DESIGN AND CONSTRUCTION TEMPERATURE MONITOR (DIGITAL THERMOMETER)

BY

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DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

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MINNA
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SUBMITED TO

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FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE

IN PATIAL FUFILMENT OF THE AWARD OF BACHELOR OF ENGINEERING (B. ENG) IN ELECTRICAL AND COMPUTER ENGINEERING

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DECLARATION

I hereby declare that this work was carried out by me Eleam Chikezie .O. It was closely supervised by Mr Eronu Department of Electrical and computer Engineering, federal university of technology, Minna during 2004/2005 session. Information derived from published or unpublished of others was duly accredited in the reference.

Student.

05/10/2005

Date

ACKNOWLEDGMENT

I gratefully acknowledge and remember the marvellous works of Almighty God upon my life these past years, for this protection and mercy on me before, during and by this grace even after this project. To him be the glory for in Jesus name (Amen).

My inexpressible gratitude however remain for my parents Mr. & Mrs. C.U Eleam for their love which has kept me in good steed. I have, I find succour for my financial need, and moral support and spirit of don't give up child.

My heart felt thanks goes to my supervisor Mr E..Eronu who allowed me to take challenge and whose intellectual comment, kindness, advice readiness and patience led to the completion of this project. The same goes to my H.O.D Engr. Musa Abduallahi, staffs and students of electrical and computer engineering especially my friends like Asuguo, Ngbede, Innocent, Yomi and Seun Elias for their assistance and contributions towards the completion of this project.

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I acknowledge the prayers of my fellowship Anglican students fellowship(ASF)and all undergraduate union FUT Minna branch which every effort has been made to acknowledge everyone that has useful suggestion in improving the presentation of this work and the overall realization of my academic dream ,any omission is an inadvertent.

CERTIFICATION

This work was carried out entirely by ELEAM CHIKEZIE .O. 99/8158EE.It was submitted and duly approved as satisfying part of the requirement of the Department of Electrical and computer engineering FUT Minna for the award of Bachelors of engineering (B.Eng.) degree in Electrical and computer engineering.

5-12-2005

Mr E Eronu

Project Supervisor

DATE

06/02/06

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Head of Department

DATE

External Examiner

DATE

DEDICATION

This work is dedicated to God almighty who led me through his path. To my dear parents Mr. and Mrs. C.U.Eleam who made this dream a reality and the entire Eleamfamily for their love, kindness and support.

ABSTRACT

The composition of the body temperature monitor project (Digital thermometer) using an integrated circuit (LM35) sensor comprise of the power supply, temperature sensor, analogue to digital converter, counter, the decoder and the seven segment display.

Power supply of 9V which is regulated to 5V by 7805 regulator is provided by the battery to power the whole circuit. The temperature sensor (transducer) converts the temperature into corresponding voltage. For one degree Celsius change in temperature, it generates 10mV. The output voltage of the sensor (V_{out}) is fed into the analogue to digital converter (ADC). It is an 8-bit ADC having eight digital outputs which provides 256 codes. This analogue-to-digital converter gives out a specific code for every voltage input generated by the temperature sensor.

The binary output from the ADC received by the down counter which counts down from the terminal to zero, immediately it reaches zero, it will give an output through the detector pin which latch the decoder with the correlation of NOT an AND gates. A binary to decade logic converter is required to manipulate a group decade counters so as to display a comprehensive visual information corresponding to the temperature.

The seven segment display unit is made originally of LEDs (light emitting diode) connected as a common cathode. The degree Celsius (^oC) display feature is made of LED too but powered from the battery directly.

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CHAPTER ONE

1.1 INTRODUCTION

The concept of temperature originated in human sensory perception of the surrounding environment. When the condition of the atmosphere changes, it is felt to be relatively 'hot' or 'cold'. Man found the need to measure temperature in order to make things, exchange and control things.

The body temperature monitor (digital thermometer) is an instrument used to measure temperature variation. In industries especially electric power station and manufacturing companies, so many equipment and machines are designed to operate within a particular range of temperature for effectiveness and efficiency. Thermometers are usually attacked to the equipment to measure temperature of things like cooling oil, cooling water instantaneously as the machine is in operation. Their exact value at an instant of time must be known. The need to measure these quantities led to the design of an instrument which can not only tell, at any instance the magnitude of this quantity but also display the value on a display device. Without the display in the digital format, the instrument cannot be termed DIGITAL THERMOMETER therefore a digital display device form part of the vital section of a digital thermometer

1.2 OBJECTIVES AND MOTIVATION

Thermometer is an instrument used for measuring temperature. There are various forms of thermometer based on the type of thermometric substance it uses to measure on the temperature. Some of the popular types are the liquid in glass thermometer like-clinical thermometer for measuring human body temperature, maximum and minimum thermometer for recording maximum temperature in the day and minimum temperature in the night. Others are resistance thermometer and thermoelectric thermometer which measure s very high temperature.

The thermometers mentioned above mostly uses scale or calibrated. Most users find it difficult to interpret the exact value of the temperature indicated by the thermometer. Some of them especially those with pointers are prone to error due to parallax, bended pointer, and scale calibration and pointer vibration.

One of the main objectives of this project is to design and construct a simple thermometer that measure temperature from 0 °C and 99 °C and displays the temperature in digits.This relieves the user with interpretation of exact temperature problem and eliminate the errors associated with analogue meters.

Finally the aim is to construct a digital thermometer suitable for use in measuring temperatures of non-conducive fluid such as air, ice and water.

1.3 PROJECT LAYOUT

This project write-up is in five chapters as it is customary to most other projects from the department.

Chapter one encompasses the general introduction, the author discussed briefly the importance of thermometer especially in industries, techniques employed and the objectives and motivation for the project.

Chapter two is the literature review and the discussions are about the various temperature monitoring devices\, the scaling, sensor, the economic importance of digital thermometer and why digital thermometer is preferred.

The chapter three is basically system design. The whole project was divided into subsystems for easy understanding and designing. It comprises the power supply unit, the transducer section, the power supply unit, the transducer section, the analogue-to digital conversion unit, the binary to decade convention unit. The principles of operation of the subsystems were fully explained and designed.

Chapter four deals with the construction and testing. The two were explained and effort was made to achieve result. Discussion of results and made to achieve result. Discussion of results and problem encountered ere briefly discussed. The last chapter includes recommendation and conclusion of the project. Recommendation is mad of some other temperature sensing devices and other ICs that could be used in achieving the aim of this project.

CHAPTER TWO

2.1 LITERATURE REVIEW

Temperature measuring instrument was discovered during the seventeenth century AD. Before then there was no way to quantify heat or cold. Heat and cold were considered as fundamental quantities like dry and wet. Heat and cold were quantities that combine to make up the elements: earth water, air and fire. One might speak of degree of heat or cold.

There was no distinction between what could be called extensive concept or degree of the heat and the intensive concept or degree of temperature. Also these degrees were not measured except in a very crude way as when a physician puts his hand on the patients' forehead and diagnosed rise temperature.

Measuring of heat was a puzzle in the circle of practical knowledgeable men in which Galileo belong. The first solution was thermoscope built by Hero of Alexandra (1st century BC), first published in the west in 1575 AD. Several authors thereafter began playing with the expansion of air as its heat increases and vice versa.

The first versions usually called thermoscope were little more toys. Benedetto Castelli wrote in 1638 about a device he had seen in Galileo's hand around 1603 AD. Over the next several years the thermoscope was developed by Santorio and Galileo's friend Gian Frrancesco Sagred (both in Venice) Galileo's thermometer and other to include a numerical scale. It later became a full-fledged air thermometer.

The liquid in glass thermometer was developed in the 1630 but universal standard of temperature remained elusive. Each scientist has his own scale division often based on different reference points. In the early eighteenth century, based on several fiduciary, Fehrenheit (1686-1736), Andrenş Celsius (1701-1744) and Rene-Antoine Ferchalt de Roemer (1683-1757) did remarkable work on temperature measurement. But out of these, the first two are used. The system of Celsius has become the standard Scientific Scale. [4]

2.2 SCALING

Roemer (famous for making the first measurement on the velocity of light showing that it is finite) devised a temperature scale of his own for with alcohol in glass thermometer he constructed.

Fahrenheit by 1724 adopted a new scale similar to Roemer's but with mush finer divisions. For the zero point he used the same reference as Roemer. However since he is interested in the metreological observations, he took reference point that is nearer to maximum observed temperature for weather. He chose the human body as upper reference point (96 °F). the Fahrenheit scale use today differ slightly from original the two fixed points being 32 °F and 212 °F as the temperature of ice and boiling water respectively.

Today the Celsius scale and Kelvin scale have replaced Fahrenheit scale for scientific work. The choice of thermometer depends on the temperature to be measured. The Celsius has two fixed points reference which are the ice point and the steam point. The number assigned to these two points in the Celsius scale are arbitrarily chosen as zero degree for ice point and 100 degrees for the steam point by Andrews Celsius (1701-1744). [4]

2.3 SENSOR

The sensor used in this project is an analog sensor-integrated circuit LM35- which can be used to measure temperature with an electrical output proportional to the surrounding temperature.

The typical characteristics of various temperature sensors are:

a) Thermocouple – these are inexpensive, and the most common sensors with a wide range of temperature range. It works on the principle that when two dissimilar metals are combined, a voltage appears across the junction between the metals. Different combinations of metal crate different thermocouple voltages and there is a wide range of thermocouple voltage available for different applications. Thermocouples generate very low voltage about 50μV/ °C. Thermocouples have non-linear relationship to measured temperature and as a result, it is necessary either to linearise the characteristics or to use look-up tables to obtain the actual temperature from the measured voltage.

b) Resistive temperature devices (RTDs) - an RTD is a resistor with its resistance changing with temperature. The most popular type of RTD is made of platinum and has a resistance of 100Ω at 0 °C. The change in resistance is very small (about 0.4Ω/ °C) and special circuitry is generally needed to measure the small changes in temperature. One of the drawbacks of RTDs in their non-linear change in resistance with temperature.[1]

c) Thermistor – thermistor are metal oxide semiconductor devices whose resistance changes with temperature. One of the advantages of thermistor is their fast responses and high sensitivity e g a typical thermistor may have a resistance of 50kΩ at 25 °C but have a resistance of only 2kΩ at 85 °C. Like RTDs, a current is passed through the device and the voltage across is measured. Thermistors are very non-linear device and look-up tables are usually used to convert the measured voltage to temperature. One disadvantage of thermistor is that they can be self heating under large excitation current and this increase the temperature of the device and can gives erroneous results.

d) IC temperature sensor – integrated circuit sensors are usually 3-pin Or 8-pin active device that require a power supply to operate and give out a voltage which in directly proportional to the temperature.

IC temperature sensors are basically two types: (a) Analog sensor which are usually 3-pin devices and give out an analog voltage of 10mV/°C which is directly proportional to the temperature. LM35-sensor used in this project is basically an analog type. (b) Digital temperature sensors provide 8 or 9 –bit serial digital output data which is directly proportional to the temperature. [1]

2.4 WHY DIGITAL THERMOETER IS PREFERRED

In industries and manufacturing companies, many equipment and machine are designed to operate within a particular range of temperature for efficiencies are usually attached to equipment to measure temperature of things like cooling air, cooling oil, water and the temperature at which machine is to operate to avoid overheating when operated. Most of the thermometers are calibrated, in scales which are prone to error due to parallax, bended pointers, error in calibrated scale and vibration of the pointer when they are in service.

Digital thermometer display instantaneous temperature digitally that is showing the instantaneous temperature, in digits which can be read off without any error, and also relief the user the ability to interpret the exact value of the temperature measured relative to the scale calibration of the analogue meter.

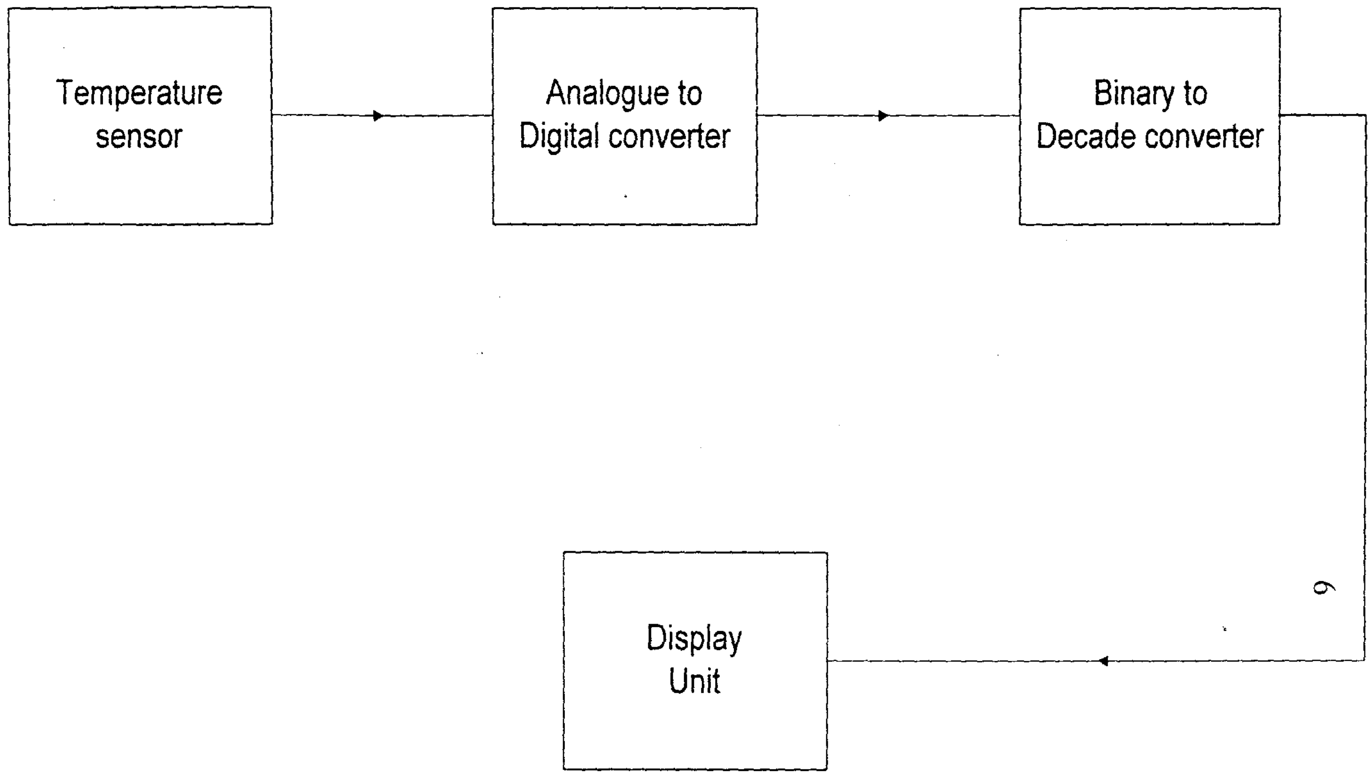
2.4.1 ECONOMIC IMPORTANCE OF DIGITAL THERMOMETER TO INDUSTRIAL SYSTEMS

1) It reduces the rate at which industrial machine are damaged due to overheating.
2) It enhances the life span of industrial machine.
3) It facilitates industrial process and production of fault free commodity.

CHAPTER THREE

SYSTEM DESIGN

3.1 BLOCK DIAGRAM



BLOCK DIAGRAM OF DIGITAL CLINICAL THERMOMETER

3.2 POWER

The past few years have seen reduction in the size and also the power requirement of electronics circuits. This has led to smaller, more portable devices and consequently to the need for small relatively cheap, independent power supplies. Many take the form of battery or dry cell.

Batteries are ideal for satisfying the power requirement of modern electronic circuits. On the whole, they are small, fairly cheap and can maintain a reasonably constant d.c voltage at low lead counts for an appreciable length of time. Also they need no maintenance and can be replaced by another one.

Batteries do have a number of disadvantages for instance have to be replaced on a fairly regular basis and this can be constantly over a period of time. Old batteries have a tendency to leak chemicals which will corrode electrical contacts and therefore disrupt the proper operation of the device.

The potential difference or voltage between the two terminals of battery is called electromotive force (e m f). The e m f is at maximum when the battery is new and decreases over time, the rate of decrease depends on the rate at which current in drawn from the battery.

The current rating of the battery is the amount of discharge current it can produce for a specified period of time with the output voltage not falling bellow a minimum level. The rating most commonly used is ampere hour (Ah). The specified discharge time is usually eight hours and therefore a zero ampere-hour can deliver 200A in eight hours or 200/8=25A per hour. If the current being drawn is greater then the battery will discharge in a shorter period of time and if it is smaller hen it will take longer to discharge.

The cells of the battery are made from a chemical called the electrolyte which reacts with electrodes to provide energy. Therefore a battery changes chemical enegy to electrical energy. The chemical offers certain resistance of battery this tends to increase in value over the life of the battery. The making of a battery are two main type called primary and secondary cells.

3.2.1 PRYMARY CELLS.

These are the ones which are thrown away when they are exhausted or polarized. They are sometimes referred to as dry cells due to fact that the electrolyte is gelatinous or cannot be spilled.

3.2.2 SECONDARY CELL

These can be recharged on the reversal of the chemical reaction within the cell. When the cell drives a current through a load it discharges and this is associated with the neutralization of the coils within the electrodes. When the current is reversed the process is reversed. Thereby reforming the electrodes and changing the cell. The changing current must be a steady d.c current which is obtained from an external source.

3.3 TRANSDUCER (SENSOR)

A transducer is any device which converts energy from one form to another such as magnetic energy to electrical energy. Heat energy into electrical, electrical energy into sound energy e t c

There are input transducers and output transducers. Typically input transducers are thermocouple, thermistors and integrated circuits such as the LM35 used in this project. Also typical output transducers are loudspeakers, motors, solenoids e t c.

They are important in electrical and electronics as the success of any control system depends on the sensitivity and selectivity of the input transducer.[2]

3.4 ANALOGUE TO DIGITAL CONVERTERS

The measured variables have to be converted into voltages. Then the analogue to digital converter (ADC) converts this analogue input voltage to its equipment digital form. There are a vast number of conceivable circuit designs for ADCs.

The most popular of these are:

a) Parallel types

b) Successive approximation types

c) Pulse-counting types

The type used in the project is the successive approximation type.

3.4.1 SUCCESIVE APPROXIMATION

This type of ADC are quite used especially for interfacing with computers because it is capable of both high resolution (up to 16 bits) and speed (up to 1MHz throughput rates).conversion time, being independent of the magnitude of input voltage, is fixed by the number of bits in the register a and the clock rates. Each conversion is unique and independent of the result of the previous conversion because the internal logic is cleared at the start of a conversion. ADC084 performs about 5000 to 10000 conversion in a second.

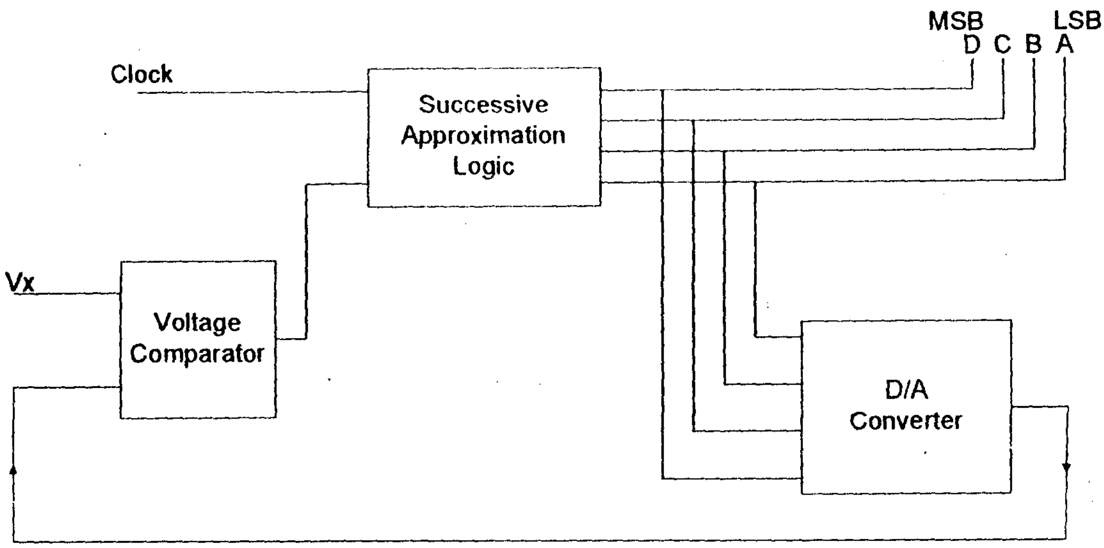


Fig 3.1 block diagram of successive approximation ADC

Modern integrated circuit converters include three state data output and bytes control to facilitate interfacing with microprocessor. A three stage output has in addition to normal 1 and 0 state, a not-enable condition, the output is simply disconnected via an open voltage switch. This permits many devices output to be connected to the same bus, only the device that is enable (one at a time) being able to drive the bus. The converter techniques consist of comparing the unlike input against a precisely generated internal voltage at the output of a digital to analogue converter (DAC) The input of DAC is digital number at the output of the ADC.

After the conversion command is applied, and the converter has been cleared, the DAC's most significant bit (MSB) output (half full scale) is compared with the input. If the input is greater than MSB, it remains ON (i. e 1 in output register) and the next bit (quarter full scale) is tried. If the inputs less than MSB is turned OFF (i. e 0 in the output register), the next bit is tried. The process continues in order of descending bit weight until the last bit has been tried. When the process is completed, the status line changes state to indicate that the content of the output register now constitute a valid conversion. The content of the output register form a binary digital code corresponding to the input signal.

3.5 COUNTER

A counter is a sequential circuit that tallies or counts the number of input pulses it receives; basically a counter is a memory device that stores the number of input pulses. The number of count can be determined at any time since its bit are those stored at the time since its bit are those stored at the time in the flip flops that comprise the counter, counters are used in the temperature measuring circuit, timing circuits. Signal generators and many other digital systems.[5]

Counters are constructed of flip flops having characteristic such as:

- Synchronous and Asynchronous operation
- Free running or self starting
- Up and down count
- Maximum number of count

3.5.1 SYNCHRONOUS COUNTER

A synchronous counter or parallel counter is one which all stages are triggered simultaneously. The resulting action of each stage depends on the gating input (synchronous input) of each respective stage. With the advent of considerable gating in a small low cost integrated circuit unit and this form of counter is quite popular. It is obvious faster than a ripple, since higher order stages don't have to wait, for lower order than to occur first as in ripple counter.

3.5.2 SYNCHRONOUS DOWN COUNTER

A synchronous down counter counts words from the terminal count to zero and recycled. Flip flop, A, has to change state at each count for this reason J and K input are permanently connected to J=K=1, so that it will toggle at each negative transition. Flip flop, B, has to change state at each negative transition which occur when A=0. flip flop ,C, changes state when A=B=0.

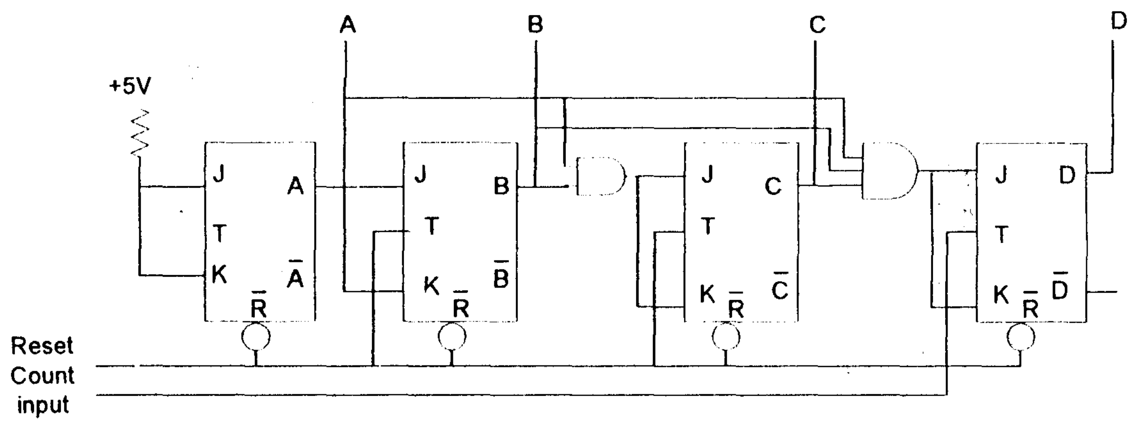


Fig 3.2- block diagram of synchronous down counter

3.5.3 SYNCHRONOUS DECADE COUNTER

The counter that recycles in 10 pulses is called a decade counter. It is also a basic 10 or modulo 10. The requiring of each counter stage can be done as specified below.

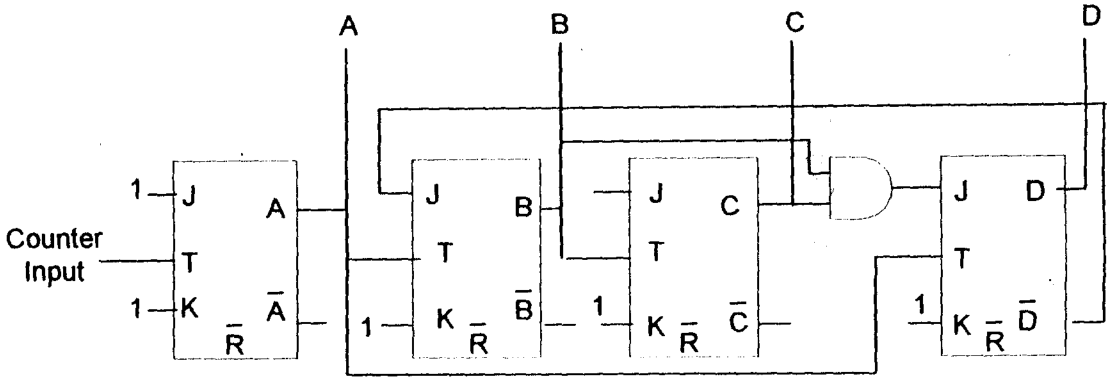


Fig 3.3 block diagram of synchronous decade counter.

Stage A toggled each input pulse, stage B is toggled each 1 to 0 change of A except when D is logical 1, when stage B remain reset. Stage C is toggled each time B goes from 1 to 0, stage D is reset each time A changes from 1 to 0 except when B and C are both logical 1.

In order to obtain BC using NAND gate, two NAND units were needed. Perhaps the only feature is designing the counter was using the A signal as trigger to stage D. it is noted that going from 9 to 10 (or 0) only stage A changes (stage D change is due to stage A as trigger signal). Then there is no other choice of trigger signal for D. the truth table is shown in table 3.1

Table 3.1 Truth Table

Count	A	B	C	D
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10 or 0	1	0	0	0

3.5.4 SYNCHRONOUS UP COUNTER

These counters count from zero to the terminal count and recycle. It operate in this format, the JK inputs of flip flop that is those flip flops that toggle on a given negative transition will have their J=K=1. the counting sequence shows that flip flop (X) has to change at each negative transition, for this reason J and K input are permanently connected to J=K=1, so that it will toggle at each negative transition. This ensures that flip flop Y would be in toggle mode when X=1. Also flip flop Z changes state on each transition that occur when X=Y=1. thus XY is connected to the J and K input of flip flop (Z), this ensure that flip flop Z would be in toggle mode when X=Y=1.[2]

3.5.5 ASYNCHRONOUS DOWN COUNTER

Generally counter in which clocking pulse does not change at the same time with the output is an synchronous. They are arranged in series (cascade) made up of J-K flip flop such that the output of one flip flop serves as that input of the next stage.

These asynchronous counters count downward from a maximum count to zero. The counter flip flop toggles on the application of the clock-pulses. It toggles at each negative transition of the clock pulse. The inverted output of flip flop K acts as the input and goes from 1 to 0. Similarly flip flop (Z) will toggle each time the Y output makes the negative transition. If the flip flop output XYZ represents a binary number, then counting from 111 to 000 on the eight clock pulse XYZ=000 on the eighth clock pulse, X makes a negative transition and so on till XYZ=111.

The individual change of flip flop in asynchronous counter makes them unstable for driving a digital circuit like one that require instant output to drive them.

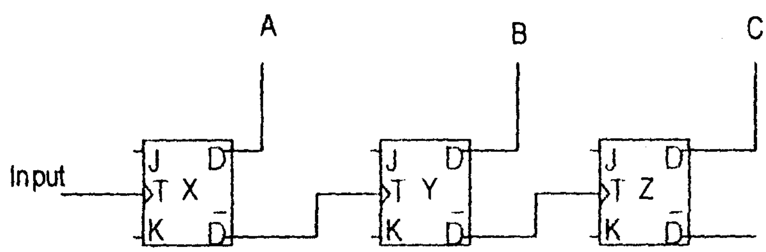


Fig 3.4 block diagram of asynchronous down counter

3.5.6 ASYCHRONOUS UP COUNTER

The asynchronous up counter are used to count upward from zero. A three bit asynchronous up counter is shown below

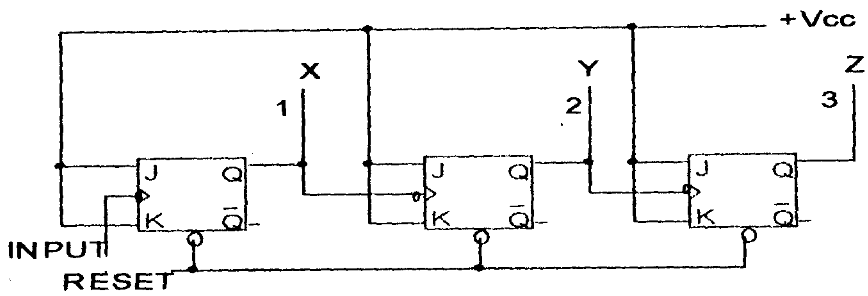


Fig 3.5 block diagram of asynchronous up counter

The clock pulse are applied only to the input of flip flop, this will toggle each time the clock pulse move in negative transition. The normal output of flip0 flop X acts as the clock input of flip flop Y, so flip flop Y will also toggle each time the output X goes from 1 to 0. Similarly flip flop Z will toggle each output of B makes a negative transition.

If the outputs of XYZ represent a binary number with z being the most significant bit (MSB) then binary sequence from 000 to 111 is produced.

After seventh clock pulse has occurred, the counter flip flop X make negative transition which cause flip flop Y to make a negative transition and so on till the counter has gone through one complete cycle (000) through (111) and has recycle to 000, from where it start a new counting cycle. It has shown that each of the next stage flip flop toggle depend on the output of the flip flop before it.

3.6 SEVEN SEGMENT DECODER

A decoder is a device that converts code into unencoded signal it represents for example a decoder may translate a message made up of 0's and 1's into its equivalent in turns of A, B,...... e t c. in such a case the input to the decoder is in the form of binary input lines and the output is a signal representing the decimal integers from 0 to 7. Since each decimal integer is represented by specific code combination of the input signals. It follows that one feature of the decoder is that only one output line can be active at a given time.

The truth table is shown below

Table 3.2

A	B	C	D_0	D_1	D_2	D_3	D_4	D_5	D_6	D_7
0	0	0	1	0	0	0	0	0	0	0
0	0	1	0	1	0	0	0	0	0	0
0	1	0	0	0	1	0	0	0	0	0
0	1	1	0	0	0	1	0	0	0	0
1	0	0	0	0	0	0	1	0	0	0
1	0	1	0	0	0	0	0	1	0	0
1	1	0	0	0	0	0	0	0	1	0
1	1	1	0	0	0	0	0	0	0	1

$D_0 = \bar{A}\,\bar{B}\,\bar{C}$ $D_4 = A\,\bar{B}\,\bar{C}$

$D_1 = \bar{A}\,\bar{B}\,C$ $D_5 = A\,\bar{B}\,C$

$D_2 = \bar{A}\,B\,\bar{C}$ $D_6 = A\,B\,\bar{C}$

$D_3 = \bar{A}\,B\,C$ $D_7 = A\,B\,C$

If the input signals are at the logic value 011 (i. e $\bar{A}BC$), then the only line that represent the decimal integer must be activated.

3.7 DISPLAY UNIT

Many modern digital devices provide numerical result as their output. The numerical result appear on the visual display as decimal numbers, example of such devices are an electronic calculator, a digital thermometer, digital stop watch e t c. we know that the actual circuitry within one of these devices can produce output only in binary either 0's or 1's. One may ask how the appearance of a decimal number can be generated when only binary digits are produced as the output of a digital circuit.

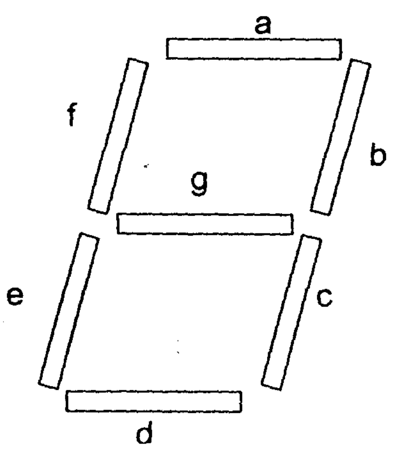


Fig 3.6 seven bar configuration

It is possible to create the impression of a decimal digit by a particular combination of vertical and horizontal bars. The resulting image may not be as pleasing to the eye as a printed decimal digit but suitable for electronic construction in which each bar is independent of illuminated. By turning ON the proper combination of vertical and horizontal bars, the image of decimal digit is seen. Various combinations on (common cathode or common anode) give the appearance of digit shown below.

Table 3.3 Appearance of digits

DECIMAL DIGIT	SEGMENT ON	APPEARANCE
0	0	a, b, c, d, e, f
1	1	b, c
2	2	a, b, d, e, g
3	3	a, b, c, d, e, f, g
4	4	b, c, f, g
5	5	a, c, d, f, g
6	6	c, d, e, f, g
7	7	a, b, c
8	8	a, b, c, d, e, f, g
9	9	a, b, c, f, g

3.7.1 COMMON CATHODE

Seven segments may be connected as a common cathode display in which the negative side of the power supply is connected to the cathode of each segment. A high voltage "1: on the segment anode lights the segment.

3.7.2 COMMON ANODE

Segment mat also be connected as a common anode display in which the positive side of the power supply is connected to the anode of each segment and a low voltage "0" at the segment light the segment.

CHAPTER FOUR

DESCRIPTION OF COMPONENTS AND CONSTRUCTION

4.1 REGULATOR

The power supply from a battery of 9V was regulated to 5V by the regulator (LM 7805)

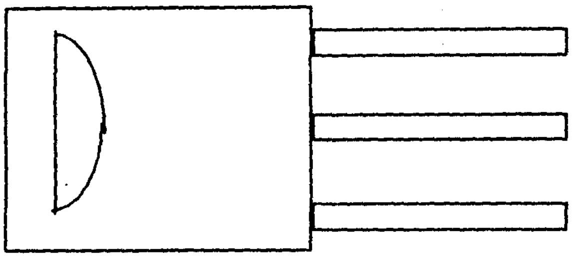


Fig 4.1 pin diagram of LM 7805

It has three terminals, the input, output and the common ground. The input pin was connected to the positive terminal of the battery (9V d c), the output was connected to the input of the transducer and the power input of all the ICs a capacitor 47μF connected between the output and grounded to smoothen the output voltage regulated.

4.2 TEMPERATURE SENSOR

Temperature sensor or transducer is a device that senses the temperature variation in an environment to give useful electrical signals, then properties are made from different materials but generally' their properties changes with rise in temperature and it is by exploiting these changes in the electrical possible to these device that it has been possible to create wide variety of useful temperature sensors. Some known types are listed below.

SENSOR		FEATURE	TEMPERATURE RANGE
1.	Thermocouple	Voltage output rise with temperature	0^{O} C to 100^{O} C
2.	Platinum Resistance	Resistance rise with temperature	-50^{O} C to 0^{O} C
3.	Thermistor	resistance fall with temperature rise	-80^{O}C to300^{O} C

In this project the input transducer or sensor used is an integrated circuit (IC) known as LM35 which is a precision integrated circuit temperature sensor whose output voltage is linearly proportional to the Celsius (centigrade) temperature. It has advantage over linear temperature sensor calibrated in degree Kelvin as the user is not required to subtract a constant voltage from its output to obtain convenient centigrade scaling. The LM35 does not require any external calibration or trimming to provide typical accuracies of $\pm 0.25^{O}$C at room temperature and $\pm 0.52^{O}$ C over a full 0^{O} C to 100^{O} C temperature range.

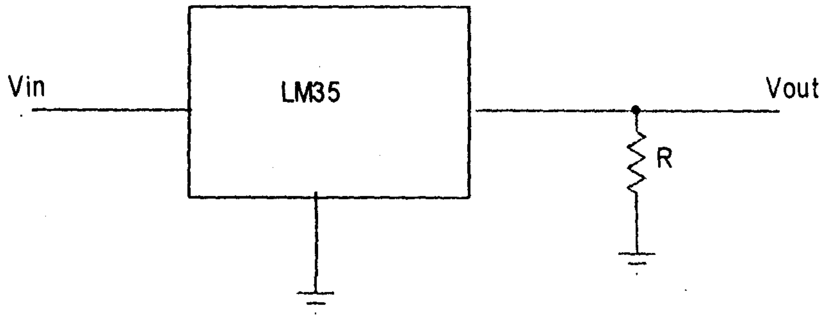


Fig 4.2 LM 35 (temperature sensor)

Another important characteristic of LM35 is that it draws only 60μA from its supply and possesses a low self-heating effect. The sensor self heating causes less than 0.1^{O} C temperature rise is still air and also has a scale factor of 0.1 V/^{O}C.

4.3 ANALOGUE TO DIGITAL CONVERTER (ADC 0804)

Digital thermometer can handle only binary data, analogue signal generated must be converted to digital form. An ADC 0804 (8 bit) complimentary metal oxide semiconductor (CMOS) family, successive ADC was used to achieve this.

The ADC 0804 operation depends on the input from the sensor which is an analogue signal voltage fed is through pin 6 and produces an equivalent digital output at a conversion time of 100 microseconds (100μs) with full 8-bit resolution. Pin 1, 2, 7, 8 and 10 are connected to a common ground while pin 3 and pin 5 are connected to start switch of the ADC, pin 9 was connected to the variable resistor (reference voltage) pin 4 and pin 19 are connected to 150 Pico Farad (150 pF) and 100kΩ for which the internal clock is been generated. The pin connection of ADC 0804 is shown below.

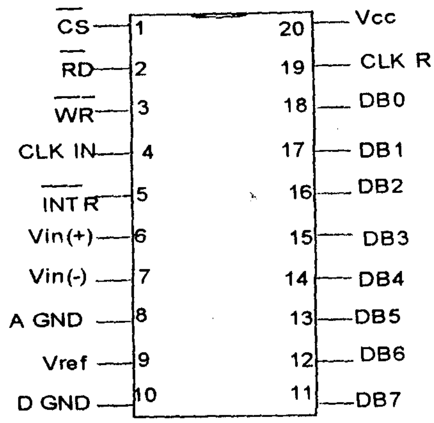


Fig 4.3 pin configuration of ADC 0804

Table 4.1 the configuration of ADC 0804

PIN NUMBER	SYMBOL	DESISGNATION	DESCRIPTION
1	$\overline{CS}$	INPUT	Chip select/Enable
2	$\overline{RD}$	INPUT	Read to enable
3	$\overline{WR}$	INPUT	Write
4	CLK IN	INPUT	Clock input
5	INTR	OUTPUT	Interrupt
6	Vin(+)	INPUT	Differential input
7	Vin(-)	INPUT	Differential input
8	A GND	OUTPUT	Analogue GND
9	Vref	INPUT	Voltage reference
10	D GND	INPUT	Digital GND
11	DB7	OUTPUT	Data output

12	DB6	OUTPUT	Data output
13	DB5	OUTPUT	Data output
14	DB4	OUTPUT	Data output
15	DB3	OUTPUT	Data output
16	DB2	OUTPUT	Data output
17	DB1	OUTPUT	Data output
18	DB0	OUTPUT	Data output
19	CLK R	INPUT	Clock input
20	Vcc(ref)	POWER	Power suppy

The bar above CS, RD, WR and INTR indicate negative logic, that is a low on those pins indicate a true condition

The frequency is calibrated by the formula given below

$T \alpha RC$

$T=KRC$

Where T= the turn on time,

K= constant given as (1.1, the pulse width)

Then

$F= 1/T$

$F= 1/(1.1RC)$

Given

$R=100\ k\Omega =100 \times 10^3$

$C= 150\ pF= 150 \times 10^{-12}$

$F = 1/(1.1 \times 100 \times 10^3 \times 150 \times 10^{-12})$

$= 60606Hz.$

Some important parameters of ADC include:

a) Conversion time,

b) Resolution.

4.3.1 CONVERTION TIME

The time interval between the commencement of conversion and the appearance at the output of the complete digital equipment of the analogue values, conversion rate is free-running mode (the configuration used in this project) fall within the range of 100μsec.

4.3.2 RESOLUTION

This is the smallest change in input variable to which the measuring instrument respond

$V = V_{ref} / 2^n$

Where

R is the resolution

V_{ref} is the reference voltage

n is the number of bit

then $R = 5V/2^8$

$= 5V/256$

$= 0.0195$ sec

or (1/256) X 100% =0.39%

4.4 COUNTERS

An 8-bit binary counter (40103B) was used which consists of an 8-stage synchronous down counter and when the internal count is zero, its single output become active. All control inputs and the carry-out zero detect ate active low logic. For maximum clearance of the clock the counters, it has enabling and disenabling of the clock inputs.

In every positive transition of the clock the counter is decremented by one count when the CARY IN (CI) or COUNTER ENABLE (CE) input is high, the counting is inhibited. The CARRY OUT/ZERO DETECTEZ (CD or ZD) output goes low when the count reaches zero. If the CI/CE input is low and remains low for full clock period, when the SYCHRONOUS PRESET ENABLZE (SPE) input is low, gate at the JAM input is clocked into the counter on the next possible clock transition regardless of the state of the CI/CE input.

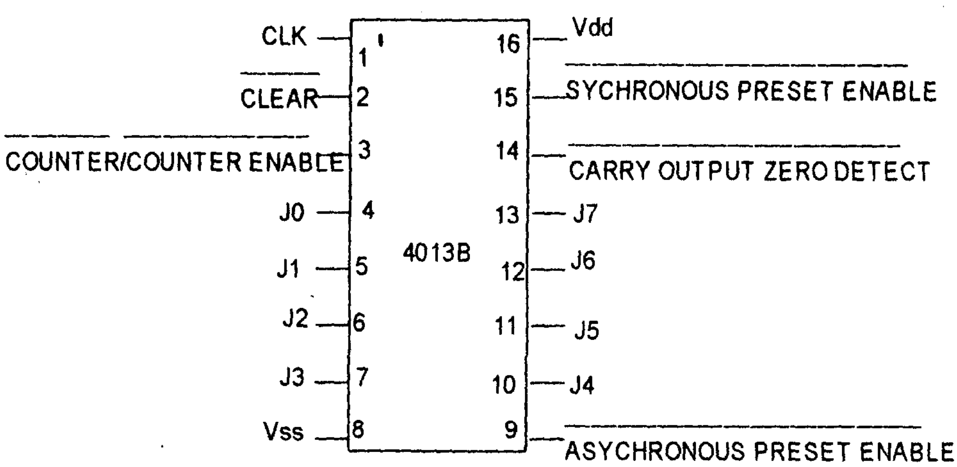


Fig 4.4 connection of counter 40103

4.5 GATES

The gates used in this project are AND 4081B and NOT 4049B gates. The relationship between the gates control inputs controls the preceding section of the circuit.

4.5.1 NOT GATE

The NOT gate is the simplest of all logic gates as it has only one inut and one output it changes the input A so that a "1" input becomes a "0" output and vice versa. The action of logic gates is most easily represented by means of a truth table.

Table 4.3 NOT gate truth table.

INPUT	OUTPUT
1	0
0	1

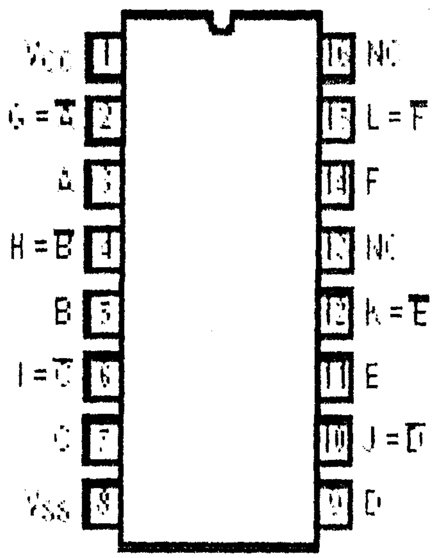


Fig 4.5 pin connection of NOT gate (4049B)

4.5.2 AND GATE

An AND gate can have several numbers of input but only one output for simplicity with due a two input AND gate which gives a high output if input A and B are both high (1) otherwise the output is low. The truth table is shown below

Table 4.4

INPUTS		OUTPUT
A	B	
0	0	0
0	1	0
1	0	0
1	1	1

The pin connection is shown below

MC 14081B Quad 2-input AND gate.

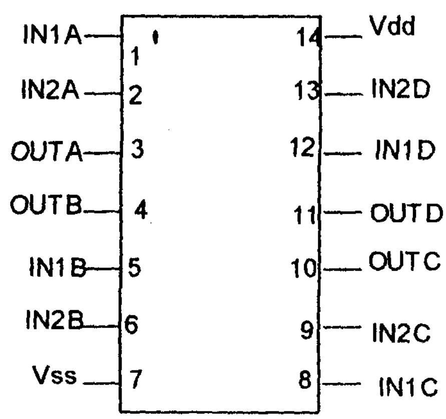


Fig 4.6 pin connection of AND gate (4081B)

4.6 BCD COUNTER

The BCD counter (4518B) used in this project is a dual binary coded decimal (BCD) counter. It is an internally synchronous 4-state counters each consisting of two D-type flip flop having interchangeable CLOCK and ENABLE lines for incrementing on either the positive-going or negative-going transition. For single unit operation the ENABLE input is maintained high and the counter advances on each positive-gong transition of the CLOCK. The counters are cleared by high level on their RESET lines.

The counter can be cascaded in the ripple mode Q4 to he enable input of the subsequent counter while the CLOCK input of the later is held low.

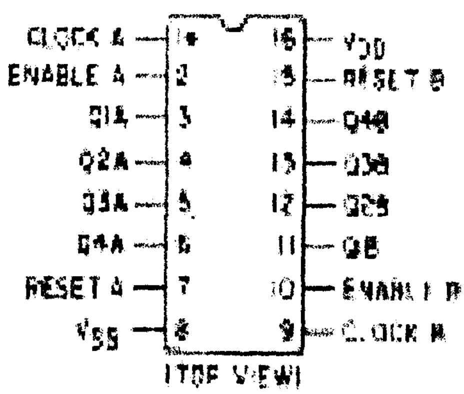


Fig 4.7 pin connection of 4518B (BCD counter)

4.7 SEVENSEGMENT DECODER/COUNTER

The 4511B is a binary coded decimal to seven segment decoder/driver with four addresses inputs (D_A to D_D), and active low latch enable input (EL), and active low ripple blanking input (BI), and active low lamp test input (LT), and seven active high n-p-n bipolar transistor segment output O_A to O_G.

When EL is LOW the state of the segment output (OA to O_G) is determined by the data on D_A to D_D. when EL goes high the last data present on D_A to D_D are stored I the latches and the segment output remains stable. When LT is LOW, al the segment output are HIGH independent of all other input conditions with LT HIGH. a LOW on B1 forces all segment output LOW the input LT and B1 do not affect the latch circuit. The pin connection is shown below.

Pinning	**Address (data) input**
EL	latch enable input (active low)
BI	ripple blanking input (active low)
LT (O_A to O_G)	segment output

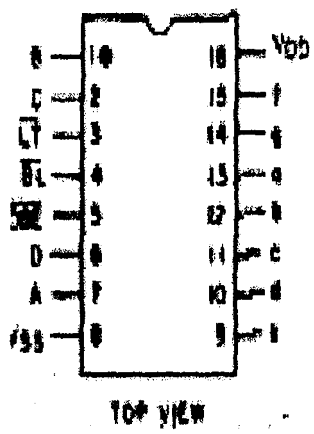


Fig 4.8 pin connection of seven segment decoder (4511B)

Table 4.5 functional table of BCD 4511B

TRUTH TABLE

LE	BI	LT	D	C	B	A	a	b	c	d	e	f	g	Display
X	X	0	X	X	X	X	1	1	1	1	1	1	1	8
X	0	1	X	X	X	X	0	0	0	0	0	0	0	Blank
0	1	1	0	0	0	0	1	1	1	1	1	1	0	0
0	1	1	0	0	0	1	0	1	1	0	0	0	0	1
0	1	1	0	0	1	0	1	1	0	1	1	0	1	2
0	1	1	0	0	1	1	1	1	1	1	0	0	1	3
0	1	1	0	1	0	0	0	1	1	0	0	1	1	4
0	1	1	0	1	0	1	1	0	1	1	0	1	1	5
0	1	1	0	1	1	0	0	0	1	1	1	1	1	6
0	1	1	0	1	1	1	1	1	1	0	0	0	0	7
0	1	1	1	0	0	0	1	1	1	1	1	1	1	8
0	1	1	1	0	0	1	1	1	1	0	0	1	1	9
0	1	1	1	0	1	0	0	0	0	0	0	0	0	Blank
0	1	1	1	0	1	1	0	0	0	0	0	0	0	Blank
0	1	1	1	1	0	0	0	0	0	0	0	0	0	Blank
0	1	1	1	1	0	1	0	0	0	0	0	0	0	Blank
0	1	1	1	1	1	0	0	0	0	0	0	0	0	Blank
0	1	1	1	1	1	1	0	0	0	0	0	0	0	Blank
1	1	1	X	X	X	X				*				*

X = Don't Care

* Depends on BCD code previously applied when LE = 0

1= high state

0= low state

X= don't care

*= depends upon the BCD code applied during the low or high transition of EL

Fig 4.9 display unit

4.8 SEVEN SEGMENT DISPLAY

Many numerical displays like a 7-segmesnt configuration to produce the decimal character 0-9, 7-segment displays are used to a 4 bit BCD number into a visible read out, each segment is made of material that emits light when current is p[assed through it.

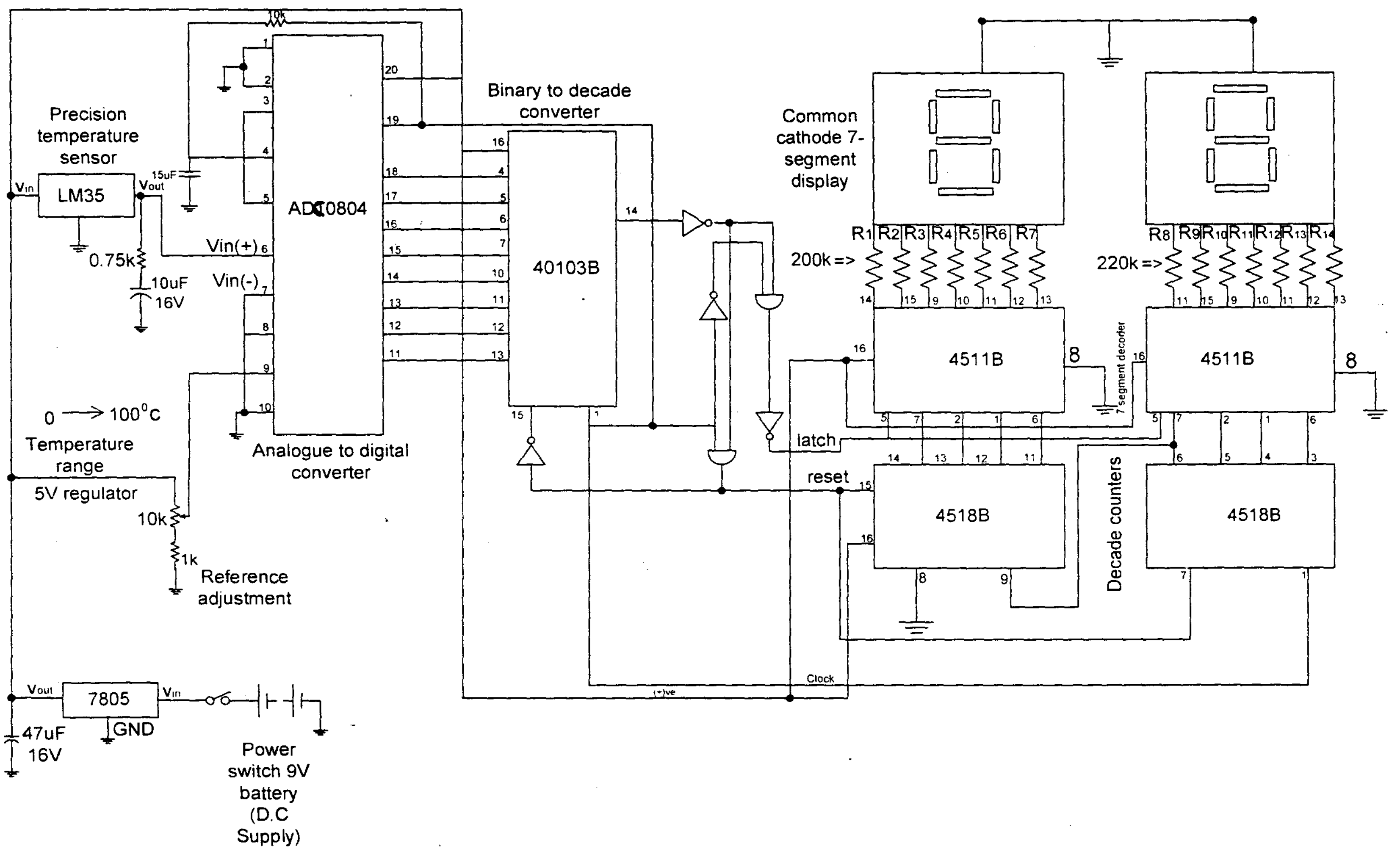
The seven-segment display used in this project is the LED type connected to a common cathode that is all the common cathodes are tied up together to the ground. LED is commonly used because of its brightness, low cost, reliability and con compatibility with low voltage integrated circuit.

4.9 CONSTRUCTION AND TESTING

The components were selected as described in the previous section. They were gotten from the market and were carefully checked to avoid damage ones. The additional integrated circuit to ADC is 0804 – 40103B – is designed to convert the binary 8-bit code output from the device into calibrated decade format which is readable on a seven segment display. Their eight jam inputs are directly connected to the corresponding output of the ADC 0804. the integrated circuit IC 40103B is a binary down counter in which any jam input or code in eight bit number is counter down to zero . The step or clock is diverted to a set decade up counter- the 4518B. The counter is clocked by the same pulse attributed to the other counter 40103B. The logical operation is that as the binary down counters goes down towards zero at the same time the decade up counter goes up or maximum. Whenever the count down reaches zero count the up counter stop, and the data or bit form the up counter are latched into the set of 4511B (7-segment decoder). This IC converts 4 bit decade code into bit that is compatible with sevensegment display. The set of logical AND-NOT gate is designed to put the operation is accordance. The operation is done at a very high speed attributed to the high conversion time of ADC 0804. The operation is in cyclic form.

Each of the stages from power section to display unit were carefully tested and checked to obtain the final output. The circuit was transferred carefully to the Vero board and soldered after series of checking as described in the circuit diagram. All the connection wires were soldered carefully to the right pins. Numbers as indicated in the pin connection diagram from the data sheet and also care was taken to avoid bridging within the circuit. The possible faults and error were immediately rectified. Bringing heating elements and iced block nearer to test the sensor was done and the sensor accurately detects their temperature while the value is being display by the display unit.

The circuit diagram is presented in fig 4.10 with the detail of connection proceedings.



CIRCUIT DIAGRAM FOR A DIGITAL THERMOMETER

CHAPTER FIVE

CONCLUSION AND RECOMMENDATION

5.1 CONCLUSION

The digital body temperature monitor (digital thermometer) was designed and constructed successfully and it's worth mentioning how fascinating to see a designed system constructed and working satisfactorily.

The project has increased my knowledge and understanding and identifying components made from different companies and how they are connected especially the integrated circuit.

Engineers, industrialist, technicians and students alike will find this device very important both in laboratory and industries as the case may be for measuring temperature variation.

5.2 RECOMMENDATION

- For accurate results, a higher resolution analogue to digital (ADC) of a faster sampling rate such as the flash or parallel conversion type, a 16-bit resolution or high bit ADC e t c, should be used for any further work on this project.

- The temperature range covered 0-99^{O} C can be extended to 1000 ^{O} C, this drastically widen its application and diversify its use.

5.3 PROBLEM FACED

A number of problems were encountered with during the execution of the project which one summarized below.

i) Some of the discrete components got burnt while soldering and some got damaged during construction, which have to be replaced as a learning process.

ii) Obtaining certain components such as the sensor, this is not readily available in the market.

iii) Fixing the problem of short circuiting or wrongly bridging component while constructing the project.

5.4 RESULTS

The results obtained during the construction stages after necessary troubleshooting were satisfactory. Results got is different temperature were imputed into the device were found to be almost the same as that of meteorological thermometer.

5.5 CONSTRUCTION TOOL AND EQUIPMENT

A number of construction tools and equipment are used for effective end result.

a) BREAD BOARD: This was used to test the circuit by constructing trial version on the top side of the board.

b) LEAD SUCKER: This was used in the case of bad component to suck up molten solder to enhance ease of removal.

c) DIGITAL MULTIMETER: The meter serves several purposes such as measuring capacitance, measuring resistance of components, verifying the legs of electronic components.

d) WIRE CONNECTORS: These enable linking components and sub circuits together are required.

e) SOLDER: The electronic components are joined or soldered together firmly together to the Vero board with a flux-core soldered type used.

f) VERO BOARD: This board allows permanent prototype. It is pre-etched having all its traces on the other side with pre-drilled pads for ICs and other components.

g) SOLDERING IRON: A 60 watts heating element (modular type) was used in this project to solder all these components in place.

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