DESIGN AND CONSTRUCTION OF A TEMPERATURE MONITORING AND CONTROL DEVICE FOR INDUSTRIAL AND DOMESTIC BAKING PURPOSES

BY

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A PROJECT SUBMITTED TO THE DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING, FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF BACHELOR OF ENGINEERING (B.ENG) DEGREE IN ELECTRICAL AND COMPUTER ENGINEERING
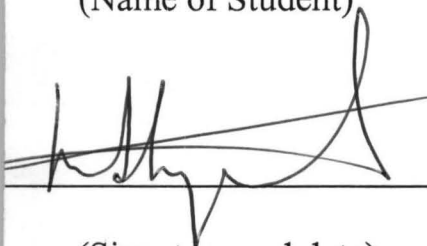
November 2010

DEDICATION

I am dedicating this work to Almighty Allah (SAW) for seeing me through all these years of my life.

DECLARATION

MOHAMMED NMAYA MOHAMMED, declare that this work was done by me and

as never been presented elsewhere for the award of a degree. I also hereby relinquish

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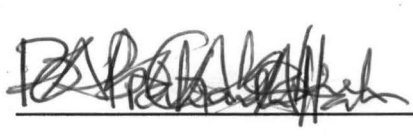

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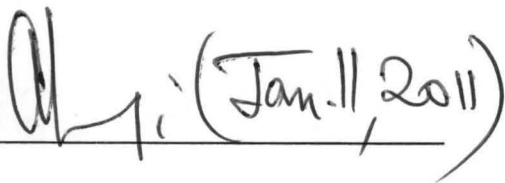
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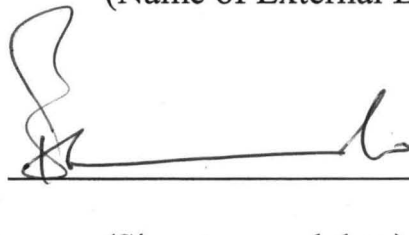
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ACKNOWLEDGEMENT

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ABSTRACT

his device is designed for industrial / domestic baking. The user simply power it on

d input temperature and time values which are desired for baking via the preset

ttons. The device immediately start comparing the values of the ambient temperature,

e system temperature and the desired time starts to count-down .When the time finally

apse, the microcontroller system sends control signals to disconnect the heating

ement by energizing a relay connected to the heating element. Power is cut-off from

e heating element and the alarm start to sound.

TABLE OF CONTENTS

Chapter Three:

CHAPTER FOUR

CHAPTER FIVE

CHAPTER ONE

1.0   INTRODUCTION

Food is one of the basic physiological needs of man that make him/her both physically and mentally alerts for his/her daily survival. They contain supplements which the body requires to regulate its sub-systems properly. The application of heat in the form of cooking is known to reduce the nutritional values of this supplements and therefore, care must be take for proper monitoring and controlling of the temperature for cooking.

Furthermore, the monitoring and controlling of temperature in making plays a crucial role in efficient time management, reduce food wastage, increase flavor characteristics in food and increase the shelf-life of the food.

From the time of early stoves and ovens, improvements have been made to enhance the monitoring and controlling of cooking temperature in cooking devices but all of them have great set-back to that effect. More recently is the microwave oven which uses the microwave radiation to heat-up and cook the food. Timers are incorporated into these devices which the user "set" to the maximum time to cook a particular type of food. This is suppose to regulate the "cooking time" but the fact is that these times are averages and factors like the surrounding temperature of the environment are not considered, therefore need for a more precise and accurate monitoring systems.

This device controls the temperature more accurately and efficiently for both domestic and industrial devices. It provides means of timing the baking process as well as regulating the operating temperature between defined or set limits. It further makes provisions for changing the temperature and even time to suit the particular food being cooked and the interest of the cook. To use this device,

he user simply set the appropriate temperature and time at which the wants to cook the food and the

ooking, monitoring and control process are automatically carried out by the device. It possesses the

bility to monitor and control the process by switching off the source of power when the set time

lapses.

.1 STATEMENT OF PROBLEM

easons for embarking on this project is largely influenced by some difficult faced by both the

aditional and modern devices for cooking which are present today. This difficulty is seen in different

orm like.

(i)   Improper time management

(ii)   Product consistency and increase in food hazards

(iii)   Crust-crumb flavor characteristics

(iv)   Reduction of shelf-life of the food

2   PURPOSE OF THE STUDY

ie purpose for which this project is embarked upon can be listed as follows:

(i)   To provide a more accurate means of measuring and controlling the temperature of cooking devices especially for industrial device.

(ii)   To increase the consistency in baking products and safer food for consumption.

(iii)   To increase the shelf-life of the finished food

(iv)   To provide proper time management for the user.

2

1.3 SIGNIFICANCE OF THE STUDY

This work shall find great significance in the baking and confectionary industries so as to increase productivity and creativity. It shall also find application in refineries when it is highly necessitated to control and monitor the temperature of equipment like heater, boilers, furnaces etc. Also one can find its application in domestic cooking devices in microwave as to reduce food poisoning hazards.

1.4 SCOPE OF THE STUDY

This work will focus on its application on the baking and confectionary industries though it's application varies and can be seen in other industries like the oil and gas industries research institute and other domestic uses.

1.5 LIMITATION OF THE STUDY

The condition under which the research work was carried out were affected by the limitation of finance and also the large application areas in which the topic covers. Also sourcing related materials for the literature review that narrow down to the scope of the study also posed a serious limitation to the research work.

1.6 REPORT STRUCTURE

This project work is implemented in five chapters. The first chapter is basically an introduction, while chapter two reviews some related literatures, which provide the required sound theoretical base necessary for the research work. Whereas chapter three considers the various materials and method employed in realizing this project, chapter four present and analyses the data, finding and

3

esult obtained. The project concludes in chapter five by presenting a summary of the main points

ised in the body of the research work; make recommendation for further research.

CHAPTER TWO

LITERATURE REVIEW

This chapter is intended to provide a sound theoretical framework for the study. In other words, brief history of temperature, analogue to digital converters, various types of ovens will be discoursed.

2.1 BRIEF HISTORY OF TEMPERATURE

The temperature of a body is define as its thermal state considered with reference to it's power of communicating heat to other bodies or substance[1]. As a very important and salient parameter, it became important that better devices be made for its measurement. These leads to various scientist and inventors researching and finding better means of measurement.

In the eighteen centuries, alcohol was better referenced than mercury when used to measure temperature because alcohol freezes at $-113^{\circ}C$ while mercury freeze at $-39^{\circ}C$[2]. At that time, thermometers were calibrated between the freezing point of salted water and human body temperature. These two extreme were subtended by Fahrenheit into ninety-six points, giving his thermometer more resolution and a temperature scale very close to the Fahrenheit scale.

Close to the middle of the eighteen century Ander Celsius saw that it would be nice to use common calibration reference and to divide the scale into 100 increments instead of ninety six normally used[2]. That is why we have hundred degrees centigrade as the boiling point of water and zero degree centigrade as the freezing point of water

The Nineteen century saw tremendous growth in temperature measurements. The work of Lord Kelvin and William Hershel made known that when sunlight was spread into colours, he could detect

5

in increase in temperature when moving a blackened thermometer across the spectrums[2]. He later found out that the effect of heating increased beyond the red region "infrared". The radiation effect was measured from stores, candle fire and later concluded on the similarity of radiant heat light more over not until the following century that the measure of temperature became really understood by people.

The end of nineteenth century saw the introduction of bimetallic temperature sensor [2]. This thermometer contain no liquid but operate on the principle of unequal expansion between two metals, one metal that is bonded to another will bend one direction when heated and will bend in opposite direction when cooled hence the name bimetallic thermometer[2]. The bimetallic thermometers are handier, easy to understand, and also have a wider span. Thus making them useful industrially. In 1821, Humphrey Dary discovered that all materials have positive temperature coefficient (PTC) unlike semi conductors that have negative temperature co-efficient (NTC) and that plutonium can be use as a very good detector of temperature. It was also known that year by another scientist Tsetback that current can be produced heating the junction of two dissimilar metals unequally. This type of current generated is referred to as thermocouple effect. The two discoveries open up the introduction of electrical transducers[5].

In the twentieth century, the discovery of semiconductor devices such as thermostat, fiber optic temperatures, and integrated circuits sensors marked a great turn improvement in the history of science. Lord Kelvin and Anders Celsius where reward for their works, thus instead of hundred degree Kelvin, we say one hundred Kelvin and the "centigrade" scale was changed to Celsius scale[3]. Temperature can now be measured over a wider range to as little as $0.001^{\circ}C$.

6

2.2   ANALOGUE-TO-DIGITAL CONVERTERS.

The basic operation of an Analog-to-Digital converter depends on comparing two analog signals, with the digital output depending on the outcome of such comparison[4]. It takes in analogue signal and produces a digital output code, which represent the analogue signal. Because it is often used between the interface of analogue system and digital systems, it is sometime called an "encoding device".

In an ADC arrangement, the input analogue voltage is encoded into binary fraction of the reference voltage very so that the output of the ADC consist of digital word given by the expression

$$Vout = b2^{-1} + b_1 2^{-2} + b_2 2^{-3}.................b_n 2^{-n}$$

Where n is the number of bits in the digital word and $b_0, b_1 b_2$...... are binary coefficient which can have the logic value 0 or 1[5].Below is a block diagram showing a possible arrangement of a 3 bit ADC
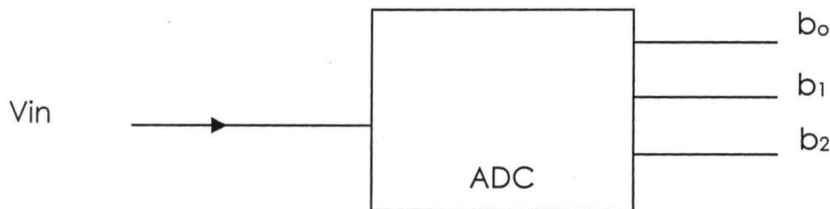
Fig 2.1: Diagram of a 3-bit ADC

From the expression above the analogue input voltage to an ADC quantizes this voltage at a particular sampling instance to give a digital word. The transfer characteristic shown below shows clearly the digital translation process.
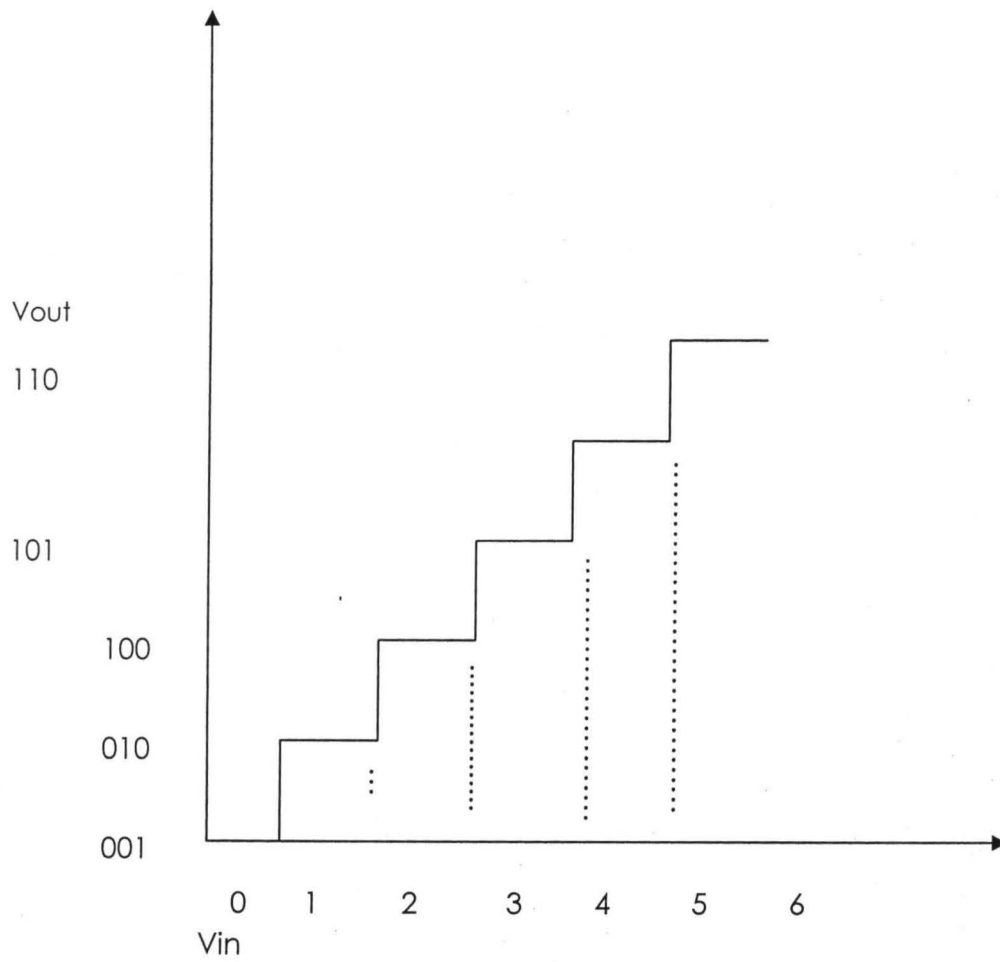
Fig 2.2: Input / Output characteristic of a 3-bit ADC.

This shows clearly that an analog voltage of say 2V can be represented by 001 digital word. This give rise to quantization error in the ADC. This error can be reduced using digital word of greater length. But clearly quantization errors still remains, it can only be minimized.
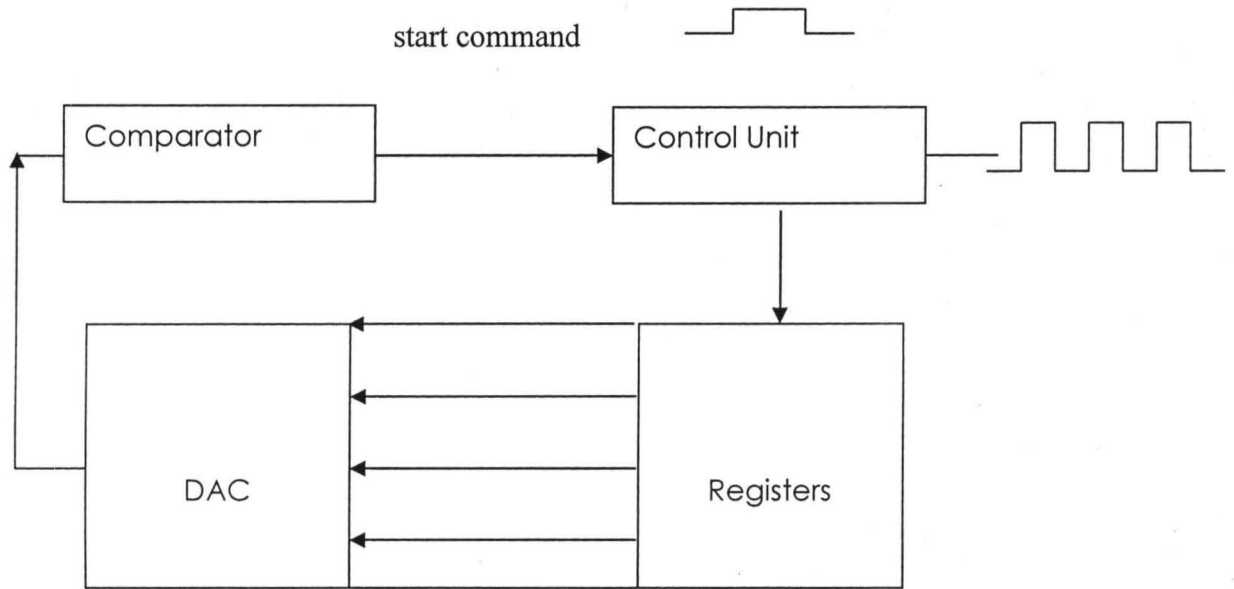
start command

Fig 2.3: Block diagram of an ADC

The ADC consists of two main block; a comparator and a control unit , as well as digital-to-nalogue converter (DAC) unit and registers. The control unit has three inputs which are Vin, a clock nd start command. It's output to the control unit depends on which analogue signal is greater [6].

The following operation sequence will commence when an ADC is switched on.

1. Start command goes high and this cause the A/D to start operation

2. The clock determines the rate at which data is sent by the control to register

3. The register holds a binary number, which is passed into the DAC

The input signal of the ADC is also fed into the comparator, which it's compares with that provided by the DAC [5]. Now letting the analogue signal be a VA and the output signal from the DAC be VDA

If VDA < VA, the comparator output is high

If VDA > VA, the comparator output is low

2.3 HISTORY OF OVENS

Before the invention of microwave oven, stoves have been used extensively for cooking and baking of foods. As early as 1849[7], there have been historical records of stoves built in Alsace, France. It structures was made of bricks and became very popular in America. The Germans also designed their first kind of stove which was known as the "fire plate" Benjamin Franklin also late designed the iron furnace stove which was called the "Franklin stove". Jordan Mott. Invented the first practical coal stove in 1833. While James sharp, a British inventor invented the first gas stove in 1826. As time pass, other inventions and improvement were made but perhaps the greatest discovery of all is he microwave oven.

The heating effect of microwave was discovered accidentally in 1945 [8]. Percy Spencer, an American self-taught engineer from howlandmain was building magnetrons for radar sets with American company Raytheon. He was working on an active radar set when he noticed that a peanuts chocolate bar he had in his pocket started to melt. The radar had melted the chocolate bar with microwave. He later use pop-corn to verify his findings Spencer created a high density electromagnetic field by feeding microwave power into a metal box from which it has no way to excape.Food place inside the box increases in temperature and start to cook.

2.3.1 TYPE OF OVEN - The common type of ovens are:

- Hearth ovens- this type of oven is made up of different strata of layers or tray all in one compartment. Each level is an independent oven since it is equipped with industrial stream producer, temperature regulator, timer and lightings[9].

- Conventional ovens – conventional ovens apply heat from the buttom and as the heat rises. It create different temperature areas within the oven, hence, they are referred to as "zoned ovens".

- Fan assisted ovens – like conventional ovens, it operation are similar only different is fans are incorporated into the fan-assisted ovens to ensure even temperature distribution[10].

2.3.2 DANGERS ASSOCIATED WITH MICROWAVE

- Tin foil, aluminum foil, ceramic decorated with metals and products containing metal or conductive object can cause sparks when they are used in microwave [11]. This is as a result of the metal object placed into microwave will act as an antenna absorbing microwave radiation. If the object is pointed, the pointed end will act to concentrate the electric field formed at the tip. This has the effect of exceeding the dielectric breakdown gradient of air about $3x10^6$ v/m causing sparks to form.

- The most controversial hazard of microwave food is the health implications. Research conducted by German and Russians reveal three main categories of hazard [12]

Category 1: cancer – causing effect

Category 2: Nutrition destruction of food

Category 3: Biological effect of exposure

11

CHAPTER THREE

3.1 DESIGN AND IMPLEMENTATION

This project work, the designing and construction of a micro controller temperature monitoring and controlling device was realized in modules. These modules were brought together to form the whole system. This chapter seeks to look into design approach and material involved.

3.1.1 MODULES

(i)   5 – volts power system modules

(ii)   Temperature-to-voltage conversion module

(iii)   8-bit analog-to-digital conversion modules

(iv)   8-bit microcontroller chip module

For effective communication with the user, 7-segment is also used.
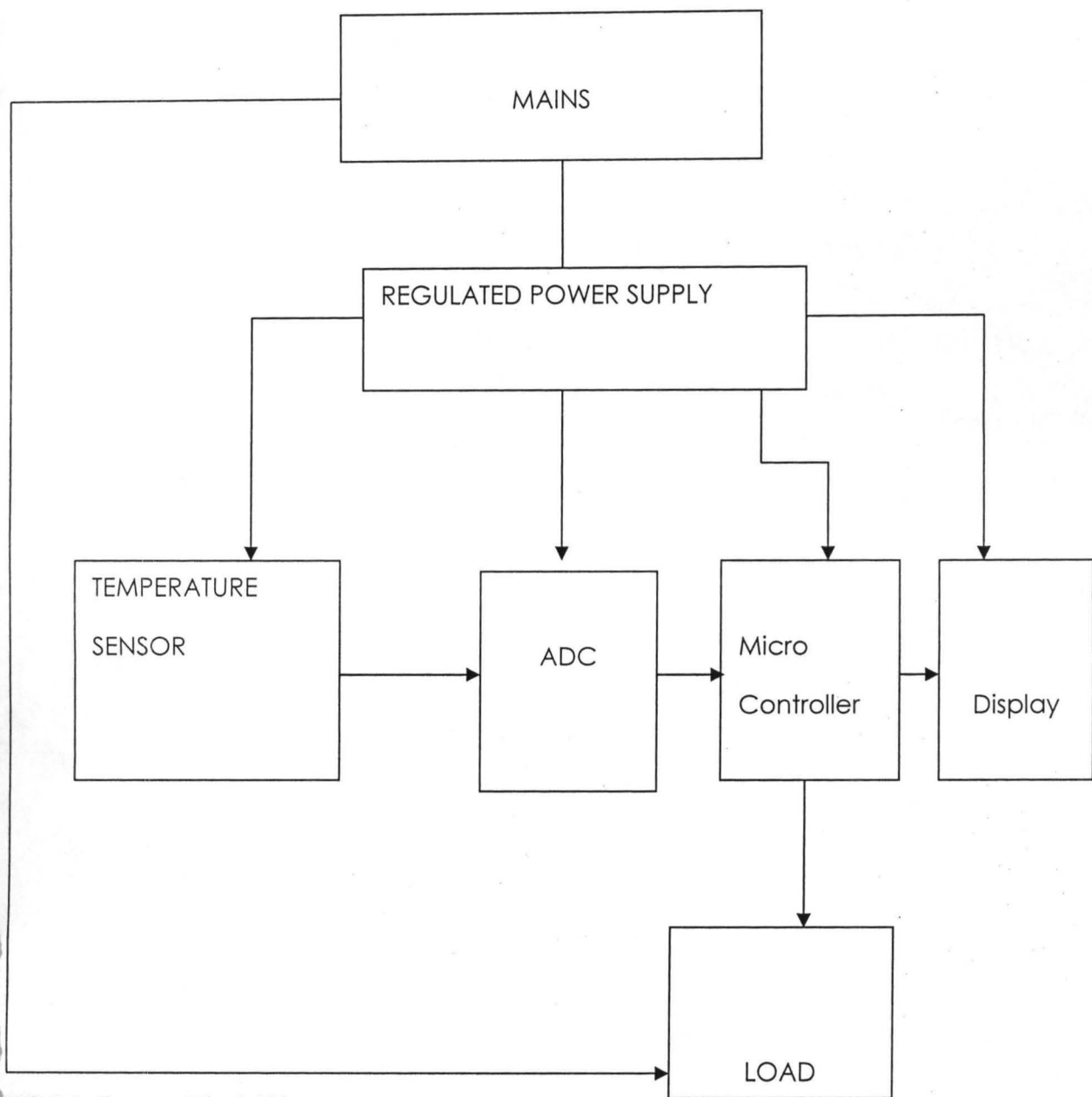
FIG 3.1: System Block Diagram

Considering the function of each blocks in the figure above, fully explain the operation of the whole system.

- **Main** – from public electricity or generator etc.

- **Regulated power supply** –This is the maximum demand voltage of the system i.e. 5V. This serves all the integrated circuit chips on the system.

- **Temperature sensor** – this unit serves the purpose of converting the temperatures into measurable linear voltage.LM 35, a temperature transducer senses and converts the baking temperature into electrical voltage equivalent.

- **Analog-to-Digital converters** - This unit deals with converting varying electrical voltage (analog) into digital form that can be understood and interpreted by the microcontroller.

- **Microcontroller** – this unit perform all operation on the quantized voltage, store results of operation, display results depending on the result of the comparison, the microcontroller issues command through the switch control unit to either maintain the baking device in operation or turn it off.

- **Display** – for real time communication of system status with the human world, a visual display will be necessary. This display is a 4digit, 7-segment common multiplexed display.

- **Load** – the heating element of the baking device.

- **Buzzer** – an alarm unit.

.2 DESIGN IMPLEMENTATION OF POWER SYSTEM

All the integrated circuit (IC) dip used to realize this project work requires a 5V direct current, ady supply to make it operational. A simple power module consisting of a 12V, O.5A step-down nsformer, a bridge rectifier and LM 7805, 0.5V voltage regulator was used to achieve this.

14

The 12V voltage transformer takes an input voltage of about 230-240v Vac from the main supply and steps it down to approximately 12 Vac at the secondary side. The bridge rectifier is used to convert the Ac into Dc by removing the ripples frequency produce by the sinusoidal voltage. Capacitors are incorporated into the power circuit to couple the unstabilized voltage output from the rectifier to the voltage regulator. The LM 7805 voltage was included to accept an unstablized dc voltage at its pin 1 terminal and produce a stabilized voltage 05 5Vdc at its pin 3 terminals.The pin 2 terminal is common and grounded. The stabilized voltage is collected between pin 2 and pin 3 terminal
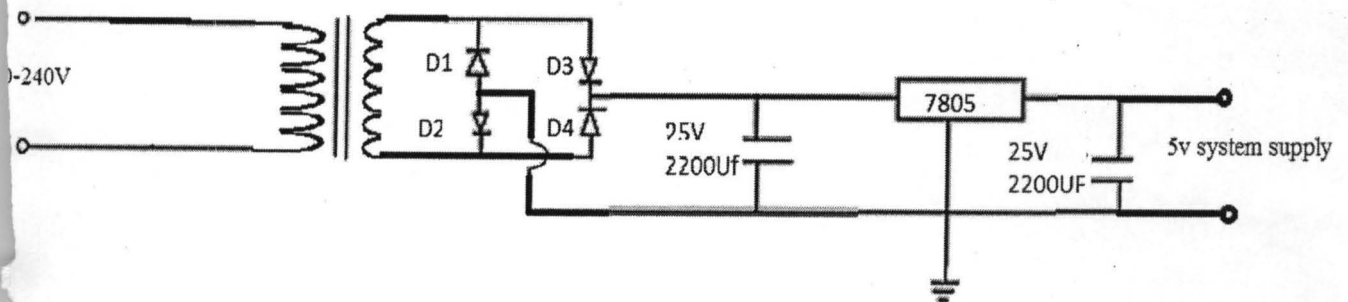
fig 3.2 system power module

3.1.3 DESIGN IMPLEMENTATION OF TEMPERATURE-TO-VOLTAGE CONVERSION

This module is intended to play the role of converting the physical quantity of temperature into a measurable electrical voltage. As a result, it is desire to select a suitable temperature sensor capable of carrying out the required conversion, function, conveniently and be compatible with the ADC.

To achieve this, the LM 35 chip package was used in this project work. It is a centigrade temperature sensor used to convert the ambient temperature to voltage. The device is a 3pin plastic package chip[14]. It has the advantage of calibrating directly in degree Celsius. Other advantages are:

i.   The LM 35 does not require external calibration and provide accuracy of $+1/4^{\circ}C$ at room temperature

ii.   It can be used with single power supplies

iii. It has low self-heating capabilities of less than $0.1^{\circ}C$ in still air

Due to some of LM 35 specification it became necessary to use the device for the project. Some specifications of LM 35 are

1. A guaranteable accuracy of about 05% (at $+ 25^{\circ}C$)

2. It needs only about 60 A of current from its supply

3. It is directly calibrated in degree Celsius

4. Can operate over a temperature range of $- 55^{\circ}C$ to $150^{\circ}C$

5. Suitable for remote application

6. Can operate from 4V to 30V

3.1.4 DESIGN OF ANALOGUE-TO-DIGITAL CONVERSION MODULE

The design of this module followed a very careful selection of a suitable analogue-to-digital converter capable of performing the required conversion functions.ADC 0804 IC chip analogue to-digital converter was used in this project work.

The ADC0804 is a CMOS, 8-bit successive approximation analogue-to-digital converter that uses a differential potentiometric ladder[13].

CS	01	20 — V$_{cc}$ (OR V$_{REF}$)
RD	02	19 — CLK R
WR	03	18 — DBO (LSB)
CLK IN	04	17 — DB 1
INTR	05	16 — DB 2
VIN (+)	06	15 — DB 3
VIN (-)	07	14 — DB 4
AGND	08	13 — DB 5
VREF /2	09	12 — DB 6
DGND	10	11 — DB 7 (MSB)
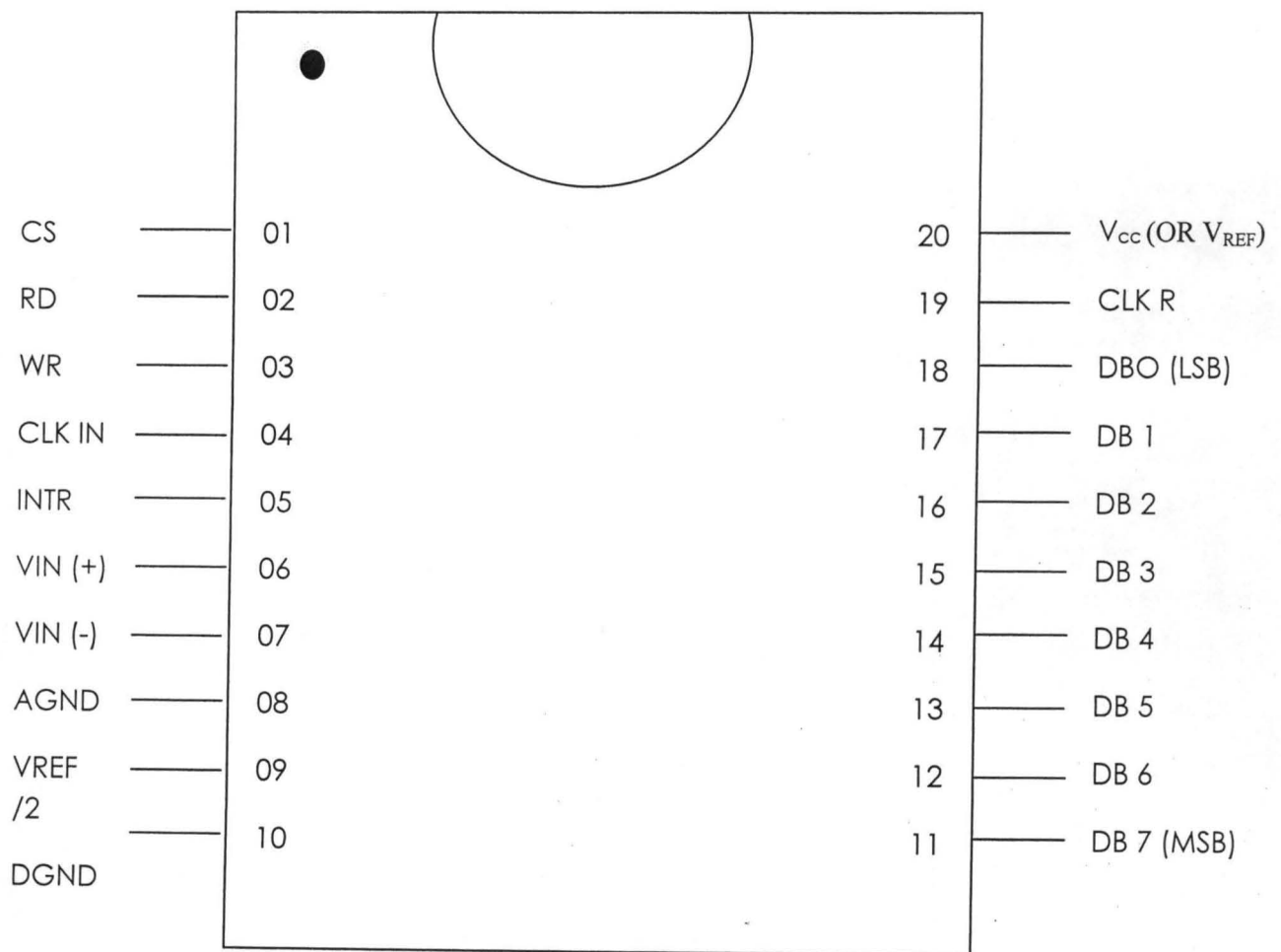
Fig. 3.3 conection digram for ADC 0804

3.1.5.:DESIGN CONSIDERATIONS AND SPECIFICATIONS

The choice and subsequent application of this converter in this project was necessitated by a number of outstanding features it posses as well as other numerous capabilities it offers, which include the following:

i.   It is compatible with 8080 microprocessor derivatives, and requires no interfacing logic.

ii.   Easy interface to all microprocessors, or can operate "stand alone"

iii.   Logic inputs and outputs meet both CMOS and TTL voltage level specifications.

iv.   It has on-chip clock generator

v.   It can use 0V to 5V analogue input voltage range with single 5V supply.

vi.   No zero adjust required

The converter the following key design specifications.

i.   Resolution – 8 bits
ii.   Total error - + ILSB
iii.   Conversion time-100us.

1.6.: DESIGN IMPLEMENTATION OF ADC

For the purpose of this project, the module was designed and applied microcontroller interface mperature-to-digital converter. To achieve this objective, the ADC 0804 chip was wired as shown low.
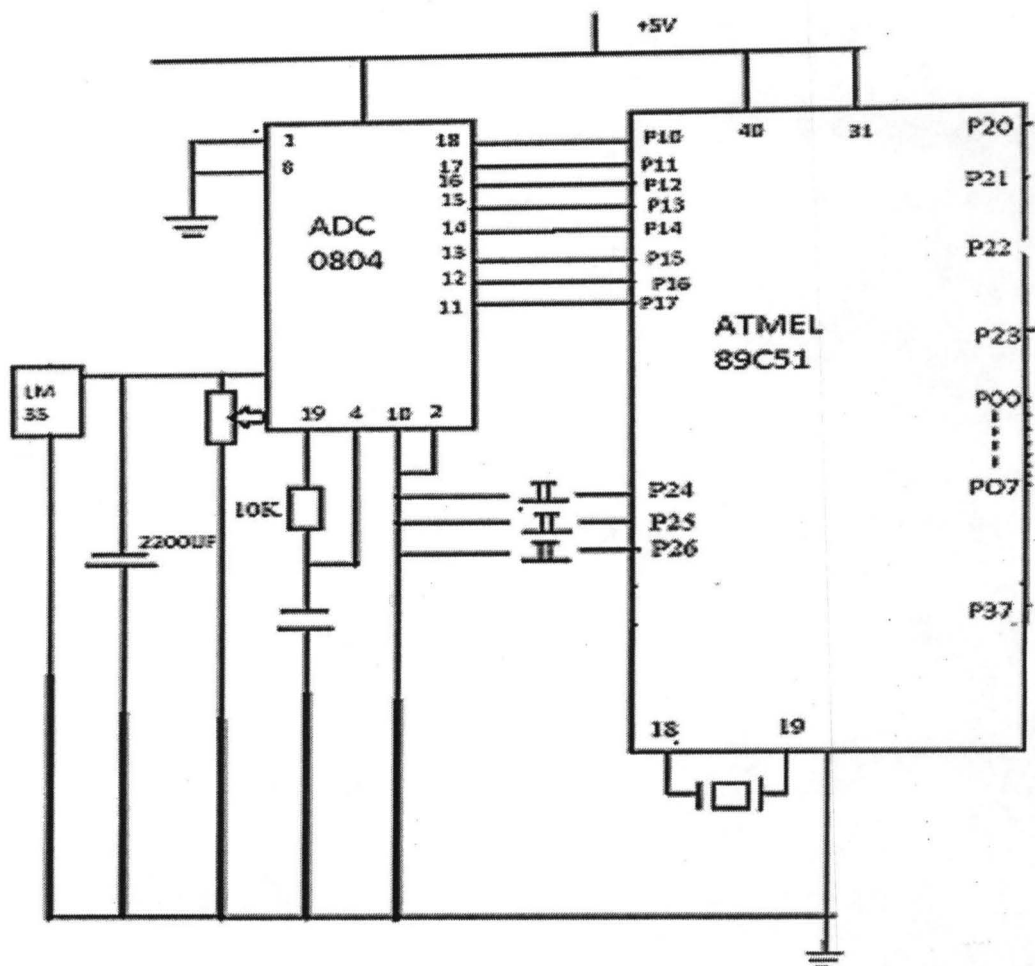
Fig 3.6.: An ADC 0804 interface micro controller

1.7.: 8-BIT SYSTEM CONTROLLERS

8-bit 89C51 microcontroller is used for system control. The system control among other things

rform the following:

1) Control the conversion process

2) Perform logical operations on the converted data

3) Write the decimal equivalent to the seven segment display

4) Respond to key press that provide user control

5) Store and load user setting

The controller is a fully stable CMOS device with 4KB of on chip re-writable and re-programmable flash memory, 128bytes of internal memory and numerous on-chip hardware functionalities

The device is programmed in C language. The system controlled interface with other board components is depicted in the figure below.
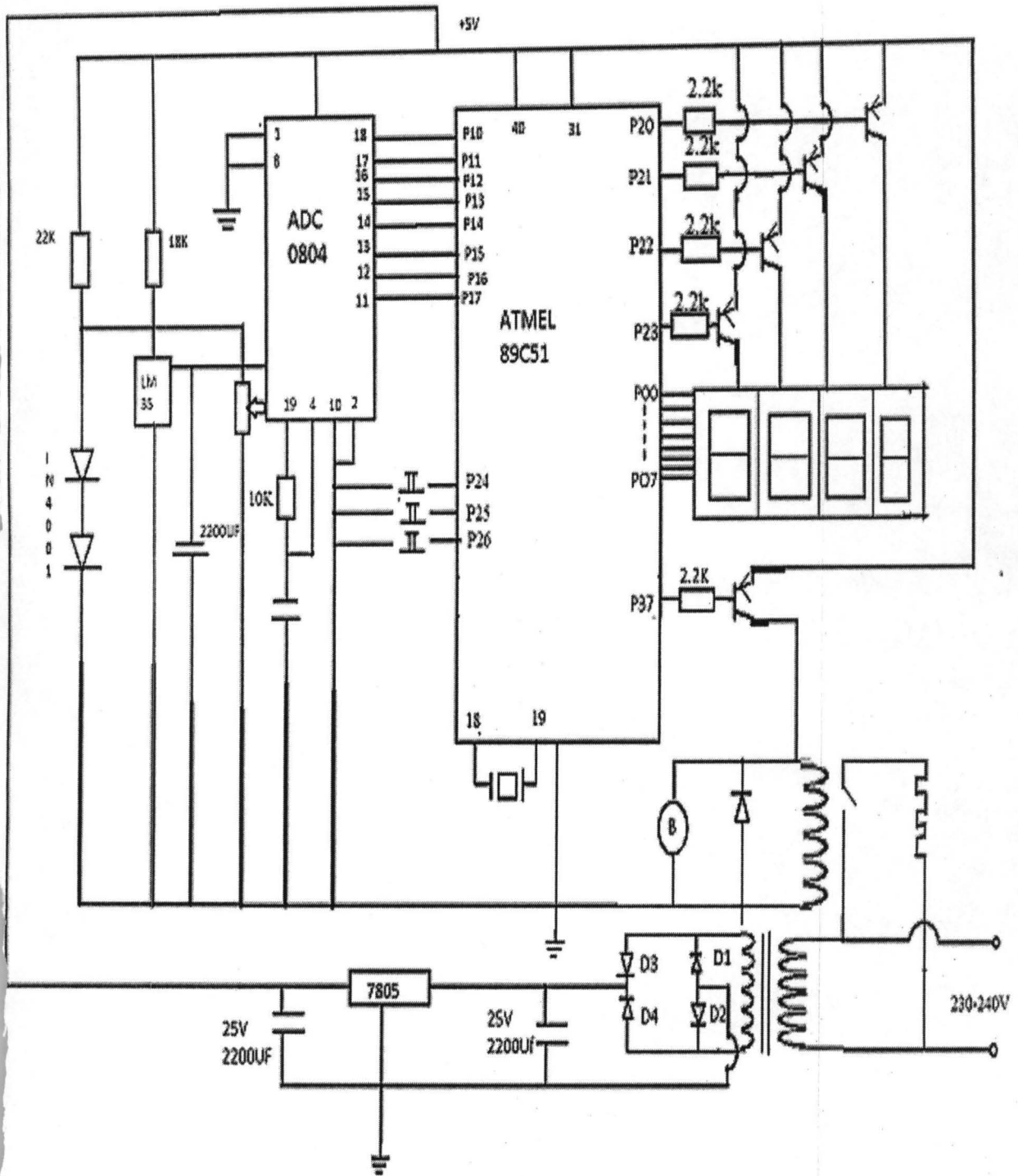
fig 3.5 system circuit diagram

3.1.8: DIGIT 7-SEGMENT DISPLAY

For real-time communication of system status with the human world, a visual display system is incorporated. This display is a 4-digit 7 segment common anode multiplex display. The circuitry connection for the display is as show below.

Design Calculation

For an n-digit multiplexed display the segment current required to produce the same brightness in such a segment would be as if it were individually connected to a port nxI segments

I segment's chosen as 10mA, a digit multiplexed display would require 40mA per segment. This n-fold increase in segment current is to counter the current discontinuity caused by the time slicing due to multiplexing. A 15mA forward current was selected for each segment the required pulsed current therefore is 5 x 15mA = 75mA

The total alphabet used is 8 giving a total current of 8 x 75mA = 600mA

(8 i.e. alphabet a,b,c,d,e,f and g with decimal point.
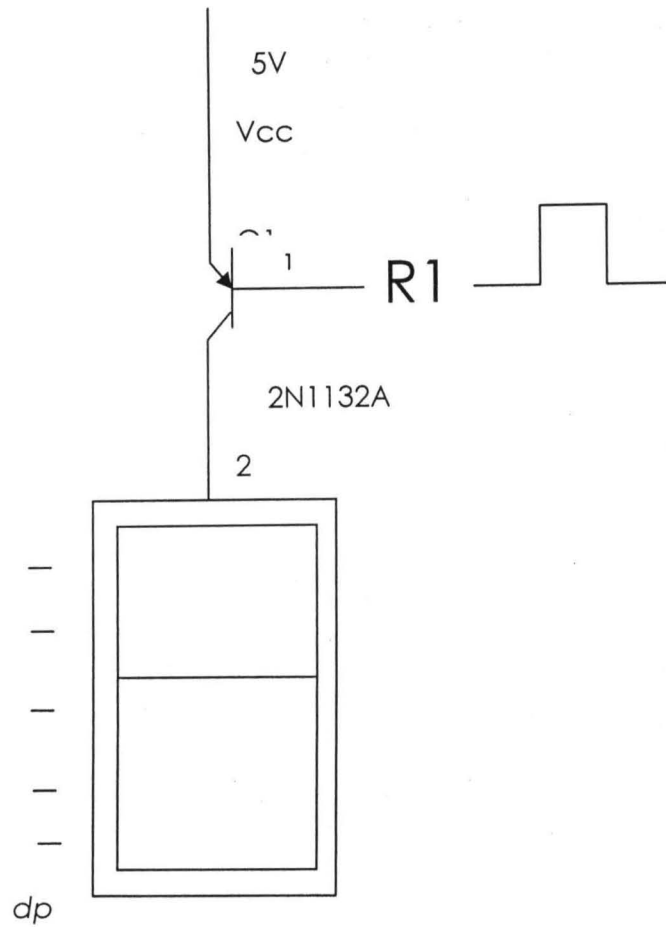
Fig 3.7 -7 Segment Display.

The transistor used for digit control must therefore be capable of handling this value of pulsed current

1c = total segment current = 600mA

$1_c = \beta I_B$

The 25 A1015 GR transistors has an Hre typically 200

$$1_B = \frac{1_c}{Hre} \quad 1_B = \frac{0.6}{200} = 0.003A$$

$$R_B = \frac{Vcc - Vbe - Vol\ (8951)}{1_B}$$

$$R_B = \frac{5 - 0.7 - 0.2}{0.003A} = \frac{4.1}{0.003} = 1366\Omega$$

A 2.2 K Ω base resistance was used instead the system control also interfaced with electromechanical relays via PNP transistor.
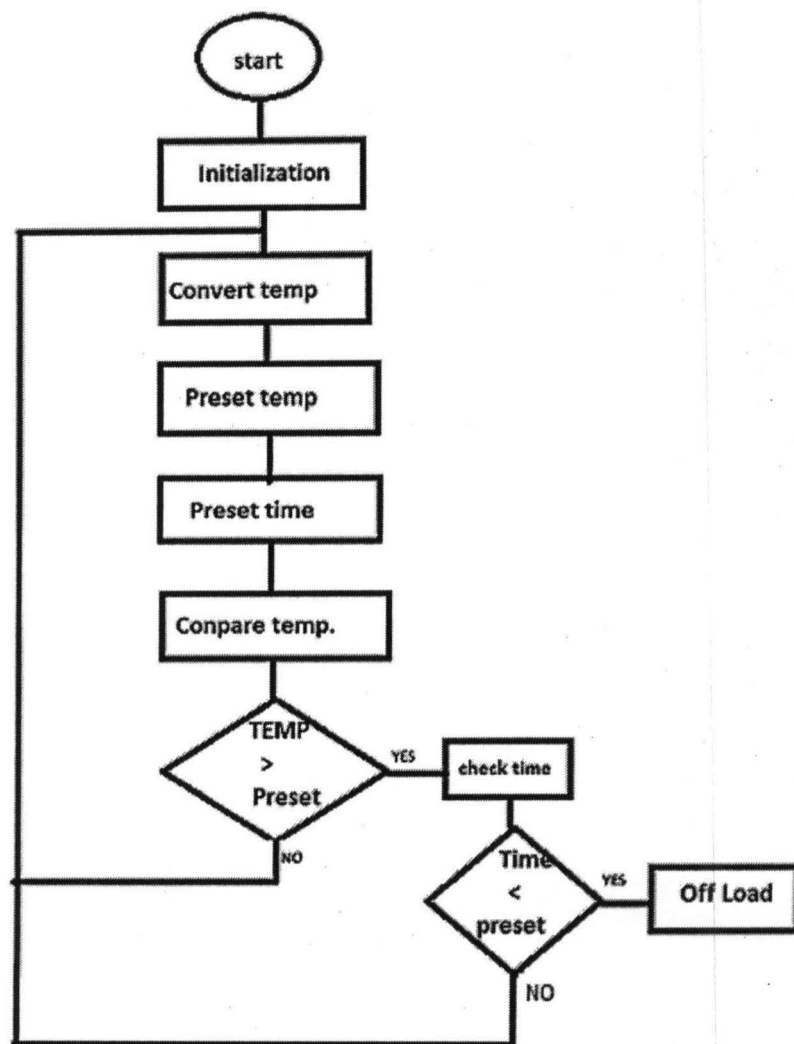
ig. 3.8.: System Flowchart

25

CHAPTER FOUR

4.0.: RESULTS AND DISCUSSION OF RESULTS

After any hardware realization of any engineering system, test must be completion, we get to see if actually the system, test must be conducted and results are obtained. At this stage of completion, we get to see if actually the system functioned properly and satisfactorily as describe in the previous chapter. Specification are also considered to see if design objectives are met. But some precautionary measures were taken before the realization of the system which are discussed below.

(1) It was ensured that all component are good approximate of their rated specification.

(2) All faulty component detected were replaced with functional ones.

(3) Care was taken during soldering on the vero-board to avoid leakage of current.

(4) The temperature sensor was well position to read accurate temperature of the heating device

(5) The circuit board was firmly attached to the "house" and unnecessary movement disallowed.

(6) The reset buttons an also well fixed for optimal functionality.

4.1.: LIMITATION

Some challenges faced during the construction of this work are

1. Inability to get good components that meet specification accurately

2. Some components not easily accessible

3. Replacement of faulty components

4. Instability of the public electricity supply

5. Financial involvement

4.2.: GENERAL PROCEDURE FOR OPERATION

(i)   The heating device is connected via the system to the main supply. It is normally "off"

(ii)   The monitoring and controlling device is now connected to the main and the actual temperature of the surrounding is displayed i.e 29°C.

(iii)   First two upper most reset buttons are used to either increment of decrement

(iv)   The bottommost button when hold-down and using the previous buttons increment or decrement the time. Note that time count is in minute for this design.

(v)   When time has been set, a click sound is heart and the load automatically turns ON. Note for the sake of better illustration, light bulb can be used as load.

(vi)   The monitoring and controlling operation continues till the time elapse and the bursar start to sound indicating load "off".

(vii)   Sensor displays the new temperature of the surrounding

4.3.: TROUBLE SHOOTING

1. Ensure proper correction of load to the circuit system

2. Ensure a stable main power supply

3. Follow procedure of operation carefully

CHAPTER FIVE

5.1 SUMMARY

This project is a portable temperature monitoring and controlling device designed for baking purposes. The baker simply set the desired cooking temperature and also set the time in which the food cooks properly. The baker simply goes about other routine as when the time set elapse, the oven in automatically disconnected from supply and an alarm is sound to notify the baker.

It is a fast, convenient and effective way of baking and equally reduces to the minimum food wastage. Also considering it flexibility for programming it to handle the operation of high temperature industrial equipment such as glass furnace, iron melting and smelting plant, compressor etc.

5.1.1 Improvement

Several improvement can be made to optimize this project some which are highlighted below

- A computer – software model can be built that will handle more complex temperature operator

- Cooling system i.e. fan can be provided for better heat dissipation

- Re-designing similar temperature system to fit other engineering application and discipline i.e. Engine of a car.

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C51 COMPILER V8.06   CODE
C51 COMPILER V8.06, COMPILATION OF MODULE CODE
OBJECT MODULE PLACED IN code.OBJ
COMPILER INVOKED BY: C:\Keil\C51\BIN\C51.EXE code.c ROM(SMALL) BROWSE DEBUG
OBJECTEXTEND CODE

line level   source

```
1         #include<reg51.h>
2         #include<intrins.h>
3
4         #define adc_port P1
5         #define data_port P0
6         #define dx_port P2
7         #define key_port P2
8         #define ctrl_port P3
9
10        #define seconds_count_reload 4000
11        #define size 8
12        #define centigrade_mask 0x46
13        #define dp_mask 0x80
14        #define digits 4
15        #define minutes_count_reload 60
16        #define max_time 9999
17        #define max_temp 255
18
19        code char table[]={0xc0,0xf9,0xa4,0xb0,0x99,0x92,0x82,0xf8,0x80,0x90};
20
21        unsigned int preset_time,seconds_count;
22        unsigned char sys_temp,preset_temp,minutes_count;
23        bit time_ok,time_set,temp_set;
24        unsigned char data buffer[size];
25
26
27        sbit load_dx = P3^7;
28
29        sbit mode_key = P2^0;
30        sbit plus_key = P2^1;
31        sbit minus_key = P2^2;
32        sbit adc_write=P3^0;
33        sbit alarm_dx=P3^6;
34        //*****************
35        //*****************
```

```
36        void tf0_isr(void) interrupt 1
37        {
38  1         if(!(--seconds_count))
39  1         {
40  2             time_ok=1;
41  2             seconds_count=seconds_count_reload;    //4000 ticks here
42  2             if(time_set)
43  2             {
44  3                 if(!(--minutes_count))
45  3                 {
46  4                     minutes_count=minutes_count_reload;
47  4                     if(!(--preset_time))
48  4                     {
49  5                         load_dx=1;
50  5                         time_set=0;
51  5                         alarm_dx=0;
52  5     }}}}}
53        //******************
54        //******************
55        void delay(unsigned char z)
```

C51 COMPILER V8.06   CODE

```
56        {
57  1         while(--z);
58  1     }
59        //*****************
60        //*****************
61        void write_display(unsigned char data *ptr)
62        {
63  1             unsigned char z;
64  1             for(z=4;z<8;z++)
65  1             {
66  2         dx_port=0xff;
67  2         data_port=*ptr++;
68  2         dx_port&=~(1<<z);
69  2         delay(200);
70  2         dx_port|=1<<z;
71  2         data_port=0xff;
72  2         delay(200);
73  2             }
74  1     }
75        //*****************
76        //*****************
77        unsigned char get_adc(void)
```

31

```
78        {
79   1          unsigned char z;
80   1
81   1          adc_write=0;
82   1          adc_write=1;
83   1          z=60;
84   1          while(--z);
85   1          return adc_port;
86   1        }
87        /// *******************88
88        //*********************
89        unsigned char get_avg(unsigned char t)
90        {
91   1          unsigned int avg=0;
92   1          unsigned char z;
93   1
94   1          time_ok=0;
95   1          for(z=0;z<size;z++)buffer[z]=buffer[z+1];
96   1          buffer[size-1]=t;
97   1          for(z=0;z<size;z++)avg+=buffer[z];
98   1          return avg/size;
99   1        }
100       //******************
101       //*******************
102       void init_timer(void)
103       {
104  1          TCON=0x00;
105  1          TMOD=0x02;
106  1          TH0=0x06;
107  1          TL0=0x06;
108  1        }
109       //****************
110       //****************
111       void init_irq(void)
112       {
113  1          ET0=1;
114  1          EA=1;
115  1        }
116       //****************
117       //****************
```

C51 COMPILER V8.06   CODE

```
118       void start_timer(void)
119       {
120  1          TR0=1;
```

```c
121 1      }
122        //***************
123        //**************
124        unsigned char init_temp(void)
125        {
126 1          unsigned char z;
127 1          unsigned int avg=0;
128 1          for(z=0;z<size;z++)buffer[z]=0x00;
129 1          for(z=0;z<size;z++)buffer[z]=get_adc();
130 1          for(z=0;z<size;z++)avg+=buffer[z];
131 1          return avg/size;
132 1      }
133        //******************8
134        //*******************
135        void show_temp(unsigned char x)
136        {
137 1          unsigned char loop=50;
138 1          unsigned char r;
139 1          unsigned char data d_buffer[10];
140 1
141 1          if(x>=200)
142 1          {
143 2          x/=2;
144 2          d_buffer[0]=table[x/100];
145 2          d_buffer[1]=table[(x%100)/10];
146 2          d_buffer[2]=table[(x%100)%10];
147 2          }
148 1          else
149 1          {
150 2          r=(x%2)*10/2;
151 2          x/=2;
152 2          d_buffer[0]= table[x/10];
153 2          d_buffer[1]= table[x%10]&(~dp_mask);
154 2          d_buffer[2]= table[r];
155 2          }
156 1          d_buffer[3]=centigrade_mask;
157 1          while(--loop)write_display(d_buffer);
158 1      }
159        //******************
160        //******************
161        void show_time(unsigned int x)
162        {
163 1          unsigned char loop=50;
164 1          unsigned char data d_buffer[10];
165 1
```

33

```
166  1          d_buffer[0]=table[x/1000];
167  1          d_buffer[1]=table[(x%1000)/100];
168  1          d_buffer[2]=table[(x%100)/10];
169  1          d_buffer[3]=table[((x%1000)%100)%10];
170  1          while(--loop)write_display(d_buffer);
171  1      }
172      //****************
173      //****************
174      void sys_init(void)
175      {
176  1          IE=0x00;
177  1          adc_port=0xff;
178  1          dx_port=0xff;
179  1          data_port=0xff;
```

```
180  1          key_port=0xff;
181  1          ctrl_port=0xff;
182  1          time_ok=0;
183  1          time_set=0;
184  1          temp_set=0;
185  1          preset_time=0;
186  1          preset_temp=0;
187  1          minutes_count=minutes_count_reload;
188  1          seconds_count=seconds_count_reload;
189  1          load_dx=1;
190  1          init_timer();
191  1          init_irq();
192  1          sys_temp=0x0;
193  1          start_timer();
194  1          while(!time_ok);
195  1          sys_temp=init_temp();
196  1      }
197      //****************
198      //****************
199      void delay_key(unsigned char mode, unsigned int z)
200      {
201  1          unsigned char t=4;
202  1          unsigned char d;
203  1          switch(mode)
204  1          {
```

34

```c
205  2                    case 0: d=0;break;
206  2                    case 1: d=1;break;
207  2                    default:return;
208  2               }
209  1
210  1                    while(t)
211  1                    {
212  2                         if(d==0)show_time(z);
213  2                         if(d==1)show_temp(z);
214  2                         t--;
215  2                    }
216  1     }
217       //*********************
218       //*********************
219       void set_time_plus(void)
220       {
221  1         delay_key(0,preset_time);
222  1         if(!plus_key)
223  1         {
224  2              if(++preset_time>max_time)preset_time=max_time;
225  2              show_time(preset_time);
226  2         }
227  1     }
228       //******************
229       //******************
230       void set_temp_plus(void)
231       {
232  1         delay_key(1,preset_temp);
233  1         if(!plus_key)
234  1         {
235  2                   if(++preset_temp>max_temp)preset_temp=max_temp;
236  2                   show_temp(preset_temp);
237  2         }
238  1         if(preset_temp>0)temp_set=1;
239  1         else temp_set=0;
240  1     }
241       //******************
```

```
242            //*****************
243            void set_time_minus(void)
244            {
245     1          delay_key(0,preset_time);
246     1          if(!minus_key)
247     1          {
248     2              if(preset_time>0)preset_time--;
249     2              show_time(preset_time);
250     2          }
251     1      }
252            //******************
253            //******************
254            void set_temp_minus(void)
255            {
256     1          delay_key(1,preset_temp);
257     1          if(!minus_key)
258     1          {
259     2              if(preset_temp>0)preset_temp--;
260     2              show_temp(preset_temp);
261     2          }
262     1          if(preset_temp>0)temp_set=1;
263     1          else temp_set=0;
264     1      }
265            //********************
266            //********************
267            void  scan_key(void)
268            {
269     1          if(!plus_key)
270     1          {
271     2              while(!plus_key)
272     2              {
273     3                  if(!mode_key)set_time_plus();
274     3                  else set_temp_plus();
275     3              }
276     2          }
277     1          if(!minus_key)
278     1          {
279     2              while(!minus_key)
280     2              {
281     3                  if(!mode_key)set_time_minus();
282     3                  else set_temp_minus();
283     3              }
284     2          }
285     1      }
```

```
286    //*********************
287    //*********************
288    void compare_temp(void)
289    {
290  1      if(temp_set)
291  1      {
292  2          if(preset_time>0)alarm_dx=1;
293  2          if((sys_temp>=preset_temp)&&preset_time>0)
294  2          {
295  3              time_set=1;
296  3              load_dx=0;
297  3              alarm_dx=1;
298  3          }
299  2          else time_set=0;
300  2      }
301  1    }
302    //*****************
303    //*****************

304    void main(void)
305    {
306  1      sys_init();
307  1      while(1)
308  1      {
309  2          if(time_ok){time_ok=0;sys_temp=get_avg(get_adc());}
310  2          show_temp(sys_temp);
311  2          scan_key();
312  2          compare_temp();
313  2      }}
314    END
```