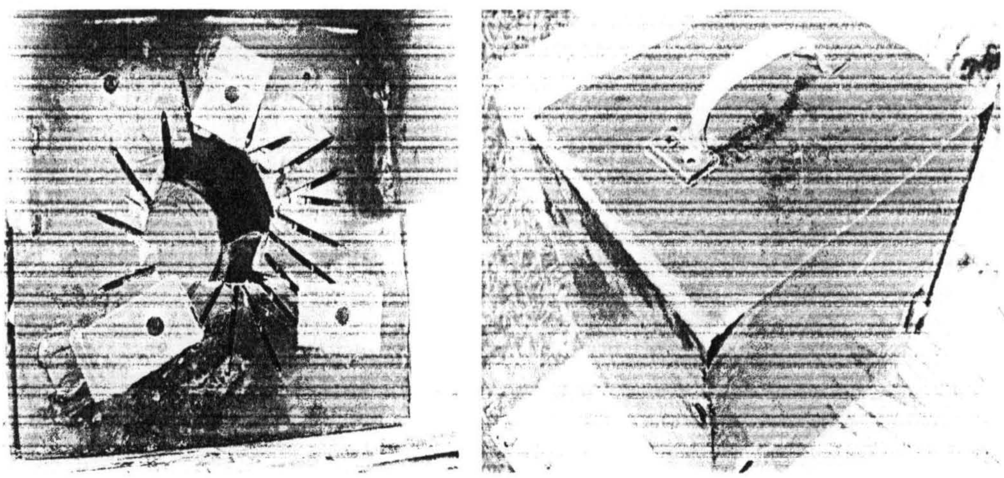

Fig 4.2 Construction of the Heating Case Unit

4.2 Testing

The purpose of every engineering project is to solve a problem, to achieve a particular set objective. In science and technology, testing is an important procedure employed for the effective presentation of genuine result. When testing is correctly concluded, absolute theories are confirmed and effective result obtained. On this basis, proper testing was ensured at various stage of construction to enable proper execution of the project.

All components excluding I.C's were tested immediately after purchase to determine their operability and confirm stated values. The testing was carried out by using a digital multimeter so as check its response and performance with the aim of the project.

Firstly, continuities of copper wires used in the construction were tested. The plugging of the device to the a.c mains supply and powering it ON by the use of the power switch and getting the required output voltage measured approximately 12V as expected, the output of the regulated voltage as approximately 5V and the desired output at each unit were tested using a digital multimeter.

When switched ON, the system displays the temperature of the room at that moment and having a preset lower and upper limit temperature range of 20°C – 40°C. For test, the temperature of the room at that time was 30°C so, a range was set for the lower and upper limit as 30°C – 35°C and it worked. That is, cuts off the heater at higher limit and turns it on at lower limit via a relay in the circuit. Other ranges were tested.

Now testing for lower temperature values less than the room temperature say 25°C or less, the use of an ice block was needed for the test as an example in colder regions or during rainy season.

4.3 Result

The result obtained at the end of repeated tests was found to be consistent and matched up to expected results. Thus, following the construction of this project, the desired aim of this project was achieved.

The switching ON and OFF of the heating element and the display of values by the display unit performed to expectation. Also, the relays worked effectively because at both the upper and lower limit that was set at each instance of test, the heater was TURNED OFF and TURNED ON respectively. The light indicator (LED) indicates that the heater is manually turned ON that is, whenever heating was in process or not.

4.4 Limitations

It is weather dependent (not suitable during hot weather). The device is dependent of power supply (not useful where there is no electricity supply).Since it is a simple project, the heating element is to close to the circuit system which is not to be and because of this, when the relay cuts the heater when the temperature rises above the upper limit, the temperatures rises 3°C above the upper limit value.

Finally, when writing the program to be burnt on the microcontroller using a programmer then stimulating, it is very prone to errors and mistakes.

To overcome these limitations, I suggest the following:

- It should be used in very cold regions to effectively work well.
- An uninterrupted power supply should be used for the system.
- The heating element should be far from the circuit system.
- Acquire more knowledge about microcontroller and its pin configuration.

CHAPTER FIVE

Conclusion and Recommendation

5.1 Conclusion

A functional room regulated heater for room temperature regulation, control and protection has successfully been designed and constructed. The device demonstrated how easily its output signal can be manipulated into heat control or regulation. The results obtained are close enough to theoretical and expected results given room for construction errors.

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

The project provided a real practical experience in electronics and has broadened my knowledge on many topics. The importance and applications of the theory taught in the lecture room are now well appreciated.

Finally, it is economically valuable when the cost of the entire construction is weighted with its usefulness on the same balance scale.

5.2 Problems encountered

During the construction of this project, the problem encountered was that the heating element draws a lot of voltage, making the extension cable hot and a little shock feelings on the body of the metal casing.

5.3 Recommendation

Having completed this project, the following are hereby recommended for future improvement.

- An alarm unit can be incorporated into the device to sound when either the upper or lower limit is reached that is when the heater is turned ON or OFF to increase its functionality.
- The distance between the heating casing and the circuit casing should be considered for accurate temperature reading for subsequent work on this project.
- A more standard, safe and portable heating casing should be considered to easily case the heating compartment.
- The upper limit should be considered due to the temperature around the sensor after turn OFF in the implementation of the software programme.

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APPENDIX

89S51 Assembly language

```
;*****************************************************
adc_intr BIT p3.1        ; correct  here
adc_write BIT p3.0
adc_port EQU p1
display_port EQU p0
digit_1_dx BIT p2.0
digit_2_dx BIT p2.1
digit_3_dx BIT p2.2
digit_4_dx BIT p2.3
;*********************************************************
power_key BIT p3.2   ; corect here
preset_plus BIT p2.4
preset_minus BIT p2.6
mode BIT p2.5
power_led BIT p3.7
;*******************************************************
temp_Value DATA 00h         ; correct
digit_1 DATA 01h
digit_2 DATA 02h
digit_3 DATA 03h
digit_4 DATA 04h
lo_preset DATA 05h
hi_preset DATA 06h
;****************************************************
lo_preset_on BIT 00h ; correct
hi_preset_on BIT 01h
hysterisis_on BIT 02h
;**************************************

c_bit_pattern EQU 01000110b          ; correct
h_bit_pattern EQU 10001001b
l_bit_pattern EQU 11000111b
;*******************************************
stack EQU 40h

;***************************************************
heater_dx BIT p3.5    ; correct
;**************************************************
power_flag BIT 03h   ; correct
hysterisis_on BIT 04h; correct
```

```
;**********************************************************

power_key BIT p2.4
power_led BIT p3.6

;*********************************************************8
org 0000h


init_system:    CLR ea
                        MOV sp,#stack
                        ACALL initialize
mainloop:               ACALL scan_key
                        ACALL process_Temp
                        SJMP mainloop
;******************************************************
;check for power button press here
scan_key:       JB power_key, scan2
                CPL power_flag
                JNB power_flag, heater_off
heater_on:      CLR power_led
                CLR heater_dx
                ACALL show_Scan
                sjmp scan2
;*******************************************************
heater_off:     SETB power_led
                SETB heater_dx
                ACALL show_Scan

;*******************************************************
scan2: jb preset_plus, scan3
                acall preset_Temp_plus
                jnb preset_plus, scan2
;*******************************************************
scan3: jb preset_minus, scan4
                acall preset_temp_minus
                jnb preset_minus, scan3
scan4: ret
;********************************************************
initialize:
                        clr power_led
                        setb rs0
                        setb rs1
                        acall reset_delay
                        acall reset_Delay
                        acall reset_delay
```

```
                    acall reset_delay
                    acall reset_delay
                    acall reset_Delay
                    MOV p0,#0ffh
                    MOV p1,#0ffh
                    MOV p2,#0ffh
                    MOV p3,#0ffh
                    CLR power_flag
                    MOV temp_Value,#0
                    MOV lo_preset,#20
                    MOV hi_preset,#40
                    CLR lo_preset_on
                    CLR hi_preset_on
                    CLR hysterisis_on
                    MOV DPTR,#xlate_table
                    ACALL convert_2_bcd
                    RET

;*******************************************************88

process_temp: MOV R0,#20
                    CLR A
next_temp:          ACALL convert_Temp
                    ADD A, temp_value
                    ACALL convert_Temp
                    ADD A, temp_Value
                    RRc A
                    DJNZ R0, next_temp
                    ACALL compare_temp
                    ACALL convert_2_bcd

show_scan:          MOV R1,#40
show_Again_2:       ACALL display_temp
                    DJNZ R1, show_Again_2
                    RET

;*************************************************************************
****************8

xlate_Table:  DB
11000000b,11111001b,10100100b,10110000b,10011001b,10010010b,10000010b,11111
000b,10000000b,10010000b

;*************************************************************************
*************88
display_temp: CLR digit_1_dx
```

```
            MOV display_port, digit_1
            ACALL delay_2_Show
            SETB digit_1_dx
            CLR digit_2_dx
            MOV display_port, digit_2
            ACALL delay_2_Show
            SETB digit_2_Dx
            CLR digit_3_Dx
            MOV display_port, digit_3
            CALL delay_2_show
            SETB digit_3_Dx
            CLR digit_4_dx
            MOV display_port, #c_bit_pattern
            ACALL delay_2_show
            SETB digit_4_Dx
            RET

;*************************************************************************
**********

convert_temp: CLR adc_Write
            nop
            SETB adc_Write
convert_lp: ACALL display_temp
            ACALL display_temp
            ACALL display_temp
chk_adc:    MOV temp_Value, adc_port
            RET


;*************************************************************************
*******8
convert_2_bcd: MOV A, temp_value
            MOV B, #100
            DIV ab
            JZ blank_msb
            MOVC A, @a+dptr
            MOV digit_1, A
            SJMP do_next
blank_msb:  MOV digit_1,#0ffh
do_next:    MOV A,B
            MOV B, #10
            DIV ab
            MOVC A, @a+dptr
            MOV digit_2,A
            MOV A,B
```

```
                    MOVC A, @a+dptr
                    MOV digit_3,A
                    RET
;*********************************************************************
*****
compare_Temp:       JnB power_Flag, exit_compare_Temp
                    JNB lo_preset_on, exit_compare_Temp
                    JNB hi_preset_on, exit_compare_temp
                    JB hysterisis_on, go_hysterisis
                    MOV A, temp_value
                    CJNE A, hi_preset, go_temp1
back_temp:          CLR heater_dx
                    CLR hysterisis_on
exit_compare_temp:RET

go_temp1:           JC back_temp
                    SETB heater_dx
                    SETB hysterisis_on
                    RET

go_hysterisis: MOV A,temp_Value
                    CJNE A, lo_preset, go_temp2
back_temp2:         RET

go_temp2:           JNC back_temp2
                    CLR heater_dx
                    CLR hysterisis_on
                    RET
;*********************************************************************
*
delay_2_Show:       MOV R3,#5
show_Again:         MOV R4,#250
show_loop:          DJNZ R4, show_loop
                    DJNZ R3, show_Again
                    RET
;*********************************************************************
*8
preset_temp_plus:   JB mode,preset_hi_plus
                    SETB lo_preset_on
                    MOV temp_value, lo_preset
                    ACALL convert_2_bcd
                    MOV digit_1,#l_bit_pattern
                    acall show_Scan
                    MOV A, lo_preset
                    CJNE A,hi_preset, chk_Again3
skip_Back3:         DEC lo_preset
```

```
                        SJMP skip_this2
chk_Again3:             JNC skip_back3;
                        INC lo_preset
                        MOV A, lo_preset
                        XRL A, hi_preset
                        JNZ skip_this2
                        DEC lo_preset

skip_This2:             MOV temp_value, lo_preset
re_Enter1:              ACALL convert_2_bcd
                        MOV digit_1, #l_bit_pattern
                        acall show_Scan
fall_out:               RET
;***************************************************************************
*******
preset_hi_plus:         SETB hi_preset_on
                        MOV temp_value, hi_preset
                        ACALL convert_2_bcd
                        MOV digit_1,#h_bit_pattern
                        acall show_Scan
                        MOV A, hi_preset
                        XRL A,#99
                        JZ fall_out
                        INC hi_preset
re_enter2:              MOV temp_value, hi_preset
                        ACALL convert_2_bcd
                        MOV digit_1, #h_bit_pattern
                        acall show_Scan
                        LJMP fall_out



;***************************************************************************
******8
preset_temp_minus:JB mode,preset_hi_minus
                        SETB lo_preset_on
                        MOV temp_value, lo_preset
                        ACALL convert_2_bcd
                        MOV digit_1,#l_bit_pattern
                        acall show_Scan
                        MOV A, lo_preset
                        JZ fall_out1
                        DEC lo_preset
                        MOV temp_Value, lo_preset
                        LJMP re_enter1
```

```
fall_out1:          JMP fall_out


;*************************************************************************
***
preset_hi_minus:    SETB hi_preset_on
                    MOV temp_value, hi_preset
                    ACALL convert_2_bcd
                    MOV digit_1,#h_bit_pattern
                    acall show_Scan
;**************************************************
                    MOV A, hi_preset
                    CLR C
                    SUBB A, lo_preset
                    DEC A
                    JNZ go_on_a
                    LJMP re_Enter2

go_on_a:            DEC hi_preset
                    LJMP re_Enter2
;****************************************************
reset_Delay:  mov r7,#5
reset_lp1:          mov r6,#0
reset_lp2:          mov r5,#0
                    djnz r5,4
                    djnz r6, reset_lp2
                    djnz r7, reset_lp1
                    ret
;****************************************************
```