DESIGN AND CONSTRUCTION OF A DIGITAL TEMPERATURE MEASURING DEVICE

BY

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2003/15468EE

A Thesis submitted to the Department of Electrical and Computer Engineering, School Of Engineering and Engineering Technology, Federal University Of Technology Minna, Niger State.

November, 2008.

DEDICATION

I dedicate this project work to the Almighty Allah and to my parents: Alhaji Saidu yahaya and Hajiya Maryam who have seen to the fulfillment of my dream in life.

DECLARATION

I SAIDU MUSLIM declare that this project work was done by me and has never been presented elsewhere for the award of degree. It conducted under the supervision of Mr. Okenna Agbachi, to the Department of Electrical and Computer Engineering, School of Engineering and Engineering Technology, Federal University of Technology, Minna, Nigeria.

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ACKNOWLEDGMENT

I am first of all grateful to almighty Allah, the creator of the universe that created me, for sparing my life up to this moment and for his grace given to me to complete this program successfully.

My profound gratitude first goes to my parent: Sheikh Alhaji Saidu and Hajiya Maryam kyatswa for the parental role played from the beginning of my life to date. May Allah reward then with aljanna.

After my parent goes to The H.O.D. Electrical/computer Eng. Dept. ENGR. DR. A.Y. Adediran, and my project supervisors;Mr Okenna Agbachi and Mr James Tola, for guiding me through out the project work. Next is to Alhaji Usman Yatswachi who provided me with accommodation may Allah reward him abundantly.

Also to: My Uncle; Alhaji Nma Mustapha, $ Alhaji Ndako yahaya, My Brothers and Sisters; Mall Mustapha saidu, Musa Saidu Hamzat, Umar saidu, Shehu Abubakar saidu, Kabir hamzat, Gimba Hamzat, Abdulkadir Hamzat, Ahmad Tijjani(Danladi), Aishat(yaushe) saidu, Amina(yaladidi) saidu & maimunat(Hajiya iyawo) saidu, My cousin brothers; Mohammad Mustapha & Yunusa Mustapha, and all the entire family for their moral and financial support towards the success of the program. May Allah's blessing and guidance shower on them.

I also appreciate the contribution of my course and room mates Mohammad Abdullahi, Abubakar Sadiq, Abdullahi Umar, Adamu Umar, Mohammad A. Abdulmalik, Shehu Ahmad, and Saidu N. Kasim. May Allah continue to guide then to the right path.

Also worth acknowledge, the effort of my friends/brothers: Alhaji Hamzat Magaji, Ahmad . I. Abdulrahman, Abdulmalik saidu, Abdullahi saidu, Late Aliyu Hamzat, Danjuma abubakar, and Mohammad B. Isyaku. May Allah assist them in all their undertaken.

ABSTRACT

The project titled the design and construction of digital temperature measuring device. The device displays temperature information numerically, thus help to avoid the limitation due to parallax error in analogue device. The whole system incorporates a microcontroller which is interfaced to other components. These components include temperature sensor, an analog-to-digital converter, and four seven segment displays. The temperature sensor used is an Integrated Circuit (LM35). The sensor senses temperature and generates at its output an analog voltage that is proportional to the sensed temperature. The analog voltage is then feed to the microcontroller. The microcontroller then converts the binary voltage to seven segments display code and sends it to the seven segment display. The seven segment display then displays numerically the temperature sensed by the temperature sensor.

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CHAPTER ONE

1.0 INTRODUCTION

1.1 EXPOSITORY INTRODUCTION

As a result of the experiments of Rumford, Joule, and others, it was demonstrated (explicitly stated by Helmholtz in 1847) that various forms of energy (heat, electrical etc) can be transformed one to another.[1]

Heat is among the commonest form of energy which brings about change in temperature, or described as an energy being transferred from one object to another as a result of temperature difference.[2]

Temperature is an important measurable physical quantity which could be defined or describe in different manner. Daily experience tells us that it is a measure of coldness and hotness. It plays an important role in almost all fields of science including physics, chemistry, and biology.[2]

The measurement and control of temperature is one of the fundamental requirements for environmental control as well as certain chemical, electrical and mechanical control. It found utilized in wide variety of applications in which it is necessary to monitor temperature. It plays an important role in a wide variety of industrial, domestic and scientific activities as many physical properties of material including the phase (solid, liquid & gaseous), density, solubility, vapor pressure and electrical conductivity depends on temperature. These might be expected because most physical, chemical, electrical and biological systems are affected by temperature. A large number of circuits or functional unit in some electronics devices today are temperature sensitive & require accurate temperature information in order to take corrective action when the temperature becomes too high. In petrochemical industry, process control industry, oil and gas exploration & mining industries, the exact measurement of a particular temperature has to be at specific level in order to get the desired product or composition.[5, 8]

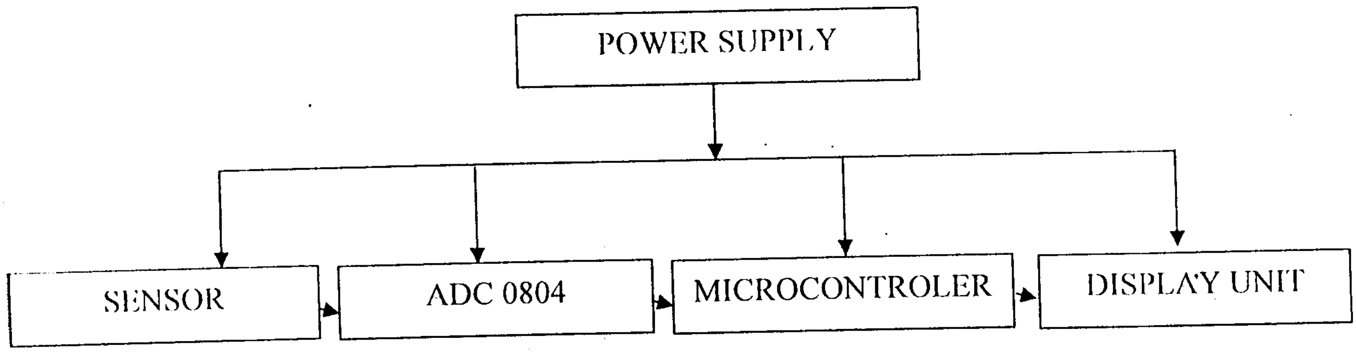
Thermometer is an instrument that measures the temperature of a system in a quantitative way. The easiest way to achieve this is to use any measurable property of the system that varies with its temperature. The three commonest properties are: expansion of liquid, change in pressure, and change in resistivity of a conductor with respect to temperature change. [1]

The earliest thermometer (liquid in glass thermometer) used mercury or ethanol in glass as thermometric fluid. The level of the liquid varies reflecting the change in temperature. Temperature sensors such as resistance temperature detector (RTD), thermocouple and thermistor consist of conducting wires of electrical resistance R which varies with temperature change. The precision integrated temperature sensor also available that senses the ambient temperature and give out useful electrical signal as its output.[8]

Due to the certain limitations, low sensitivity, inaccuracy, and error due to parallax associated with analog thermometer, there is need to minimize those deficiencies by designing a digital thermometer that help to great extent in measuring the temperature using precision temperature sensor and provide a digital means of displaying the sensed temperature.

This project titled; DIGITAL TEMPERATURE MEASURING DEVICE is a simple digital thermometric device that provides a means of measuring temperature and display information digitally.

The device as shown in the block diagram below (fig 1.0) employed a precision integrated temperature sensor (LM 35) which sense the ambient temperature and produce its analog voltage equivalent. Analog to digital converter which converts the analog output voltage of the sensor to its digital equivalent while microcontroller processes the digital output of the converter, and seven segment display unit which display the temperature information.



Block diagram of the design.

1.2 OBJECTIVE AND MOTIVATION.

This project is aimed at designing and constructing of a thermometric device for measuring and displaying temperature in degree Celsius. The experience acquired during first semester of my final year in courses like ECE 511(hard ware and soft ware techniques), and ECE 518(high level and low level language) together with practical experience acquired during the microcomputer system design workshop, organized by Ejosy Tech Consult, at Amitech Computer Institute, handled by Engineer Emmanuel Eronu, from 28 to 31st of may 2008, motivated me to undertake a project that will involve the use of microcontroller, in other to acquire more practical experience in that aspect.

1.3 METHODOLOGY

The basic concept of the design involves the application of a temperature sensor (LM35). It possesses a linear relationship of 1 degree Celsius to 10mv at the output. The output of the sensor is connected to analog-to-digital converter. The ADC is then connected to microcontroller and allows the output to be displayed on the seven-segment display unit (LED)

1.4 SCOPE AND LIMITATION

The temperature range of the sensor (LM35) as stated by the manufacturer is from -55 to 155 degree Celsius. It can not be use for temperature out of this range. The switching between the two available power sources (AC and DC) is manual not automatic.

1.5 SOURCE OF INFORMATION.

The information was sourced from different sources which include; websites, textbooks, past and present lecture note, and past project. Colleagues and lecturers were also contributed towards the implementation of the project design.

CHAPTER TWO

2.0 LITERETURE RIVIEW

2.1 TEMPERATURE FOUNDAMENTAL.

It is easy to demonstrate that when two objects of the same materials are placed together or when two systems with fixed volume are brought together (physicist say when they are put in thermal contact), the hotter object cools while the cooler one becomes warmer or in the other hand changes most likely will take place in the thermal properties of both systems. These changes are caused by the transfer of heat between the systems or objects, until a point is reached after which no more changes occur. The systems at this point are said to be in thermal equilibrium.[3]

A basis for definition of temperature can be obtained from the zeroth law of thermodynamics which states that if two systems A and B are in thermal equilibrium and a third system C is in thermal equilibrium with A, system B and C will also be in thermal equilibrium. Since A, B, and C are in thermal equilibrium, it is reasonable to say that each of these system shares a common property called TEMPERATURE.[3]

The kinetic theory of gases uses statistical mechanics to relate the temperature of an ideal gas to the average kinetic energy of the atoms in the system. Temperature is related only to the average kinetic energy of the particles in gas. The temperature of an ideal gas is related to its average kinetic energy via the equation below;

$E = 3/2\ KT$, where $K= NR$

N= number of moles

R=ideal gas constant.

T=temperature of the gas.

The second law of thermodynamics states that any two given systems when interacting with each other will later reach the same average energy per particle and hence the same TEMPERATURE.[3]

2.2 BRIEF HISTORY OF THERMOMETER.

Temperature measurement using modern scientific thermometer and temperature scale goes back to at least as far as the early 18th century when Gabriel Fahrenheit adopted a thermometer i.e. using mercury as thermometric fluid. [5]

The earliest device use to measure temperature was called thermoscope invented by Galileo in 1610. It consisted of a glass bulb having a long tube extending down ward in to a container of a liquid. The glass bulb contained air which when heated or cooled, the level of liquid in the tube could vary reflecting the change in the air temperature. The air in the bulb is referred to as thermometric medium, i.e. the medium whose property changes with temperature. It has poor accuracy as it responds to atmospheric pressure. [3]

In 1641, the first sealed thermometer that used liquid rather than air as thermometric medium was developed by Ferdinand 2, grand duke of Tuscany. His thermometer used a sealed alcohol-in-glass. The thermometer was not considered accurate, as there was no form of calibration.

One of the earliest attempts at calibration and standardization between thermometers was made in October 1663 in London by Robert hook curator of royal society. The member of the royal society of London agreed to use his thermometer as a standard that the reading of others could be adjusted to it. The method of making scales were in confusion at that time because craft men in different countries uses different calibration points thus scaling remained a problem.

It was in 1724 that Gabriel Fahrenheit, an instrument maker of Amsterdam, used mercury as thermometric liquid. Mercury has large thermal expansion and fairly uniform, it does not adhere to the glass, and remains a liquid over a wide range of temperatures. The above properties of mercury led to more accuracy of the thermometer. Fahrenheit measured the boiling point of water to be 212 degree and freezing point to be 32 degree. Temperatures measured on this scale are designated as degree Fahrenheit ('F).

In 1745, Carolus Linnaeus of upsula described a scale in which the freezing point of water was zero, and the boiling point 100, making it a centigrade (one hundred steps) scale. Anders Celsius used the reverse scale in which 100 represented the freezing point and zero the boiling point of water, still with 100 degrees between the two defining points. By international agreement in 1948.the centigrade scale becomes known as Celsius scale and still in use till date.

The absolute temperature or Kelvin scale was proposed by sir William Thomson in the year 1848.This scale had its zero degrees as being the theoretical lowest temperature possible (i.e. where molecular motion ceases.) this value turned out to be -237.16 degree Kelvin. The degree Kelvin is the current standard unit of temperature.

Sir William siemens, in 1871, proposed a thermometer whose thermometric medium is a metallic conductor whose resistance changes with temperature. He used the platinum element as it does not oxidize at high temperatures and has a relatively uniform change in resistance with temperature over a large range. The platinum resistance thermometer is now widely used as a thermoelectric thermometer and covers the temperature range from about -260'C to 1235'C.

T.J. Seebeck, in 1826, discovered that when wires of different metals are fused at one end and heated, a current flows from one to the other. The electromotive force generated can be quantitatively related to the temperature and hence, the system can be used as a thermometer known as thermocouple. It is use in industries and many different metals are used.[6,7]

The early thermometers were non electrical in nature because they used thermal expansion of matter i.e. solid and liquid. They had the disadvantage of possessing a limited temperature range and were also subjected to reading error. In "the design and construction of digital thermometer using thermistor" by Ajagunna Bamisaye James. He employed thermal resistors (thermistor) as his temperature sensor and his recommendation proposed the use of integrated circuit sensors for better linearity and accuracy.

Thereafter, in "the design and construction of a digital thermometer" by Adeiza O. Peter. He used this recommendation and so used an integrated circuit as a sensor.

This project work used the sensor of wider temperature range (LM35) and incorporated the AC power source so that the power source should be two, either AC main or DC battery, unlike the previous one which provide means of using only DC battery.

2.3 TEMPERATURE SENSOR.

The basic concept of this project work is the application of a temperature sensor. Temperature sensor or transducer is an electronic device that senses the ambient temperature and gives out useful electrical signal as its output.

Many different types of temperature sensors are commercially available. The type to be used in any particular application will depend on several factors e.g. cost, durability, and accuracy of the sensor. Depending on the temperature to be measured some provides a wide range of temperature measurement whereas others may only provide temperature information for small temperature range. The temperature sensor that are commonly used are: thermocouple, resistance temperature detector (RTD), thermistor and precision integrated temperature sensors.

Thermocouple consist of two different conductor coupled together at their ends. It utilizes the principle that when two wires of dissimilar electrical properties are joined at both ends, and one junction is made hot and other cold, a small electric current is produced which is proportional to the difference in the temperature.

Resistance temperature detector (RTD) takes advantage of the principle that the resistivity of a metals is to a small degree dependent upon temperature. Thermistor is a special type of resistance sensor made from a small piece of semiconductor material. Its resistance value changes with temperature. It offers greater accuracy and stability than thermocouple, but its non uniform resistance temperature characteristics can be disadvantageous in some application where it is required to obtain a more linear variation. [8]

The LM 35 integrated circuit temperature sensor used in this project work is a precision semi conductor sensor whose output voltage is linearly proportional to the Celsius temperature, with output of 10mv/°C i.e. 10mv per degree centigrade. It thus has an advantage over linear temperature sensor calibrated in Kelvin scale (LM 34) as the user is not require to subtract a constant value from its output to obtain convenient centigrade scaling. It is a 3 terminals (input, output, ground.) device with the following features;

- Calibrated directly in degree celcius
- Linear +10.0mv/°C scale factor.
- 0.5 Accuracy guaranteed at +25°C.
- Rated for full -55 to 150°C.
- Low self heating, 0.08°C in still air.
- Low output impedance, 0.1 ohms for 1mA load.

Its low output impedance, linear output and precise inherent calibration make interfacing to readout or control circuitry especially easy.[4]

CHAPTER THREE

3.0 DESIGN ANALYSIS.

The digital temperature measuring system comprises the following basic units.

- 5-V power supply unit.
- Control unit
- Output display unit.

The control unit consists of the following sub units.

- Temperature sensor
- Analog to digital converter.
- Microcontroller.

The block diagram of the design is shown in fig 3.0 bellow.

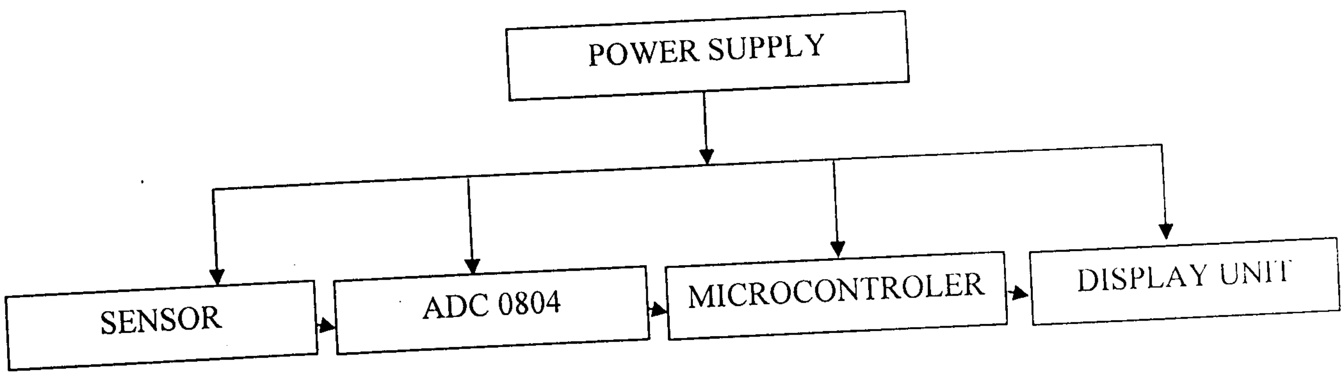


Fig 3.0 The block diagram

3.1 POWER SUPPLY UNIT

Most electronic devices and circuits required a D.C (direct current) source for their operation. Due to the fact that dry cells and batteries are expensive, require frequent replacement, hence the most convenient and economical source of power is domestic A.C supply. This is because it is easy to convert this A.C voltage (usually 230V RMS) to a D.C voltage (12V in this case) which is accomplished through the process called rectification. [9]

The system being a digital system with digital logic parts stipulated for 5V operational voltage had to be fed with clean 5V DC supply. The system required operational voltage was derived from a 12V, 0.5A step down transformer and full-wave bridge rectifier connected as in fig 3.1 below.

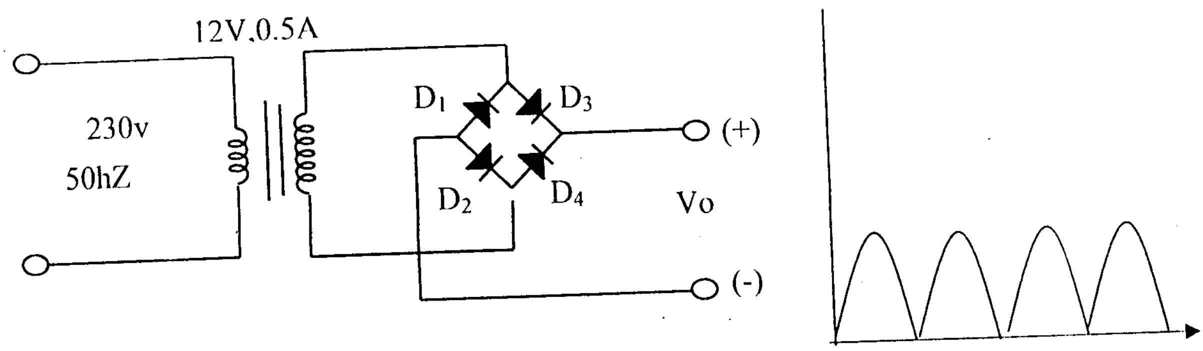


Fig 3.1 Ratification

The current rating of the transformer was chosen based on the calculated system current consumption as shown bellow.

- ADC 0804: 5mA
- AT89S51 system controller: 10mA
- Visual display unit: 280mA

Total current consumption = 295mA (0.295A) approximated to 0.3A. The stepped down 12V AC was connected to a pulsating DC output shown in fig 3.1b

The D.C output voltage has amplitude

$V_{DC\ PEAK} = V_{rms}\sqrt{2} - 1.4$

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

Where 1.4 volt is the drop across the two rectifier diode, each with 0.7 forward voltage drops.

The dc voltage was smoothened by a capacitor of a value deduced from the expression; CV = IT: A 7805 regulator was used to derive the needed system voltage. The minimum input voltage for 5 volt output regulator is 7.5V. On a 15.5 V peak to peak input voltage, The maximum allowable A.C ripple voltage is (15.5-7.5)V = 8V. Using the expression CV = IT where

C = value of smoothening capacitor

I = maximum load current.

V = maximum AC ripple voltage.

T= period of the pulsating dc voltage. [9, 10]

For half wave rectifier T= 1/f and for full wave = 1/2f.

There fore T= 1/2f = 1/(2*50)= 0.01second.

$$.C = IT/V = \frac{0.3 * 0.01}{8}$$

$$= 3.75 * 10^{-4}F = 375\mu F$$

This minimum value of capacitance was multiplied six fold and a 2200µF was used as shown in fig 3.2 below.

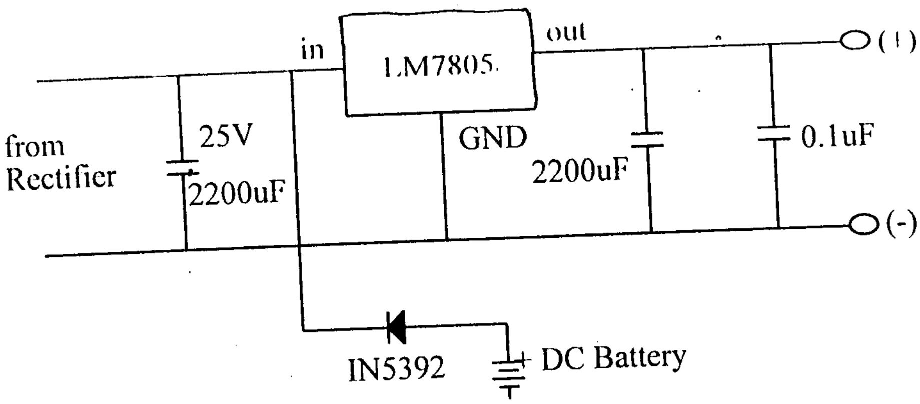


Fig 3.2 power regulation

The smoothened dc voltage was regulated using a LM7805, 5-volt regulator as shown above. The 5 volt was buffered by a 2200uF capacitor and 0.1uF was use to remove high frequency noise that might be superimposed on the power line. And the 5V output feeds the remaining parts of the system. DC battery can be use as an alternative source as shown above.

3.2 CONTROL UNIT.

This unit is responsible for controlling the system through software written in assembly language. The unit consists of temperature sensor, ADC (an analog-to-digital converter), and system controller.

3.21 TEMPERATURE SENSOR.

Temperature sensor is an electronic device that senses the ambient temperature and gives out useful electrical signal as its output.

The LM 35 integrated circuit temperature sensor used in this project work is a precision semi conductor sensor whose output voltage is linearly proportional to the celcius temperature, with output of 10mv/°C i.e. 10mv per degree centigrade. It thus has an advantage over linear temperature sensor calibrated in Kelvin scale (LM 34) as the user is not require to subtract a constant value from its output to obtain convenient centigrade scaling. It is a three pin device with the following features;

- Calibrated directly in degree celcius
- Linear +10.0mv/°C scale factor.
- 0.5 Accuracy guaranteed at +25°C.
- Rated for full -55 to 150°C.
- Low self heating, 0.08°C in still air.
- Low output impedance, 0.1 ohms for 1mA load.

Its low output impedance, linear output and precise inherent calibration make interfacing to readout or control circuitry especially easy. The sensor converts the thermal energy to electrical energy. The sensor is housed in a TO-46 transistor package with 3-pins (+V_S, V_{out}, and GND) as shown in fig 3.3 below[4]

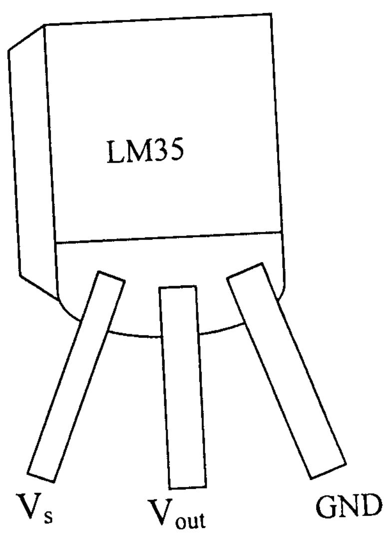


Fig 3.3pin out

The sensor was interfaced to an 8-bit analog-to-digital converter that converts the sensor's analog output voltage to its digital equivalent needed by the microcontroller. The circuit connection is shown in fig 3.4 below.

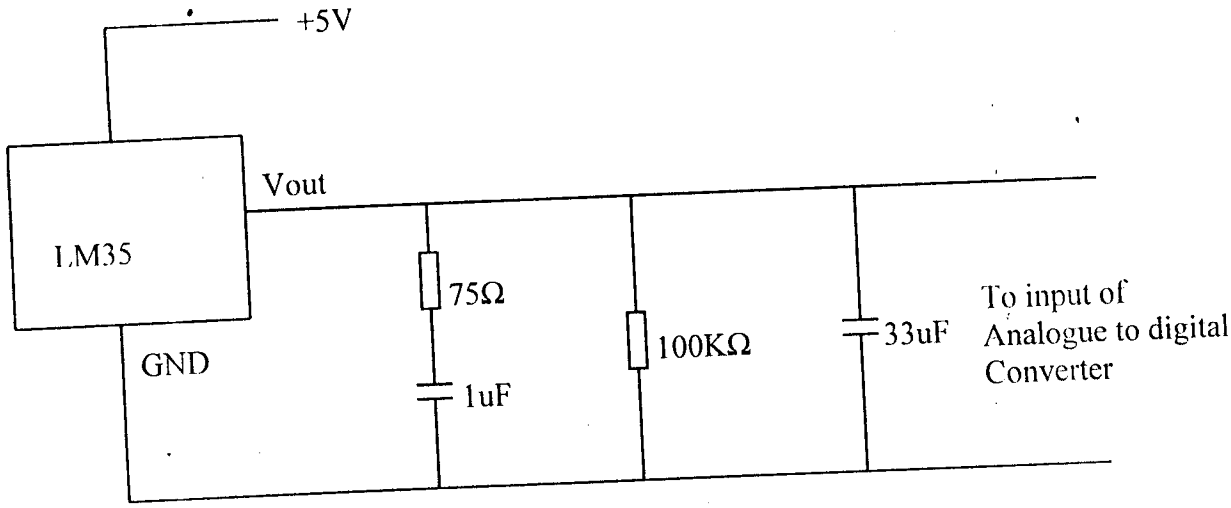


Fig 3.4 LM 35 Circuit connection

The device was run from the regulated 5-volt power supply. Its output is connected to a series RC capacitance damper circuit comprised of 75 ohms resistance and 1µf capacitance, as recommended by the manufacturer. A parallel 100k ohms resistor and 33uf capacitor connected across the output prevents the sensor's output voltage from fluenctuating badly, and also prevent the ADC output from changing rapidly. The RC combination has a time constant of T=RC=10^5*33uf=3.3 seconds. It implies that average temperature reading varies over a 3.3second span.[4]

3.22 ANALOG-TO-DIGITAL CONVERTER (ADC).

To convert the analog voltage equivalent of the sensed temperature to its equivalent digital value, which can be manipulated by system controller, an interface device capable of translating the quantity from the analog domain to digital is needed. This was realized using an ADC 0804 8-bit analog-to-digital converter. It belongs to the ADC 080X family, which is a Cmos 8-bit, successive approximation ADC that uses a differential potentiometric ladder for conversion. The device is package in 20-pin DIP package. The key features are listed below;

- Compatible with 8080 microprocessor derivates.
- Easy interface to all microprocessors, or operates stand alone.
- Differential analog voltage inputs.
- Logic inputs and outputs meet both CMOS & TTL voltage level specifications.
- On-chip clock generator.
- Resolution of 8-bit.
- Conversion time of 100 microseconds.

The device is capable of operating on a clock frequency up to 1.4MHZ. The pin out is shown in fig 3.5 below.

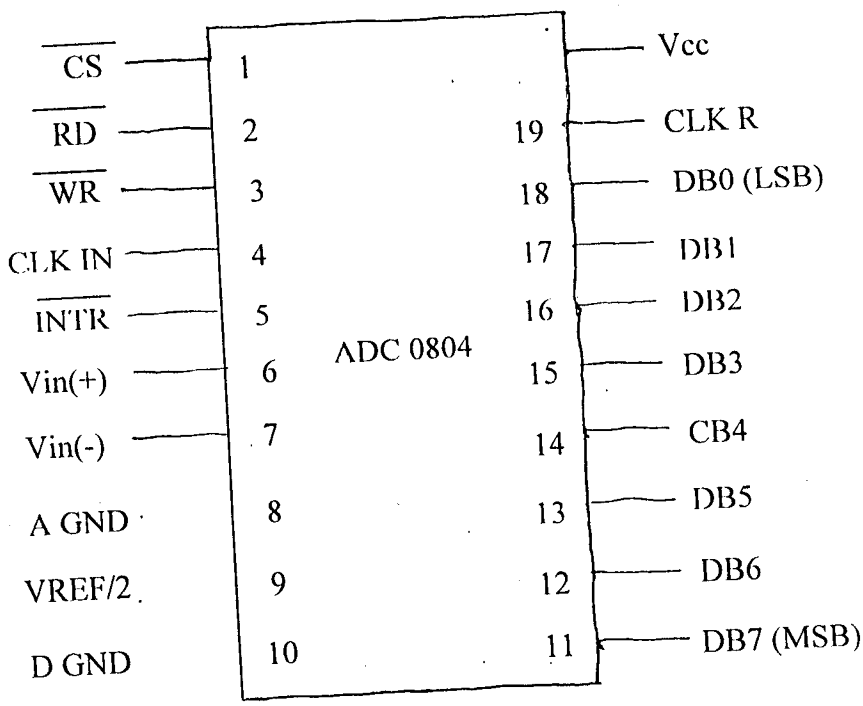


Fig 3.5 ADC 0804 pin out

The analog voltage from the sensor was applied to pin 6 and 7 of the ADC. The binary equivalent is available at pin11 through pin 18(DB7—DB0).pin1 & 2(chip select CS and RS) were connected to ground so that the chip should be always enable. ADC 0804 includes an internal oscillator which requires an external capacitor and a resistor to operate. 150PF capacitor (as specified by manufacturer) was connected from pin 4 (clock in) to ground and 10kohms resistor from pin 4 to pin 19(clock R). The device was run at a clock frequency given by RC combination on pin 19 as;

F= 1/1.1RC. R= 10Kohms and C=150PF.

The conversion is initiated by pulsing the WR pin low and then high and completed about 100microsecond after, and the INTR pin goes low to indicate end of conversion. The device was configured for system operation as shown in fig 3.6 below.[11]

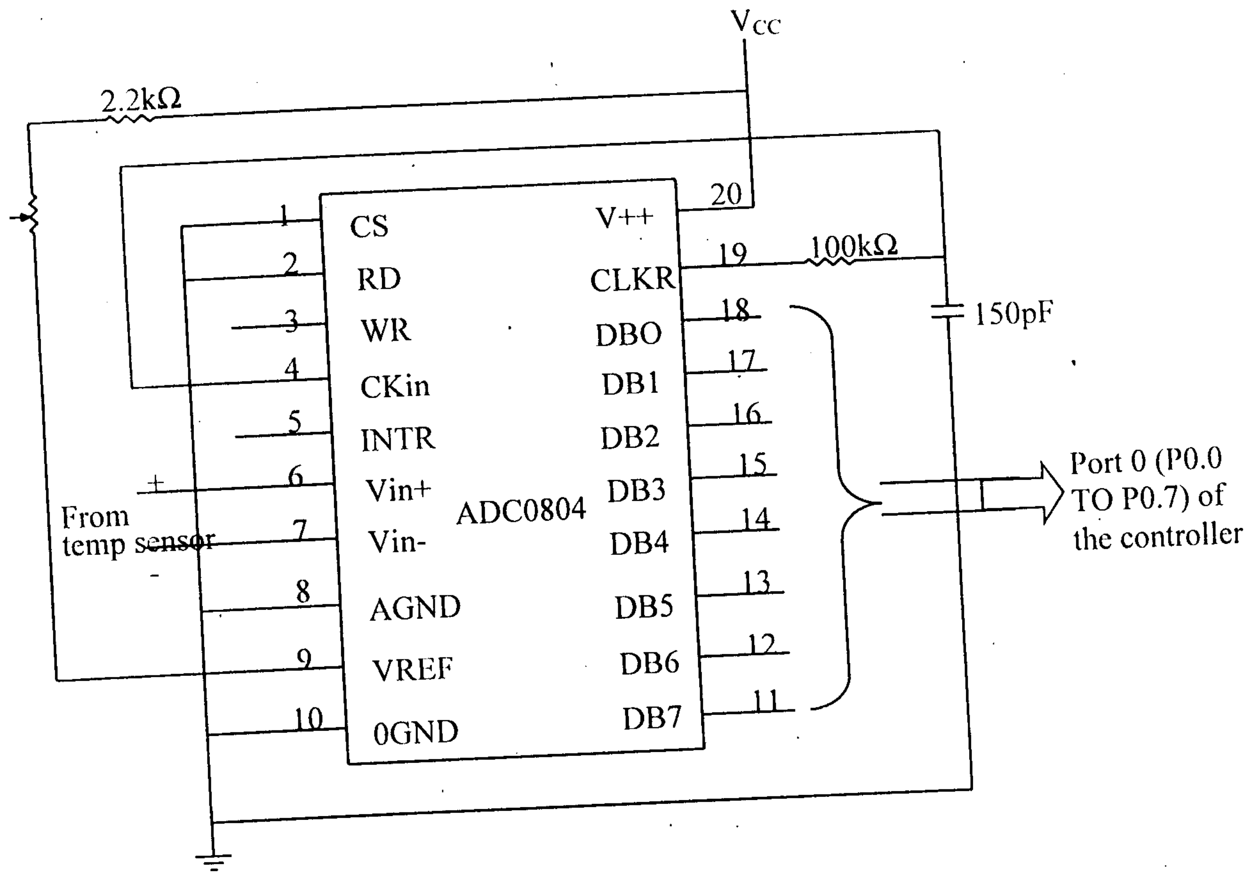


Fig 3.6; the interface between ADC and controller.

The device as shown was interfaced with system controller over port 1 and two pits on port 3(P3.0 & P3.1). A reference voltage of 1.25V (2.5 in side) was set on pin 9 (Vref) to establish the relationship between the input analog voltage and the digital output voltage.

3.2.3 SYSTEM CONTROLLER.

Microcontroller is employed in modern electrical system today to co-ordinate the system operation. An AT89S51 microcontroller was used in this project to capture, save and display digital data. The device possessed the following standard features.

- 4KB of in-system programmable flash memory.
- 128 bytes of internal ram.
- 32 programmable input/output lines.
- Two 16-bits timer/counter

The device is a low power, high performance, CMOS 8-bits microcontroller with 4KB of flash programmable and erasable read only memory (PEROM). The on chip flash allows the program memory to be reprogrammed in system or by a conventional non volatile memory programmer. [14]The device has the pin out as shown in fig 3.7 below.

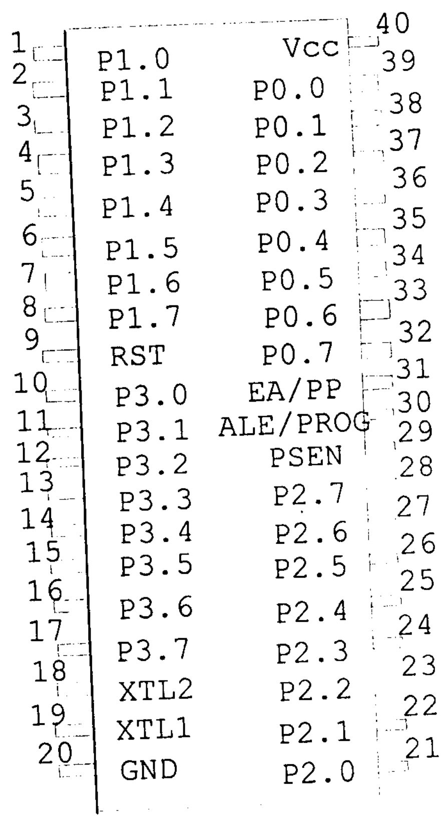


Fig 3.7 microcontroller pin configuration

The device was programmed to control the whole system via software written in assembly language. The 18.432MHZ crystal was connected to the device to provide the required clock pulse for the controller to execute instructions[15]. The circuit connection is shown fig 3.8 below.

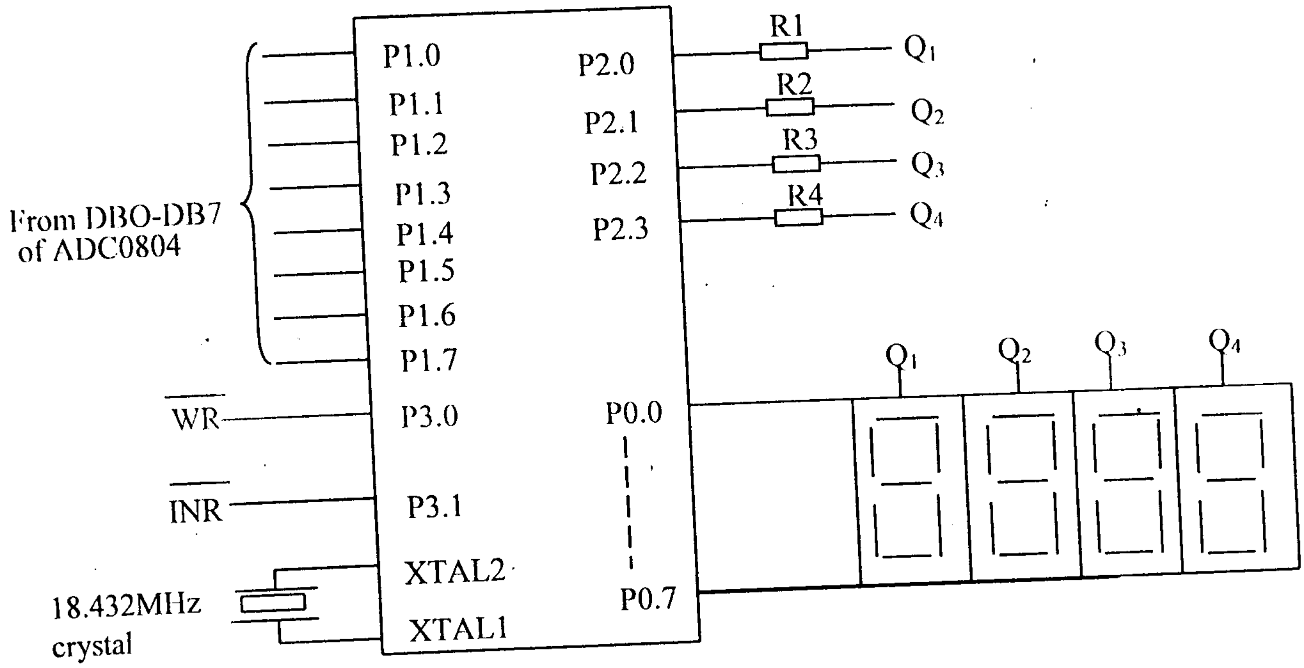


Fig 3.8 interface of microcontroller with other component

The device as shown was interfaced with ADC through port 1. P2.0 — P2.3 controlled the four transistors used for display multiplexing. Port 0 interfaced with 4-dgits common-anode seven segment display operating in the multiplexed mode. The order by which each of the four segments displayed is controlled by the

four transistors. The device executes the system control soft ware from power on till power off. The system controlled soft ware consists of the following main bodies of the code.

1. Power up system initialization.
2. Conversion via ADC.

3. Processing of digital value.

4. Writing of data to display

5. Loop to 2

The soft ware turns the anode drivers (transistors) on and off at a high speed, giving the illusion of the stationary display. In reality only one digit position is on at a time. The processing of digital equivalent of the ambient temperature is done in the following stages.

- Start conversion.
- Take 2 reading from ADC and find the average.
- Convert the average reading to BCD digits.
- Convert the BCD digits to 7-segment code.
- Refresh the display.

The conversion of the binary ADC value to BCD value is effected using repeated division. The BCD to 7-segment encoding was effected via a look-up table where the 7-segment 8-bit codes were stored. The table was referred via the content of the accumulator. Writing the 7-segment code to port 0 and turning on the anode driver for the corresponding digit position writes the value to the display.

3.3 OUTPUT DISPLAY UNIT.

The unit basically consists of four-control transistors and four-seven segment display. As mentioned earlier, a multiplexed 4-digit 7 segment display was used. The display was wired with all their common cathodes wired together i.e. all the 'a's, on the 4-digits were interconnected, the 'b's, 'c's, etc. The segment was interfaced with microcontroller through port 0. The digits were controlled by digits drivers (2SA1015GR PNP transistors). The display requires an I_{LED} of 20mA at V_F of 1.7V. Since no current limiting resistors were used in series with segments, the current through them had to be tightly regulated. The maximum I_C current was programmed using R_B resistors in the base-emitter circuit of each anode driver. The circuit diagram of the unit is shown in fig 3.9 below.

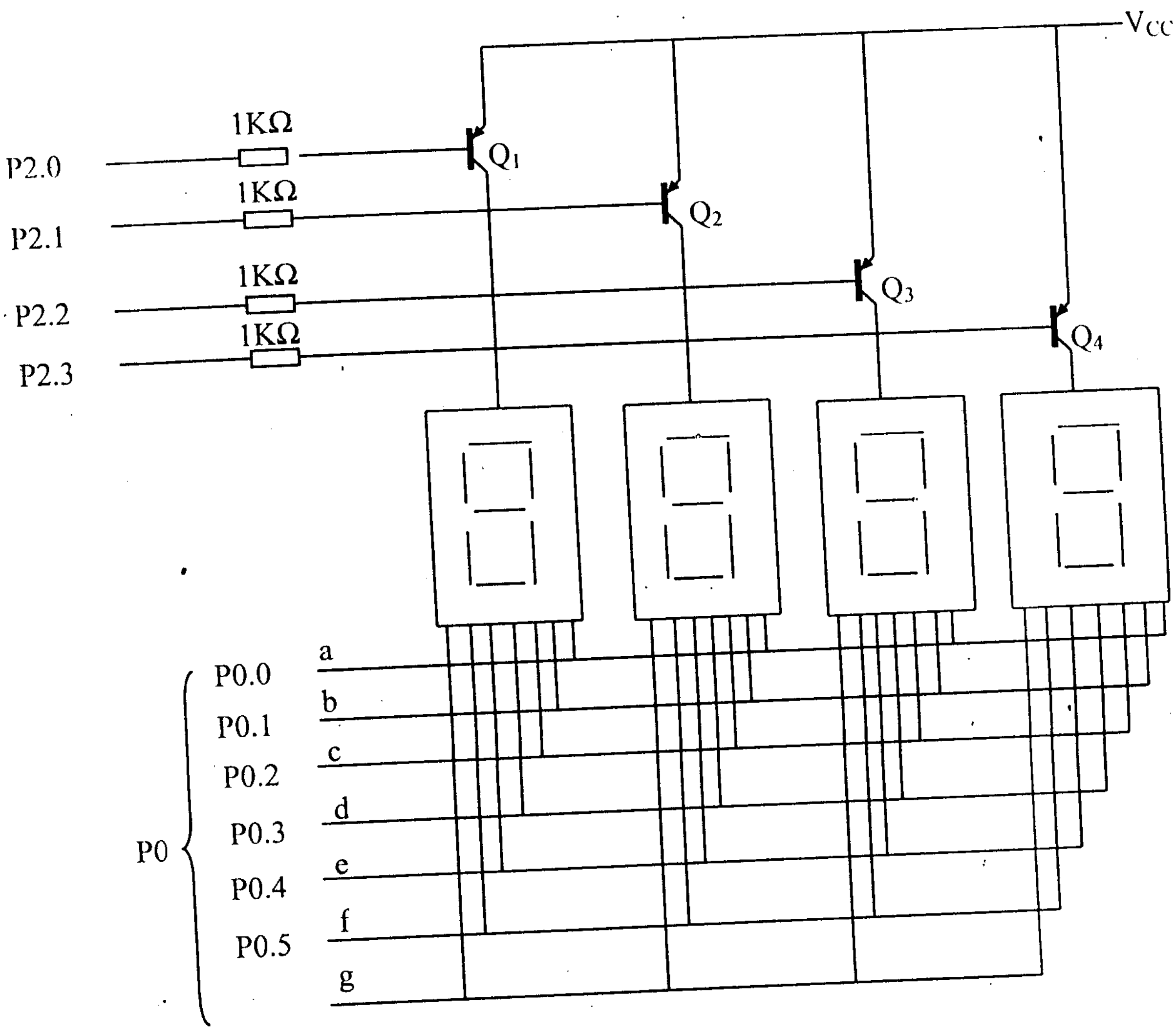


Fig 3.9 display unit

The transistor used has an hfe (gain) of 200. for an-digits display, the average forward current through each segment is $n*I_L$, for equal brightness. For a 4-digits display, with each LED running with a steady forward current of 2omA, 80mA of pulsed current was therefore required for acceptable brightness.

$I_B = I_C/hfe$

$=80mA/200$

$=400\mu A.$

R_B was calculated via the expression;

$$R_B = \frac{V_E - V_{BE} - Voi\ (8951)}{I_B}$$

$V_E = 5V$, $V_{BE} = 0.7V$, V_{OI} (8951) = 0.2V, $I_B = 400\mu A$

$$R_B = \frac{5-0.7-0.2}{400\mu A} = 10250\Omega = 10.25K\Omega$$

This value was noticed to produce a dull display. A 1KΩ R_B resistance was used instead and it produced a display with full brightness. A display program involves the under listed sequence of software events.

1. Turn off all digit drivers(Q1—Q4)
2. Write 7-segment code of value to display to common data port.
3. Turn on the associated digital driver.
4. Delay for visibility.
5. Turn off the digit driver.
6. Goto 2.

The above process was done at a high rate, the software time to provide a display refresh of about 250HZ. For a refresh frequency greater than 50HZ, the illusion of persistence is realized and the eyes see a continuously light 4-digit display. In actuality, only one digit position is on at a time. The source code of the programme is on appendix 1

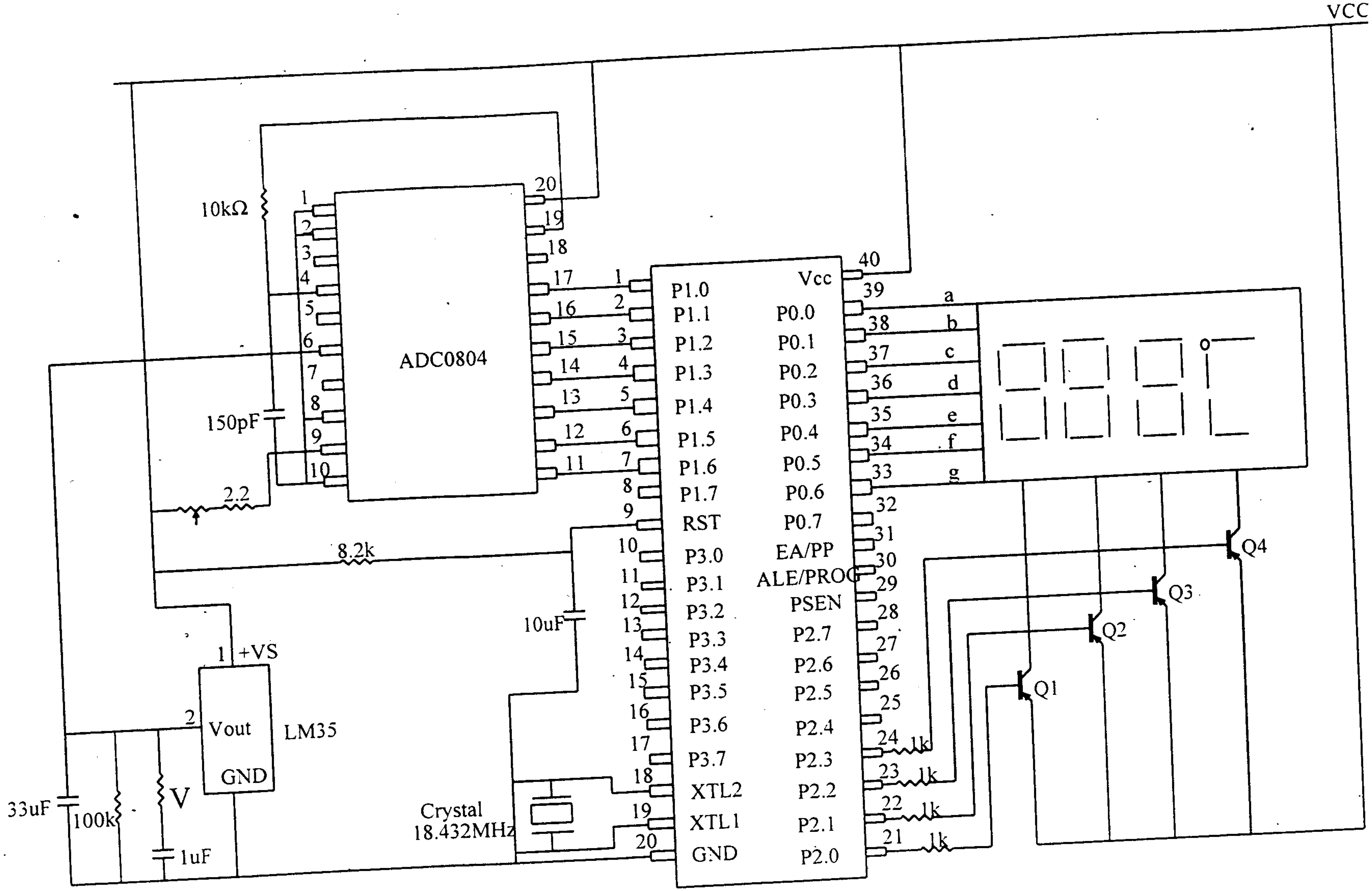


Fig 3.9 The Circuit Diagram of the Design

CHAPTER FOUR

4.0 CONTRUNCTION, TESTING AND RESULT

4.1 PROJECT CONSTRUNCTION.

The power unit was first tested on the bread board. On inspection of the required components, the components were first tested and subsequently mounted on the Vero board using circuit diagram as a guide. Modular approach was adopted and each module was separately soldered on a sectioned Vero bored. Units like temperature sensing, display, and reset button units were soldered on a vero board pieces and connected to the main board through adequate wires. The modular approach allowed each sub circuit to be soldered and tested appropriately before connection. Thereafter, the entire circuit was connected to the supply unit and tested accordingly.

4.2 TESTING.

The subsequent modules of the circuit design were tested at various stages of the project design implementation. These testes were repeatedly done to ensure the reliability of the components. The final test of the entire system design implementation was conducted by bringing the heat source such as soldering iron near the temperature sensor. to check the response of the sensor to change in temperature. The output was observed accordingly at the display output unit.

4.3 RESULT AND DISCUSION.

The output display indicates a rise in temperature when soldering iron was brought near to the temperature sensor. It also indicates drop or decrease in temperature in the absence of the heat source (soldering iron).

CHAPTER FIVE

5.0 CONCLUTION AND RECOMMENDATION

5.1 PROJECT CONCLUTION

The aims and objectives of this project were to design and construct a device that can measure the surrounding temperature and display it on a visual digital display. The aims and objectives were achieved because the TEMPERATURE MEASURING DEVICE constructed was able to measured the surrounding temperature and display it on a visual digital display. The device also overcomes the parallax error encountered in analogue thermometer. While the device is suitable for both domestic and industrial applications, it may not be suitable for measurement of high temperature.

RECOMMENDATIONS

The following recommendations are made based on the various aspects of the design

1. A Thermistor which has wider range of temperature could be used as temperature sensor.
2. The LED display could also be replaced with LCD for less power consumption.

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sahid

```
;INCLUDE 89c51.mc

$mod52
dx_port EQU p2
adc_port EQU p1
data_port EQU p0
adc_Value DATA 08h
data_0 DATA 09h
data_1 DATA 0ah
data_2 DATA 0bh
data_3 DATA 0ch
temp1 DATA 0dh
temp2 DATA 0eh
temp3 DATA 0fh
temp4 DATA 10h
centigrade_pattern EQU  01000110b
adc_Write BIT p3.0
adc_intr BIT p3.1
digit_1_dx BIT p2.2
digit_2_dx BIT p2.3
digit_3_dx BIT p2.4
digit_4_Dx BIT p2.6
stack EQU 60

org 0000h               CLR ea
start_up:               MOV sp,#stack
                        ACALL sys_init

                        ACALL convert_temp
mainloop:               ACALL process_Temp
                        ACALL display_temp
                        SJMP mainloop


sys_init:               MOV dx_port,#0ffh
                        ACALL delay_500ms
                        MOV adc_port,#0ffh
                        MOV data_3,#centigrade_pattern
                        MOV DPTR,#xlate_Table
                        SETB adc_Write
                        SETB adc_intr
                        MOV adc_value,#0
                        ACALL process_temp
                        RET


delay_500ms:     MOV R2,#10
loop_500ms:             ACALL delay_2_Show
                        DJNZ R2, loop_500ms
                        RET


convert_temp:    ACALL convert_temp2
                        MOV temp1,adc_Value
                        ACALL convert_temp2
                        MOV temp2,Adc_Value
                        ACALL convert_temp2
```

```
        MOV temp3,Adc_Value
        ACALL convert_temp2
        MOV temp4,adc_Value
        MOV A, temp1
        ADD A, temp2
        ADD A, temp3
        ADD A, temp4
        MOV B,#4
        DIV ab
        MOV A, B
        RET

convert_Temp2:    CLR adc_Write
                  nop
                  nop
                  ACALL write_display
                  ACALL write_Display
                  ACALL write_display
                  ACALL write_display
                  MOV adc_Value,adc_port
                  CLR adc_Write
                  nop
                  nop
                  SETB adc_Write
                  ACALL write_display
                  ACALL write_display
                  ACALL write_display
                  ACALL write_display
                  MOV A, adc_port
                  ADD A, adc_Value
                  CLR C
                  RRC A
                  MOV adc_Value,A
                  RET

xlate_Table:    DB
11000000b,11111001b,10100100b,10110000b,10011001b,10010010b,10000010b,11111000b,1000
0000b,10010000b

process_Temp:     MOV A, adc_value
                  MOV B,#100
                  DIV ab
                  MOV data_0,a
                  MOV A,b
                  MOV B,#10
                  DIV ab
                  MOV data_1,a
                  MOV data_2,b
                  MOV A, data_0
                  ;JNZ go_show
                  ;MOV data_0, #0ffh
                  ;SJMP skip_on
go_Show:          MOVC A,@a+dptr
                  MOV data_0,a
skip_on:          MOV A, data_1
```

```
        sahid
        MOVC A,@a+dptr
        MOV data_1,a
        MOV A, data_2
        MOVC A,@a+dptr
        MOV data_2,A
        RET

display_temp:   ACALL write_display
                RET

write_display:  ORL dx_port,#0ffh
                MOV data_port, data_0
                CLR digit_1_dx
                ACALL delay_2_show
                ORL dx_port,#0ffh
                MOV data_port,data_1
                CLR digit_2_dx
                ACALL delay_2_Show
                ORL dx_port,#0ffh
                MOV data_port,data_2
                CLR digit_3_Dx
                ACALL delay_2_Show
                ORL dx_port,#0ffh
                MOV data_port, data_3
                CLR digit_4_dx
                ACALL delay_2_Show
                ORL dx_port,#0ffh
                RET

delay_2_show:   MOV R7,#2
reload:         MOV R6,#0
                DJNZ R6,$
                DJNZ R7, reload
                RET

                end
```