DESIGN AND CONSTRUCTION OF TEMPERATURE MONITORING DEVICE

BY

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MAT. NO.: 2001/12002EE

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

NOVEMBER, 2007

DEDICATION

This project work is dedicated to **Almighty God**

DECLARATION

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

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The successful completion of this work was aided and guided by my supervisor, Mr. J. A. Ajiboye, I therefore seize this opportunity to say thank you for your patience and tolerance.

My profound appreciation also goes to my late Dad, MR. P. A. IJAH (may his gentle soul rest in peace), who tailored my mentality towards self-reliance and success in life, and for his financial and moral support before he left this sinful world. My thanks also goes to my Mum, MRS. MARGRET I. IJAH, for the love, care and financial support throughout my stay in school, my brothers and sisters were not left out. May the good lord continue to strengthen us each day and his presence will never depart from us. (Amen).

Kudos to my geez and colleagues: Emife Daniel, Emmanuel Adedeji, Obamila Ekundayo, Chibueze Anibude, who offered useful criticism during the design and construction of the project work.

ABSTRACT

A temperature monitoring device consist of a sensor, which senses the temperature of the environment, converts it to an analog signal, sends it to an Analog to Digital Converter (ADC), which converts this analog signal to a digital format suitable for the microcontroller, which thereafter processes this digital formats from the ADC in accordance to a pre-defined instruction code and generates an output via the anode drivers (transistors) to the seven segment visual display unit.

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CHAPTER ONE

INTRODUCTION

1.1 INTRODUCTION

Heat is among the commonest form of energy, changes in temperature are brought about by the degree of heat. These changes, no matter small they are have great effect on our personal comfort.

Thermometry is the science of measuring temperature and the instrument used for this purpose is called a thermometer. There are many definitions of temperature, but in lay man terms it is defined as a measure of the hotness and coldness of the body.

Temperature measurements based on our senses (sensational measurements) are not reliable enough for scientific purposes. Thermometers are considered more reliable because different thermometer of same type agrees with one another than different people do. The temperature of a body is not a fixed number but depend on the type of thermometer used and the temperature scale adopted.

Temperature is the most commonly measured physical variable. It is a very important measurement in a multitude of disciplines. The control of temperature and the regulation of heat are important in many aspects of human activity. It is the wide temperature ranges and the way they can be measured, which have lead to the three main elements used to convert temperature values into electronic signals. Each of the three elements has different specific properties which determine their practical application and use:

- **Thermocouples**

Thermocouples comprise two wires of different alloys welded together, and rely on a thermoelectric effect in their operation. The most popular design being the "K" type (NiCr-Ni).

- **Resistance Sensors**

Resistance sensors make use of the temperature dependant resistance change in platinum resistances. The measurement resistance is supplied with a constant current and the voltage drop (which changes with the resistance value according to the temperature) is measured.

- **Thermistors (NTC)**

Measuring temperature using thermistors is also based on a temperature dependant change in resistance at the element. The difference being that, in thermistors, resistance decreases as the temperature rises.

The need for temperature monitoring device arises because of the role it plays in scientific and domestic activities. In such cases conventional temperature monitoring device such as thermometer (which is analogue in nature) becomes undependable and time wasting because of its inability to perform accurately.

This device (temperature monitoring device) works by sensing the temperature through temperature transducer. The transducer converts the temperature to analogue voltage and sends it to an analogue digital converter. The temperature transducer converts the temperature sensed into electrical signals. There are several temperature transducers, which include; thermocouple, thermostat, infra-red sensor and temperature sensor Ics .The particular sensor (LM 35) is used in this device, this sensor has its output voltage linearly proportional to the Celsius centigrade temperature. In the sensor circuit, the high intensity or temperature which has been qualifies as wave and particles used as signal generating device in which the LM 35 component can detect high vibrate. The choice of the component is based on their availability and effectiveness.

The analogue digital converter ADC provides the microcontroller with digital data at its input port. An important parameter of an ADC is it s conversion time, the time interval between the command being given to the ADC to begin the conversion and appearance at the output of the computer, digital equivalent of the analogue value, the speed of the conversion varies with the type and method of ADC used, though it can be as short as a few nano-seconds for the ultra fast type or as slow as a several milliseconds for others.

The final result is then displayed on a seven- segment display unit. With this device, temperature could be measured and monitored easily. It is believed that using this device will make the job of temperature monitoring easier, accurate and more reliable, the discrete components used in building this device are readily available at affordable prices.

1.2 HEAT AND TEMPERATURE

Knowing the difference between heat and temperature is important if one is to have a clear understanding of energy. In this section we will define both terms and reach an understanding of how they are related ideas, but not identical ideas. What follows are some beginnings, and then some links to further explanations and animations.

1.3 A WRONG IDEA

Often the concepts of heat and temperature are thought to be the same, but they are not. Perhaps the reason the two are usually and incorrectly thought to be the same is because as human beings on Earth everyday experience leads us to notice that when you heat something up, say like putting a pot of water on the stove, then the temperature of that something goes up. More heat, more temperature - they must be the same, right? Turns out, though, this is not true.

1.4 INITIAL DEFINITIONS

Temperature is a number that is related to the average kinetic energy of the molecules of a substance. If temperature is measured in Kelvin degrees, then this number is directly proportional to the average kinetic energy of the molecules.

Heat is a measurement of the total energy in a substance. That total energy is made up of not only of the kinetic energies of the molecules of the substance, but total energy is also made up of the potential energies of the molecules.

So, temperature is not energy. It is, though, a number that relates to one type of energy possessed by the molecules of a substance. Temperature directly relates to the kinetic energy of the molecules. The molecules have another type of energy besides kinetic, however; they have potential energy, also. Temperature readings do not tell you anything directly about this potential energy.

Temperature can be measured in a variety of units. If you measure it in degrees Kelvin, then the temperature value is directly proportional to the average kinetic energy of the molecules in the substance. Notice we did not say that temperature is the kinetic energy. We said it is a number, if in degrees Kelvin, is proportional to the average kinetic energies of the molecules; that is, if you double the Kelvin temperature of a substance, you double the average kinetic energy of its molecules.

1.5 HEAT ENERGY

Heat is the total amount of energy possessed by the molecules in a piece of matter. This energy is both kinetic energy and potential energy. When heat, (i.e., energy), goes into a substance one of two things can happen:

(a) The substance can experience a raise in temperature. That is, the heat can be used to speed up the molecules of the substance. Since Kelvin temperature is directly proportional to the average kinetic energy of molecules in a substance, an factor increase in temperature causes an equal factor increase in the average kinetic energy of the molecules. And if the kinetic energy of the molecules increases, the speed of the molecules will increase, although these increases are not directly proportional. The kinetic energy of a body is proportional to the square of the speed of the body.

(b) The substance can change state. For example, if the substance is ice, it can melt into water. Perhaps surprisingly, this change does not cause a raise in temperature. The moment before melting the average kinetic energy of the ice molecules is the same as the average kinetic energy of the water molecules a moment after melting. Although heat is absorbed by this change of state, the absorbed energy is not used to speed up the molecules. The energy is used to change the bonding between the molecules. Changing the manner in which the molecules bond to one another constitutes a change in potential energy. Heat comes in and there is an increase in the potential energy of the molecules. Their kinetic energy remains unchanged.

So, when heat comes into a substance, energy comes into a substance. That energy can be used to increase the kinetic energy of the molecules, which would cause an increase in temperature. Or that heat could be used to increase the potential energy of the molecules causing a change in state that is not accompanied by an increase in temperature.

1.6 OBJECTIVES OF THE WORK

The aims and objectives of this project titled Temperature Monitoring Device (TMD) are as follows:

a) Measurement of temperature

b) Monitoring and recording of temperature.

c) Determination of temperature at a particular time of interest.

d) Determination of temperature variation with time.

1.7 COMPONENTS OF TEMPERATURE MONITORING DEVICE

The components that are used for the construction of this device are enumerated below:

i. Temperature sensor.

ii. Analogue digital converter.

iii. The system controller.

iv. A seven-segment decoder/display unit.

v. The power unit (battery).

1.8 THESIS OUTLINE

This Thesis sets out to present an orderly account of work done .It consists of five chapters.

Chapter 1 gives an insight into the project from an introductory point of view and presents the stated objective of the project.

Chapter 2 gives a historical review of the project and also expatiate on some of the fundamentals which are applied in carrying out the task.

Chapter 3 explains the theory of the elements that comprise the temperature monitoring device and shows how they function Chapter 4 shows all the steps carried out in setting up the circuit elements and reports on the construction and testing of the circuit.

Chapter 5 reveals the level of accomplishment of the task and seeks to suggest further work that could improve on the device.

CHAPTER TWO

LITERATUREE REVIEW

2.1 A BRIEF HISTORY OF TEMPERATURE

Many devices have been invented to accurately measure temperature. It all started with the establishment of a temperature scale. This scale transformed the measurement of temperature into meaningful numbers.

In the early years of the eighteenth century, Gabriel Fahrenheit (1686-1736) created the Fahrenheit scale. He set the freezing point of water at 32 degrees and the boiling point at 212 degrees. These two points formed the anchors for his scale.

Later in that century, around 1743, Anders Celsius (1701-1744) invented the Celsius scale. Using the same anchor points, he determined the freezing temperature for water to be 0 degree and the boiling temperature 100 degrees. The Celsius scale is known as a Universal System Unit. It is used throughout science and in most countries.

There is a limit to how cold something can be. The Kelvin scale is designed to go to zero at this minimum temperature. The relationships between the different temperature scales are:

$^oK = 273.15 + {}^oC$ $\quad$ $^oC = (5/9)*(^oF-32)$ $\quad$ $^oF = (9/5)*{}^oC+32$

Table 2.1: Shows the standard value of some quantities.

	^0F	^0C	^0K
Water boils	212	100	373
Room Temperature	72	23	296
Water Freezes	32	0	273
Absolute Zero	-460	-273	0

At a temperature of Absolute Zero there is no motion and no heat. Absolute zero is where all atomic and molecular motion stops and is the lowest temperature possible. Absolute Zero occurs at 0 degrees Kelvin or -273.15 degrees Celsius or at -460 degrees Fahrenheit. All objects emit thermal energy or heat unless they have a temperature of absolute zero.

If we want to understand what temperature means on the molecular level, we should remember that temperature is the average energy of the molecules that composes a substance. The atoms and molecules in a substance do not always travel at the same speed. This means that there is a range of energy (the energy of motion) among the molecules. In a gas, for example, the molecules are traveling in random directions at a variety of speeds - some are fast and some are slow. Sometimes these molecules collide with each other. When this happens the higher speed molecule transfers some of its energy to the slower molecule causing the slower molecule to speed up and the faster molecule to slow down. If more energy is put into the system, the average speed of the molecules will increase and more thermal energy or heat will be produced. So. higher temperatures mean a substance has higher average molecular motion. We do not feel or detect a bunch of different temperatures for each molecule which has a different speed. What we measure as the temperature is always related to the average speed of the molecules in a system.

One of the earliest temperature scales was that devised by the German physicist Gabriel Daniel Fahrenheit. According to this scale, at standard atmospheric pressure, the freezing point (and melting point of ice) is 32° F, and the boiling point is 212° F.

The centigrade, or Celsius scale, invented by the Swedish astronomer Anders Celsius, and used throughout most of the world, assigns a value of 0° C to the freezing point and 100° C to the boiling point. In scientific work, the absolute or Kelvin scale, invented by the British mathematician and physicist William Thomson, 1st Baron Kelvin, is most widely used. In this scale, absolute zero is at -273.15°C, which is zero K, and the degree intervals are identical to those measured on the Celsius scale. The corresponding "absolute Fahrenheit" or Rankine scale, devised by the British engineer and physicist William J. M. Rankine, places absolute zero at 0°R, which is -459.67°F, and the freezing point at 491.67°R. A more consistent scientific temperature scale, based on the Kelvin scale, was adopted in 1933.

Temperature as a measured parameter impacts the physical, chemical and biological in numerous ways, yet a full appreciation of the complexities of temperature and its measurement has been relatively slow to develop.

People have known about temperature unconsciously for a long time: fire is hot and snow is cold. Greater knowledge was gained as man tries to work with metals through the bronze and iron ages. Some of the technological processes required a degree of control over temperature, but to control temperature, we need to be able to measure what we are controlling.

2.2 EARLIER TEMPERATURE MEASUREMENT

Temperature measurement in early days was subjective. For hot metals the colour of the glow was a good indicator. For immediate temperatures, the impact of various materials could be determined. For example does the temperature melts an iron, sulphur, lead or wax, or even boils water?

More so, a number of fixed points could be stated (defined), but there was no scale or means to measure the temperature between these points. Its clear that there is a gap in the recorded history of technology in this regard as it is difficult to believe that the Egyptians', Assyrians, Greeks, Romans or Chinese did not measure temperature in the same way.

Galileo invented the first documented thermometer in 1592.It was an air thermometer consisting of glass bulb with a long tube attached. The tube was dipped into a cooled liquid and the bulb was warmed, expanding the air inside. As the air continues to expand, some of it escaped. When the heat was removed, the remaining air contracted causing the liquid to risen the tube and indicating a change in temperature. This type of thermometer is sensitive but is affected by changes in atmospheric pressure.

2.3 CELSIUS AND FAHRENHEIT

Early 18th century, about 35 different temperature scales had been devised. In 1714, Daniel Gabriel Fahrenheit invented both mercury and the alcohol thermometer. Fahrenheit's mercury thermometer consists of a capillary tube which after being filled with mercury is heated to expand the mercury and expel the air from the tube. The tube is then sealed, leaving the mercury free to expand and contract with temperature changes. Although the mercury thermometer is not as sensitive as the air thermometer, by being sealed, it is not affected by the atmospheric pressure. Mercury freezes at -39°Celcius, so it cannot be used to measure temperature below this point. Alcohol on the other hand freezes at -113°Celsius allowing much lower temperature to be measured.

When thermometers were calibrated between the freezing point of salted water and the human body temperature (salt added to crushed wet ice produced the lowest artificially created temperature at a time) The common Flemish thermometer of the day divided this range into twelve points. Fahrenheit further sub-divided this range into ninety-six points giving his thermometer more resolution and temperature scale very close to today's Fahrenheit scale.

More so, Anders Celsius realized that it would be advantageous to use more common calibration references and to divide the scale into 100 increments instead of 96.He chose to use one hundred degrees as the freezing point and zero degree as the boiling point of water. Sensibly the scale was later reversed and the centigrade scale came into existence.

2.4 THE UNDERSTANDING OF TEMPERATURE MEASUREMENT

The understanding of temperature measurement came into limelight in the nineteenth century where William Thomson postulated the existence of an absolute zero. Sir William Hershel discovered that when sunlight was spread into a colour swath using a prism, he could detect an increase in temperature when moving a blackened thermometer across the spectrum of colours. Hershel found that the heating effect increased toward and beyond the red in the region we now call 'infra red'. He measured radiation effect from fires, candles and stoves and deduced the similarity of light and radiant heat.

In 1821 T.J Seebeck discovered that a current could be produced by unequally heating two junctions of two dissimilar metals, the thermocouple effect. Seebeck assign constant to each type of metal and these constants to compute total amount of current flowing. Also, in 1821,Sir Humphrey Davy discovered that all metal have positive temperature coefficient of resistance and that platinum could be used as excellent temperature detector(RTD). These two discoveries marked the beginning of electrical sensor. Gradually, scientific community learnt how to measure temperature with greater precision. Thus, it was realized by Thomas Stevenson (civil engineer and father of Robert Louis Stevenson) that temperature measurement needed to occur in space shielded from the sun's radiation and rain. For this purpose, he developed the Stevenson screen which is still in use today.

In the late 19^{th} century, a bimetallic temperature sensor was also introduced. This thermometer contains no liquid but operate on the principle of unequal expansion between two metals. Since different metals expands at different rates. One metal that is bonded to another will bend in one direction when heated and will bend in the opposite direction when cooled, hence, the term bimetallic thermometer. This bending motion is transmitted by a suitable mechanical linkage, to a pointer that moves across a calibrated scale. Although not as accurate as liquid in glass thermometers.

2.5 ADVANCEMENT IN DISCOVERY

The discovery of semi-conductor devices such as the thermistor, the integrated circuit sensor, a range of non-contact sensors and also fiber optic temperature sensor came in the twentieth century; Lord Kelvin was finally rewarded for his early work in temperature measurement. The increments of the Kelvin scale were changed from degrees to kelvins. Now we no longer say "one hundred degree Kelvin" we instead say "one hundred kelvins". The "centigrade" scale was change to "Celcius" scale in honour of Anders Celsius.

The 20th century also saw the refinement of the temperature scale. Temperature can now measured to within about 0.001^{o}C over a wide range, although it is not a simple task. The most recent change occurred with the updating of the International Temperature Scale in 1990 to the International Temperature Scale of 1990 (ITS-90). This document also covers the recent history of temperature standards.

Due to the advent of semi-conductor technology and micro-computer and advances in integrated circuits (ICs) fabrication' a lot of temperature transducers have been developed using semi-conductor technology. Today we have a good temperature transducers in the market in the form of integrated circuits(ICs) some of which include LM 35, LM 135H, LM 235H and thermistors.

This form the basis for such discoveries of "digital thermometer" and this particular project titled "Temperature Monitoring Device" they find wider application in scientific, medical and domestic activities making temperature measurement and monitoring easier, more accurate and more reliable.

2.6 TYPES OF TRANSDUCERS

This list is confined to the narrower definition of the term.

a) Electromagnetic:

- Antenna - converts electromagnetic waves into electric current and vice versa.
- Cathode ray tube (CRT) - converts electrical signals into visual form
- Fluorescent lamp, light bulb - converts electrical power into visible light
- Magnetic cartridge - converts motion into electrical form
- Photocell or light-dependent resistor (LDR) - converts changes in light levels into resistance changes
- Tape head - converts changing magnetic fields into electrical form
- Hall effect sensor - converts a magnetic field level into electrical form

b) Electrochemical:

- pH probe
- Electro-galvanic fuel cell

c) Electromechanical (electromechanical output devices are generically called actuators):

- Electroactive polymers
- Galvanometer
- Rotary motor, linear motor
- Vibration powered generator
- Potentiometer when used for measuring position
- Load cell converts force to mV/V electrical signal using strain gauges
- Accelerometer
- Strain gauge
- Switch
- String Potentiometer
- Air flow sensor

d) **Electroacoustic:**

- Geophone - converts ground movement (displacement) into voltage

  Gramophone pick-up

- Hydrophone - converts changes in water pressure into an electrical form
- Loudspeaker, earphone - converts changes in electrical signals into acoustic form
- Microphone - converts changes in air pressure into an electrical signal
- Piezoelectric crystal - converts pressure changes into electrical form
- Tactile transducer

e) **Photoelectric:**

- Laser diode, light-emitting diode - convert electrical power into forms of light
- Photodiode, photo resistor, phototransistor, photomultiplier tube - converts changing light levels into electrical form

f) **Electrostatic:**

- Electrometer
- Liquid crystal display (LCD)

g) Thermoelectric:

- RTD Resistance Temperature Detector
- Thermocouple
- Peltier cooler
- Thermistor (includes PTC resistor and NTC resistor)

h) Radioacoustic:

- Geiger-Müller tube used for measuring radioactivity.
- Receiver (radio)

2.7 TEMPERATURE SENSORS

Temperature is arguably the most often measured physical quantity and many temperature sensors are available. We will limit our discussion to two of the mot widely used categories of sensors. The first is the Thermistor and the second is the Temperature sensor IC.

- **Thermistors**

Thermistors are solid state devices which can be used to directly measure temperature. There are essentially two types called PTC (Positive Temperature Coefficient) and NTC (Negative Temperature Coefficient) thermistors respectively. PTC thermistors have a resistance that is roughly linearly dependent on temperature but are relatively insensitive. NTC thermistors are more sensitive but have a resistance that drops off more or less exponentially with increasing temperature. We shall limit our discussion to NTC thermistors since they seem to be the most widely available.

NTC thermistors are made from semiconducting ceramic pastes of several metal oxides of magnesium, cobalt and nickel. They are relatively cheap and simple to use if all that is required is set-point thermostatic control. A typical temperature range is from $-55^{o}C$ to $+150^{o}C$.

Figure 2.1 shows some examples of NTC thermistors available from Quality Thermistor Inc. of Boise Idaho.

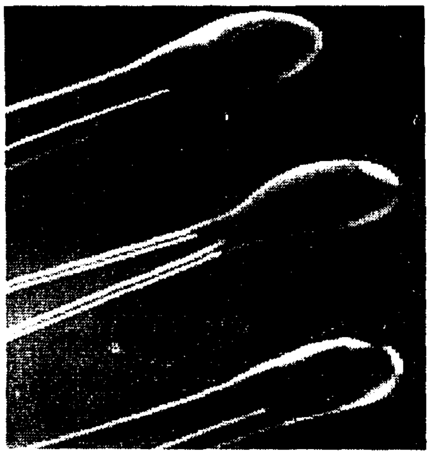


Figure 2.1 Examples of typical thermistors

The circuit symbol for a thermistor is shown in Figure 2.2

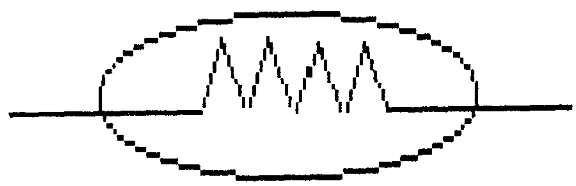


Figure 2.2 The circuit symbol for a thermistor

2.8 TEMPERATURE ICs

Integrated circuit temperature sensors are typically silicon based. As such they can include extensive signal processing circuitry within the same package as the sensor.

National Semiconductor is but one of a number of IC manufacturers that offer a variety of IC based temperature sensors. In IC based temperature sensing elements heat is conducted to the sensing element (Semiconducting material) through the sensors packaging and/or its metallic leads. In general, the dominant path for metal packaged ICs is through the package while in plastic packaged ICs it is through the leads. Hence for metal packaged ICs the case should be in intimate contact with the object whose temperature you want to measure and for plastic packaged IC the leads should be at the temperature you want to measure. If the temperature of liquids is to be measured the IC should be encased in a metal tube. The sensor itself should be kept insulated and dry (avoid condensation).

Examples of IC based temperature sensors are National Semiconductors LM35 and LM34. Both ICs produce an output voltage proportional to the temperature. The LM35 can be used to measure the temperature in degrees centigrade and produces a nominal output voltage of 10mV/°C, while the LM34 can be used to measure the temperature in degrees Fahrenheit and produces a nominal output voltage of 10mV/°F. Typical circuit connections to measure positive temperatures are shown in Figure 2.3.

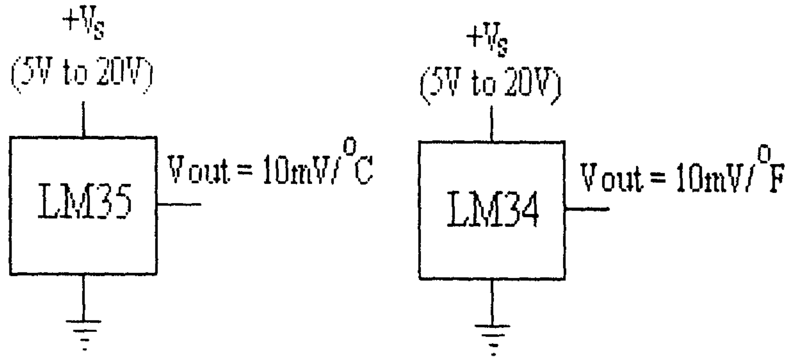


Figure 2.3 Circuit connections for positive temperature measurement

CHAPTER THREE

DESIGN ANALYSIS

3.0 TEMPERATURE MONITORING DEVICE

The temperature monitoring device is subdivided into the following under listed subsystems;

i. The 5-volt regulator/power supply.

ii. The 8 bit analog- to- digital converter.

iii. The LM35 temperature sensor.

iv. The system controller.

v. The 4-digit 7-segment visual display unit.

(A) THE 5-VOLT REGULATOR/POWER SUPPLY

The power supply for the system was derived from a 9-volt DC battery source. The 9V DC was buffered by a 16V2200UF capacitor, and stepped down to a steady 5-volt output using a 7805 5-volt 1-amp regulator. The power supply is configured as shown below:

The 5-volt supply was by passed using a 0.1UF capacitor to remove high-frequency noise that might be superimposed on the power line. The 5-volt supply feeds the remaining parts of the system.

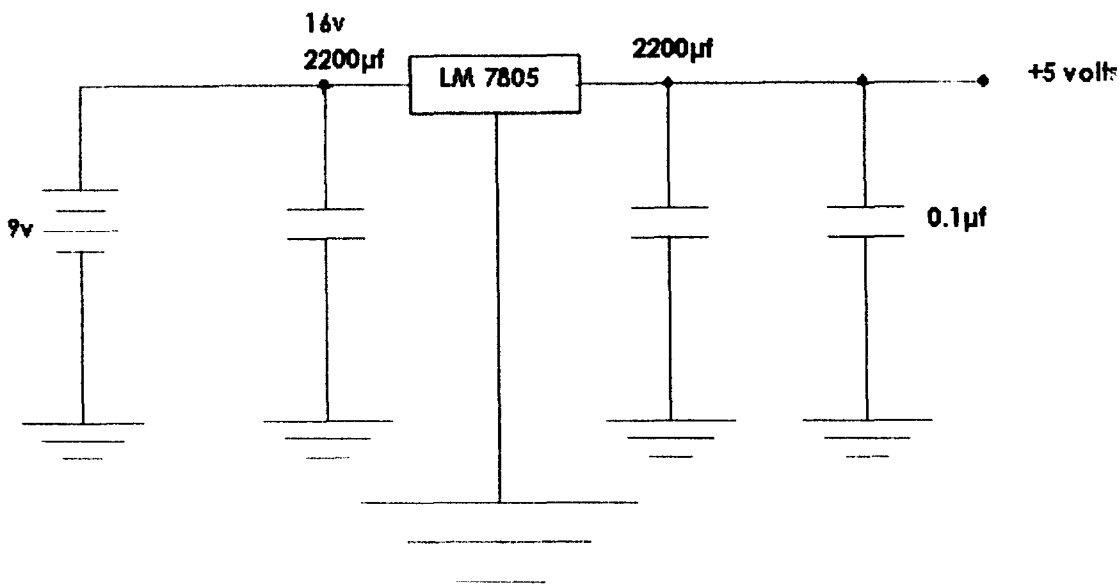


Figure 3.0 Power Supply Unit

(B) 8-BIT ANALOG-TO-DIGITAL CONVERTER

The ADC is a vital component of the circuit, which receives analog voltage from the sensor and converts it to digital equivalent. ADC 0804 was used in this case. The ADC 0804 belongs to the ADC 084x family which is a CMOS 8 bit, successive approximation A/D converters. The ADC has conversion time of less than 100m/s and a differential analog voltage input ranging from 0 to +5volts for a single +5v supply.

The normal operation of the ADC proceed as follows;

On the high to low transition of the WRITE input, the inter SAR (successive Approximation Register) latches and the shift register stages are reset, and the $\overline{\text{INTR}}$ (interrupt) output will be set high. As long as the $\overline{\text{CS}}$ (chip select) input and WRITE input remain low, the A/D will remain in a reset state conversion starts from 1 to 8- clock period after at least one of these inputs makes a low to high transition. The $\overline{\text{INTR}}$ pin will make a high -- to -- low.

Transition after the requisite numbers of clock pulses is generated to complete the conversion. A $\overline{\text{RD}}$ (READ) operation (with $\overline{\text{CS}}$ low) will clear the $\overline{\text{INTR}}$ line again.

The device operates in free running mode when $\overline{\text{INTR}}$ is connected to the WRITE input with $\overline{\text{CS}}$ set to low. An external WR pulse is required during the first power –up cycle to ensure start up under all possible conditions issuing a second start command can interrupt a conversion in progress. The diagram is shown below:

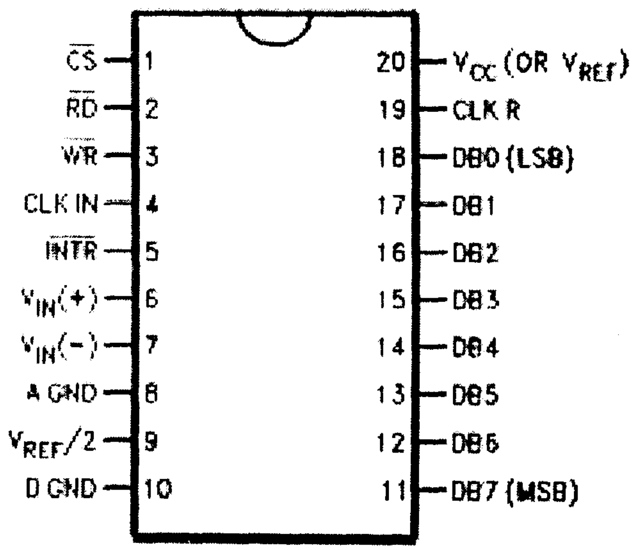


Figure 3.1 ADC0804

ADC Resolution

Resolution by definition is the ratio of the voltage range to that of the weight of a non-zero digital output. Minimum weight at the digital output occurs when all are set to zero logic and maximum when all are set to logical 1 i.e. 0 and 255 respectively.

Number of digital weight = 2^n

Where n = number of digital lines = 8

Number of digital weight = 2^8-1 (because of the zero start bit) = 255.

Therefore, resolution = voltage range/255. Also, the higher the number of digital output lines, the more accurate the ADC.

DC Conversion Time of the ADC.

The conversion time is the period within which the ADC converts the analogue input voltage into its digital equivalent. The clock can be derived from an external source such as the CPU or an external RC network added to provide self- clocking.

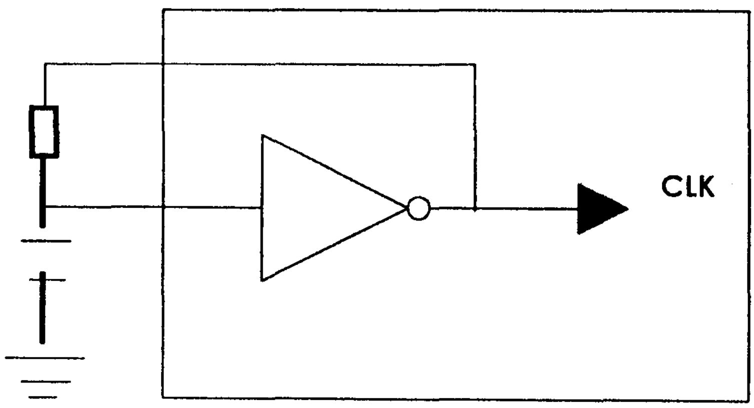


Figure 3.2 Self clocking of the ADC

Where $F_{clk} = \frac{1}{(1.1 \times RC)} = \frac{1}{1.1 \times 10\Omega \times 150\ PF} = 606kHz$

The conversion time:

$T = \frac{1}{Freq} = \frac{1}{Fclk} = \frac{1}{606kHz} = 100\mu s$

To realize the implementation form of the digital system, a means of interfacing the analog voltage generated by the temperature sensor to the system controller is needed. The solution comes in the form of a circuit that can convert the analog voltage input into a digital signal consisting of 1s and 0s. The solution is commonly called an analog to digital converter.

An 8-bit ADC suffices for the design requirement hence a good enough ADC meeting the demands of the system was found in the name of ADC 0804 successive approximation register analog to digital converter.

The ADC 0804 enclosed in a 20 pins IC package with input and output, and control pins suited for microprocessor bus interfacing. The ADC 0804 converts typically in 100micro sec, and since the temperature to be measured usually is a slowly varying low- bandwidth input, the conversion time is vey okay.

The conversion dual is generated by an RC combination on pin 18. The frequency of oscillation as determined by the value of the RC combination is stated thus;

$$F_{osc} = \frac{1}{1.1RC}$$

R= Typically 10KΩ.

C = Typically 150pf

The ADC can handle conversion clock frequencies as high as 1.460MHz.

Conversion

The $\overline{ADC}$ has a chip select ($\overline{CS}$), read ($\overline{RD}$), write ($\overline{WR}$), and interrupt ($\overline{INTR}$) pins for convention to suitable processors or controllers

Conversion is initiated in three main ways; but the method employed in this design work is explained below:

1) Set $\overline{CS}$ to logical zero.
2) Set $\overline{WR}$ to logical zero
3) Set $\overline{WR}$ to logical one.
4) Set $\overline{CS}$ to logical one
5) Wait until $\overline{INTR}$ goes low.
6) Set $\overline{RD}$ to logical zero to read conversion result.
7) Go to 1

The clock frequencies used in this design work is :

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

Where R = 10KΩ, C = 150PF

F = 6.062kHz

For correct input –output relationship between the analog input and the digital output, a form of scaling is needed.

Scaling is done by fixing the relationship between the input voltage and the maximum full scale value of the ADC.The full scale value of binary ADC is 2^n-1.Where n = number of output bits.

For the ADC0804 with n equals 8, the maximum possible output binary value is 2^8-1 = 255. Since a rather small range of temperature is desired to be measured resolution can be improved by making the input voltage corresponding to the maximum binary value small.

In this case, the upper temperature value was fixed at 42°C.Thus at 42°C the binary output would be 255.This output value can be divided down by six to yield the input analog voltage level. Dividing by the upper limit yielded a value complicated to manipulate digitally on an 8-bit machine, hence a value of 42.66°C was chosen to facilitate temperature measurement by dividing down by six.

Thus, with the maximum input (voltage fixed), the input-output relationship for any signal can simply be deduced from:

0.4266 = 256

X = y

Where X = unknown analog input voltage; y = conversion result ADC.

A stable voltage of 0.2133V was fed into pin 9 of the ADC. This internally amplified by a factor of two to yield the 0.4266V maximum input.

The 10kΩ resistance was adjusted to yield 0.2133V.The conversion results is sent to the system controller over an 8-bit bus, where it is processed before displaying.

(C) LM 35 TEMPERATURE SENSOR.

The temperature transducer used in this circuit as temperature sensor is the LM 35 made by National Semiconductor company. The LM 35 sensor is a non-contact integrated circuit temperature sensor whose voltage (analog) is linearly proportional to the Celsius temperature scale.

The LM 35 temperature sensor is a 3-pin analog temperature measurement device withy the following specifications:

- Output calibrated directly in centigrade.
- Linear +10.0mV/^{o} C scale factor.
- 0.5^{o} C accuracy guarantee able (at +25^{o} C).
- Low impedance output 0.1Ω for 1mA load.

The sensor is housed in a 70-92 package.

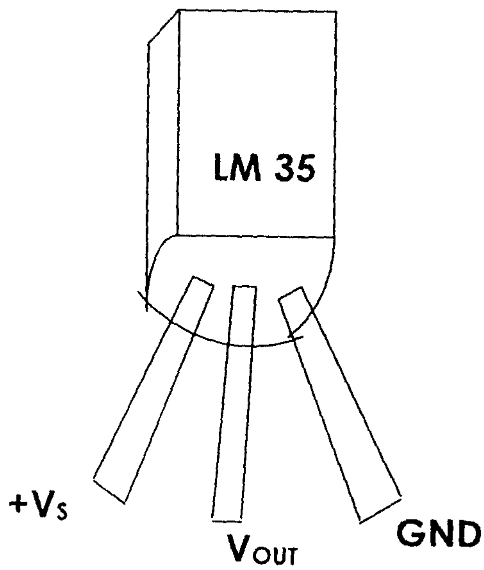


Figure 3.3 LM35 Sensor

The sensor output is held steady by a 10μF electrolytic capacitor to prevent rapid display fluctuations

(D) SYSTEM CONTROLLER

The system controller is an 8-bit AT89C51 microcontroller unit with specifications stated below:

- 4 KB flash memory.
- 128 byte of internal RAM.
- DC-24MHz operation.
- 4, 8-bit I/O port.
- Full duplex serial port.

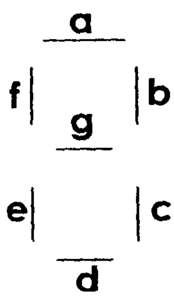
The micro controller executes the program code loaded into its internal program memory at power up. The system controller ,amongst other things, performs the following :

- Controls the ADC
- Manipulates the conversion data.
- Converts the result s in the step above to the appropriate seven-segment display code.
- Controls the multiplexing of the digits on the seven- segment display.

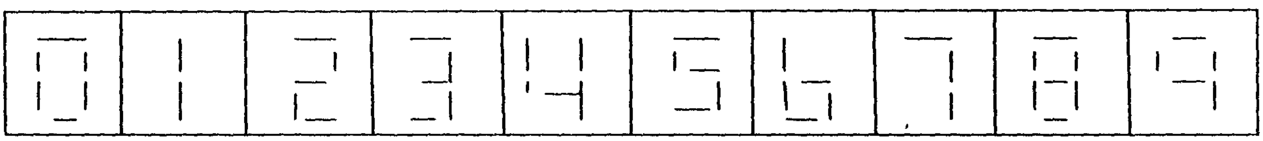
- Waits for the user to press the convert key to initiate temperature conversion and subsequent display.

(E) 4-DIGITS 7-SEGMENT VISUAL DISPLAY UNIT.

The displaying unit used in displaying the results of the temperature measured by the device in decimal form in the 7-segment display which comes in the form of an integrated circuit (Ic).



A 7-segment display consists of seven rectangular LEDs which can be from the digit 0 – 9 as shown below;



They came in two types of arrangements. Common cathode and common anode. In common-cathode arrangement, all the cathode of the segment are tied together and connected to ground while in common anode type, the anode of all the segment are connected together to Vcc.

The display unit comprises four common anode, seven-segment displays, four transistors anode drivers, and an 8-bit port on the controller; POA .O.

The display is written to software after every conversion, and is updated after each conversion for as long as the measure key is held pressed. The anode drivers are illustrated below.

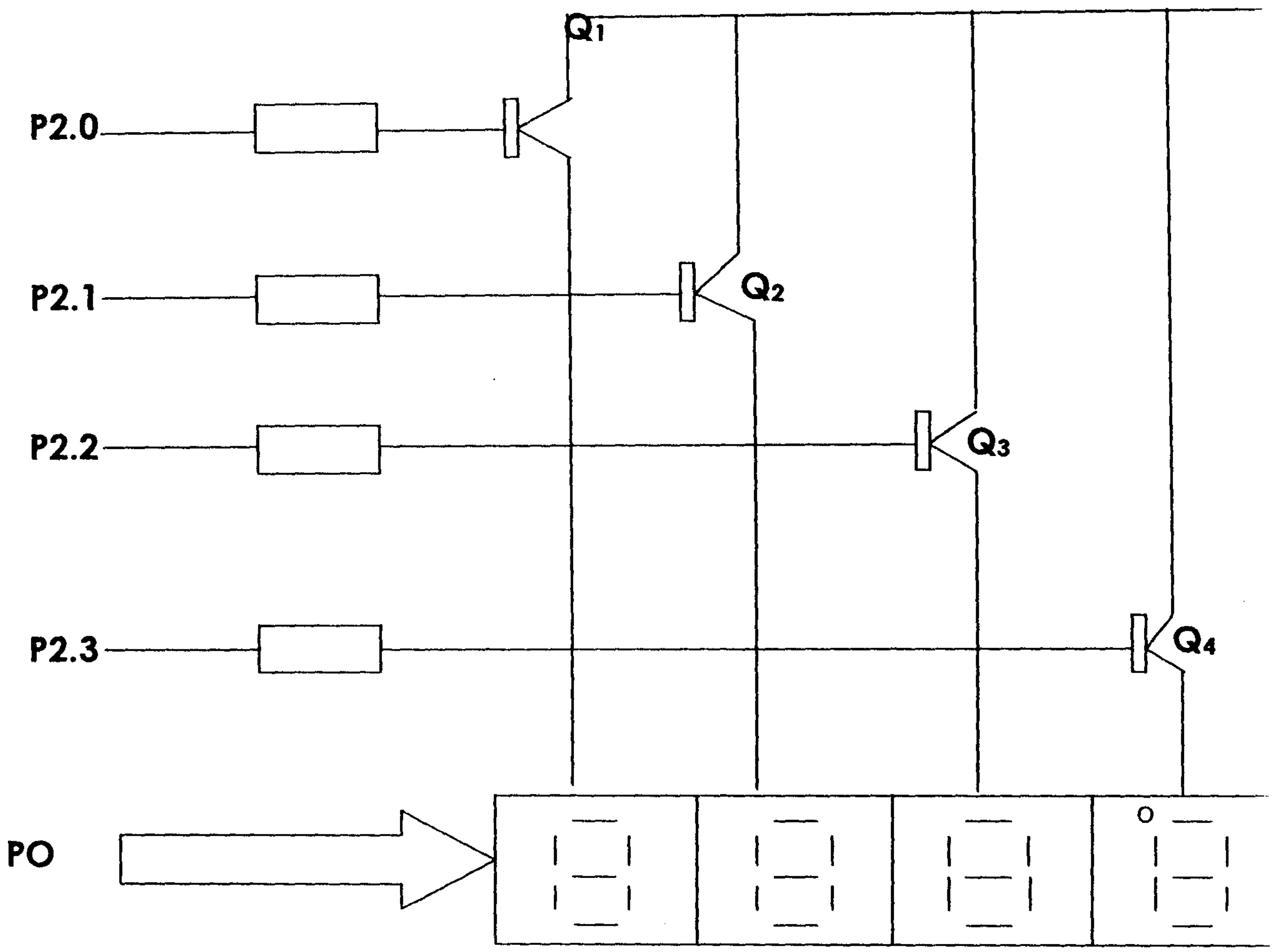


Figure 3.4 Four Seven Segment Display Unit

Where Q1 – Q4 is given as : 4 × 2SA1015GR.

Each digit is controlled by its anode driver transistor .A simple scheme whereby the four digits are multiplexed is employed.

Multiplexing involves switching the digits on and off rhythmically while the bit pattern to be displayed is sent to the common data output port. For example, to display numeral 4 on digit 1, the following steps are followed:

- Switch off all anode drivers, Q1-Q4.
- Present the bit pattern corresponding to |_| on the data port, Po.
- Turn on Q1
- Display for about 10ms
- Turn off Q1
- Go back to step 1.

If more than one digit is needed to be display, e.g 5678 is to be display on the four digits successively, the following sequences are followed:

- Turn off Q1 to Q4.
- Turn on Q1.
- Send the bit pattern corresponding to |¯ _| , i.e, 0010010, to the common data port.
- Generate appropriate delay.
- Turn off Q1
- Send the bit pattern of |_| to the display port, i.e. X0000010.

- Turn on Q2.
- Generate time delay so that the light segments are visible.
- Turn off Q2.
- Repeat for the next two digits.

Software bit patterning is used to directly interface the displays to the controller. Bit patterning involves associating each segment of the display with a unique bit position. For example, numeral will have the following bit pattern when a common –anode display is used for the display.

1	gfedcba
1	1111001

The bitmask is stored in memory and when the binary coded decimal is to be converted to the seven-segmented code, the memory –stored table is looked up to fetch the required bit pattern.

A feature of the system is the inclusion of a ° indicator. This was obtained by turning the seven –segment display upside down, and using the decimal point to indicate the degree symbol.

The table below shows the pattern associated with each decimal numeral;

 11000000

11111001

10100100

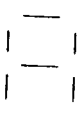
10110000

10011001

10010010

10000010

11111000



10000000

10010000

01000110

The design features a 0.2 degree resolution which is considered ideal enough, and powers down when not in use.

The program execution flow is detailed as shown below:

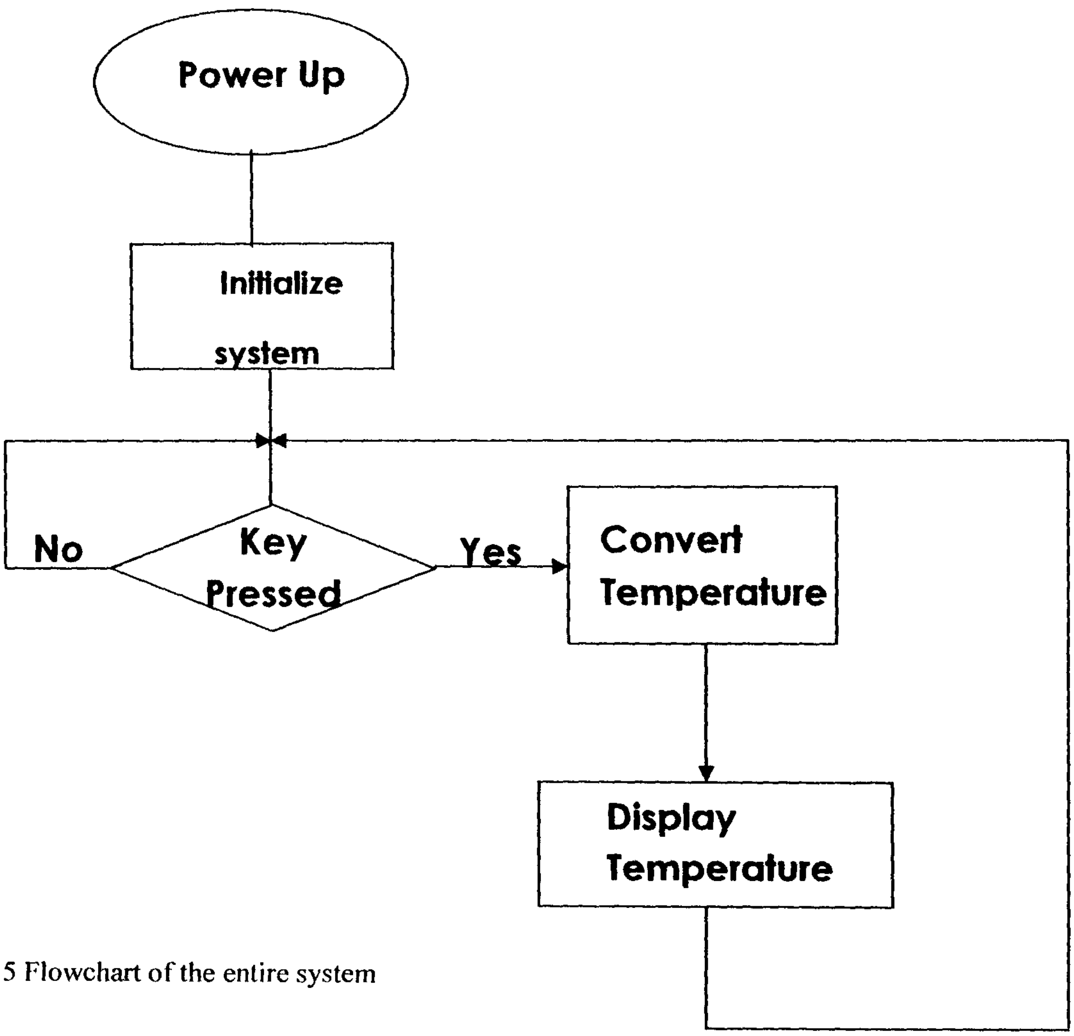


Figure 3.5 Flowchart of the entire system

3.1 BLOCK DIAGRAM

The block diagram shown in the figure below shows the techniques that was employed for carrying out the task. It shows a schematic diagram of temperature control of a body . The temperature is converted to an analogue voltage by a thermo-electric devices (in this case LM35 which is an analog device). The analog voltage is converted to a digital voltage by Analog to Digital converter (ADC).

The digital voltage is fed to a controller which in this case a micro- controller AT 89C51. This controller sends out signals to the display unit as shown in the diagram below;

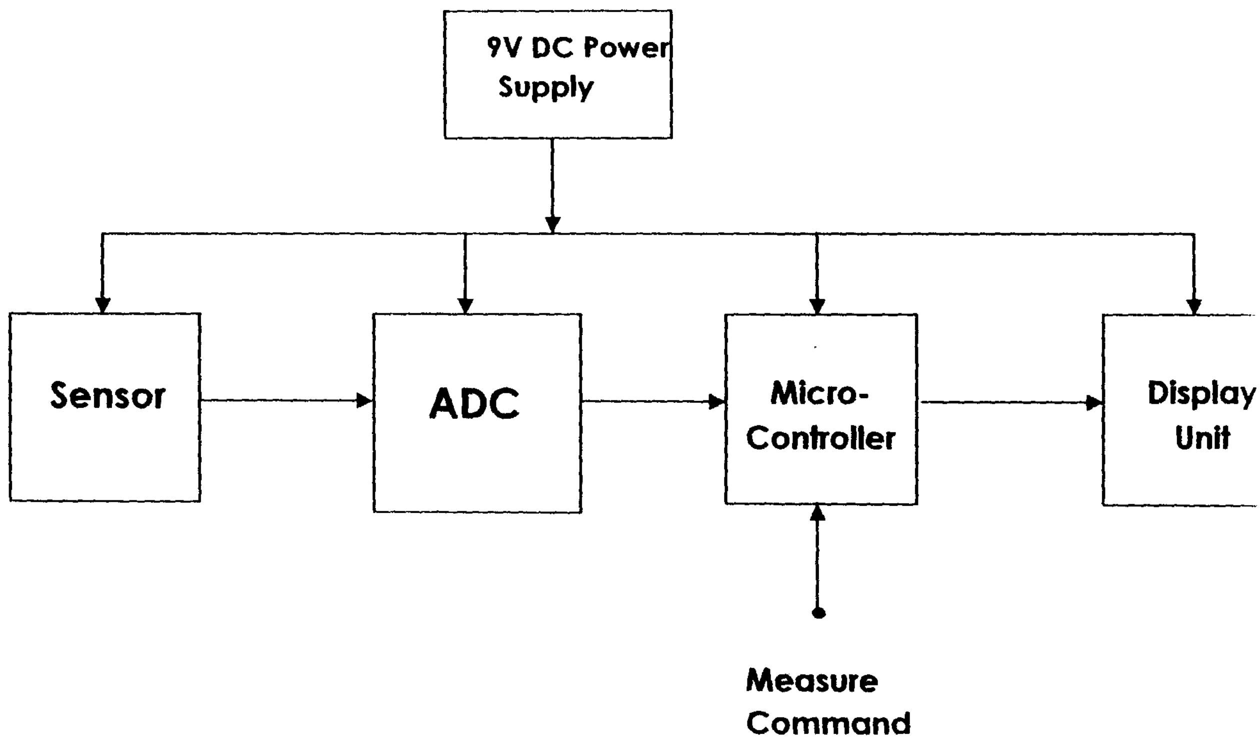
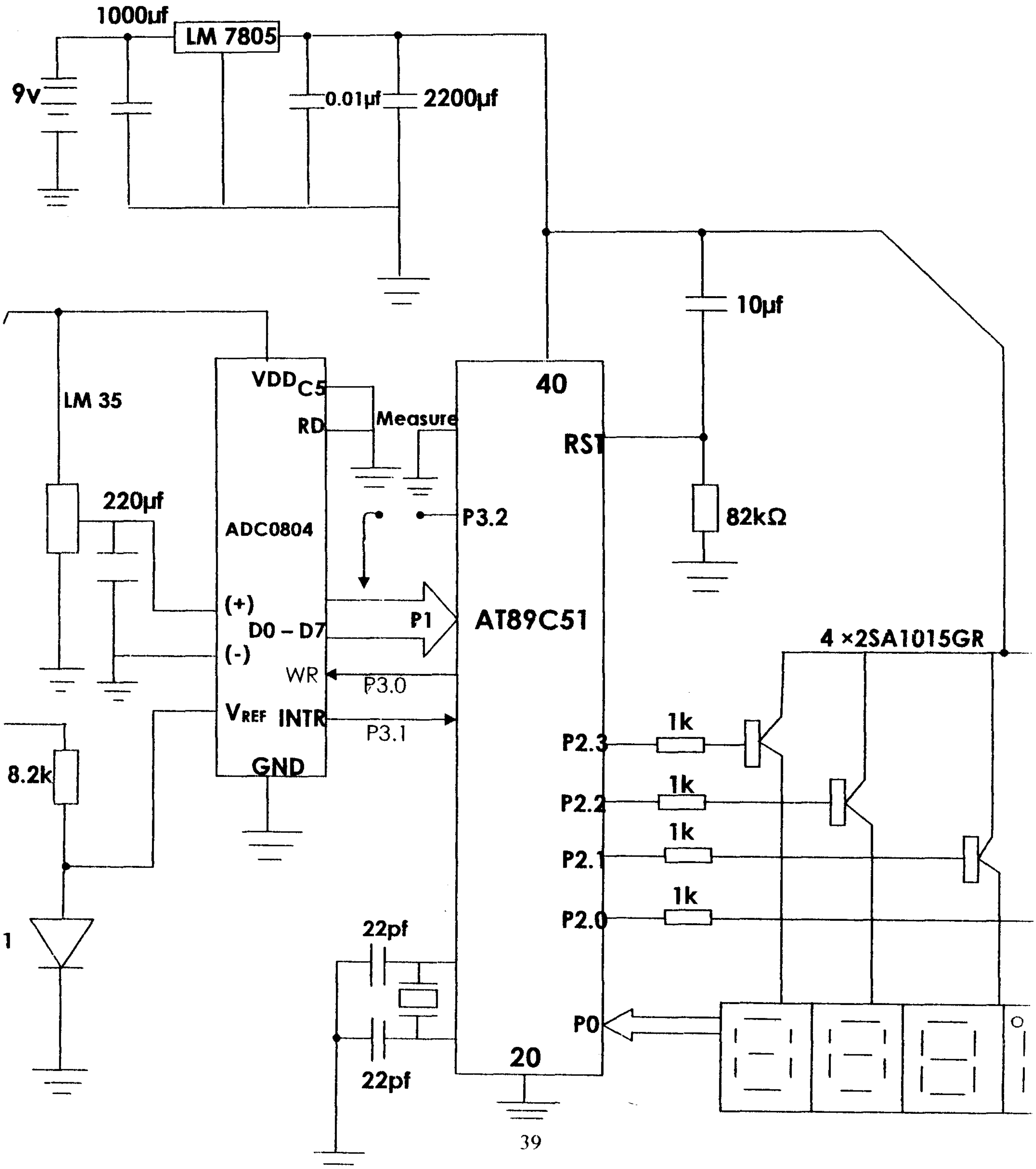


Figure 3.6 Block Diagram of the system

3.2 THE ENTIRE CIRCUIT DIAGRAM OF THE PROJECT WORK



CHAPTER FOUR

SYSTEM IMPLEMENTATION AND TESTING

4.0 CONSTRUCTION AND TESTING

Some of the stages of the circuits like the power unit were first tested on bread board. The wire links made as short as possible to prevent unnecessary interference from external signal and all the component were to be firmly connected.

It was then transferred to the vero board as designed and soft soldering was applied with the aid of some connecting wire links to form a permanent system. All component except the temperature sensor were accommodated on the vero board , all component were ensured to have a common ground and also distinct and different colours of wires were used to avoid confusion and enable distinguish ability. When constructing, ribbon were used to ensure an orderly arrangement of wires along the vero board. A casing structure was constructed to house the system for adequate protection and to suit portability

4.1 OPERATIONAL MODE OF CONTROL UNIT

The operation of the temperature monitoring device (TMD) is thus; The switch is press down and held in that position while the temperature measure is being displaced through the LED, each time the switch is released, the reading stops and vice versa.

4.2 PROGRAM CODE OF THE CONTROLLER

This is presented in appendix A

CHAPTER FIVE

DISCUSSION, CONCLUSION AND RECOMMENDATION.

5.1 DISCUSSION OF RESULT

According to the results obtained, the temperature monitoring device has proved to be reliable and effective. The results obtained as compared with mercury- in –glass thermometer clearly demonstrated the effectiveness of the device. The little difference between the temperature measured by the device and that measured by the thermometer show that the device is more sensitive.

5.2 CONCLUSION AND RECOMMENDATION

In conclusion, the aims and objectives of this project have been achieved. Temperature can be measured and monitored simultaneously and effectively. Any results obtained can easily be analyzed and used or kept for future purpose.

Thus, due to some limiting factors, this device could not be interfaced with a computer. Hence, my recommendation therefore is that this project is interfaced to a computer system to make it more effective and efficient and that sensor with higher temperature range be used.

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APPENDIX A

```
INCLUDE 89c51.mc

adc_port EQU p1

display_port EQU p0

temp_Value DATA 08h

stack EQU 40h

digit_1_data DATA 09h

digit_2_Data DATA 0ah

digit_3_data DATA 0bh

digit_4_Data DATA 0ch

temp DATA 0dh

digit_1_dx BIT p2.7

digit_2_dx BIT p2.6

digit_3_Dx BIT p2.5

digit_4_dx BIT p2.4

adc_write BIT p3.0

adc_intr BIT p3.1
```

```
centigrade_bit_pattern EQU 01000110b

measure_in bit p3.2

org 0000h

start_up:           CLR ea

                    MOV sp,#stack

CHK_aGAIN:          JB measure_in, $

                    ACALL get_Temp

                    ACALL process_temp

                    ACALL show_temp

                    SJMP chk_Again

show_temp:          MOV R5,#250

show_Again:         ACALL write_display

                    DJNZ R5, show_Again

                    RET

convert_Temp:       CLR adc_Write

                    NOP

                    NOP
```

```
                SETB ADC_wRITE
                JB adc_intr, $
                MOV A, adc_port
                MOV temp_Value, A
                RET
display_temp:   ACALL write_display
                RET
get_temp:   MOV R0,#20
            CLR A
  next_temp:    ACALL convert_Temp
            ADD A, temp_value
            MOV R6,#10
            DJNZ R6,$
            ACALL convert_Temp
            ADD A, temp_Value
            RR A
            MOV R6,#10
```

```
              DJNZ R6,$

              DJNZ R0, next_temp

              RET

process_Temp:       MOV A, temp_Value

                    MOV B,#22

                    DIV ab

                    MOV digit_1_data, A

                    MOV A,B

                    MOV B,#10

                    MUL ab

                    MOV B,#22

                    DIV ab

                    MOV digit_2_data ,A

                    MOV A,B

                    MOV B,#10

                    MUL ab

                    MOV B,#22
```

```
                DIV ab
                MOV digit_3_data, A
xlate_2_7seg:   MOV DPTR,#xlate_table
                MOV A, digit_1_data
                MOVC A, @a+dptr
                MOV digit_1_data, A
                MOV A, digit_2_Data
                MOVC A, @a+dptr
                ANL A,#01111111b
                MOV digit_2_Data, A
                MOV A, digit_3_data
                MOVC A, @a+dptr
                MOV digit_3_data, A
                MOV digit_4_data, #centigrade_bit_pattern
                RET
xlate_Table:    DB
11000000b,11111001b,10100100b,10110000b,10011001b,10010010b,10000010b,1111
1000b,10000000b,10010000b
```

```
write_display:  MOV display_port,digit_1_data

                CLR digit_1_Dx

                ACALL delay_2_Show

                SETB digit_1_dx

                CLR digit_2_dx

                MOV display_port, digit_2_data

                ACALL delay_2_Show

                SETB digit_2_dx

                CLR digit_3_dx

                MOV display_port, digit_3_data

                ACALL delay_2_Show

                SETB digit_3_dx

                CLR digit_4_dx

                MOV display_port, digit_4_data

                ACALL delay_2_show

                SETB digit_4_dx

                RET
```

```
delay_2_Show:   MOV R7,#250

                NOP

                nop

delay_2_Show_loop:DJNZ R7, delay_2_Show_loop

                RET
```