DESIGN AND CONSTRUCTION OF MICROCONTROLLER BASED ELECTRIC OVEN AND COOKER WITH TIME AND TEMPERATURE CONTROL

BY

JACOB JIYA GANA
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DEDICATION

This project is dedicated to GOD Almighty, the great I AM, fountain and source of all wisdom, knowledge and understanding and my lovely mother.

DECLARATION

I, Mr. Jacob Jiya Gana, declare that this work was done by me and has never been presented anywhere else for the award of a degree. I also hereby relinquish the copyright to the Federal University of technology Minna.

JACOB JIYA GANA

(Name of student)

09/02/2010

(Signature and Date)

ENGR J. A. ABOLARINWA

(Name of supervisor)

09.02.2010

(Signature and Date)

DR Y. A. ADEDIRAN

(Name of Head of department)

(May 6, 2010)

(Signature and Date)

DR. (MRS.) B. A. [illegible]

(Name of External Examiner)

09/03/10

(Signature and Date)

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ABSTRACT

The design and construction of microcontroller based electric oven and cooker with time and temperature control is presented in this project. The project is built around an Atmel 89C52 microcontroller which is programmed to carry out some user defined function. The project is design to meet the safety requirement that is lacking in many similar systems in the market and also make it operation as easy to operate as possible. The microcontroller unit was interfaced with some other components to achieve the set objectives. A temperature sensor LM35 senses the temperature of both the cooker and the oven units which is in analogue form and fed the output voltage to the input of the analogue to digital converter (ADC) which convert the analogue signal to a digital equivalent signal. The microcontroller performs the mathematics and display the result appropriately on the display unit.

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CHAPTER ONE

1.1 INTRODUCTION

Electric oven and cooker are electrical appliances that convert electrical energy into heat energy for domestic and commercial cooking and baking. Electric cooker is an electric powered cooking device for heating and cooking food. [1]

The advent of microcontroller has made a remarkable impact in the field of engineering design and construction due to the accuracy of the result obtains in their usage. With these microcontrollers, automation is possible and hence life is made easier.

Microcontroller is an integrated circuit (IC) that executes a user program, for the purpose of either monitoring or regulating the equipment of interest. hence, it is named "Microcontroller".[2] The programmed (user) that runs on the integrated circuit in most cases are stored in its internal memory and in very rare cases contain in a second chip called an EPROM. Microcontroller base systems are generally smaller, more reliable and cheaper. [1] They are ideal for applications were cost and units are very important.

The design and construction of Microcontroller based time and temperature controlled electric cooker and oven is implemented to solve the problem of energy wastage and risk that is associated with many similar product available in event of improper monitoring. It is unique because of the flexibility and simplicity of its operation. It gives room for the user to determine how long and to what degree the system should supply heat to whatever it is intended, either to cooked or baked as the case may be, the user can set a default time and temperature within which the device should operate. Once the preset time elapses, the device will power off. The user do not necessary have to be around to monitor the whole process which may waste time that could have been judiciously used to meet other important issues.

1.2 AIMS AND OBJECTIVES

In every engineering design such as this, safety of human life and property should be of topmost priority. So many hazards associated with electric cooker/oven in developing country like ours today is due to poor control system design for these devices. Thus, this project is aimed at constructing a timer and temperature controlled electric oven/cooker using a simple assembly language programming for domestic use. The aim is look at from the under listed perspective:

I. To construct an electric oven/cooker that one can be cooking or baking and go to sleep without having any fear of burning the food item by incorporate operational timer and temperature regulator.

II. To provide both cooker/oven an additional direct ON and OFF switch to the power supply voltage when temperature regulator and timer are not to be use.

III. The Oven/cooker should be very easy to operate and to minimize risk of electric shock

1.3 METHODOLOGY

This project was built around an Atmel 89C51 microcontroller, which is interfaced with other components like; the relay and relay driver, analogue to digital (ADC) which convert the analogue signal in the case temperature, to a digital value which the microcontroller understood. The controller compares the input value of the temperature with the preset temperature, and check for equally. If the two values agreed, the system continues to supply power to the heating element until the temperature exceeds the preset value, it continues to operate within the given temperature range until a time allocated time for the cooker or oven expires.

1.4 SCOPE OF WORK

This work, Design and Construction of microcontroller based time and temperature control electric cooker/oven, provides flexibility for user to input desire time and temperature for whatever purpose it might be intended for.

The work though very interesting has its limitations which basically is the range of operation of the sensor (LM35) which is between -55to 150

1.5 THESIS LAYOUT

This project write-up is divided into five chapters.

Chapter One: This chapter introduces the project. It also states the objectives for which the work was undertaken, motivations behind the work, the scope of work (areas covered by the work) and also outlines the entire work.

Chapter Two: This chapter gives the theoretical background behind the study. It reviews relevant literatures and hypothesis,

Chapter Three: This chapter contains steps taken to implement the design. The modular design is clearly outlined.

Chapter four: This chapter covers the testing of each sector of the project from component level to the final construction level.

Chapter Five: This chapter concludes the entire work. Conclusion based on findings and possible modifications/improvements were all outlined.

CHAPTER TWO

LITERATURE REVIEW

An electric oven/cooker is an electrically powered cooking device for heating and cooking food, besides stoves or ranges commonly types includes;

Hot plates, microwave oven, slow cookers (crock pots). Electric oven, Electric Toasters Rice cookers, Electric tea kettle, 'Abacha' stoves and the now obsolete Dub cookers.[4] Many are familiar with the traditional radiant oven, which usually features a heating element on the bottom, a few cooking racks in the middle and possibly an upper heating element for broiling the problem with this radiant heat arrangement is that the heated air remains fairly motionless and food must be placed in the center to avoid direct heat of the elements. [3] One solution to this dilemma is called a convection oven.

A convection oven uses forced air to circulate the heat evenly around the cooking area to avoid the creation of hot or cold sports. Although, the concept of convection oven was popular in European countries, for decades, most people could not afford to buy one until Jenn-Air began offering the models in 1978. [3]

Many commercial restaurants rely on a convection oven to give their food more visual appeal, along with improved texture and flavor. The forced air of the oven cut down the overall cooking time, and also allows roasted foods to retain more moisture. It is difficult if not impossible to duplicate the effects of a convection oven when using a standard radiant oven.

One advantage of a convention oven has is a more evenly heated cooking space. In a true convection oven there are three separate heating elements along the top, bottom and rear of cooking space. When a fan forces the heated air to circulate, it does not matter the position of the food is placed. This is not the case with the radiant oven in which the heat can not go round well to bake. There is also a noticeable improvement in both cooking temperature and time. In the cooking industry, there is a rule dealing with convection ovens called the rule of 25s.when using a convection oven in place of radiant one, the cooking temperature can be reduced to 25 degrees with the same end result. This means a substantial saving in heat energy over time. Many foods cook 25% faster in a convention oven, which also means less overall time is needed to prepare dishes. [1]

The heating effect of current discovered by Joules in 1841 now finds a wider range of applications today in industrial, commercial and domestic settings. Most appliances today are electrically powered, example of such devices includes, the electric oven, cooker, electric iron, refrigerators to mention but a few. [4]

Electricity has made a lot of impart since its inception in human history, for instance, skyscraper are easily accessible by means of electric lifters. The following are also few transformations that have taken place as a result.

- Burning of firewood as a source of fire is gradually been replaced by electric cooker.
- Baking with local oven has been replaced by electric oven toaster.
- Charcoal iron has been replaced by electric iron.
- Electric heater or kettles has also replaced boiling with naked fire.

All these devices, uses electricity which is been converted to heat energy, since heat flows from higher temperature gradient to a lower temperature gradient.[2] Temperature is the measure of the intensity of heat and it is recorded in the lower ranges by thermometer. the higher ranges can be measured using pyrometer pyrometer. Heat is cause by difference in body temperature between a body and its surrounding. [1]

Whenever the surrounding temperature goes higher than the temperature of a body, the body gains heat energy otherwise loses energy to the surrounding. A common conductor in use as a heating element is the Nichrome wire which is an alloy of 60% of Copper and 25% of Manganese and 15% of Chromium. The thickness and the length of the wire is carefully selected so that it becomes red hot at the require voltage. [3]

Several heating methods has been discover today by man, but among these numerous options of heating a material, electric heating is considered to be superior for these reasons:

I. Electric heating system is a clean system requiring minimum cost of cleaning.
II. Simple and accurate temperature control can be made either by manual or fully automatic switches.
III. Electric systems does not produce any smoke or waste gases.
IV. Automatic protection against overheating or over current can be provided through suitable switch gears.
V. An electric heating system provides better working conditions.
VI. It is quite safe and responds quickly.
VII. The overall efficiency of electric heating is much higher.

2.1 MICROWAVE OVEN

An appliances that uses electromagnetic energy to heat and cook foods. A microwave oven uses microwaves, very short radio waves commonly employed in radar and satellite communications. When concentrated within a small space, these waves efficiently heat water and other substances within foods. [4]

In a microwave oven, an electronic vacuum tube known as a magnetron produces an oscillating beam of microwaves. Before passing into the cooking space, the microwaves are sent through a fanlike set of spinning metal blades called a stirrer. The stirrer scatters the microwaves, dispersing them evenly within the oven, where they are absorbed by the food. Within the food the microwaves orient molecules, particularly water molecules, in a specific direction. The oscillating effect produced by the magnetron changes the orientation of the microwaves millions of times per second. The water molecules begin to vibrate as they undergo equally rapid changes in direction.

Microwaves cook food rapidly and efficiently because, unlike conventional ovens, they heat only the food and not the air or the oven walls. The heat spreads within food by conduction. Microwave ovens tend to cook moist food more quickly than dry foods, because there is more water to absorb the microwaves. [4] However, microwaves cannot penetrate deeply into foods, sometimes making it difficult to cook thicker foods. Microwaves pass through many types of glass, paper, ceramics, and plastics, making many containers composed of these materials good for holding food; microwave instructions detail exactly which containers are safe for microwave use. Metal containers are particularly unsuitable because they reflect microwaves and prevent food from cooking. Metal objects may also reflect microwaves back into the magnetron and cause damage. The door of the oven should always be securely closed and properly sealed to prevent escape of microwaves. Leakage of microwaves affects cooking efficiency and can pose a health hazard to anyone close to the oven.

The discovery that microwaves could cook food was accidental, in 1945 Percy L. Spencer, a technician at the Raytheon Company, was experimenting with a magnetron designed to produce short radio waves for a radar system. Standing close to the magnetron, he noticed that a candy bar in his pocket melted even though he felt no heat.

Raytheon developed this food-heating capacity and introduced the first microwave oven, then called a radar range, in the early 1950s. Although it was slow to catch on at first, the microwave oven has since grown steadily in popularity to its current status as a common household appliance. [6]

2.2 ELECTRONIC OVEN.

An electronic oven was developed from which a precooked frozen meal is ready to serve in seventy-five seconds. The electronic oven is not a home unit and is limited in use to eating places wishing to serve hot precooked frozen meals quickly. The unit heats these meals to an average temperature of 160° F.

The oven uses microwave energy similar to that used in the operation of the electronic canteen, which was also produced by General Electric. The amount of power required to operate the new unit is the same as that used for a domestic range. In appearance the oven resembles a small domestic refrigerator, 54 in. tall, 33 in. wide, and 22 in. deep — with a small aluminum door near the top through which meals are passed into the oven. The operator places the pre-cooked food in the heating cavity and closes the oven door by treading on a bar near the bottom of the unit. The high-frequency radio power goes on automatically and later is turned off by the timer. When the power shuts off, the door opens and the meal is ready to be served. [2]

2.3 BRICK OVEN

Brick ovens are a type of oven that features a chamber that is constructed of brick and concrete. Sometimes refers to as a masonry oven, the bricks may be constructed of fired clay or even cut from stone. The brick oven has a long history dating back to the Roman Empire. Brick oven still found used among the Native American prior to the arrival of explorers from Europe or Spain. By the 19th century, most versions of brick ovens made good use of wood and coal as the means of generating the heat to bake various types of breads meats and even sweets. [5]

2.4 STOVE

Stoves are devices or appliances used primarily for cooking food. Iron stoves fueled by wood and coal have been in use for over hundred years as a source of heat for domestic cooking and baking. Modern gas and electric stoves were design specifically for cooking food, such stove are called Ranges. [6]

A range consists of several heating units within the oven, which is an enclosed space use for baking purposes. The heating units on top of an electric range called element consist of flat coiled metal tubes that contain insulated electric wires. Pots are directly placed on these elements. Electric current is allowed to pass through these wires and as a result heat is been generated, the generated heat radiate out of the heating element and the heat is utilized. The heat can be control either by regulating the amount of voltage flow through the wires or by using a thermostat to turn ON and OFF the current as necessary. In some electric ranges, the heating elements are covered by a smooth glass ceramic surface. Inside the oven of an electric range, a larger heating element generates heat for baking and broiling. Stoves were developed over thousands of years back in a number of ancient civilizations. By 2000BC, Egyptians were using clay and brick ovens to bake bread. Roman in central and northern Europe, were using stoves developed from earthenware materials to heat the dwellings. Cast iron stoves were used in china as early as the 2nd century AD and in Europe as way back to 15th century. [7]

In 1744, an American inventor Benjamin Franklin develops an efficient cast iron stove that could be installed inside a fireplace. [8] One of the earliest cooking ranges was design by Anglo-American Benjamin Thompson in 1790. Even with these improved designs, cooking was done primarily over an open flame until the early 1800s. The closed-top cast iron was patented in 1902 by English man George Bodley. Stove, appliance used to generate heat. Iron stoves fueled by wood and coal have been used for hundreds of years to heat homes and are still popular in some regions as primary heating units. Modern gas and electric stoves are designed specifically for cooking food; such stoves are also called ranges. [7] A range controls open and close the burner valves, which in turn regulate the flow of gas, controlling the size of the flame and the amount of heat. Another, larger burner unit inside the oven works in the same manner. The oven burner heats the oven space above the burner and can also broil food in the smaller space below the burner. [2, 5]

The heating units on top of an electric range, called elements, consist of flat, coiled metal tubes that contain insulated electric wires. Pots are placed directly on these tubes. Electric current passes through the wires and generates heat that radiates out of the heating elements. The different heat settings are controlled by either adjusting the voltage through the wires or by using a thermostat to turn the current on and off as necessary. [1, 4]

Stoves were developed over thousands of years in a number of ancient civilizations. By 2000 BC Egyptians were using clay and brick ovens to bake bread. During Roman times in central and northern Europe, people developed earthenware stoves to heat their dwellings. Cast-iron stoves were used in China as early as the 2nd century AD and in Europe as early as the 15th century. In 1744 American inventor Benjamin Franklin developed an efficient cast-iron stove that could be installed inside a fireplace. Even with improved designs, cooking was done primarily over an open flame until the early 1800s. One of the earliest cooking ranges was designed in the 1790s by Anglo-American Benjamin Thompson. The closed-top, cast-iron range was patented in 1802 by Englishman George Bodley. [3]

Cast-iron stoves became popular during the early 1800s with improvements in insulation and the development of coal as an efficient fuel. The first gas stoves were introduced in the 1830s, and electric stoves were first marketed during the 1890s. Both types of stoves grew in popularity during the early 1900s as gas and electricity became widely available. During the 20th century alternate home heating methods, including central heating, gradually replaced the heating stove. This left cooking as the stove`s primary function. [2]

2.5 IRON STOVES

In the 18th century, the first iron stoves appeared. An early example is the Franklin stove, a wood burning stove said to have been invented by Benjamin Franklin in 1742. [6] It has a labyrinthine path for hot exhaust gases to escape. This allows heat to enter the room instead of going up the chimney. The Franklin stove was however design for heating not for cooking.

Benjamin Thompson in the 19th century was among the first to present the working non kitchen stove. It is Rumford stove used on fire to heat several pots that were also hung into holes so that they could be heated from the sides too. It was even possible to regulate the heat individually for each hole. His stove was designed for large canteen or castle kitchens though; it took closely 30 years until the technology had been refined and the size of the non stove been reduced enough for domestic use.

Stewart stove was a much more compact iron stove, patented in the U.S in 1934.[6] It became a huge commercial success with some 90,000 units sold in the next 30 years. In Europe, similar design also appeared in the 1830s. In the following years, these stoves evolved into veritable cooking machines with the water.

The originally open holes into which the pots were hung were now covered with concentric iron rings on which the pots were placed. Depending on the amount of the heat needed, one could remove the inner rings. [7]

2.6 GAS AND ELECTRIC STOVES

The first gas stove was developed in the 1820s, it is rather unwieldy, but soon the oven was integrated into the base and the size reduced to fit in better with the rest of the kitchen furniture. In the 1910s, producers stated to enamel their gas stores for easier clearing. A high-end gas stove called the AGA cooker was invented in 1922 by Swedish Nobel prize winner Gustaf Dal A©n.[2] it is consider to be the most effective and design thus a most sought after in the kitchen. The AGA and similar products such as the Raybum Range are some examples of always on-stoves which continuously burn fuel even when cooking is not being been performed.

In 1880s, the electrical stove were made, which had a slow start, partly due to unstable technology and partly because first cities and town need to be electrified. By the1930s, the technology had matured and the electrical stove started to slowly replace the gas stove especially in domestic kitchens. [7]

The electric stove technology has developed in several successive generations:

The first technology used resistor heating coils which heated iron hot plates, on top of which the pots were placed. Though the technology is slowly fading into obsolescence, coil ranges skill provides the best durability out of all electric cook top implementations.

In the 1970s, glass ceramic cook tops, started to appear, glass ceramic has a very low heat combustion coefficient, but let infrared radiation pass very well. Electric heating coils or halogen lamps are used in heating elements. Because of the physical characteristics the cook top heat quicker, there is less heat after, and only the plate is heats up while the adjacent surfaces remains cool. Also these cook tops have a smooth surface and are thus easier to clean, but they only work with fit bottomed cook ware and are markedly more expensive.

A third technology developed first for professional kitchens, but today also enter the domestic market are induction stoves. These heat the cookware directly through electromagnetic induction and thus require pots and pans with ferromagnetic bottoms. Induction stoves also often have a glass ceramic surface. [8, 3]

Advantages of electric oven/cooker

Electric heat is one of the most common types of heating available in many areas, especially where natural gas (propane) is not available or practical. In such cases electricity becomes one of easiest source of heat. Whether it is through a central system or space heater, electric heat is used all over the world.

The advantages of electric heat are numerous, though there are also some disadvantages. However, for many the benefits far outweigh any liability. Many may even prefer to use electric heat over other forms whenever possible. Few out of numerous advantages includes:

Electric heat may represent the most efficient and economical form of heating in some areas. Availability, nearly every place in the world has the infrastructure to deliver electricity. The electric heat can be provided at no additional cost or investment in infrastructure. This make it easy choice, especially when heat is needed very quickly.

Another advantage is safety, especially when heat is needed for central heating systems because of it clean nature [5].

Similar previous works

The evolution of technology is a continuous phenomenon. As researchers continue doing their work, new products are introduced while existing ones are being modified. This project, design and construction of microcontroller based time and temperature controlled electric cooker and oven is not the first of its kind and will definitely not be the last. It is however an improvement upon previous works carried out. It was the limitations of those works that was worked upon to produce this device.

Of all the devices mention above, no mention was made to timer controller which is the essence of microcontroller based time and temperature control electric oven and cooker. In our day to day life, we seems to look out for thing that gives us comfort with little or no stress attached most equipment already provide temperature control but you still have to be around to monitor what you are baking or cooking. With this device, that is not the case you don't have to be tied down until what you intend to cook or baked get done. Once you set the time/temperature you can conveniently go to attain to other issue as the device will automatically power down when the preset time elapses.

CHAPTER THREE

DESIGN REVIEW

This project is a microcontroller based design and construction of time and temperature programmable electric oven and cooker, it is built/design around the under listed sub systems.

5- Volt power supply.

LM35 temperature sensor.

8 - Bit ADC0804 analogue-to-digital converter.

8- Bit Atmel 89c51 system microcontroller.

4- Digit 7-segment common anode multiplex display

6 V, 10A Relay.

Shift Register (74HC156) EEPROM

3.1 POWER SUPPLY

The block diagram of the design is as shown below for analysis purpose.

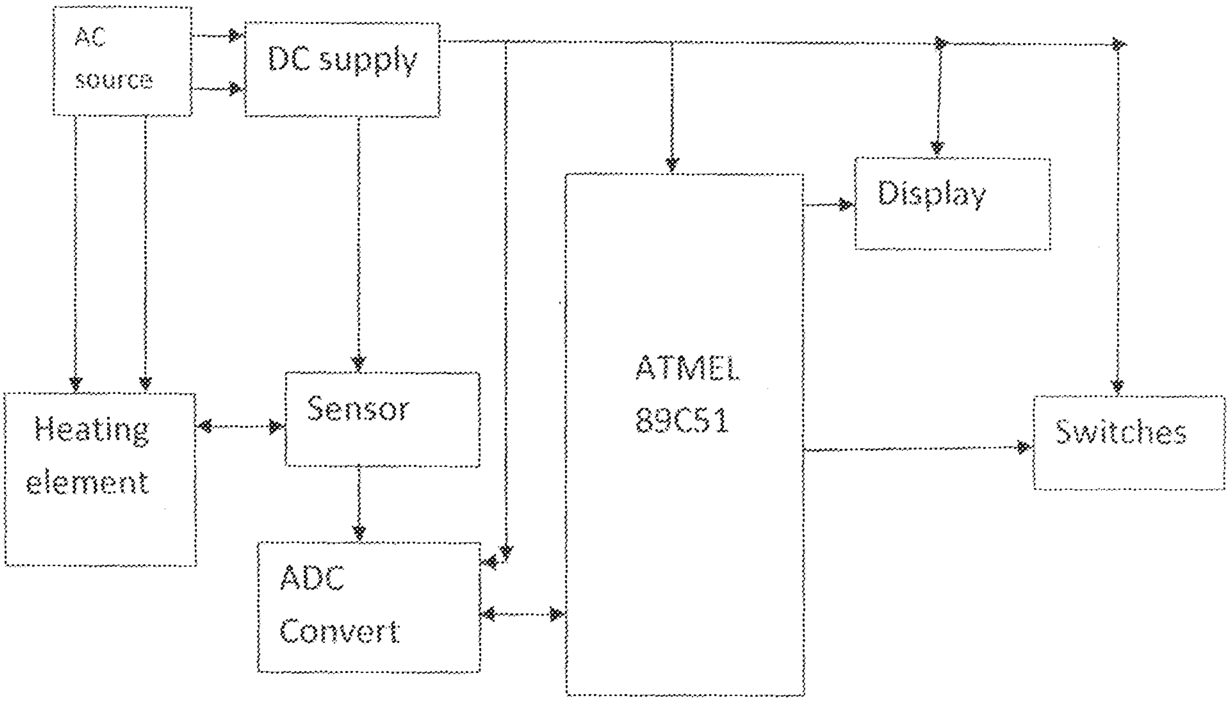

Fig 3.1 The system block diagram

A 5-volt regulated DC supply voltage is required by the element for operation. This 5-volt supply was derived from a 12v, 0.5A step down transformer, a full wave bridge rectifier, and 7805 voltage regulator. The low voltage AC was converted to pulsating DC of amplitude given by the relation:

$Vdc = V\sqrt{2} - 2Vd$

For a 12V supply,

$Vdc = 12\sqrt{2} - 1.4 = 15.5V.$

The DC voltage was smoothening by a capacitor, whose capacitance value is deduced by the relation:

$Q = CV = It$

$$C = \frac{It}{\Delta V}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where I =maximum load current, $t=\frac{1}{f}$, ΔV= peak–peak AC ripples voltages.

The load current was computed from the summation of the current drains of the various subsystems as stated in the Data sheet.

ADC0804	5mA
LM 35	Negligible
Atmel 89c51	15mA
Display (common anode seven segment)	280mA
Relay	40mA

$\sum I = 0.334A$

The peak to peak ripple voltage is thus determined by the minimum regulator input voltage of 7V for a 5V regulated output. On a 15.5Vpeak to peak DC voltage supply, the AC ripple voltage is thus;

V= 15.5–7 =8.5.

F=50 Hz.

Computing these values in equation (1).

$$C = \frac{0.338 \times (\frac{1}{2\times 50})}{8.5} = 397.65\mu F.$$

The value of the capacitance obtained above, is the least smoothening value require for maintaining system operations, hence, the value was increased to 2200μF. To obtain a 5V regulated system voltage supply, a 7805 5-volt, 1-ampere regulator was place in the potential path. The 7805's output was regulated down to +5V and smoothens by 2200μF capacitances against voltage dips during relay turn on and off.

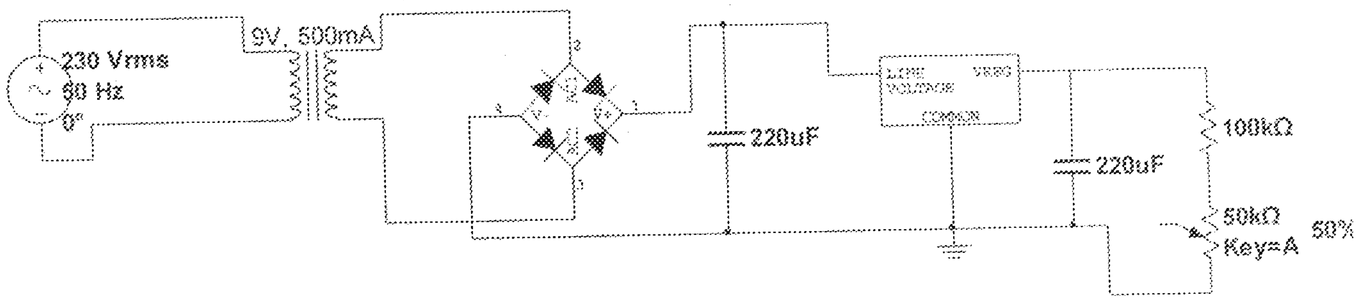

Fig 3.2 The power supply unit

3.2 LM35 precision centigrade temperature sensor

LM 35 is an integrated circuit temperature sensor, it is require in this circuit for the conversion of non-electrical, physical quantity (temperature) to an electrical quantity (voltage). It has an output that is calibrated in degree Celsius, with an output voltage gradient of 10m V/°C. The LM 35 sensor was chosen because it generates a higher output voltage than thermocouples and does not require amplification of the output voltage; it can measure temperature more accurately than a thermistor. It has an operational temperature span of -55 to 150°C maximum. (With proper scale it can measure negative temperature).The device was interfaced with an analogue–to–digital converter which effects the conversion of the analogue sensor output voltage to digital values. The sensor has an operational supply voltage of 4V-30V, less than 60μA and does not require trimming. The device is power by the 5V system supply; the output was filtered by a 220µF capacitor in parallel with 10kΩ, and converted to digital values by the ADC 0804 analog to digital converter. [9]

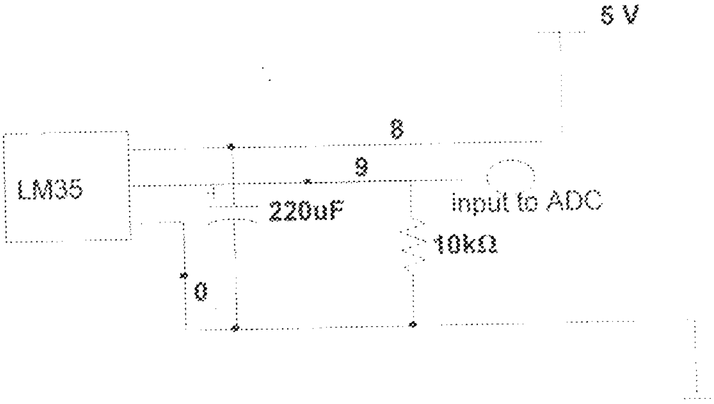

Fig 3.3 LM35 Temperature sensor

3.3 An 8-bit ADC0804 analogues to digital converter

Analogue signal are very common inputs to embedded systems. Most transducers and sensors such as temperature, pressure, velocity, and humidity are analogue signals. Therefore, the need to convert this analog signal into its equivalent digital signal the microcontroller can read. Commonly used ADC device is the ADC804. This device has an internal clock generator to determine the conversion time of the ADC. Frequency is determined by connecting it pins 19 and 4 to a resistor, capacitor net work as shown in fig3.3.the relationship between time and frequency is given by $T={}^{1}/_{F}$, and

$$F=\frac{1}{1.1RC},$$

For every degree rise in temperature, of the input voltage step voltage of 10mV digital output is measure at the data lines.

Input voltage range at pin 9 (Vref/ 2), Vref/ 2 =1.28volts

The data out is evaluated using the relation;

$$\frac{Vin}{Vref} = \frac{Dout}{256}$$

Therefore, Dout $= \frac{Vin}{Vref} \times 256$ [11]

The reference voltage source is shown below

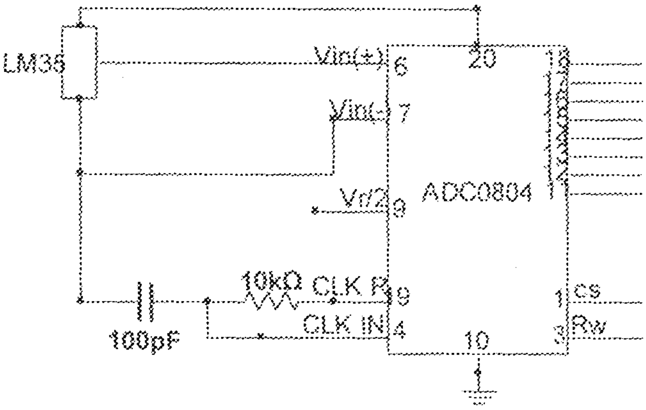

Fig 3.4 Analogue to digital converter (ADC) interface

3.4 Shift Register (74HC156)

For storage of user settings, an Electrically Erasable Programmable Read Only Memory (EEPROM) was incorporated into the design. The EEPROM was interfaced to P3.7 and P3.6, as the SDA and SCI input/output pin as specified in the Philips™ I2C bus specification. The memory device was used to hold the time and temperature settings. This provides an easy means of controlling the cooker/oven without always having to re-input into variable after a power outage. The settings are recalled from memory and stored in

RAM. The system settings are stored in the EEPROM device as BCD values, both time and temperature settings occupy 3 bytes each (from 000-999).The settings can be manipulated in software yielding maximum flexibility. They can also be operated and written back to the memory.

The EEPROM interface was implemented in software as the microcontroller does not possess a dedicated I2C hardware port. This involves substantial software overhead, but achieves the objective.

The device was configured for read at address 10100001B, and for write at address 10100000B. Single byte addressing was used as the entire memory array could be read using an 8bit address.

3.5 THE MICROCONTROLLER UNIT

For coordination and generation of the necessary control signals, an 8-bit 8951 device was embedded into the design. The controller was run at 12MHz clock source determined by the crystal between pin 18 and 19. Internally, the machine runs on a 1 MHz system clock. The interfacing between other system elements is as shown below.

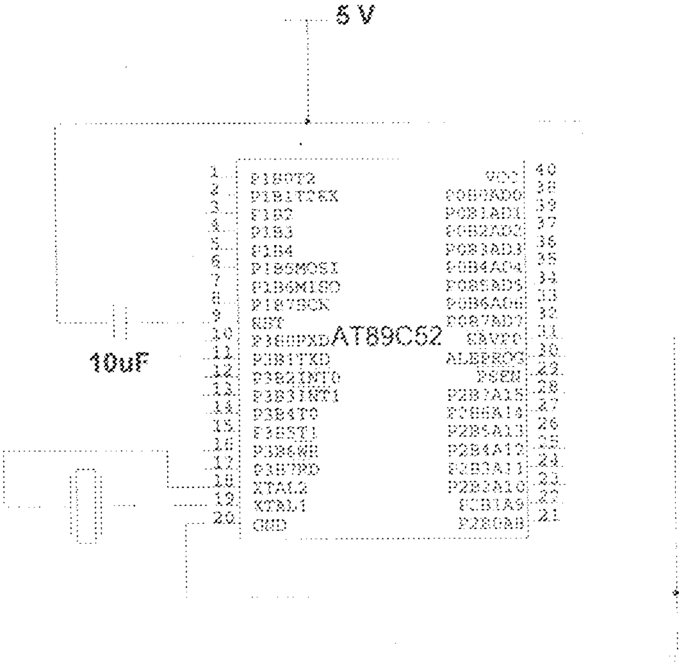

Fig 3.5 Microcontroller unit

The controller was programmed to execute the following loop:

- Generate temperature reading through ADC/parallel in, serial out (PISO)
- Convert the seven segment display format and show the display.
- Compare the preset time and temperature values with the measure values, at every minute elapsing, decrement preset time. If measured temperature is greater than preset temperature, turn off AC power supply to the system.
- Scan the key buttons for user programming. The keypad scan routine was used to select one of any possible user actions depending on the key pressed.

SYSTEM KEY: - Enables a display of the measured temperature and elapsed system time.

HUNDRED KEY: - Enables programming of the system/user hundredth value of either the temperature or time.

STORE: - Enables a save of preset time and temperature to memory.

RECALL: - Enables a sequential recall of the different user preset settings.

CLEAR: - Enables a delete of any desired preset (in case of memory full or otherwise).

START: - Turns ON the AC power it time and temperature set.

STOP: - Manually turns OFF AC power.

The microcontroller was interfaced with a 256-byte 24CO2 electrically erasable programmable read only memory (ROM). The device was interfaced with P21 and P22 over which the low-level 12C communication protocol was implemented. User settings were written to/read from the 24CO2 as required. The microcontroller also multiplexed a 4-digit seven segment display over port 0 (P0) and port 2(P2.2, P2.3, P2.4 and P2.5).

Four 1015GR PNP drivers were utilized for controlling the four digits. A multiplexed frequency of about 100Hz was implemented in the display redraw routine for a flicker-free display. The microcontroller also drove a 6V, 10A change over relay through a PNP driver interfaced to P3.1.

3.6 CD4049 PORT EXPANDER

An 8bit serial-in parallel-out device was used for port expansion. The device received the serial data stream for the display segment via pin 2.2 and 2.3 being the clock and data respectively, the device was used to interface with the display as shown in the figure

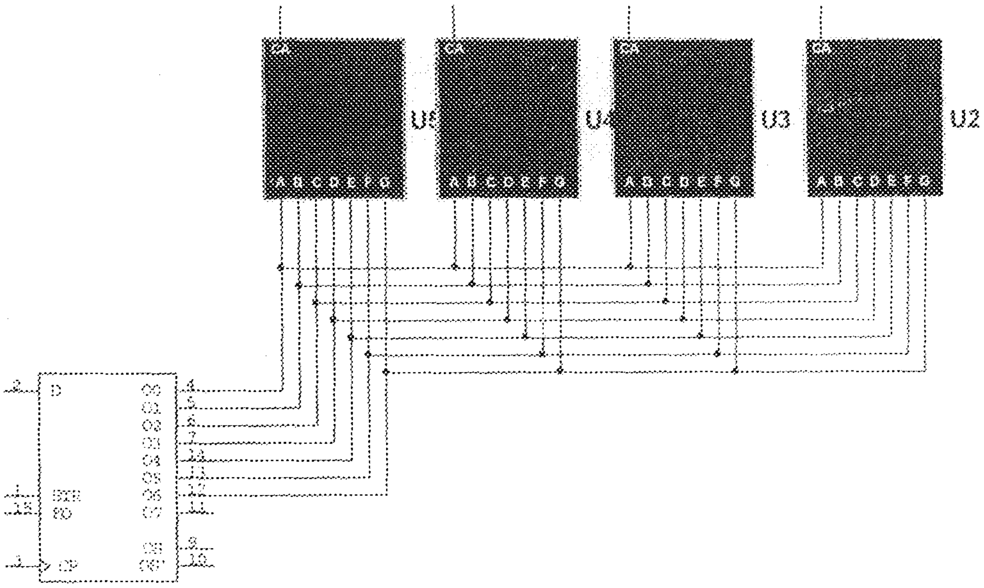

Fig 3.6 Serial in parallel out configuration

The display was multiplexed at a display refresh rate of about 200 Hz using software timing. The seven segment binary pattern was shifted serially into the expander. The serial in parallel out eight outputs interfaced with the 8-pins of the common anode display through the digits were controlled by 4 PNP drivers. Current limiting resistors were not used due to the internal port resistors. [12]

The maximum LED segment current was programmed by the base resistors of the 4-driver transistors. For a multiplexed display, the magnitude of the current (I) flow through each segment is defined by the relation. $I = n \times I_f$

Where n = number of digit position in the display. I_f = LED forward current. A typical I_f of 10mA was selected yielding a peak segment current of 40mA. When a digit with all its segments is lit, it draws a current of 320mA. The 1015GR device is rated for I_c of 150mA and a d.c gain of about 200.

$I_C = \beta I_B$

$I_B = 0.32/200$

$= 1.6mA.$

The base resistances were evaluated using the relation below.

$$R_b = \frac{Vcc - Vbe}{Ib} \quad [10]$$

$$= \frac{5-0.7}{1.6mA}$$

$Rb = 2937\Omega$

3.7 FOUR (4)-DIGIT DISPLAY

For a human-machine interface (HMI), a 4-digit, 7-segment display was used. The display was multiplexed to reduce input/output pins required to interface the different segments to the microcontroller. The individual digits positions were controlled by four transistors as shown in figure 3.6.

Figure 3.6 multiplexed 4-digit, 7-segment common anode display.

Transistor 01-04 was PNP transistor part A1015GR.

Display multiplexing consists of:

I. Turning off all digit drivers (01-04)

II. Writing the 7-segment data to the data port, (PO)

III. Turning on the PNP driver associated with the displayed position

IV. Delay for persistence to forward-bias segments

Turning off the driver selected in step (iv) and repeating the sequence for step i-iv for multiplex display, the refresh rate for the whole display must be greater than (50x4)= 200Hz. An 8-bit multiplexed display requires (n x I_f) A of current to approximately produce the same level of brightness as if it were a single non-multiplexed digit. Considering a typical continuous forward current of 10mA, the peak pulsed current per segment will be 4x10mA which equals 40mA. The current draw per digit is hence 7x40mA=280mA. These transistors were sized to handle this current even though the 1015GR is rated for 150mA I_C max, it can safely withstand a pulse current up to 4x I_C max. The individual diver mode is shown below

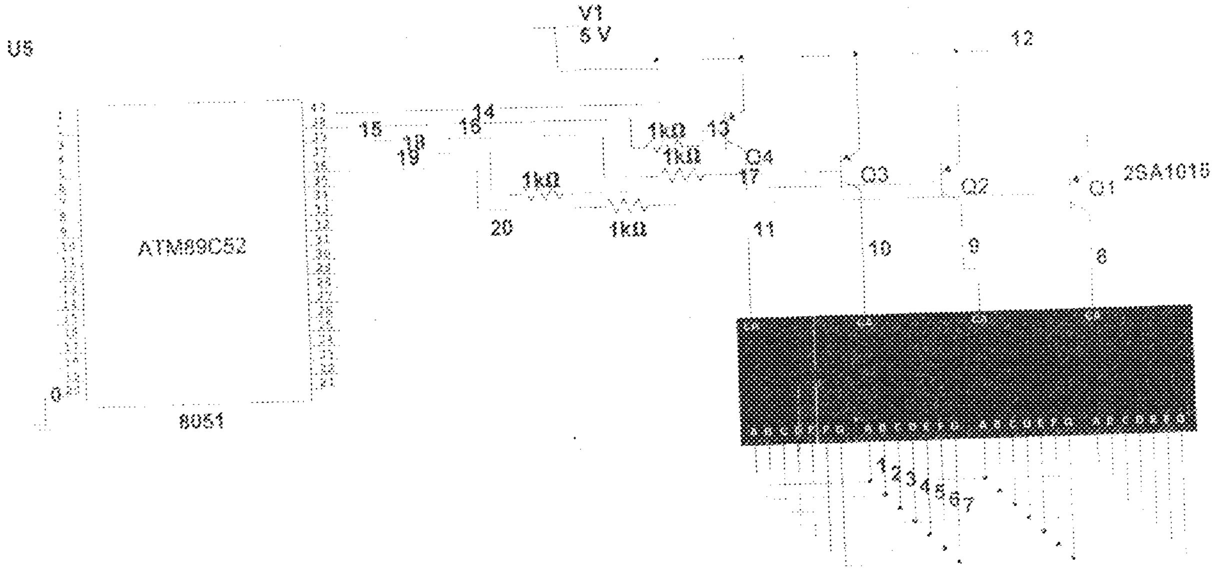

Fig.3.7 PNP Transistor driver.

For a pulse of peak current of, $IB = \frac{IC}{hFe}$

$$IB = \frac{0.28A}{200}$$

$= 1.43mA$

(1015GB has a quotient gain of 100-250).

$IB = 0.0014A$

$$RB = \frac{Vcc - VBE}{IB}$$

$$RB = \frac{5 - 0.7}{0.0014}$$

$$= \frac{4.3}{0.0014}$$

$RB = 3 \times 10^3 \Omega$.

The value was reduced to 2 K **Ω** as it did not violate the20mA maximum IF typically quoted for LEDs

3.9 RELAY AND RELAY DRIVER

To make and break the AC current through the load, a device capable of passing alternating current is required. A 6V, 10A relay was selected. [14] The relay was driven by a 1015 PNP driver over P3.1.

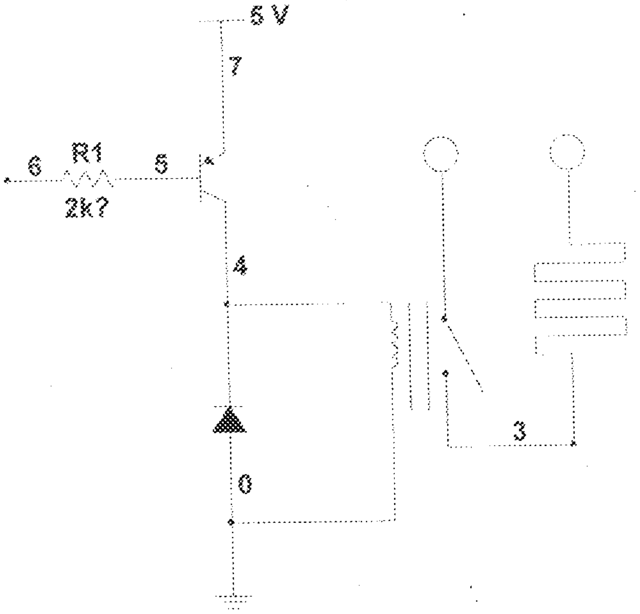

Figure 3.8 Relay driver connections.

The base resistance for the transistor was calculated as shown previously. An IN4001 diode was placed across the relay coil to absorb inductive backlash generated by the decaying events through the coil when it is turn off.

3.1 USER INPUT KEYS

Nine keys interfaced with the microcontroller provided user inputs. These keys enabled various system parameters to be set up. They are designated as S1-S9, with the respective functions of each stated below:

S1	Provides a view of the system countdown timer
S2	Toggle the display between timer and temperature
S3	Hundred Key
S4	Tens Key
S5	Units Key

S6	Store key
S7	Recall key
S8	Start key
S9	Stop key

KEY DEFINATION

S1: When this key is held is held down, the system countdown timer value is displayed. Releasing it returns the display to the fault temperature viewing mode.

S2: Holding this key down, enables the preset to be altered using the hundred, tens and unit keys.

S3, S4, and S5: This are the hundred, tens and unit keys used to adjust the time and temperature value over the entire 7-segment display BCD values.

S6: This is the store key that helps to store the preset values for times and temperature in the register.

S7: Recalls (reloads) the preset values to the RAM.

S8: Start the system

S9: Stops the system.

CHAPTER FOUR

TEST, RESULT AND DISCUSSION

4.1 TESTING

Having implemented the design, the work (as it was carried out in modules) was tested to ensure that the construction conforms exactly to the design. The various tests were carried out as follows;

4.1.2 POWER SUPPLY TEST

The various tests carried out under the power supply test include continuity test, polarity test and short-circuit test. The power supply was disconnected from the circuit and the voltage output measured using a multimeter, to ensure a steady +5V. With the power supply still disconnected, a test on the overall circuit was carried out to ensure that no short-circuit is present anywhere especially, between adjacent IC pins. The power supply was then connected back to the circuit.

A polarity test was carried out to ensure that all terminals marked Vcc or +V are on the +5V potential and that all terminals marked -V or GND are on the 0V potential of the power supply

4.1.2 SENSOR TEST

A test was carried out to ensure that the LM35sensor is in good condition and should be able to sense changes in the temperature of the oven and cooker units. The sensor was brought very close to the heating element of the cooker, and the display unit shows the temperature of the environment which ranges between 29°Cand 32°C. The cooker was the powered and from the display the temperature was observed to be rising as the heat increases.

The device was then power down and the temperature fall back to 33°C was the cooker gradually cools off.

4.1.3 DEVICE TEST

The overall behavior of the device was then tested. The circuit was powered and certain preset values were choosing for both time and temperature. It was discovered that as soon as the timer countdown, the relay switch off the oven and cooker supply which is the aim of my project. A power switch provided for direct ON and OFF was also tested when the device was running, the off switch was pressed and the system eventually stop working.

4.2 RESULTS OBTAINED

For each individual test carried out, a result was obtained and is outlined below:

4.2.1 POWER SUPPLY

The voltage measured at the output of the power supply was found to be 5.00V though it occasionally falls to 4.99V or rises to 5.01V. The short-circuit test reveals that no two terminals of different potentials are short-circuited together and that no two legs of an IC are bridged. From the polarity test, it was found that all terminals marked Vcc or +V are on +5V potential while terminals marked –V or GND are on 0V potential.

4.2.2 SENSOR

The test carried out on the sensor confirms that the sensor is ready for use in the device.

4.2.3 DEVICE

The overall behavior of the device was tested and a Simulation test was carried out on the written code. The code was debugged and simulated appropriately. This was done using

Edsim51 Simulator. Several simulations and debugging were carried out before the code could be burn into the microcontroller by a compatible programmer.

4.3 DISCUSSION OF RESULTS

The implication of the various results obtained is explained thus;

4.3.1 POWER SUPPLY

The voltage measured at the output of the power supply, which was found to be 5.00V (though it occasionally falls to 4.99V or rises to 5.00V) indicates that the circuit is properly powered. For an IC to behave well, it needs to be powered by the proper supply voltage it needs. ICs usually malfunction when their biasing voltage fluctuates continuously or when ripples are present. Thus from the perspective of power supply, this device is bound to perform optimally and function properly since it is being powered from a +5V power supply that contain no ripples (a pure dc voltage) and does not fluctuates (only falls to 4.99V or rises to 5.01Voccasionally, representing a 0.2% fluctuation which is insignificant to impair the performance of any IC present in the circuit.

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The basic design of a microcontroller based time and temperature controlled electric cooker and oven is the same with the other electrical cooker and oven common found in the market but with a little modification. The user friendly nature of this device is what makes the difference. Therefore, from the results obtained, it can be concluded that the aim of this project work has been practically and theoretically achieved.

5.2 RECOMMENDATIONS

This device is recommended for every home to avoid the risk that is associated with the conventional oven and cooker, since it can cut off the supply as soon as the pre-set time elapses. Future work to be done in this area can also in cooperate and alarm system that will notify the user, that cooking process has been concluded.

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```
;**************************
org 0013h
RETI
;**************************
org 001bh
RETI
;**************************
org 0023h
RETI

;**************************
org 0030h
start_up:               CLR ea
                        MOV sp,#stack
                        acall sys_init
;********************************
mainloop:               ACALL get_temp
                        acall show_temp
                        ACALL compare_temp
                        ACALL scan_key
                        SJMP mainloop
;********************************
sys_init:               MOV tcon,#0
                        MOV tmod,#02h
                        MOV th0,#06h
                        MOV tl0,#06h
                        MOV count1,#200
                        MOV count2,#20
                        MOV COUNT3,#60
                        CLR sec1
                        CLR start_ok
                        SETB relay_dx
                        CLR clock_out
                        CLR data_out
                        MOV sys_temp,#0
                        ACALL load_preset
                        CLR adc_Select
                        SETB adc_write
                        MOV ie,#10000010b
                        SETB tr0
                        RET
;**********************************
get_Temp:               JNB sec1, exit_Get_temp
                        CLR sec1
                        CLR adc_Write
                        NOP
                        SETB adc_Write
                        MOV R0,#100
                        DJNZ R0,$
                        MOV sys_temp, adc_port
exit_Get_Temp:  RET
;*********************************
tf0_isr:                PUSH psw
                        PUSH acc
                        DJNZ count1, exit_isr
                        MOV count1,#200
                        DJNZ count2, exit_isr
                        MOV count2,#20
                        SETB sec1
                        DJNZ COUNT3, EXIT_ISR
                        MOV COUNT3,#60
                        ACALL adjust_time
exit_isr:               POP acc
```

```
                        POP psw
                        RETI
;*************************************
get_bcd:                MOV B,#100
                        DIV ab
                        MOV @R0,A
                        MOV A, B
                        INC R0
                        MOV B,#10
                        DIV ab
                        MOV @R0,A
                        INC R0
                        MOV @R0,B
                        RET
;**************************************
get_7_seg:              MOV DPTR,#xlate_table
                        MOV R2,#3
                        MOV R1,#digit1
get_7_loop:             MOV A,@R0
                        MOVC A,@a+dptr
                        MOV @R1,A
                        INC R0
                        INC R1
                        DJNZ R2, get_7_loop
                        RET
;***************************************
show_long:              MOV R2,#120
show_long_loop: acall write_display
                        DJNZ R2, show_long_loop
                        RET
;***************************************
write_display:  MOV A, R0
                        PUSH acc
                        MOV R0,#digit1
                        MOV dx_Ctrl,#11111110b
                        MOV dx_port,#0ffh
show_display_loop:mov data_port,@R0
                        MOV dx_port,dx_ctrl
                        ACALL delay_Show
                        MOV dx_port,#0ffh
                        MOV A,#0ffh
                        ACALL delay_blank
                        MOV A, dx_Ctrl
                        RL A
                        MOV dx_Ctrl,A
                        INC R0
                        CJNE R0,#digit1+4, show_display_loop
                        POP acc
                        MOV R0,A
                        RET
;***********************************
show_temp:              MOV A, sys_temp
                        call get_bcd
                        call get_7_seg
                        call write_display
                        RET
;***********************************
adjust_time:    RET
;***********************************
delay_Show:             MOV R7,#100
                        DJNZ R7,$
                        RET
;***********************************
```

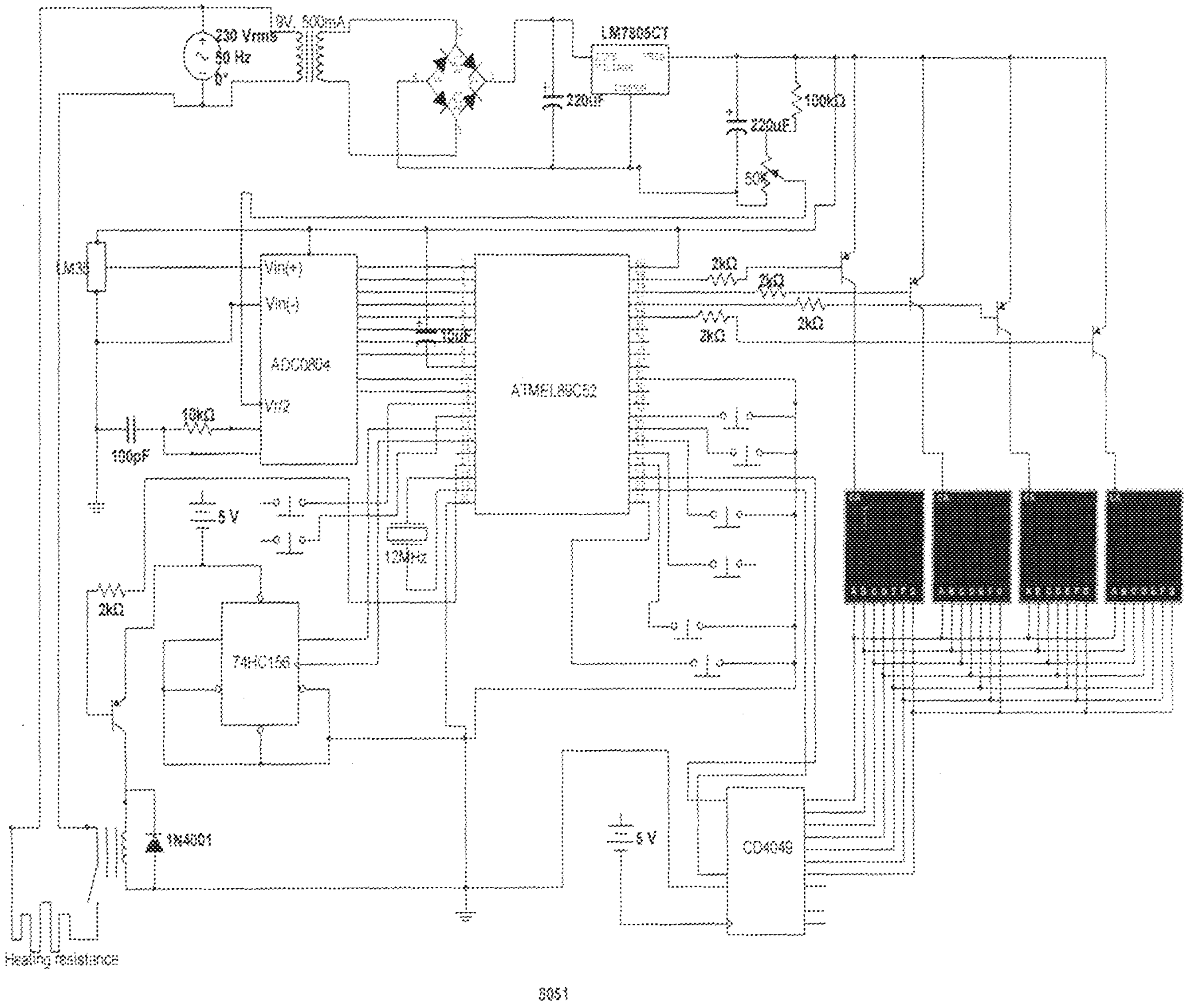
```
delay_blank:    MOV R7,#0
                        DJNZ R7,$
                        RET
'***********************************
;***********************************
xlate_Table:    DB
11000000b,11111001b,10100100b,10110000b,10011001b,10010010b,10000010b,11111000b,1000
0000b,10010000b

;*************************************************************************
;**********************************************************************
load_preset:    MOV address,#preset_temp_address
                        MOV R0,#preset_Temp
load_preset_loop:       ACALL read
                        JC show_read_error1
                        MOV @R0, data_read
                        INC R0
                        CJNE R0,#preset_temp_Address+6, load_preset_loop
                        RET

;*****************************************************
show_read_error1:       MOV digit1,#e_mask
                        MOV digit2,#r_mask
                        MOV digit3,#r_mask
                        MOV digit4,#1_mask

show_loop1:             ACALL show_long
                        SJMP show_loop1
;**********************************************************************8
write_preset:           MOV address,#preset_temp_address
                                MOV R0,#preset_temp
                                MOV data_2_write,preset_temp
write_preset_loop:      ACALL write
                                JC show_error2
                                INC R0
                                INC address
                                CJNE R0,#preset_temp,write_preset_loop
                                RET

show_error2:            MOV digit1,#e_mask
                                MOV digit2, #r_mask
                                MOV digit3,#r_mask
                                MOV digit4,#2_mask
show_loop2:                     ACALL show_long
                                SJMP show_loop2
;*****************************************************
compare_temp:   MOV A, sys_temp
                        CJNE A,preset_temp, chk_2
back1:          CLR relay_dx
                        RET

chk_2:          JC back1
                        SETB relay_dx
                        RET
'**************************************
write:                  ACALL i2c_Start
                                MOV A, #slave_Address
                                ORL A, #write_flag
                                CALL write_byte
                                JC write_Abort
                                MOV A, address
                                CALL write_byte
                                JC write_Abort
```

```
                                MOV A, data_2_write
                                CALL write_byte
                                JC write_Abort
                                CLR C
                                CALL i2c_Stop
                                call write_time_out
                                RET
write_abort:            CALL i2c_Stop
                                CALL write_time_out
                                RET
;************************************************************

read:                           CALL i2c_Start
                                MOV A, #slave_Address
                                ORL A, #write_flag
                                CALL write_byte
                                JC read_Abort
                                MOV A, address
                                CALL write_byte
                                JC read_abort
                                CALL i2c_Start
                                MOV A, #slave_Address
                                ORL A, #read_flag
                                CALL write_byte
                                JC read_Abort
                                CALL read_byte
                                MOV data_Read, A
                                CALL no_Ack
                                CLR C
                                CALL I2C_STOP
                                RET
read_Abort:                     CALL i2c_Stop
                                RET
;*****************************************
i2c_start:                      SETB data_out
                                SETB clock_out
                                CALL dly_7us
                                CLR data_out
                                LCALL dly_5us
                                CLR clock_out
                                CALL dly_7us
                                CLR C
                                RET
;*****************************************
i2c_stop:                       CLR data_out
                                CALL dly_5us
                                SETB clock_out
                                CALL dly_7us
                                SETB data_out
                                RET

;*****************************************
write_byte:     MOV R2,#8
write_loop:     RLC A
                MOV data_out, C
                NOP
                NOP
                SETB clock_out
                CALL dly_7us
                CLR clock_out
                CALL dly_7us
                DJNZ R2,write_loop
                SETB data_out
```

```
                NOP
                NOP
                NOP
                SETB clock_out
                NOP
                NOP
                MOV C, data_out
                CLR clock_out
                RET
;*****************************************
read_byte:      MOV R2,#8
                SETB data_out
read_loop:      NOP
                SETB clock_out
                CALL dly_7us
                SETB data_out
                NOP
                NOP
                MOV C, data_out
                RLC A
                NOP
                NOP
                CLR clock_out
                CALL dly_5us
                DJNZ R2,read_loop
                MOV data_Read, A
                RET
;*****************************************
write_time_out: ACALL write_display
                        RET
;*****************************************
no_Ack:         SETB data_out
                        NOP
                        NOP
                        SETB clock_out
                        NOP
                        NOP
                        NOP
                        CLR clock_out
                        RET
;*****************************************
dly_7us:                NOP
                        NOP
                        NOP
                        NOP
                        NOP
                        NOP
                        NOP
                        RET
;*****************************************
dly_5us:                NOP
                        NOP
                        NOP
                        NOP
                        NOP
                        NOP
                        RET
;*****************************************
INCLUDE "c:\batronix\prog-studio\include"
```

APPENDIX B

COMPLETE CIRCUIT DIAGRAM



APPENDIX C

BILL OF QUANTITY

S/No	Component	Qty	Price (N)	Amount (N)
1	220/12V Transformer	1	300	300
2	1N4001 Diodes	4	20	80
3	7805 Voltage regulator	1	70	70
4	2200uF Capacitor	2	150	300
5	LM35 Temperature Sensor	1	1200	1200
6	0804ADC (Analogue/Digital Conv.)	1	1500	1500
7	(74HC156) Shift Register	1	1000	1000
8	AT89C52 Microcontroller	1	2000	2000
9	CD4049 Port Expander	1	600	600
10	Seven Segment-Com Anode	4	200	800
11	Electromagnetic Relay	1	300	300
12	GR1015 PNP Transistors	5	40	200
13	Toggle Switches	9	20	180
14	Resistors	10	10	100
15	Casing		10000	10000
16	IC Sockets	4	30	120
17	12MHz Crystal Oscillator	1	150	150
18	Capacitors	4	50	200
19	Transportation		2000	2000
20	Consultancy		4000	30000
21	Variable Resistor	1	50	50
22	Miscellaneous		2500	2500
Total				**27650**