DESIGN OF AN ELECTRONIC DIGITAL DATA DISPLAY SYSTEM

By

K.M.S.Bandara

(03/AS/015)

This thesis is submitted in partial fulfillment of the requirement for the degree of Bachelor of Science in Physical Sciences of the Faculty of Applied Sciences, Sabaragamuwa University of Sri Lanka

Department of Physical Sciences

Faculty of Applied Sciences

Sabaragamuwa University of Sri Lanka

Belihulloya

Tel: +94 (0)45-2280291

Fax: +94 (0)45-2280291

MARCH, 2009

DECLARATION BY CANDIDATE

I hereby declare that this thesis is my own work and effort and that it has not been submitted anywhere for any award. Where other sources of information have been used, they have been acknowledged.

..07/04/09.....

Date

.....Saroji.............

K.M.S.Bandara

CERTIFICATE OF APPROVAL

Ve hereby declare that this thesis is from the student's own work and effort, and all other ources of information used have been acknowledged. This thesis has been submitted with ur approval.

rof. I.K.Perera ....

nior Professor - Department of Physical Sciences (Signature/Internal supervisor)

aculty of Applied Sciences

abaragamuwa University of Sri Lanka ....01 April 09........

elihulloya. Date

Irs.J.P.D.S.Athuraliya ....

esearch Engineer – Electronic division (Signature/External supervisor)

rthur C Clarke Institute for Modern Technology

atubedda ....01 Apr 09..............

Ioratuwa. Date

r .C.P.Udawatte ....

he Head, Department of Physical Sciences (Signature/Head of the Department)

aculty of Applied Sciences

abaragamuwa University of Sri Lanka ....2009 . 04 . 07..........

elihulloya. Date

Dr. C. P. Udawatte
Head
Department of Physical Sciences & Technology
Faculty of Applied Sciences
Sabaragamuwa University of Sri Lanka
Belihuloya.

Affectionately Dedicated

To My Parents

ACKNOWLEDGEMENT

First of all I would like to express my sincere gratitude to Mrs.N.Dediyagala and Mr.Saraj Gunasekara (Research scientist ACCIMT) for providing me this great opportunity to have industrial training at the Arthur C. Clarke Institute for Modern Technologies (ACCIMT). Also I would like to thank the Head of the department and academic staff members of all the departments especially to the Department of Physical sciences for their wisdom and support throughout our academic years, which was invaluable in my training period.

I am deeply indebted to my external supervisor Mrs.J.P.D.S.Athuraliya, and internal supervisor Prof.I.K.Perera for their invaluable guidance, encouragement, supervision and co-ordination given during the period of my training and preparation of thesis. Without the support of them this work would not be a success.

Also I would like to thank Mrs.Kamani Ediriweera (Principle Research Engineer- Head of the Electronics & Micro Electronics Division, ACCIMT) for her continuous support & guidance throughout the period of training. Then my special thanks go to Mr. Kavindra Jayawardena (Research and Development Engineer- Head of the Communication Division, ACCIMT), Mr. Thushantha Jayakody, Mr. Thusitha Dias(Technical Officers, Electronics Division, ACCIMT) Mr. Samantha Pushpakumara, Mr.Dinusha De Silva (Technical Officers, Communication Division, ACCIMT) for giving me chance for getting a better knowledge. Also I would like convey my gratitude to the administrative staff of ACCIMT who helped me in various ways.

Finally I would like to pay my heartiest gratitude to my colleague trainees for being with me and helping me in every occasion to make this training success.

ABSTRACT

A universal data logger with the ability to display measured values, can serve the needs of professional data loggers in a wide variety of applications. Such applications include Quality Assurance, Plant and Machine Condition Monitoring, Field Monitoring Stations, Automotive Testing, Monitoring Environmental Conditions, Food and Pharmaceutical Environmental Storage Monitoring, Water Quality Testing and also in an array of research fields.

The present project work was thus, focused on designing and developing a cost–effective, compact and a standardized data display system for a Universal Data Logger. As such, the basic outline of the instrument was designed to include two input channels independent of each other, for measuring temperature and humidity and to display the relevant values accordingly. The main approach adopted in designing the above was the study of different sensors to select the most appropriate sensor for the said purpose. Employing the selected components, a microcontroller based sensor interface circuit was designed initially, while Firmware Programming using C language was employed to operate the data logger. Finally, familiarization of the MP Lab Integrated Development Environment and a "HI-TECH" C compiler was obtained.

A PIC 16F876A microcontroller microchip was used as the main device of the data collection system. The temperature is detected by a LM35 temperature sensor. The output of the LM35 is in the form of a voltage signal, which is in general very weak so an amplifier was used to amplify this voltage. The output of the amplifier is fed into the PIC microcontroller. The inbuilt ADC of the PIC unit converts this analog data to digital form, with the parallel data received being converted to serial data by the inbuilt USART. Firmware was tested with hardware at bread board level and the resulting values are displayed by means of the LCD display.

Both, the temperature sensing unit and the humidity sensing unit were designed & tested on breadboard level successfully. Though this was tested only for two parameters, the same can also be done for several other parameters like pressure, viscosity, etc. This system is cost-effective and time efficient in its operation and functions at a relatively high speed, very accurately while being used for measurements.

CONTENTS

LIST OF ABBREVIATIONS

DA Card	Data Acquisition Card
LCD	Liquid Crystal Display
DL	Data Logger
RTD	Resistance Temperature Devices
NTC	Negative Temperature Coefficient
PTC	Positive Temperature Coefficient
IC	Integrated Circuit
RH	Relative Humidity
OP-AMP	Operational Amplifier
PWM	Pulse Width Modulation
ADC	Analogue to Digital Converter
ROM	Read Only Memory
RAM	Random Access Memory
EPROM	Erasable Programmable Memory
OTP	One-Time-Programmable
EEPROM	Electrically Erasable Programmable Read Only Memory
USART	Universal Asynchronous Receiver Transmitter
ICD	Integrated Circuit Debugger
IDE	Integrated Development Environment
ICSP	In Circuit Serial Programming

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

The Institute, at which this project was carried out, was established in 1984 under the name Arthur C Clarke Center for Modern Technologies (ACCMT) by an Act of Parliament to accelerate the process of introduction and development of modern technologies in the fields of Communications, Computers, Energy, Space Technologies and Robotics, through the provision of training and research facilities. Basic infrastructure was established in 1986 and the technical activities commenced in early 1987. With the introduction of the new Science and Technology Act in 1998 the Centre was re-named as Arthur C Clarke Institute for Modern Technologies (ACCIMT).

As at today the Institute is actively involved in conducting research in the areas of Communications, Electronics, Microelectronics and Information Technology under Five major Technical Divisions. They are, Communication Division, Electronic & Micro-Electronic Division, Industrial Services Division, Information Technology Division and Space Applications Division. Of these divisions, I shall be confining myself to only the Electronic & Micro-Electronic Division, where I carried out my project work.

Electronic and Micro-Electronic Division

The division has a well equipped laboratory with facilities to design and develop electronic products/micro-controller based systems. The divisional goal is to excel in designing smart sensor systems. The division also offers test and measurement facilities for electronic systems, especially in the area of power electronics Data Acquisition and Logging Systems.

- Power Quality Monitoring & Analysis
- Processor Based Monitoring & Control Systems
- Applications of Digital Signal Processors
- Analog Circuit Design
- Test & Measurement Services
- Simulation & Modeling of Electronic Circuits
- Traffic Control Signaling Systems
- Performance Testing of Surge Protection
- Devices & Surge Immunity Testing

Currently the institute has undertaken various demand driven research and development projects from both government and the private sector with a view to promoting local manufacture of high-tech products.

1.2 PROJECT BACKGROUND

Data Acquisition is simply the gathering of information about a system or process. It is the core for understanding, control and management of such systems or processes. Parameter information such as temperature, humidity or flow is gathered by sensors that convert the information into electrical signals. The signals from the sensors are transferred by wire, optical fiber or wireless link to an instrument which conditions, amplifies, measures, scales, processes, displays and stores the sensor signals. This is the Data Acquisition instrument.

In the past Data Acquisition equipment was largely mechanical, using smoked drums or chart recorders. Later, electrically powered chart recorders and magnetic tape recorders were used. Today, powerful microprocessors and computers perform Data Acquisition faster, more accurately, more flexibly, with more sensors, more complex data processing, and elaborate presentation of the final information. A data logger is an electronic instrument which can be connected to real world devices for the purpose of collecting information.

Data Acquisition can be classified into two broad sections – the real time data acquisition and data logging. Real time data acquisition is when data acquired from sensors is used either immediately or within a short period of time, such as when controlling a process. Data logging on the other hand is when data acquired from sensors is stored for later use. In reality, there is a continuum of devices between real time data acquisition and data logging that share the attributes of both of these classifications.

Most data acquisition systems require installation of a DA card in a PC and the connection and wiring of the sensors. This system work well in permanently configured, on-line applications, but is difficult to implement and their use can be costly. Data loggers significantly reduce the cost for most logging applications and are much easier to implement, and can be placed in areas that digital systems can not reach.

The purpose of this project was to design and develop a cost–effective, compact and a standard data display system for a Universal Data Logger. This, basically will include two input channels for measuring temperature and humidity and to display the corresponding readings accordingly.

1.3 MAJOR CHALLENGES

The major challenges of this project were:

- Selection of the most appropriate Sensors
- Baying components

1.4 OVERALL OBJECTIVE

- Design of an Electronic Digital Data Display System

1.5 SPECIFIC OBJECTIVES

- Studying the Different Sensor types to select the most appropriate sensor.
- Design the interface circuit using the selected sensor.
- Display the Data through an LCD panel.

CHAPTER 2 LITERATURE REVIEW

2.1 EXISTING DATA DISPLAY SYSTEM FOR A DATA LOGGER

The Hyper Logger: The Hyper Logger portable data logging system is a self-contained instrument, capable of recording data from 4 to 24 analog or 48 digital channels. Provide approximately 4 weeks of operation. This Field-expandable with optional Interface Modules, Hyper Logger is an excellent data collection instrument for practically any application.

The Hyper Logger System is housed in a latching, weatherproof enclosure containing the system microprocessor, data storage memory, Analog to Digital converter, 2 line x 16 character liquid crystal display, batteries, input\output terminal strip and six interface ports that accommodate a variety of Hyper Logger Interface Modules and accessories.

DL1 Data Logger: The DL1 is a highly flexible and a powerful data logging system, featuring an integrated, high accuracy, 5Hz GPS receiver, with data logging directly to compact flash. It is ideally suited to auto sport applications as well as bikes, boats and industrial/professional applications.
The DASH2 is a slim line, water resistant (IP65) data display system, with a custom backlit LCD screen, 6 fully configurable shift lights, and a die cast aluminum enclosure. With configurable display screens, independent alarms and the ability to accept sensor signals independently and via the DL1. The feature packed DASH2 can be tailored to fit almost any automotive display application.

2.2 SENSORS

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument. Active element of a sensor is referred to as a transducer, which changes one form of energy into another. For this reason, sensors can be classified according to the type of energy transfer that they could be used, and most of these are listed below.

2.2.1 Thermal

- Temperature sensors: thermometers, thermocouples, temperature sensitive resistors (thermistors and resistance temperature detectors), bi-metal thermometers and thermistors
- Heat sensors: bolometer, calorimeter, heat flux sensor

2.2.2 Electromagnetic

- *Electrical resistance sensors: ohmmeter, multimeter*
- Electrical current sensors: galvanometer, ammeter
- Electrical voltage sensors: leaf electroscope, voltmeter
- Electrical power sensors: watt-hour meters
- Magnetism sensors: magnetic compass, fluxgate compass, magnetometer, Hall effect device
- Metal detectors
- RADAR

2.2.3 Mechanical

- Pressure sensors: altimeter, barometer, barograph, pressure gauge, air speed indicator, rate-of-climb indicator
- *Gas and liquid flow sensors:* flow sensor, anemometer, flow meter, gas meter, water meter, mass flow sensor
- Gas and liquid viscosity and density: viscometer, hydrometer, oscillating U-tube
- Mechanical sensors: acceleration sensor, position sensor, strain gauge
- Humidity sensors: hygrometer
- Vibration and shock sensors

2.2.4 Chemical

- Chemical proportion sensors: oxygen sensors, ion-selective electrodes, pH glass electrodes and carbon monoxide detectors.
- Odour sensors: Tin-oxide gas sensors, and Quartz crystal microbalance (QCM) sensors.

2.2.5 Optical radiation

- Light sensors, or photo detectors: including semiconductor devices such as photocells, photodiodes, phototransistors, CCDs, and Image sensors; vacuum tube devices like photo-electric tubes, photomultiplier tubes; and mechanical instruments such as the Nichols radiometer.
- Infra-red sensor: especially used as occupancy sensor for lighting and environmental controls.
- Proximity sensor: A type of distance sensor but less sophisticated. Only detects a specific proximity. May be optical - combination of a photocell and LED or laser. Applications in cell phones, paper detector in photocopiers, auto power standby/shutdown mode in notebooks and other devices. May employ a magnet and a Hall Effect device.

2.2.6 Acoustic

- Acoustic : uses ultrasound time-of-flight echo return. Used in mid 20th century Polaroid cameras and applied also to robotics. Even older systems like Fathometers (and fish finders) and other 'Tactical Active' Sonar (Sound Navigation And Ranging) systems in naval applications which mostly use audible sound frequencies.
- Sound sensors: microphones, hydrophones, seismometers.

2.2.7 Other types

- Motion sensors: radar gun, speedometer, tachometer, odometer, occupancy sensor, turn coordinator
- Orientation sensors: gyroscope, artificial horizon, ring laser gyroscope
- Distance sensor (noncontacting) Several technologies can be applied to sense Distance: magnetostriction

2.3 TEMPERATURE SENSOR

- Resistance Temperature Devices (RTDs)
- Thermistors
- Thermocouples
- Integrated circuit sensors

2.3.1 Resistance Temperature Devices (RTDs)

Resistance Temperature Detectors or RTDs for short, are wire wound and thin film devices that measure temperature because of the physical principle of the positive temperature coefficient of electrical resistance of metals. The hotter they become, the larger or higher the value of their electrical resistance.

Of these, the devices using Platinum known as PRTs and PRT100s are the most popular RTD types, nearly linear over a wide range of temperatures and some small enough to have response times of a fraction of a second. They are among the most precise temperature sensors available with resolution and measurement uncertainties or ±0.1 °C or better possible in special designs.

Usually they are provided encapsulated in probes for temperature sensing and measurements with an external indicator, controller or transmitter, or enclosed inside other devices where they measure the temperature as a part of the device's function, such as a temperature controller or precision thermostat.

The advantages of RTDs include stable output for long period of time, ease of recalibration and accurate readings over relatively narrow temperature spans. Their disadvantages, compared to the thermocouples, have smaller overall temperature ranges, higher initial cost and less rugged in high vibration environments.

They are active devices requiring an electrical current to produce a voltage drop across the sensor that can be then measured by a calibrated read-out device.

Figure 2.1 Resistance Temperature Device

The lead wires used to connect the RTD to a read-out can contribute to their measurement error, especially when there are long lead lengths involved, as often happens in remote temperature measurement locations.

These calculations are straight forward and there exist 3-wire and 4-wire designs to help minimize or limit errors, when needed.

Often the lead error can be minimized through the use of a temperature transmitter mounted close to the RTD. Transmitters convert the resistance measurement to an analog current or serial digital signal that can be sent long distances by wire or rf to a data acquisition or control system and/or indicator.

RTDs, as mentioned above, work in a relatively small temperature domain, compared to thermocouples, typically from about - 200 °C to a practical maximum of about 650 to 700 °C. Some makers claim wider ranges though limitations are imposed by certain construction designs to only a small portion of the usual range.

Insulation resistance is always a function of temperature and at relatively high temperature the shunt resistance of the insulator introduces errors into the measurements. Again, error estimates are straight forward, provided one has a good estimate of the thermal properties of the insulator.

Insulator material such as powdered magnesia (MgO), alumina (Al_2O_3) and similar compounds are carefully dried and sealed when encapsulated in probes along with an RTD element.

2.3.2 Thermistors

Thermistors are solid-state temperature sensors that behave like temperature-sensitive electrical resistors. No surprise then that they are identified by a contraction of the two words, "thermal" and "resistor". There are basically two broad types, NTC-Negative Temperature Coefficient, used mostly in temperature sensing and PTC-Positive Temperature Coefficient, used mostly in electric current control.

They are mostly very small elements of special material that exhibit more than just temperature sensitivity. They are highly-sensitive and have very reproducible resistance Vs. temperature properties.

During the last 60 years or so, only ceramic materials (a mix of different metal oxides) was employed for production of NTC thermistors. In 2003, AdSem, Inc. (Palo Alto, CA) developed and started manufacturing Si and Ge high temperature

NTC Thermistors with better performance than any other ceramic NTC thermistors. Thermistors, since they can be very small, are used inside many other devices as temperature sensing and correction devices as well as in specialty temperature sensing probes in commercial, scientific and industrial applications.

Most of these elements, typically functions over a relatively small temperature range, compared to other temperature sensors, and can be very accurate and precise within that range.

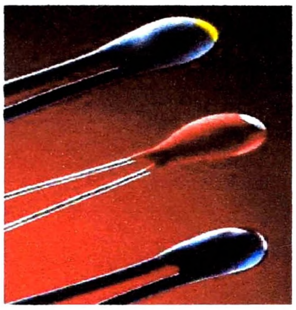
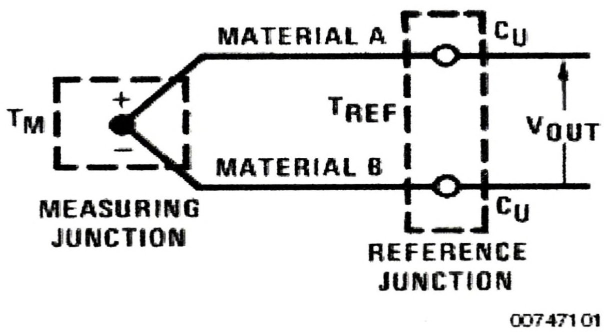


Figure 2.2 Thermistors

2.3.3 Thermocouples

Due to their low cost and ease of use, thermocouples are still a popular means for making temperature measurements up to several thousand degrees centigrade. A thermocouple is made by joining wires of two different metals as shown in Figure 2.2. The output voltage is approximately proportional to the temperature difference between the measuring junction and the reference junction. This constant of proportionality is known as the Seebeck coefficient and ranges from 5 µV/°C to 50 µV/°C for commonly used thermocouples.



$$V_{OUT} \approx \propto (T_M - T_{REF})$$

Figure 2.3 Thermocouple

Because a thermocouple is sensitive to a temperature difference, the temperature at the reference junction must be known in order to make a temperature measurement. One way to do this is to keep the reference junction in an ice bath. This has the advantage of zero output voltage at 0°C, making thermocouple tables usable. A more convenient approach, known as cold-junction compensation, is to add a compensating voltage to the thermocouple output so that the reference junction appears to be at 0°C independent of the actual temperature. If this voltage is made proportional to temperature with the same constant of proportionality as for the thermocouple, changes in ambient temperature will have no effect on the output voltage.

2.3.4 Integrated circuit sensors

The semiconductor (or IC for integrated circuit) temperature sensor is an electronic device fabricated in a similar manner to other modern electronic semiconductor components such as microprocessors. Typically hundreds or thousands of devices are formed on thin silicon wafers. Before the wafer is scribed and cut into individual chips, they are usually laser trimmed.

Semiconductor temperature sensors are available from a number of manufacturers. There are no generic types as with thermocouples and RTDs, although a number of devices are made by more than one manufacturer. The AD590 and the LM35 have traditionally been the most popular devices, but over the last few years better alternatives have become available.

These sensors share a number of characteristics - linear outputs, relatively small size, limited temperature range (-40 to +120°C typical), low cost, good accuracy if calibrated but also poor interchangeability. Often the semiconductor temperature sensors are not well designed thermally, with the semiconductor chip not always in good thermal contact with an outside surface. Some devices are inclined to oscillate unless precautions are taken. Provided the limitations of the semiconductor temperature sensors are understood, they can be used effectively in many applications.

The most popular semiconductor temperature sensors are based on the fundamental temperature and current characteristics of the transistor. If two identical transistors are operated at different but constant collector current densities, then the difference in their base-emitter voltages is proportional to the absolute temperature of the transistors. This voltage difference is then converted to a single ended voltage or a current.

An offset may be applied to convert the signal from absolute temperature to Celsius or Fahrenheit. In general, the semiconductor temperature sensor is best suited for embedded applications - that is, for use within equipment. This is because they tend to be electrically and mechanically more delicate than most other temperature sensor types. However they do have legitimate applications in many areas, hence their inclusion.

Available semiconductor temperatures sensors are presented below, followed by details on some of the more popular devices. The sensors can be grouped into five broad categories: voltage output, current output, resistance output, digital output and simple diode types. The following sensors provide a voltage output signal with relatively low output impedance. All require an excitation power source and all are essentially linear.

An IC temperature sensor such as the LM135/LM235/ LM335, which has a very linear voltage vs. temperature characteristic, is a natural choice to use in this compensation circuit. The LM135 operates by sensing the difference of circuit. The LM135 operates by sensing the difference of current levels and acts like a zener diode with a breakdown voltage proportional to absolute temperature at 10 mV/°K. Furthermore, because the LM135 extrapolates to zero output at 0°K, the temperature coefficient of the compensation circuit can be adjusted at room temperature without requiring any temperature cycling.

Table 2.1 Voltage Output Temperature Sensor

Sensor	Manuf.	Output	Tolerance (range)	Package	Comments
AD22100	Analog Devices	22.5mV/°C at 5V 250mV offset	±2°C & ±4°C (-50 to +150°C)	TO-92 SO-8	Output ratiometric with supply voltage - good with ratiometric ADC's
AD22103	Analog Devices	28mV/°C (at 3.3V), 250mV offset	±2.5°C (0°C to +100°C)	TO-92 SO-8	Output ratiometric with supply voltage
LM135 LM235 LM335	National Semi, Linear Tech	10mV/°K or 10mV/°C	±2.7°C to ±9°C (-55°C to 150°C -40°C to 100°C)	TO-92 TO-46	Zener like operation with scale trim pin, 400μA
LM34	National Semi	10mV/°F	±3°F & ±4°F (-20°C to 120°C)	TO-46 TO-92 SO-8	Needs a negative supply for temperatures < -5°C
LM35	National Semi	10mV/°C	±1°C & ±1.5°C (-20°C to 120°C)	TO-46 TO-92 SO-8	Needs a negative supply for temperatures < 10°C
LM45	National Semi	10mV/°C 500mV offset	±1°C & ±1.5°C (-20°C to 120°C)	TO-46 TO-9 SO-8	LM35 with 500mV output offset
LM50	National Semi	10mV/°C 500mV offset	±3°C & ±4°C (-40°C to 125°C)	TO-46 TO-92 SO-8	Low cost part, 500mV off set, easy to use
LM60	National Semi	6.24 mV offset	±3°C & ±4°C (-40°C to 125°C)	SOT-23	Supply voltage down to 2.7V
S-8110 S-8120	Seiko Instruments	-8.5 mV/°C (note neg. TC)	±2.5°C & ±5°C (-40°C to 100°C)	SOT-23 SC-82AB	Very low 10μA operating current
TC102 TC103 TC1132 TC1133	Telcom Semi	10 mV/°C	±8°C (-20°C to 125°C)	SOT-23 TO-92	.
TMP35	Analog Devices	10 mV/°C	±3°C ±4°C (10°C to 125°C)	TO-92 SO-8 SOT-23	Similar to LM35 plus shutdown for power saving (not in TO-92)

2.4 HUMIDITY SENSOR

Humidity Refers to the water vapor content in air or in other gases. Humidity measurements can be stated in a variety of forms and units. The three commonly used formats are absolute humidity, dew point, and relative humidity (RH).

Absolute humidity is the ratio of the mass of water vapor to the volume of air or gas. It is commonly expressed in grams per cubic meter or grains per cubic foot (1 grain = $^{1}/_{7000}$ lb.). It can be calculated from known RH, temperature, or wet bulb or it can be measured directly. Refinements in thermistors technology in the 1960s led to the development in the 1980s of a thermal conductivity principle that permits absolute humidity measurements at elevated temperatures (>200°C) even in a polluted environment. The system uses two thermistors in a bridge configuration.

Dew point, expressed in °C or °F, is the temperature and pressure at which a gas begins to condense into a liquid. Chilled mirror hygrometers have reliably made dew point measurements since the early 1960s, but the development of stable thin film capacitive sensors in the 1980s now allows measurement of dew points as low as – 40 °F at a fraction of the chilled mirror cost. Calibration data for each specific sensor are stored in nonvolatile memory for improved accuracy. In contrast, chilled mirrors measure dew point in real time and do not require stored data for measurements.

The relative humidity, abbreviated as RH, refers to the ratio (stated as a percent) of the moisture content of air compared to the saturated moisture level at the same temperature and pressure. In the early 1900s, RH was derived from measuring a physical change caused by moisture absorption in certain natural materials such as silk or human hair. Nylon and other synthetics were subsequently used. Since the 1940s, most mechanical methods have been replaced by electronic RH sensors due to their greater accuracy and dependability and their lower cost. In the fairly recent past, specialized polymer-based resistive and laser-trimmed capacitive sensors with monolithic signal conditioners have been introduced.

2.4.1 Capacitive Humidity Sensors

Relative Humidity: Capacitive relative humidity (RH) sensors (Figure 2.4) are widely used in industrial, commercial, and weather telemetry applications.

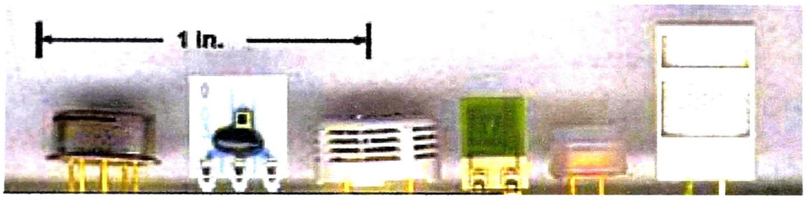


Figure 2.4 Capacitive RH Sensors

They consist of a substrate on which a thin film of polymer or metal oxide is deposited between two conductive electrodes. The sensing surface is coated with a porous metal electrode to protect it from contamination and exposure to condensation. The substrate is typically glass, ceramic, or silicon. The incremental change in the dielectric constant of a capacitive humidity sensor is nearly directly proportional to the relative humidity of the surrounding environment. The change in capacitance is typically 0.2 – 0.5 pF for a 1% RH change, while the bulk capacitance is between 100 and 500 pF at 50 % RH at 25°C. Capacitive sensors are characterized by low temperature coefficients, ability to function at high temperatures (up to 200°C), full recovery from condensation, and reasonable resistance to chemical vapors. The response time ranges from 30 to 60 s for a 63 % RH step change.

State-of-the-art techniques for producing capacitive sensors take advantage of many of the principles used in semiconductor manufacturing to yield sensors with minimal long-term drift and hysteresis. Thin film capacitive sensors may include monolithic signal conditioning circuitry integrated onto the substrate. The most widely used signal conditioner incorporates a CMOS timer to pulse the sensor and to produce a near-linear voltage output (Figure 2.5).

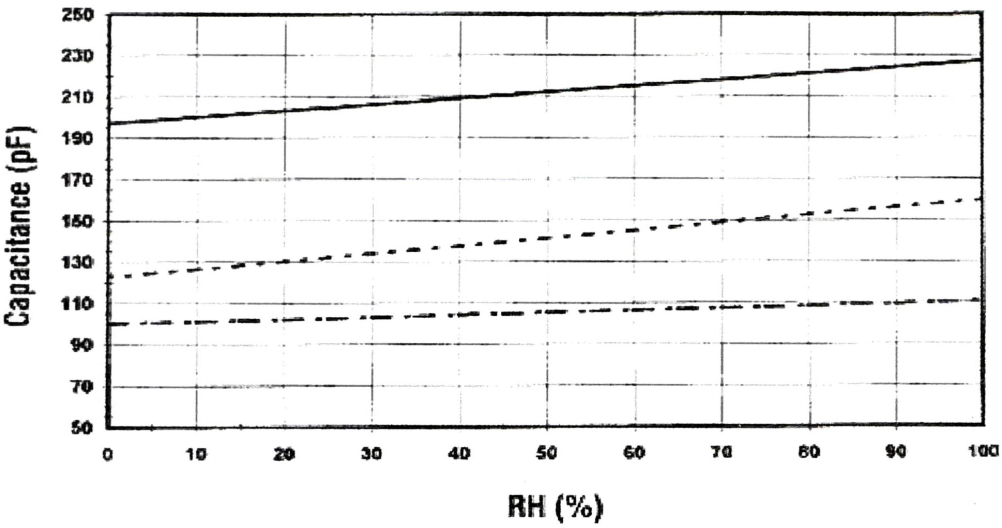


Figure 2.5 Capacitance changes vs. Applied Humidity at 25°C

The typical uncertainty of capacitive sensors is ± 2 % RH from 5 % to 95 % RH with two-point calibration. Capacitive sensors are limited by the distance the sensing element can be located from the signal conditioning circuitry, due to the capacitive effect of the connecting cable with respect to the relatively small capacitance changes of the sensor.

Direct field interchangeability can be a problem unless the sensor is laser trimmed to reduce variance to ± 2 % or a computer-based recalibration method is provided. These calibration programs can compensate sensor capacitance from 100 to 500 pF.

2.4.2 Resistive Humidity Sensors

Resistive humidity sensors (Figure 2.6) measure the change in electrical impedance of a hygroscopic medium such as a conductive polymer, salt, or treated substrate.

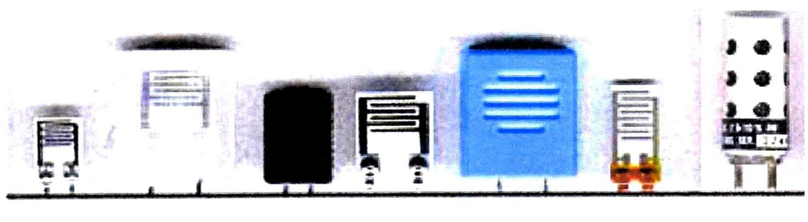


Figure 2.6 Resistive Humidity Sensors

The impedance change is typically an inverse exponential relationship to humidity

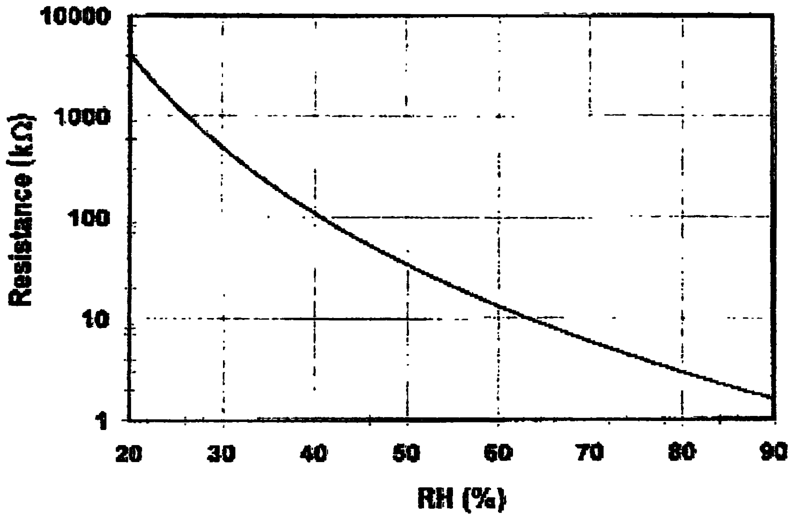


Figure 2.7 Resistivity Changes Vs Applied Humidity at 25°C

The exponential response of the resistive sensor, plotted here at 25°C, is linearized by a signal conditioner for direct meter reading or process control.

Resistive sensors usually consist of noble metal electrodes either deposited on a substrate by photoresist techniques or wire-wound electrodes on a plastic or glass cylinder. The substrate is coated with a salt or conductive polymer. When it is dissolved or suspended in a liquid binder it functions as a vehicle to evenly coat the sensor. Alternatively, the substrate may be treated with activating chemicals such as acid. The sensor absorbs the water vapor and ionic functional groups are dissociated, resulting in an increase in electrical conductivity. The response time for most resistive sensors ranges from 10 to 30 s for a 63 % step change. The impedance range of typical resistive elements varies from 1 kΩ to 100 MΩ.

Most resistive sensors use symmetrical AC excitation voltage with no DC bias to prevent polarization of the sensor. The resulting current flow is converted and rectified to a DC voltage signal for additional scaling, amplification, linearization, or A/DR conversion (Figure 2.8).

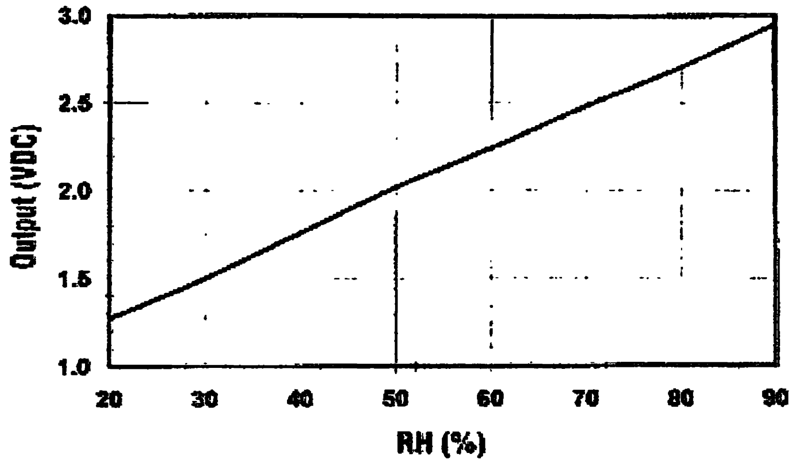


Figure 2.8 Non Linear Response Linearized By Analog Or Digital Methods

Nominal excitation frequency is from 30 Hz to 10 kHz.

The "resistive" sensor is not purely resistive, in these the capacitive effects greater than the 10 – 100 MΩ makes the response an impedance measurement. A distinct advantage of resistive RH sensors is their interchangeability, usually within ± 2 % RH, which allows the electronic signal conditioning circuitry to be calibrated by a resistor at a fixed RH point. This eliminates the need for humidity calibration standards, so resistive humidity sensors are generally field replaceable. The accuracy of individual resistive humidity sensors may be confirmed by testing in an RH calibration chamber or by a computer-based DA system referenced to standardized humidity - controlled environment. Typically, nominal operating temperature of resistive sensors ranges from – 40 °C to 100 °C.

In residential and commercial environments, the life expectancy of these sensors is greater than the 5 years, but exposure to chemical vapors and other contaminants such as oil mist may lead to premature failure. Another drawback of some resistive sensors is their tendency to shift values when exposed to condensation if a water-soluble coating is used. Resistive humidity sensors have significant temperature dependencies when installed in an environment with large (> 10 °F) temperature fluctuations. Simultaneous temperature compensation is incorporated for accuracy. The small size, low cost, interchangeability, and long-term stability make these resistive sensors suitable for use in control and display products for industrial, commercial, and residential applications.

One of the first mass-produced humidity sensors was the Dunmore type, developed by NIST in the 1940s and still in use today. It consists of a dual winding of palladium wire on a plastic cylinder that is then coated with a mixture of polyvinyl alcohol (binder) and either lithium bromide or lithium chloride. Varying the concentration of LiBr or LiCl result in very high resolution sensors that cover humidity spans of 20 % – 40 % RH. For very low RH control function in the 1 % – 2 % RH range, accuracies of 0.1 % can be achieved. Dunmore sensors are widely used in precision air conditioning controls to maintain the environment of computer rooms and as monitors for pressurized transmission lines, antennas, and wave guides used in telecommunications.

The latest development in resistive humidity sensors uses a ceramic coating to overcome limitations in environments where condensation occurs. The sensors consist of a ceramic substrate with noble metal electrodes deposited by a photo-resist process. The substrate surface is coated with a conductive polymer/ceramic binder mixture, and the sensor is installed in a protective plastic housing with a dust filter.

The binding material is a ceramic powder suspended in liquid form. After the surface is coated and air dried, the sensors are heat treated. The process results in a clear non-water-soluble thick film coating that fully recovers from exposure to condensation.

The manufacturing process yields sensors with an interchangeability of better than 3 % RH over the 15 % – 95 % RH range. The precision of these sensors is confirmed to be ± 2 % RH by a computer-based DA system. The recovery time from full condensation to 30 % is a few minutes. When used with a signal conditioner, the sensor voltage output is directly proportional to the ambient relative humidity.

2.4.3 Thermal Conductivity Humidity Sensors

These sensors (Figure 2.9) measure the absolute humidity by quantifying the difference between the thermal conductivity of dry air and that of air containing water vapor.

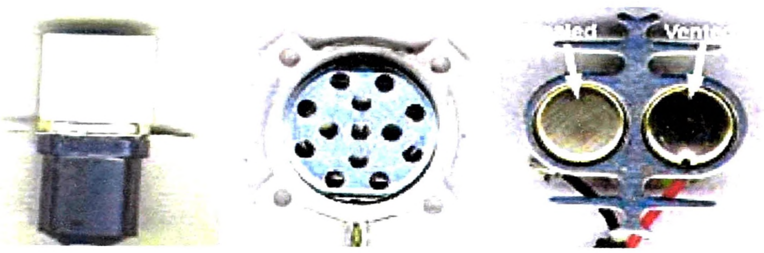


Figure 2.9 Thermal Conductivity Humidity Sensors

When air or gas is dry, it has a greater capacity to "sink" heat, as in the example of a desert climate. A desert can be extremely hot in the day but at night the temperature rapidly drops due to the dry atmospheric conditions. By comparison, humid climates do not cool down so rapidly at night because heat is retained by water vapor in the atmosphere.

Thermal conductivity humidity sensors (or absolute humidity sensors) consist of two matched negative temperature coefficient (NTC) thermistors elements in a bridge circuit; one is hermetically encapsulated in dry nitrogen and the other is exposed to the environment (Figure 2.10).

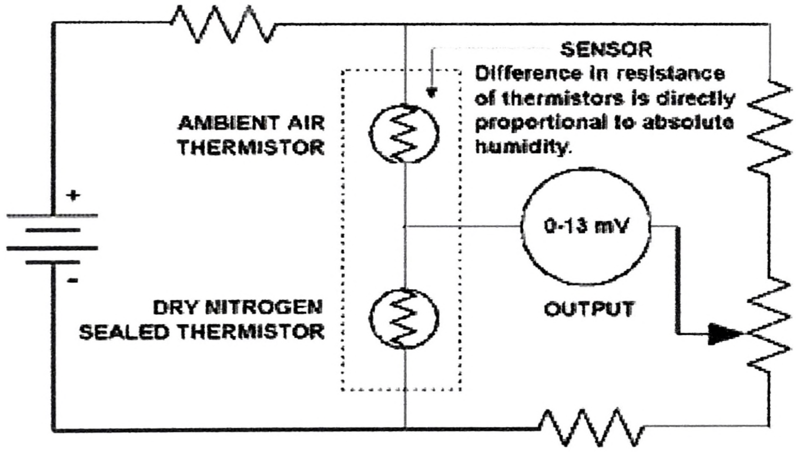


Figure 2.10 DC Bridge Circuit of Thermal Conductivity Sensors

In thermal conductivity sensors, two matched thermistors are used in a DC bridge circuit. One sensor is sealed in dry nitrogen and the other is exposed to ambient. The bridge output voltage is directly proportional to absolute humidity.

When current is passed through the thermistors, resistive heating increases their temperature to greater than 200 °C. The heat dissipated from the sealed thermistor is greater than that of the exposed thermistor due to the difference in the thermal conductively of the water vapor as

Compared to dry nitrogen. Since the heat dissipated yields different operating temperatures, the difference in resistance of the thermistors is proportional to the absolute humidity (Figure2.11).

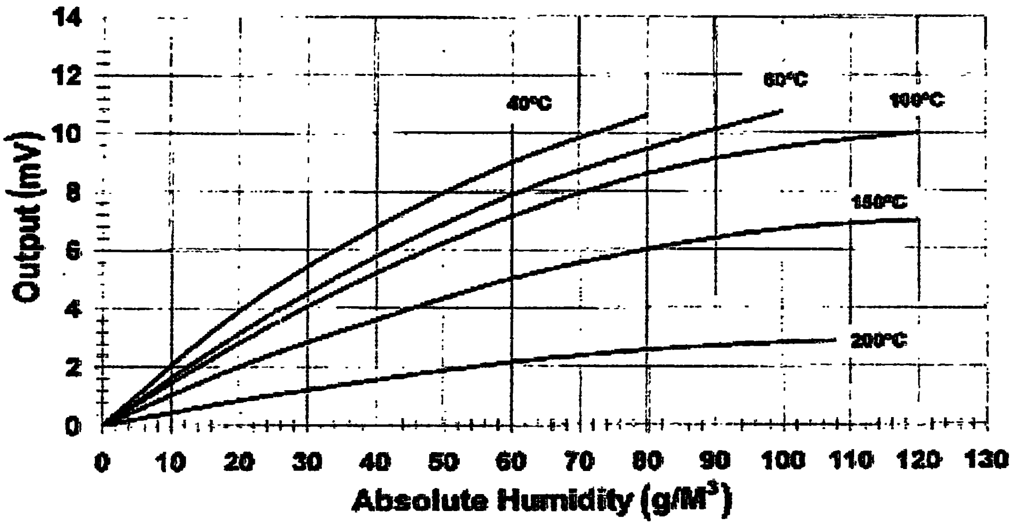


Figure 2.11 Output Of The Thermal Conductivity Sensor Vs Absolute Humidity

The output signal of the thermal conductivity sensor is affected by the operating temperature. Maximum output is at 600°C; output at 200°C drops by 70%.

A simple resistor network provides a voltage output equal to the range of 0–130 g/m^3 at 60°C. Calibration is performed by placing the sensor in moisture-free air or nitrogen and adjusting the output to zero. Absolute humidity sensors are very durable; operate at temperatures up to 575°F (300°C) and are resistant to chemical vapors by virtue of the inert materials used for their construction, i.e., glass, semiconductor material for thermistors, high-temperature plastics, or aluminum.

An interesting feature of thermal conductivity sensors is that they respond to any gas that has thermal properties different from those of dry nitrogen, which will affect the measurements. Absolute humidity sensors are commonly used in appliances such as cloth dryers and both microwave and steam-injected ovens. Industrial applications include kilns for drying wood; machinery for drying textiles, paper, and chemical solids; pharmaceutical productions, cooking; and food dehydration. Since one of the by-products of combustion and fuel cell operation is water vapor, particular interest has been shown in using absolute humidity sensors to monitor the efficiency of those reactions.

In general, absolute humidity sensors provide greater resolution at temperatures >200°F than do capacitive and resistive sensors, and may be used in applications where these sensors would not survive. The typical accuracy of an absolute humidity sensor is +3 g/m^3; this converts to about ±5% RH at 40°C and ±0.5% RH at 100°C.

2.5 OPERATIONAL AMPLIFIERS

An operational amplifier, which is often called an op-amp, is a DC-coupled high-gain electronic voltage amplifier with differential inputs and, usually, a single output. Typically the output of the op-amp is controlled either by negative feedback, which largely determines the magnitude of its output voltage gain, or by positive feedback, which facilitates regenerative gain and oscillation. High input impedance at the input terminals (ideally infinite) and low output impedance (ideally zero) are typical important characteristics.

The op-amp is one type of a differential amplifier. Other types of differential amplifiers include the fully differential amplifier (similar to the op-amp, but with 2 outputs), the instrumentation amplifier (usually built from 3 op-amps), the isolation amplifier (similar to the instrumentation amplifier, but which works fine with common-mode voltages that would destroy an ordinary op-amp), and negative feedback amplifier (usually built from 1 or more op-amps and a resistive feedback network).

The circuit symbol for an op-amp is shown to the right, where:

- V_+ : non-inverting input
- V_- : inverting input
- V_{out}: output
- V_{S+} : positive power supply
- V_{S-} : negative power supply

The power supply pins (V_{S+} and V_{S-}) can be labeled in different ways (IC power supply pins). Despite different labeling, the function remains the same that is to provide additional power for the amplification of a signal.

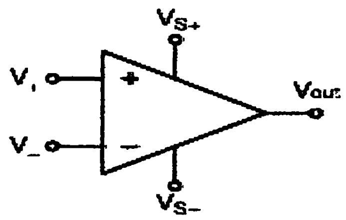


Figure 2.12 Circuit Diagram Symbol for an OP-AMP

2.5.1 Operational Amplifier Types

- General-Purpose Op-Amps: These devices are designed for a very wide range of applications and op-amps have limited bandwidth but in return have very good stability (they are called frequency compensated)

- Voltage Comparators: These are devices that have no negative feedback networks and therefore get saturated with very low (μV) input signal voltages and used to compare signal levels of the inputs

- Low Input Current Op-Amps: Op-amps with very low (Pico-amp) input currents, as opposed to μA or mA input currents found in other devices

- Low Noise Op-Amps: Optimized to reduce internal noise and typically employed in the first stages of amplification circuits

- Low Power Op-Amps: Optimized for low power consumption and These devices can operate at low power-supply voltages (I.e., ±1.5VDC)

- Low Drift Op-Amps: Internally compensated to minimize drift caused by temperature and typically employed in instrumentation circuits with low-level input signals

- Wide Bandwidth Op-Amps: These devices have a very high GB product (i.e., 100MHz) compared to 741-type op-amps (0.3-1.2MHz) and these devices are sometimes called video op-amps

- Single DC Supply Op-Amps: Devices that operate from a monopolar DC power supply voltage
- High-Voltage Op-Amps : Devices that operate at high DC power supply voltages (i.e. ±44VDC) compared to most other op-amps (±6V to ±22V)
- Multiple Devices: Those that have more than one op-amp in the same package (i.e., dual or quad op-amps)
- Instrumentation Op-Amps: These are DC differential amplifiers made with 2-3 internal op-amps Voltage gain is commonly set with external resistors

2.6 MICROCONTROLLER

2.6.1 Introduction

After developing semiconductor technology with the invention of the transistor, scientists / engineers quickly moved to develop the electronics technology. Then the applications of the transistor rapidly became widespread and the demand for these elements also enhanced. So the developers tried to integrate several transistors into a single chip, which they named as Integrated Circuit or IC. According to this development hundreds of thousands of semiconductor devices (transistor) are assembled in a single chip. This rapid development of the integrated circuit technology opened up the path to the designing of the microprocessors, eventually leading to further development of electronics and micro electronics.

The very first computers were made up of microprocessor and other peripherals such as memory input output lines, timers and other supporting devices. But further developments such as enhancing the activities of the devices the microprocessor and the other peripherals have come out in the same device. This is how the microcontroller has become popular among the designers and system developers since the beginning

2.6.2 Microprocessor and Microcontroller

When considering the microprocessor and microcontroller there are several differences between them. The main out come of the microprocessor is the functionality which it gives as an output.

Other than the functionality the peripherals such as memory analog to digital converters and timers should be provided externally to the microprocessor.

On the other hand the microcontroller has most of the other peripherals in-built, such as memory, serial communication, timer, watchdog and analog to digital converter as well as the functionality. Thus money, space and the time can be effectively reduced when devices are designed with microcontrollers.

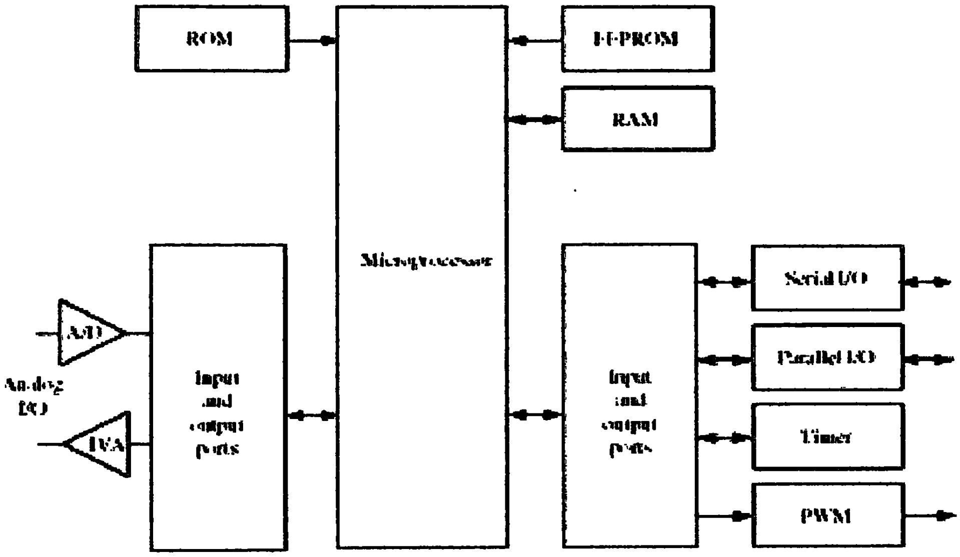


Figure 2.13 Microprocessor Based System

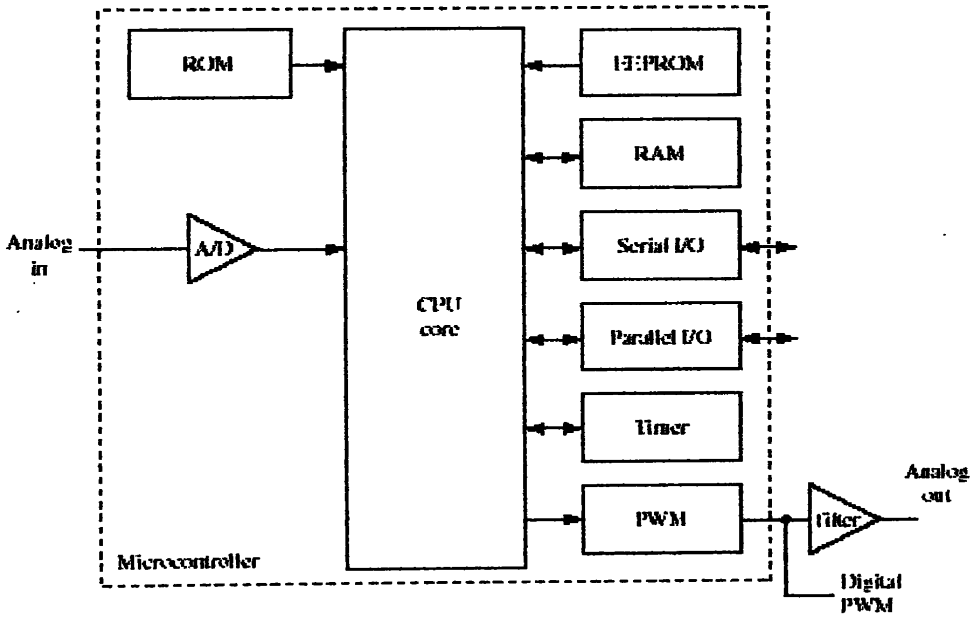


Figure 2.14 Microcontroller Based System

Figure above illustrates some of the similarities and differences between a microprocessor and a microcontroller. In the Figure2.14, the microprocessor is just one component of many in a system containing digital and analog I/O, timers, RAMS, EEPROM, etc. In the Figure2.15, all of the components in the microprocessor-based system are contained within the microcontroller itself, with the exception of the D/A converter. However, the PWM (Pulse Width Modulation) output of the microcontroller can, through a low-pass filter, generate an analog output voltage.

The microprocessor needs an external ROM or EEPROM to store its control program.

These Memories are built into the microcontroller. Thus, instead of placing a ROM into a burner to program it, the microcontroller is placed into programmer and programmed.

The instruction set of the microprocessor is more powerful than that of the microcontroller. For example, there may be microprocessor instructions to support multitasking, memory management, and floating-point calculations, but these instructions are not typically found in a Microcontroller. Thus, the complexity of the application or process helps determine whether or not to use a microcontroller.

The difference between a microcontroller and a microprocessor is best exemplified by the fact that most microprocessors have many operation codes (op-codes) for moving data from external memory to the CPU, while the Microcontrollers may have one or two. Microprocessors may have one or two types of bit-handling instructions; Microcontrollers will have many.

The popular personal computer stands out as one of the most important and useful applications of a microprocessor. But many applications do not require the impressive power of the 32-bit microprocessor or the extensive expandability that is available on many microprocessor-based motherboards. Applications such as credit card readers, automatic teller machines, and others can be handled easily with the power of an 8-bit microprocessor and some external support circuitry for I/O. When this is the case, a microcontroller becomes a suitable substitute.

2.6.3 Microcontroller Architecture

Basically two types of architectures are used in microcontrollers. They are Von Neumann architecture and Harvard architecture. In Von Neumann all memory space is on the same bus, and instruction and data are treated identically. In Harvard architecture code and data storage are on separate buses and this allows code and data to be fetched simultaneously.

Harvard architecture is a newer concept than von- Neumann.

It rose out of the need to speed up the work of a microcontroller. In Harvard architecture, data bus and address bus are separate. Thus a greater flow of data is possible through the central processing unit, and of course, a greater speed of work. Separating a program from data memory makes it further possible for instructions not to have 8-bit words.

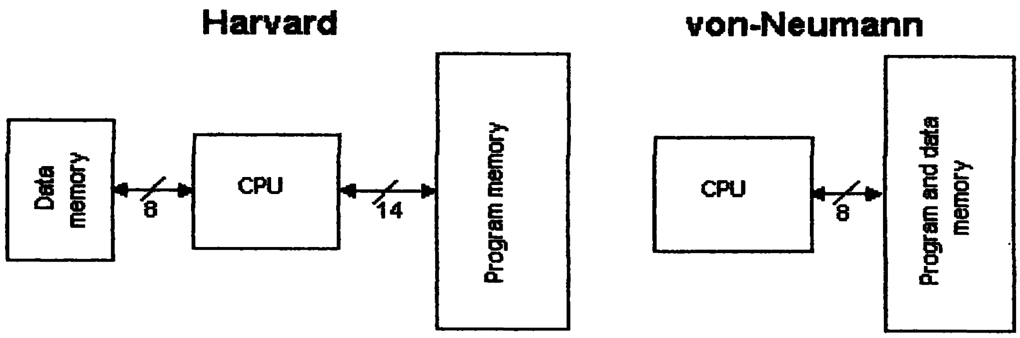


Figure 2.15 Harvard Vs. Von Neumann Block Architecture

2.6.4 The Basic Structure of the Microcontroller

When it comes to the functionalities of the microcontroller there are so many functions in it. To perform all these functions there are several essential units inbuilt in the microcontroller. The microcontrollers are designed for various purposes and the units which are included in the microcontroller depend on the purpose of the usage. But in a normal microcontroller there are some fix units to give the appropriate functions. Including those units the structure of a microcontroller has following items,

- Memory
- Central Processing Unit (CPU)
- Bus
- Input Output Unit
- Serial Communication
- Timer
- Watchdog
- Analog to Digital (A to D) Converter

Though there are several units in the microcontroller the mode of its manufacture is able to control the size of the package into a small IC.

All these things are inter connected to perform its maximum functionalities and a general block diagram of a microcontroller is shown in the following figure.

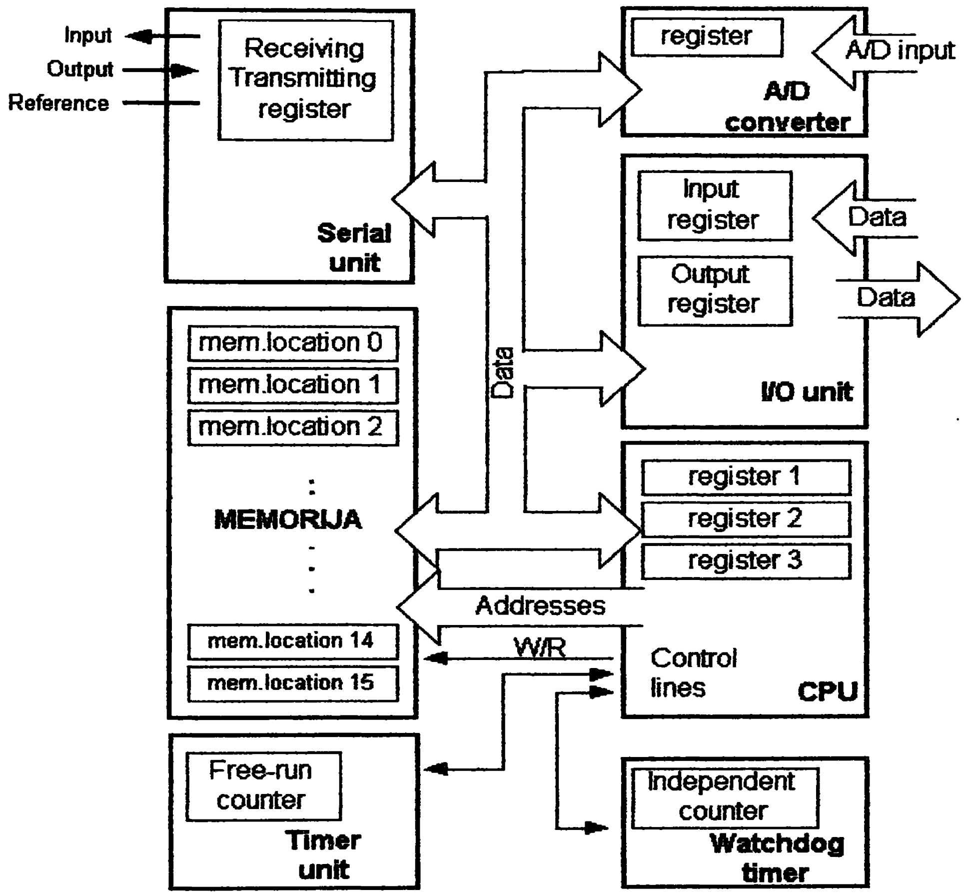


Figure 2.16 Microcontroller Outline

2.6.4.1 Memory

Function of this unit is to store data. This unit consists of large amount of memory locations which has a unique identification for each location. The diagram of memory locations and the connections between them are shown below

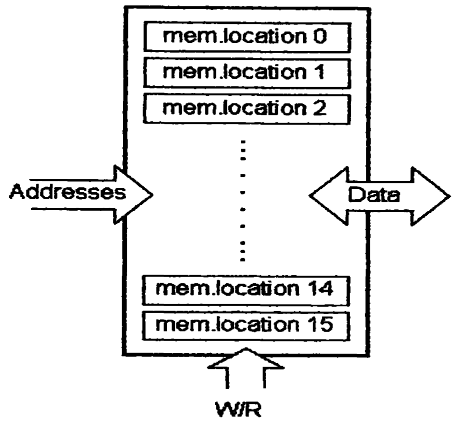


Figure 2.17 Memory Unit

To access appropriate data it should be clearly addressed at the appropriate memory location which consists of that data. The memory is used not only for reading purposes, but also to write the data on it. The additional line called Control line is used to write data on the memory. This line is also designated as R/W (Read/Write). If R/W takes a value of 1 then reading take place, and if R/W is 0 then writing takes place on the memory.

Microprocessors come with several different types of memory. The amount of memory on a single chip varies quite a bit depending on the manufacturer. Typically, 512 to 2k of program space and 256-512 bytes of RAM are available.

There are memory options available. These are RAM, ROM, EPROM, OTP, EEPROM, and FLASH EEPROM.

RAM means Random Access Memory. It is a general purpose memory that can store data or programs. RAM is 'volatile', which means when the power is shut off, the contents of the memory is lost. Most personal computers have several megabytes of RAM. Most microcontrollers have some RAM built into them, but not very much. 256 bytes is a fairly common amount. Some have more, some have less.

ROM means Read Only Memory. Microcontrollers with ROM program memory are manufactured with the desired program code already on them which cannot be changed after they have been manufactured. For this reason, microcontrollers with the ROM program memory technology are best suited in applications where the program code will not change and high volumes of the devices are required.

To be cost-effective and less expensive than microcontrollers with OTP or FLASH program memory, the devices with ROM program memory must be ordered in large quantities.

The second type of program memory is actually used in 2 different package types. This memory type is the Erasable Programmable Read Only Memory or EPROM. When an EPROM die is mounted in a ceramic package with a quartz window, the microcontroller can be erased using an ultraviolet eraser and reprogrammed many times. Erase times depend on the light intensity, light wavelength, the age (operating time) of the light source, and the device being erased. Typical erase times range between 5 and 30 minutes. EPROM is the most expensive version of program memory due to the high cost of the windowed ceramic package.

The One-Time-Programmable (OTP) microcontrollers actually use the same die as the windowed-package EPROM devices. It is the packaging that makes them unique. Since the OTP microcontrollers are in an opaque plastic package, they cannot be erased using UV light. OTP devices are shipped to the customer "blank" from the factory, and can then be programmed only once. This is why they became know as "One Time Programmable" or OTP devices. This is the lowest cost programmable version of a device. OTP devices such as the PIC16C72A/P (plastic DIP) and PIC16C74B/SO (SOIC surface mount) are of the EPROM type and are denoted by a suffix other than "/JW" such as "/P", "/PQ", "/SP" and others.

EEPROM is Electrically Erasable Programmable Read Only Memory. EEPROM is extremely useful for a variety of uses. For example, when save configuration information on many household devices, the information is commonly written into EEPROM. EEPROM can also be 'programmed' from software, so you typically do not need to remove the part from your circuit to reprogram it. This is a big advantage. It typically takes about 10 milliseconds to write each byte of EEPROM.

The final program memory technology is FLASH. FLASH memory provides the ultimate flexibility because it can be electrically erased by a programmer in just a few seconds and reprogrammed. UV erasure is not required, and is not possible. Once erased in a programmer, FLASH devices can be reprogrammed with new code. Some devices with FLASH can also self-program using a specific sequence of instructions.

These devices often include a small amount of non-volatile data EEPROM memory that can be rewritten many thousands of times. Devices such as the PIC16F77 and PIC16F877 use FLASH program memory, and are denoted with an "F" in the part number.

2.6.4.2 Central Processing Unit (CPU)

The Central Processing Unit CPU is the brain of the microcontroller. The CPU is responsible for finding and fetching the right instructions which needs to be executed. The main process of the CPU is to decode the program instruction in to machine language. Mathematical functions such as adding, subtracting dividing and multiplying is done in the Arithmetic and Logic Unit (ALU) which is in the CPU. There are several memory locations to do all the above functions and they are called as registers. The block diagram of the CPU is shown below.

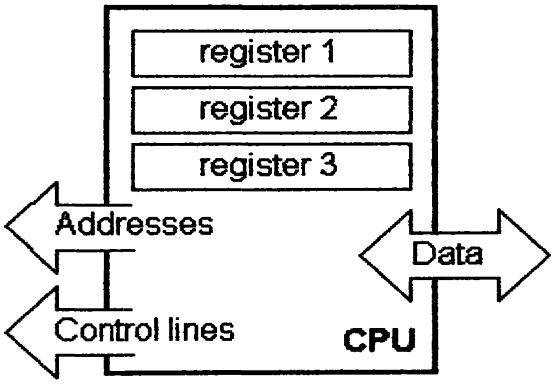


Figure 2.18 Central Processing Unit

Registers therefore act as a memory location whose role is handling mathematical functions and other related operations.

2.6.4.3 Bus

In the above sub sections a memory unit and the CPU were discussed and they work together by sharing their resources between them. This is true not only for the CPU and the memory but also for the timers, I/O ports, and A to D converters. The resources are shared among each other for obtain the out come. To establish these connections Busses are used. The Bus connections between the memory and CPU are shown below.

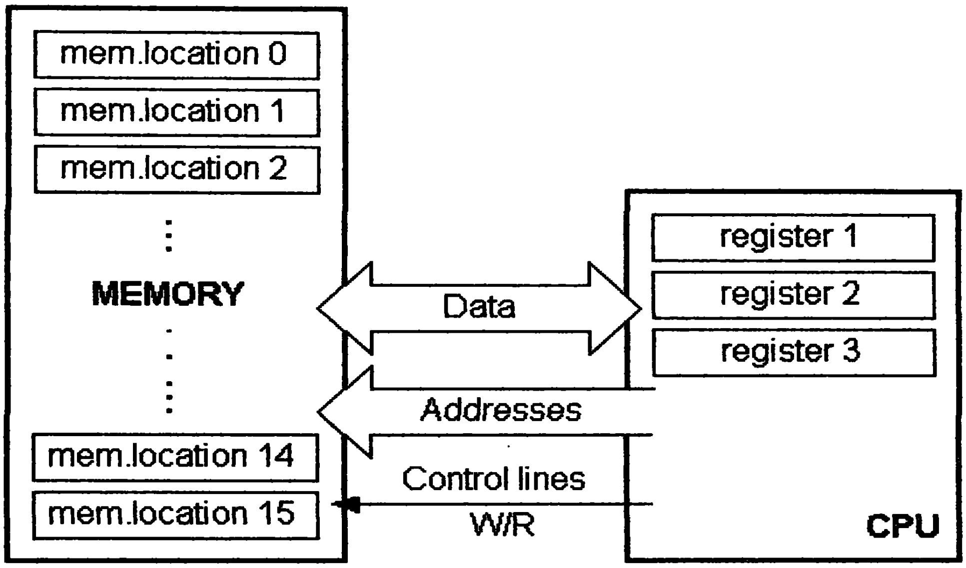


Figure 2.19 Bus

These busses are made up of eight, sixteen or more wires. There are two types of bus which are address and data. The size of the address bus depends on the size of the memory that is used and the size of the data bus depends on the width of the data bits.

2.6.4.4 Input and Output Unit

Microcontroller needs some kind of interruptions or signals to perform the appropriate outcome and to give these interrupts and signals there are several input and output ports.

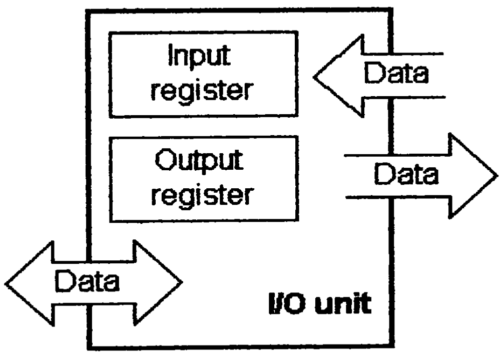


Figure 2.20 Input And Output Unit

In a PIC microcontroller the ports are input, output or bidirectional. When work is carried out with these ports the ports must be assigned as input output or bidirectional before sending the data to the port.

Serial Communication: To send and receive data from the out side the I/O ports can be used. But though this I/O ports are bidirectional there some limitations such as limit of ports (there are few I/O ports in microcontrollers) distance from the sources etc can occur. So to avoid this there is units called serial communication with only three lines for data transmit, receive and reference. Using these three lines data can be transmitted from the microcontroller and also received by the microcontroller.

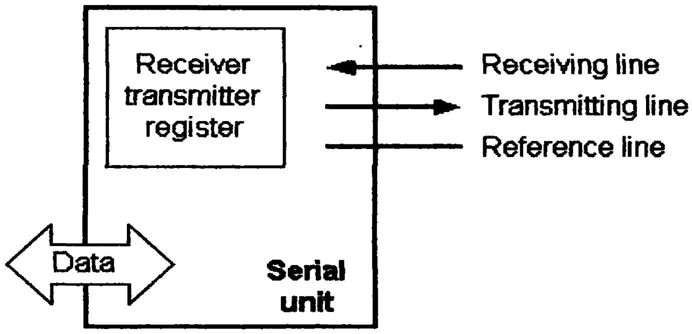


Figure 2.21 Serial Unit

Transmitting line is used to transmit data from the microcontroller, receiving line is used to receive data to the microcontroller and reference act as reference to both transmit and receive. To exchange data special rules called protocol is used. Protocol is therefore well defined to understand both sides which are transmit and receive.

Until data transmission begins the protocol is set to be logical unit 1 and when it just starts the protocol is set to 0 until end of the data transmission. On the other hand the receiving side knows that it is receiving data and it will activate its mechanism. Using these two lines to transmit and receive data can be transferred both sides at the same time. So this full duplex mode block is called as serial communication block. Unlike the parallel mode here data moves bit by bit serially.

2.6.4.5 Timer

To work with microcontroller there should be all the units above mentioned with the timer unit, because the time, durations and protocols are worked with this unit. The basic component of this unit is the free run counters which increment its value in every even interval. The counter takes the intervals from in built crystal oscillator.

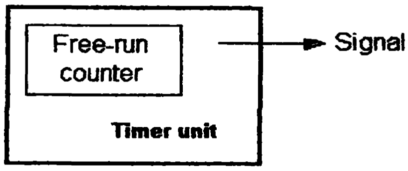


Figure 2.22 Timer Unit

2.6.4.6 Watchdog

In every automated component in the world have errors when working with the reality due to fault of manufacturing, the environment and the way it is used. Even in a microcontroller this may happen. So if some error occurs it should be corrected quickly by manually or automatically, otherwise it may badly affect the microcontroller and the other valuable component which is used in a certain project.

To avoid this there is a special free run counter called Watchdog. When a program operates correctly it writes zero in the watchdog and in the case of stuck the program doesn't write zero and automatically the microcontroller get restarted or reset. Then the program starts to work again until an error occurs. The block diagram of watchdog timer is very much similar to that of the timer, and is shown below.

Figure 2.23 Watchdog

2.6.4.7 Analog to Digital (A to D) Converter

The peripheral signals that are input to the microcontroller cannot be understood by the CPU because that signal is continuous (Analog). But CPU can only process the digital signals which are zeros and ones (0 and 1). So the analog input should be converted into digital and therefore an Analog to Digital (A to D) converter is used in the microcontroller.

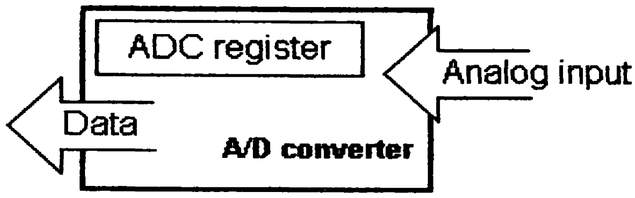


Figure 2.24 A/D Converter

2.6.5 PIC Microcontroller

'PIC' is a microcontroller module manufactured by MICROCHIP, where they have a range of microcontrollers for various kinds of specific fields. The word 'PIC' stands for Peripheral Interrupt Controller.

The Microchip's PIC is very popular and is a low cost Microcontroller in today's industry. PIC uses a RISC instruction set, which varies in length from about 35 instructions for the low-end PIC's to about 70 instructions for the high-end (16-bit) PIC. PIC Microcontrollers use very little power during operation and some of them operate at low voltages (2V). For the smallest applications, there is even an 8-pin version of the PIC. The most popular PIC Microcontrollers are 16 to 40 and 28-pin versions. There are flash versions also available for programming up to one million times as they say. The letter 'F' of the chip name denotes that the chip is a Flash one (Example: PIC16F84).

The most commonly used PIC in ACCIMT were PIC16F84A, PIC16F876, and PIC16F877. PIC16F84A has the minimum inbuilt modules. The software used to simulate and to program the PIC is called MPLAB® IDE (Integrated Development Environment), which is issued by the Microchip.

2.6.5.1 Clock Generator-Oscillator

Oscillator circuit is used for providing a microcontroller with a clock. Clock is needed so that microcontroller could execute a program or program instructions. There are two types of oscillators.

1) Crystal Oscillator (XT)

2) RC Oscillator

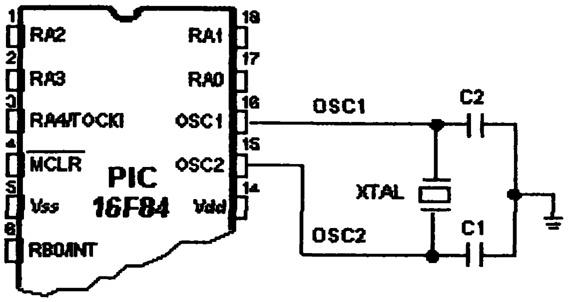


Figure 2.26 Connecting The Quarts Oscillator To Give Clock To A Microcontroller

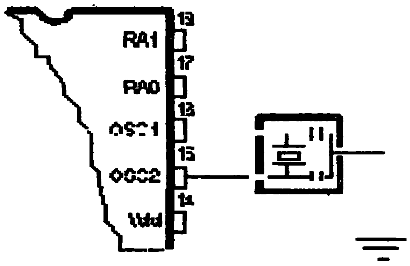


Figure 2.25 Connecting A Resonator On To A Microcontroller

2.6.5.2 Reset

Reset is used for putting the microcontroller into a 'known' condition. In order to continue its proper functioning it has to be reset, meaning all registers would be placed in a starting position. For the normal operation MCLR has to be connected via resistor (pull up) to the positive supply pole.

There are several sources of reset.

a) During power on, POR (Power-On Reset).

b) During regular work by bringing logical zero to MCLR microcontroller's pin

c) During SLEEP regime.

d) Watchdog timer (WDT) overflows.

e) WDT overflows during SLEEP work regime.

CHAPTER 3 MATERIALS AND METHODOLOGY

3.1 MATERIALS

- LM 35 Temperature sensor
- OPA 340
- HS 1101 (Relative Humidity Sensor)
- NE555N
- 7805 Regulator
- Microcontroller 16F876A
- CD74HC4060E
- LCD Display
- Resistance
- Capacitance

3.1.1 LM 35 Temperature sensor

The LM35 series IC's are precision integrated circuit temperature sensors whose output voltage is linearly proportional to the Celsius temperature. The LM35 thus has an advantage over the linear temperature sensors calibrated in Kelvin as the user is not required to subtract a large constant voltage from its output to obtain convent centigrade scaling. The LM35 does not require any external calibration to provide typical accuracies of + or – ¼°C at room temperature and + or – ¾°C over a full –55 to +150°C temperature range. The LM35's low output impedance linear output and precise inherent calibration make interfacing to readout or control circulatory especially easy. It can be used with single power supplies, or with plus and minus supply; it has very low self-heating less than 0.1 degrees Celsius in still air. The LM35 is rated to operate over a –55° to +150°C temperature range, while the LM35 is rated for a –40° to +110°C range. The LM35 series is available packed in hermetic TO-46 transistor packages. The LM35D is also available in an 8 lead surface mount small outline package and a plastic TO-220

3.1.1.1 Features

- Calibrated directly in Celsius (centigrade).
- Linear + 10.0 m V / °C scale factor.
- 0.5° C accuracy guarantee able (at +25° C).
- Rated for full -55° to +150° C range.

- Operates from 4 to 30 volts.
- Low self-heating, 0.08°C in still air.

3.1.1.2 Connection Diagram

The connection diagram for LM35 packages is shown in Fig. 3.1. Here we are using TO-220 plastic package temperature sensor. It has three leads namely +Vs, ground and Vout.

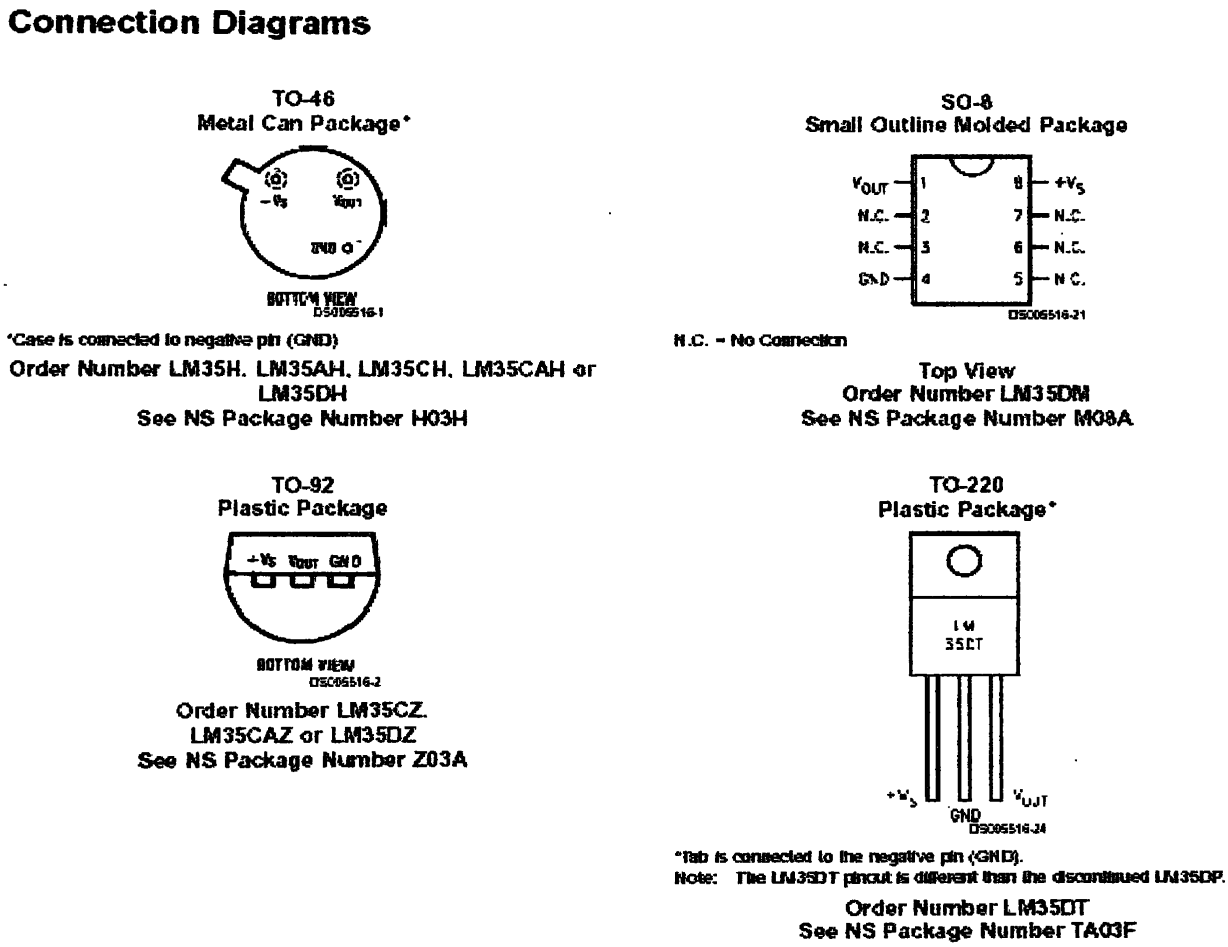


Figure 3.1 LM35 Connection Diagram

3.1.1.3 Absolute Maximum Ratings

- Supply voltage +35V to 0.2V
- Output voltage +6V to -1V
- Output current 10 mill amperes

3.1.1.4 Storage Temperature

- TO 46 package -60° C to +180° C
- TO 92 package - 60° C to +150° C
- SO-8 package -65° C to +150° C
- TO-220 package -65° C to +150° C

3.1.1.5 Lead Temperature

- TO-46 package 300°C
- TO-92 and TO-220 package 260°C
- Vapor phase 215°C
- Infra red 220°C

3.1.2 OPA 340

OPA 340 series rail-to-rail CMOS operational amplifiers are optimized for low voltage, single supply operation. Rail-to-rail input/output and high speed operation make them ideal for driving sampling analog-to-digital converters. They are also well suited for general purpose and audio applications as well as providing I/V conversion at the output of D/A converters. Single, dual, and quad versions have identical specifications for design flexibility.

The OPA340 series operates on a single supply as low as 2.5V with an input common-mode voltage range that extends 500mV below ground and 500mV above the positive supply. Output voltage swing is to within 1mV of the supply rails with a 100kΩ load. They offer excellent.

Dynamic response (BW = 5.5MHz, SR = 6V/μs), yet quiescent current is only 750μA. Dual and quad designs feature completely independent circuitry for lowest crosstalk and freedom from interaction.

The single (OPA340) packages are the tiny 5-lead SOT-23-5 surface mount, SO-8 surface mount, and 8-pin DIP. The dual (OPA2340) comes in the miniature MSOP-8 surface mount, SO-8 surface mount, and 8-pin DIP packages. The quad (OPA4340) packages are the space-saving SSOP-16 surface mount, SO-14 surface mount, and the 14-pin DIP. All are specified from –40°C to +85°C and operate from –55°C to +125°C. A SPICE macro model is available for design analysis.

3.1.2.1 Features

- Rail-To-Rail Input
- Rail-To-Rail Output(Within 1mv)
- Micro Size Packages
- Wide Bandwidth: 5.5MHz
- High Slew Rate: 6V/ms
- Low Thd +Noise: 0.0007% (f = 1kHz)
- Low Quiescent: 750mA/channel
- Single,Dual,and Quad

3.1.2.2 Applications

- Driving A/D Converters
- Data Acquisition
- Process Control
- Audio Processing
- Communications
- Active Filters
- Test Equipment

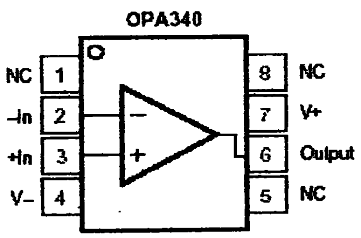


Figure 3.2 8-Pin DIP, SO-8

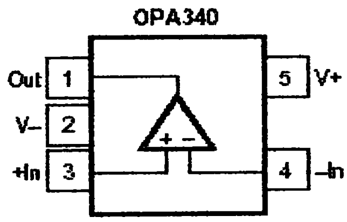


Figure 3.3 SOT-23-5

3.1.3 *HS 1101* (Relative Humidity Sensor)

Based on a unique capacitive cell, these relative humidity sensors are designed for high volume, cost sensitive applications such as office automation, automotive cabin air control, home appliances, and industrial process control systems. They are also useful in all applications where humidity compensation is needed.

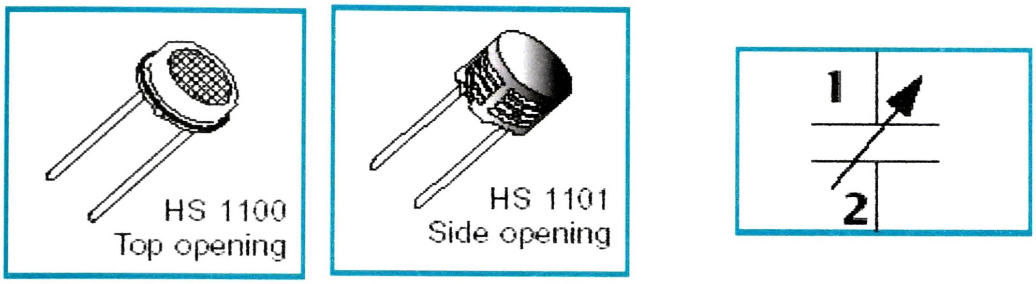


Figure 3.4 HS 1101 (Relative Humidity Sensor)

3.1.3.1 Features

- Full interchangeability with no calibration required in standard conditions
- Instantaneous desaturation after long periods in saturation phase
- Compatible with automatized assembly processes, including wave soldering,
- High reliability and long term stability
- Patented solid polymer structure
- Suitable for linear voltage or frequency output circuitry
- Fast response time
- Individual marking for compliance to stringent traceability requirements

3.1.3.2 Maximum Ratings

Table 3.1 Maximum Ratings

Ratings	Symbol	Value	Unit
Operating Temperature	Ta	-40 to 100	°C
Storage Temperature	Tstg	-40 to 125	°C
Supply Voltage	Vs	10	Vac
Humidity Operating Range	RH	0 to 100	% RH
Soldering @ T = 260°C	t	10	s

3.1.3.3 Characteristic

Table 3.2 Characteristic

Characteristics	Symbol	Min.	Typ.	Max.	Unit.
Humidity measuring range	RH	1		99	%
Supply voltage	Vs		5	10	V
Nominal capacitance @ 55% RH*	C	177	180	183	pF
Temperature coefficient	Tcc		0.04		pF/°C
Averaged Sensitivity from 33% to 75% RH	ΔC/%RH		0.34		pF/%RH
Leakage current (Vcc = 5 Volts)	Ix		1		nA
Recovery time after 150 hours of condensation	tr		10		s
Humidity Hysteresis			+/-1.5		%
Long term stability			0.5		%RH/yr
Response time (33 to 76 % RH, still air @ 63%)	ta		5		s
Deviation to typical response curve (10% to 90% RH)			+/-2		% RH
* *Tighter specification available on request*					

3.1.4 NE555N

The **555** is an integrated circuit (chip) implementing a variety of timer and multivibrator applications. The 555 timer is one of the most popular and versatile integrated circuits ever produced. Depending on the manufacturer, it includes over 20 transistors, 2 diodes and 15 resistors on a silicon chip installed in an 8-pin mini dual-in-line package (DIP-8) . The 555 monolithic timing circuit is a highly stable controller capable of producing accurate time delays, or oscillation. In the time delay mode of operation, the time is precisely controlled by one external resistor and capacitor. For a stable operation as an oscillator, the free running frequency and the duty cycle are both accurately controlled with two external resistors and one capacitor. The circuit may be triggered and reset on falling waveforms, and the output structure can source or sink up to 200 mA.

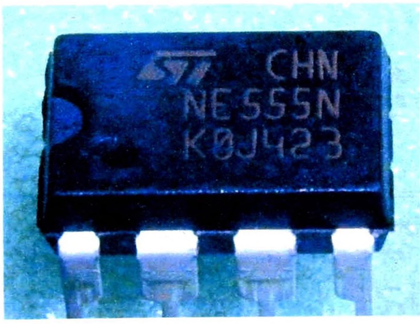


Figure 3.5 NE555N

3.1.4.1 Features

- Turn-off time less than 2 ms
- Max. operating frequency greater than 500 kHz
- Timing from microseconds to hours
- Operates in both a stable and monostable modes
- High output current
- Adjustable duty cycle
- TTL compatible
- Temperature stability of 0.005% per °C

3.1.4.2 Applications

- Precision timing
- Pulse generation
- Sequential timing
- Time delay generation
- Pulse width modulation

3.1.5 7805 Regulator

Fixed" three-terminal linear regulators are commonly available to generate fixed voltages of plus 3 V, and plus or minus 5 V, 9 V, 12 V, or 15 V when the load is less than about 7 amperes. The "78xx" series (7805, 7812, etc.) regulate positive voltages while the "79xx" series (7905, 7912, etc.) regulate negative voltages. Often, the last two digits of the device number are the output voltage; eg. a 7805 is a +5 V regulator, while a 7915 is a -15 V regulator. The 78xx series ICs can supply up to 1.5 Amperes depending on the model.

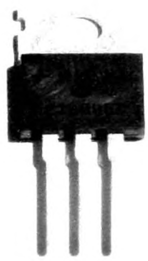


Figure 3.6 Regulator

3.1.6 Microcontroller 16F876A

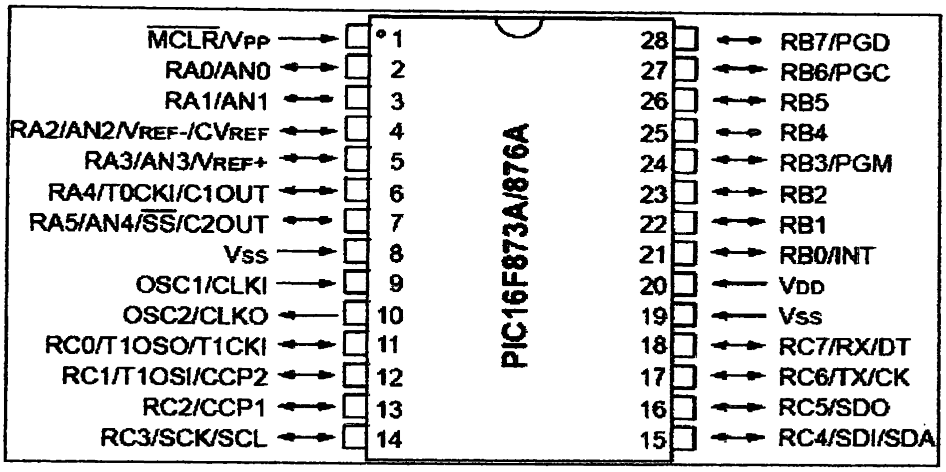


Figure 3.7 Pin Configuration PIC 16F876A

This powerful (200 nanosecond instruction execution) yet easy-to-program (only 35 single word instructions) CMOS FLASH-based 8-bit microcontroller packs Microchip's powerful PIC® architecture into an 28-pin package and is upwards compatible with the PIC16C5X, PIC12CXXX and PIC16C7X devices. The PIC16F876A features 256 bytes of EEPROM data memory, self programming, an ICD, 2 Comparators, 5 channels of 10-bit Analog-to-Digital (A/D) converter, 2 capture/compare/PWM functions, the synchronous serial port can be configured as either 3-wire Serial Peripheral Interface (SPI™) or the 2-wire Inter-Integrated Circuit (I^2C™) bus and a Universal Asynchronous Receiver Transmitter (USART). All of these features make it ideal for more advanced level A/D applications in automotive, industrial, appliances and consumer applications.

Table 3.3 Characteristic

Parameter Name	Value
Program Memory Type	Flash
Program Memory (KB)	14
CPU Speed (MIPS)	5
RAM Bytes	368
Data EEPROM (bytes)	256
Digital Communication Peripherals	1-A/E/USART, 1-MSSP(SPI/I2C)
Capture/Compare/PWM Peripherals	2 CCP
Timers	2 x 8-bit, 1 x 16-bit
ADC	5 ch, 10-bit
Comparators	2
Temperature Range (C)	-40 to 125
Operating Voltage Range (V)	2 to 5.5
Pin Count	28

3.1.6.1 Features

- 2PWM 10-bit
- 256 Bytes EEPROM Data Memory
- *ICD*
- 25mAsink/source per I/O
- Self Programming

3.1.7 CD74HC4060E

The Harris CD74HC4060 and CD74HCT4060 each consist of an oscillator section and 14 ripple-carry binary counter stages. The oscillator configuration allows design of either RC or crystal oscillator circuits. A Master Reset input is provided which resets the counter to the all-0's state and disables the oscillator. A high level on the MR line accomplishes the reset function. All counter stages are master-slave flip-flops. The state of the counter is advanced one step in binary order on the negative transition of fI (and fO). All inputs and outputs are buffered. Schmitt trigger action on the input-pulse-line permits unlimited rise and fall times. In order to achieve a symmetrical waveform in the oscillator section the HCT4060 input pulse switch points are the same as in the HC4060; only the MR input in the HCT4060 has

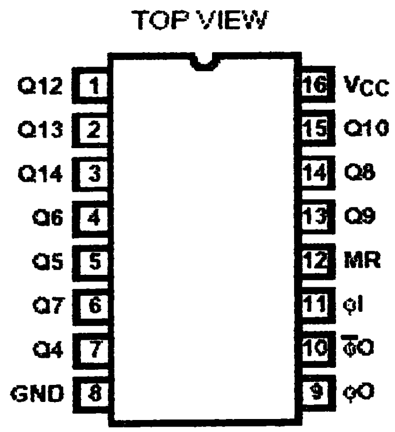


Figure 3.8 CD74HC4060E Pin Configuration

3.1.8 LCD Display

The PCD8544 is a low power CMOS LCD controller/driver, designed to drive a graphic display of 48 rows and 84 columns. All necessary functions for the display are provided in a single chip, Including on-chip generation of LCD supply and bias voltages, resulting in a minimum of external components and low power consumption. The PCD8544 interfaces to microcontrollers through a serial bus interface. The PCD8544 is manufactured in n-well CMOS technology.

3.1.8.1. Feature

- Single chip LCD controller/driver
- 48 row, 84 column outputs
- Display data RAM 48 × 84 bits
- On-chip:
  - – Generation of LCD supply voltage (external supply also possible)
  - – Generation of intermediate LCD bias voltages
  - – Oscillator requires no external components (external clock also possible).
- External RES (reset) input pin
- Serial interface maximum 4.0 Mbits/s
- CMOS compatible inputs
- Mux rate: 48
- Logic supply voltage range VDD to VSS: 2.7 to 3.3 V
- Display supply voltage range VLCD to VSS
  - – 6.0 to 8.5 V with LCD voltage internally generated(voltage generator enabled)
  - – 6.0 to 9.0 V with LCD voltage externally supplied (voltage generator switched-off)
- Low power consumption, suitable for battery operated systems
- Temperature range: -25 to +70 °C

3.1.8.2 Function description of the 48*84 pixels matrix LCD

Oscillator: The on-chip oscillator provides the clock signal for the display system. No external components are required and the OSC input must be connected to VDD. An external clock signal, if used, is connected to this input.

Address Counter (AC): The address counter assigns addresses to the display data RAM for writing. The X address X6 to X0 and the Y-address Y2 to Y0 are set separately. After a write operation, the address counter is automatically incremented by 1, according to the V flag.

Display Data RAM (DDRAM): The DDRAM is a 48 ×84 bit static RAM which stores the display data. The RAM is divided into six banks of 84 bytes (6 × 8 ×84 bits). During RAM access, data is transferred to the RAM through the serial interface. There is a direct correspondence between the X-address and the column output number.

Timing generator: The timing generator produces the various signals required to drive the internal circuits. Internal chip operation is not affected by operations on the data buses.

Display address counter: The display is generated by continuously shifting rows of RAM data to the dot matrix LCD through the column outputs. The display status (all dots on/off and normal/inverse video) is set by bits E and D in the 'display control' command.

LCD row and column drivers: The PCD8544 contains 48 row and 84 column drivers, which connect the appropriate LCD bias voltages in sequence to the display in accordance with the data to be displayed.

3.1.8.3 Instruction set of the LCD controller

Table 3.4 Instruction Set Of The LCD Controller

INSTRUCTION	$D/\overline{C}$	COMMAND BYTE								DESCRIPTION
		DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0	
(H = 0 or 1)										
NOP	0	0	0	0	0	0	0	0	0	no operation
Function set	0	0	0	1	0	0	PD	V	H	power down control; entry mode; extended instruction set control (H)
Write data	1	D_7	D_6	D_5	D_4	D_3	D_2	D_1	D_0	writes data to display RAM
(H = 0)										
Reserved	0	0	0	0	0	0	1	X	X	do not use
Display control	0	0	0	0	0	1	D	0	E	sets display configuration
Reserved	0	0	0	0	1	X	X	X	X	do not use
Set Y address of RAM	0	0	1	0	0	0	Y_2	Y_1	Y_0	sets Y-address of RAM; $0 \le Y \le 5$
Set X address of RAM	0	1	X_6	X_5	X_4	X_3	X_2	X_1	X_0	sets X-address part of RAM; $0 \le X \le 83$

BIT	0	1
PD	chip is active	chip is in Power-down mode
V	horizontal addressing	vertical addressing
H	use basic instruction set	use extended instruction set
D and E		
00	display blank	
10	normal mode	
01	all display segments on	
11	inverse video mode	

3.1.8.4 Pin Description

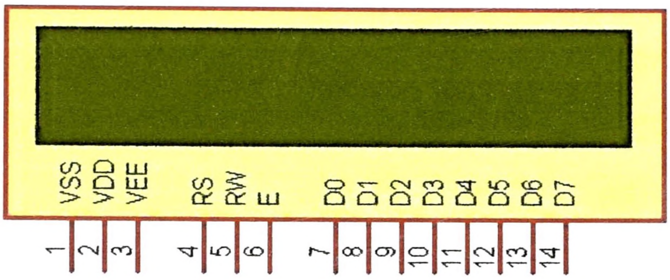


Figure 3.9 Character LCD Type PCD8544 Pin Diagram

The most commonly used LCDs found in the market today are 1 Line, 2 Line or 4 Line LCDs which have only 1 controller and support at most of 80 characters, whereas LCDs supporting more than 80 characters make use of 2 controllers.

Table 3.5 Character LCD pins with 1 Controller

Pin No.	Name	Description
Pin no. 1	**VSS**	Power supply (GND)
Pin no. 2	**VCC**	Power supply (+5V)
Pin no. 3	**VEE**	Contrast adjust
Pin no. 4	**RS**	0 = Instruction input 1 = Data input
Pin no. 5	**R/W**	0 = Write to LCD module 1 = Read from LCD module
Pin no. 6	**EN**	Enable signal
Pin no. 7	**D0**	Data bus line 0 (LSB)
Pin no. 8	**D1**	Data bus line 1
Pin no. 9	**D2**	Data bus line 2
Pin no. 10	**D3**	Data bus line 3
Pin no. 11	**D4**	Data bus line 4
Pin no. 12	**D5**	Data bus line 5
Pin no. 13	**D6**	Data bus line 6
Pin no. 14	**D7**	Data bus line 7 (MSB)

Most LCDs with 1 controller has 14 Pins and LCDs with 2 controller has 16 Pins (two pins are extra in both for back-light LED connections). Pin description is shown in the table3.5.

3.1.8.5 Application Information of the LCD

Programming Example

SERIAL BUS BYTE									DISPLAY	OPERATION
D/$\overline{C}$	DB7	DB6	DB5	DB4	DB3	DB2	DB1	DB0		
0	0	0	0	0	1	1	0	1		display control; set inverse video mode (D = 1 and E = 1)

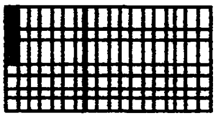
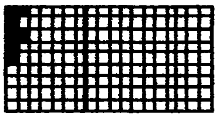
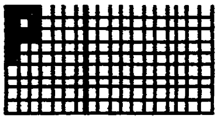
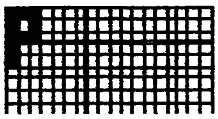
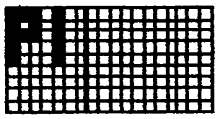
0	0	0	1	[illegible]	1	1	1	
0	0	0	0	0	1	0	1	
0	0	0	0	0	1	1	1	
0	0	0	0	0	0	0	0	
0	0	0	1	[illegible]	1	1	1	

Figure 3.10 Programming Example For The LCD

3.2 APPARATUS

- Digital Oscilloscope
- Multimeter
- PIC Programmer(JDM)
- Microchip MPLAB ICD 2 (Integrated circuit Debugger)
- Computer

We use MPLAB ICD 2, PICSTART Plus or some programmers which are used to program chips such as Chip master to program the PICs.

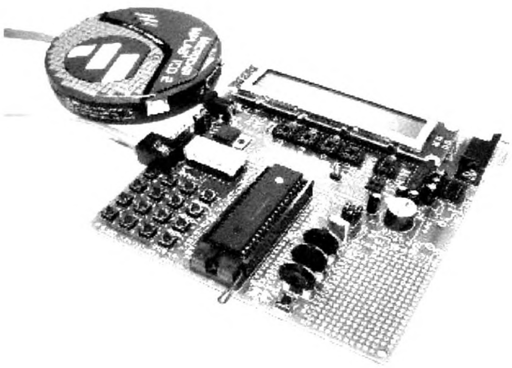


Figure 3.11 MPLAB ICD 2

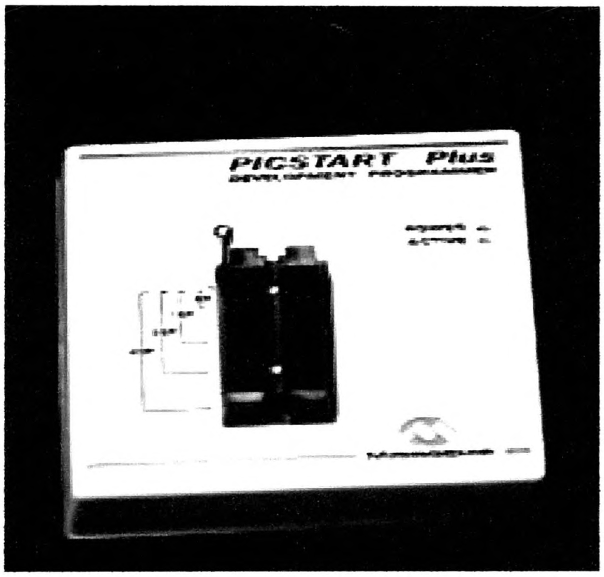


Figure 3.12 PICSTART Plus

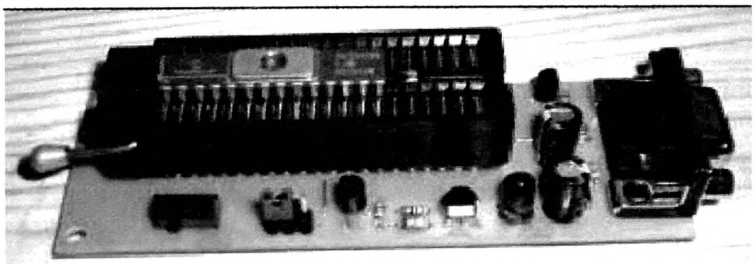


Figure 3.13 Multi PIC Programmer

3.3 SOFTWARE USED

3.3.1 MPLAB

MPLAB is a Windows program package that makes writing and developing a program easier. It could best be described as developing environment for a standard program language that is intended for programming a PC. Some operations which were done from the instruction line with a large number of parameters until the discovery of IDE "Integrated Development Environment" are now made easier by using the MPLAB

MPLAB consists of several parts:

- Grouping the projects files into one project (Project Manager)
- Generating and processing a program (Text Editor)
- Simulating program (MPSIM).
- Support systems for Microchip products (PICStart Plus and ICD)

3.3.1.1 MPLAB IDE

Preparing the program for loading into microcontroller can divide in to few basic steps. Such as designing a project, writing the program and compiling. All these things are carried out using MPLAB IDE.

3.3.1.2 MPSIM

Simulator is part of the MPLAB environment which provides a better insight into the workings of a microcontroller. Through a simulator, we can monitor current variable values, register values and status of port pins. Truthfully, simulator does not have the same value in all programs. If a program is simple (like the one given here as an example), simulation is not of great importance because setting port B pins to logic one is not a difficult task. However, simulator can be of great help with more complicated programs which include timers, different conditions where something happens and other similar requirements (especially with mathematical operations). Simulation, as the name indicates "simulates the work of a microcontroller".

As microcontroller executes instructions one by one, simulator is conceived - programmer moves through a program step-by-step (line-by-line) and follows what goes on with data within the microcontroller. When writing is completed, it is a good trait for a programmer to first test his program in a simulator, and then run it in a real situation.

3.3.2 ICPROG

ICPROG for PICMicro: ICPROG is a free windows program that we can use for PIC Programming. It interfaces using either the serial or parallel port on a PC, via programming hardware, *to the ICSP (In Circuit Serial Programming) pins on the PIC micro.*

ICPROG uses the hex file generated either from an assembler such as MPASM or a compiler such as MikroC

When we first start ICPROG this is the screen we see for selecting the hardware for the PIC programmer; I have selected JDM programmer a serial port programmer.

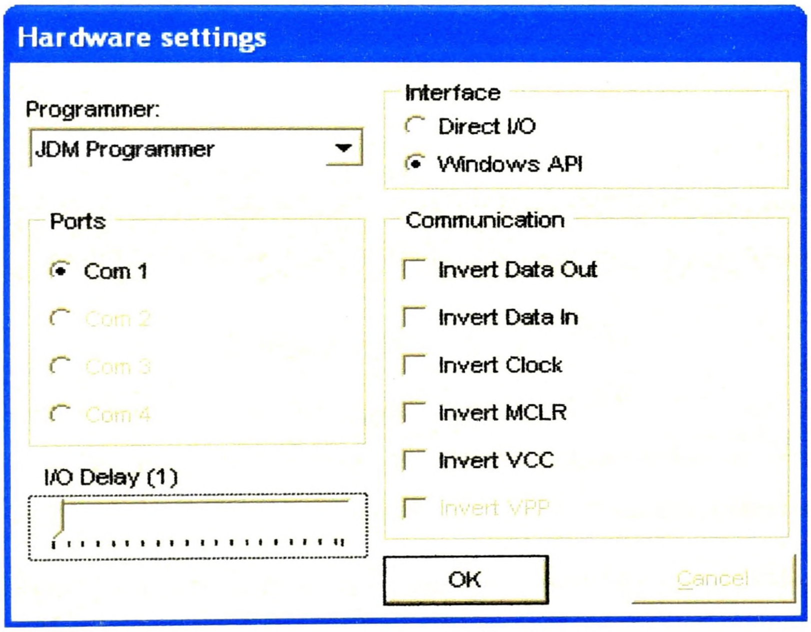


Figure 3.14 Hardware Settings Windows

After this the main program screen is displayed. To use it for PIC programming selects the device from the menu Settings--> Device--> Microchip PIC.

Here I have chosen a PIC16F876A device. And then click the File menu->Open and load the Hex file to the ICPROG.

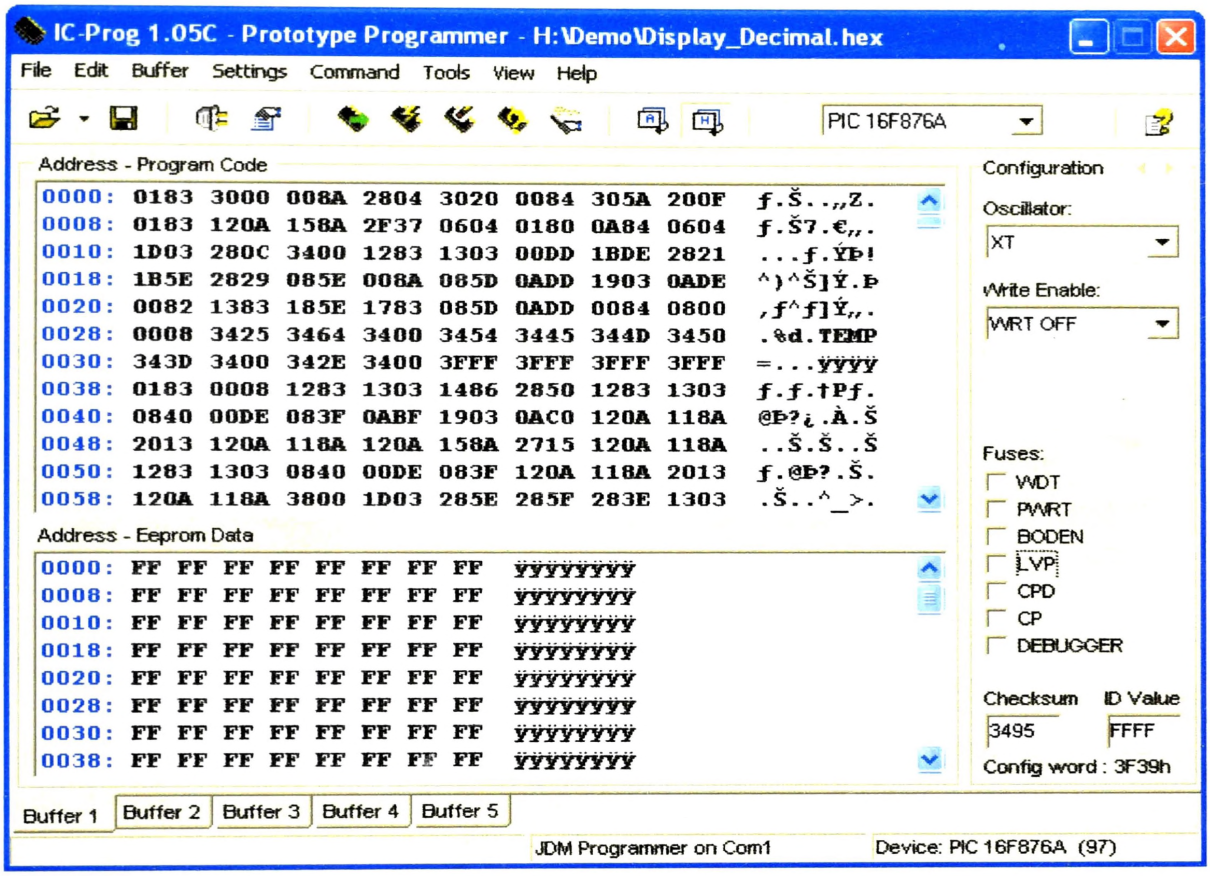


Figure 3.15 Main Screen

The next PIC programming action is to erase the device by hitting the erase device button. It sends a command to the PIC which erases the whole device including protection bits (in newer devices). Old devices used to be un-usable after we had set the protection bits!

The verify device button reads back the entire contents of the chip ensuring that it matches the hex file (loaded into ICPROG).

Note: Depending on settings in Menu:

Settings--> Options--> Programming

verification may automatically happen at the end.

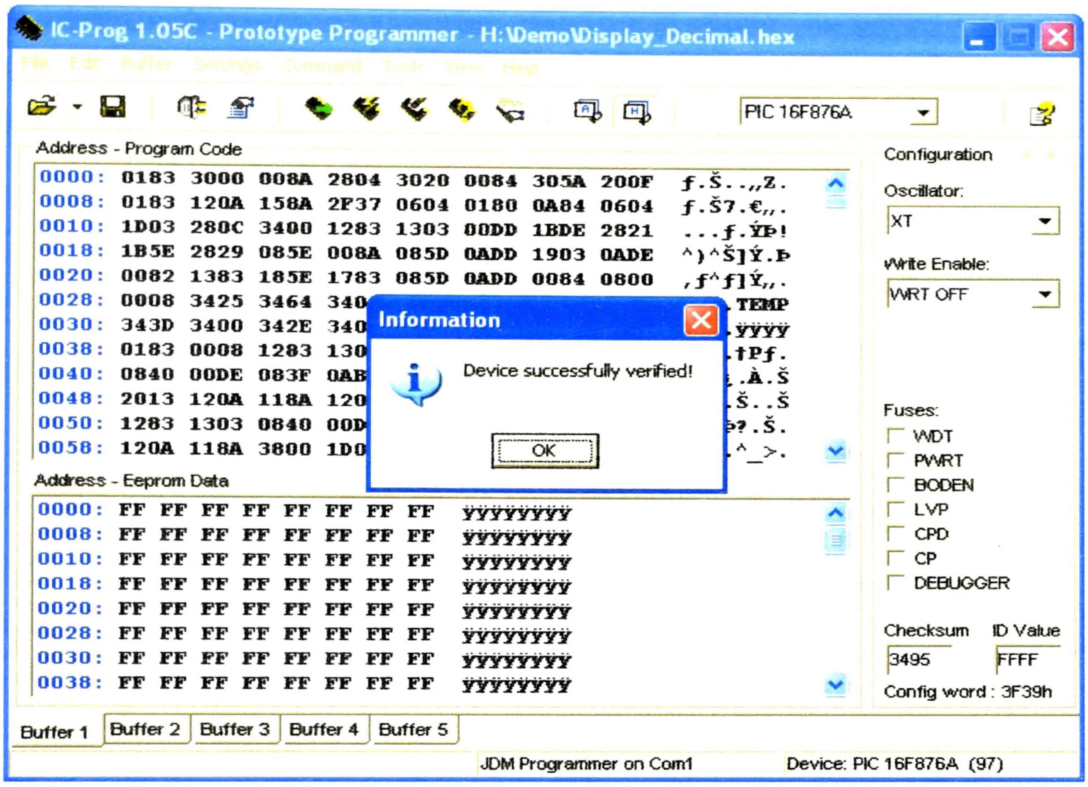


Figure 3.16 Main Screen After Verification

Once we get used to ICPROG and our hardware works reliably we may only want to do a verify if something does not work otherwise it takes more time up.

3.4 METHODOLOGY

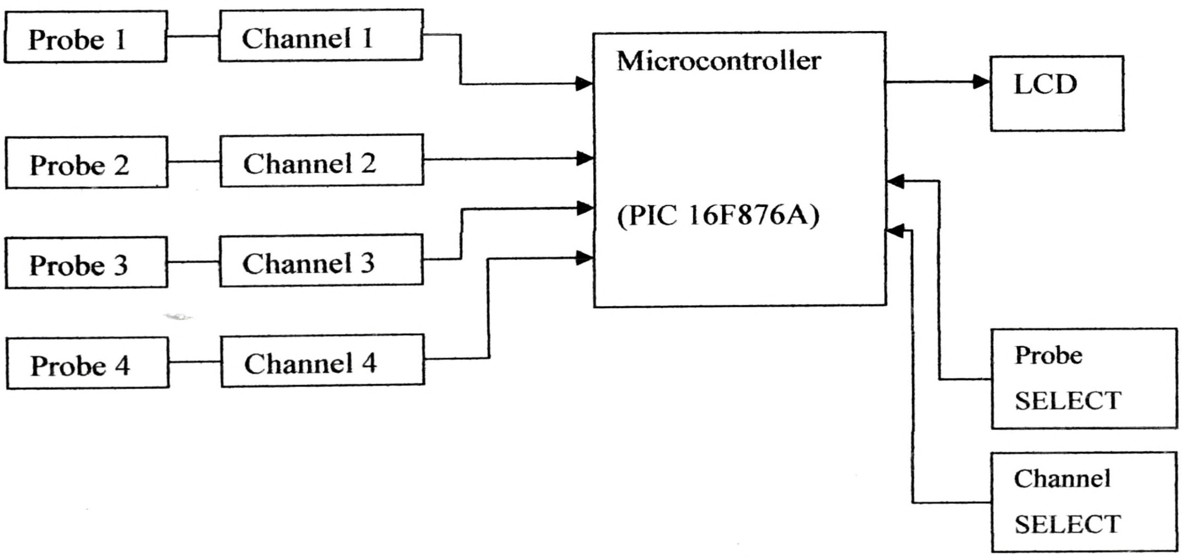


Figure 3.17 Block Diagram

The above figure shows the block diagram of the whole circuit. This project was focused to, Select the Chanel 1 and Chanel 2 as Temperature and Humidity and Display this value through LCD Display. Present work was focused on four major aspects.

1. Microcontroller based interface circuits design.
2. Firmware Programming using C language.
3. Familiarization of MP lab Integrated Development Environment & "HI TECH"C compiler.
4. Firmware testing with hardware on bread board

3.4.1 Microcontroller based interface circuits design

- Temperature Sensor circuit Design
- Humidity Sensor circuit Design
- LCD interface to PIC16F876A circuit Design

3.4.1.1 Temperature Sensor circuit Design

The temperature is sensed by the LM35 temperature sensor. The output of LM35 is a voltage signal, which is very weak. This signal is not enough to display temperature so an amplifier was used to amplify this voltage. The amplifier amplifies this signal. The output of the amplifier is given to the PIC microcontroller. The inbuilt ADC of PIC microcontroller converts this analog data to digital form. The parallel data received was converted to serial data by the inbuilt USART. This data was fed to the PIC microcontroller through pin 2(RA0). The serial data received is converted into parallel data by the inbuilt USART and is displayed on the LCD.

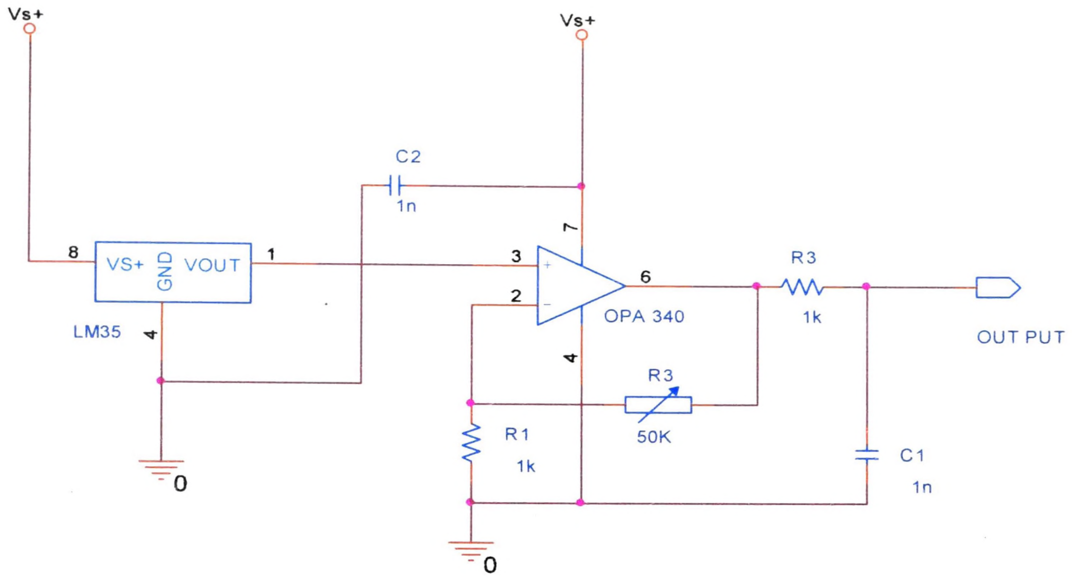


Figure 3.18 Temperature Sensor Circuit Diagram

3.4.1.2 Humidity Temperature Sensor Circuit Design

Humidity moisture content of the atmosphere, a primary element of climate . Humidity measurements include absolute humidity, the mass of water vapor per unit volume of natural air; *relative humidity (usually meant when the term humidity alone is used), the ratio of the* actual water-vapor content of the air to its total capacity at the given temperature; specific humidity, the mass of water vapor per unit mass of natural air; and the mixing ratio, the mass of water vapor per unit mass of dry air. Absolute humidity finds greatest application in *ventilation and air-conditioning problems. This circuit Diagram represents microcontroller-*based humidity sensing system. And here we used the commercial capacitive humidity sensor (HS1101) as a Sensing Device.

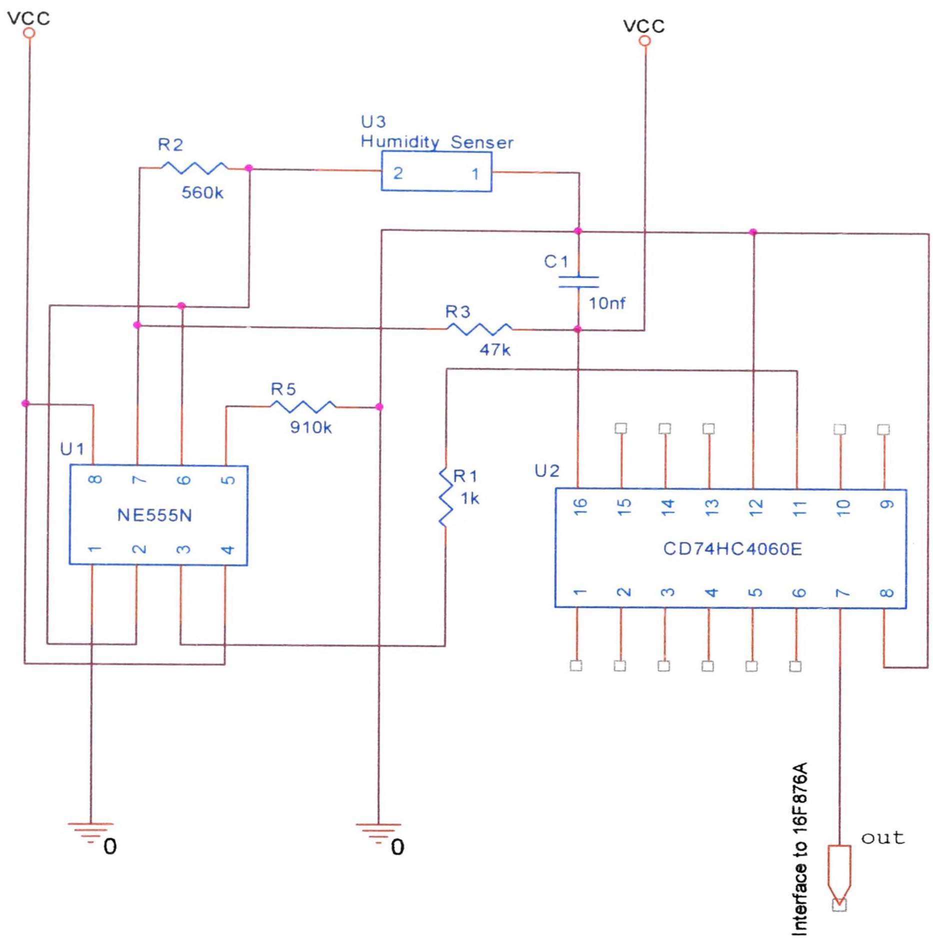


Figure 3.19 Humidity Sensor Circuit Diagram

3.4.1.3 LCD Interface to PIC16F876A Circuit Design

When we interface LCD to Microcontroller we should consider about the modes which are 4bit and 8bit modes. In this project used in 4bit mode. Figure 3.20 is the connection diagram of LCD in 4-bit mode, where we only need 6 pins to interface an LCD. D4-D7 (Microcontroller RC0-RC3) are the data pins connection and Enable and Register select are for LCD control pins. We are not using Read/Write (RW) Pin of the LCD, as we are only writing on the LCD so we have made it grounded permanently. If we want to use it. Then we may connect it on our controller but that will only increase another pin and does not make any big difference. The unwanted data pins of LCD i.e. D0-D3.

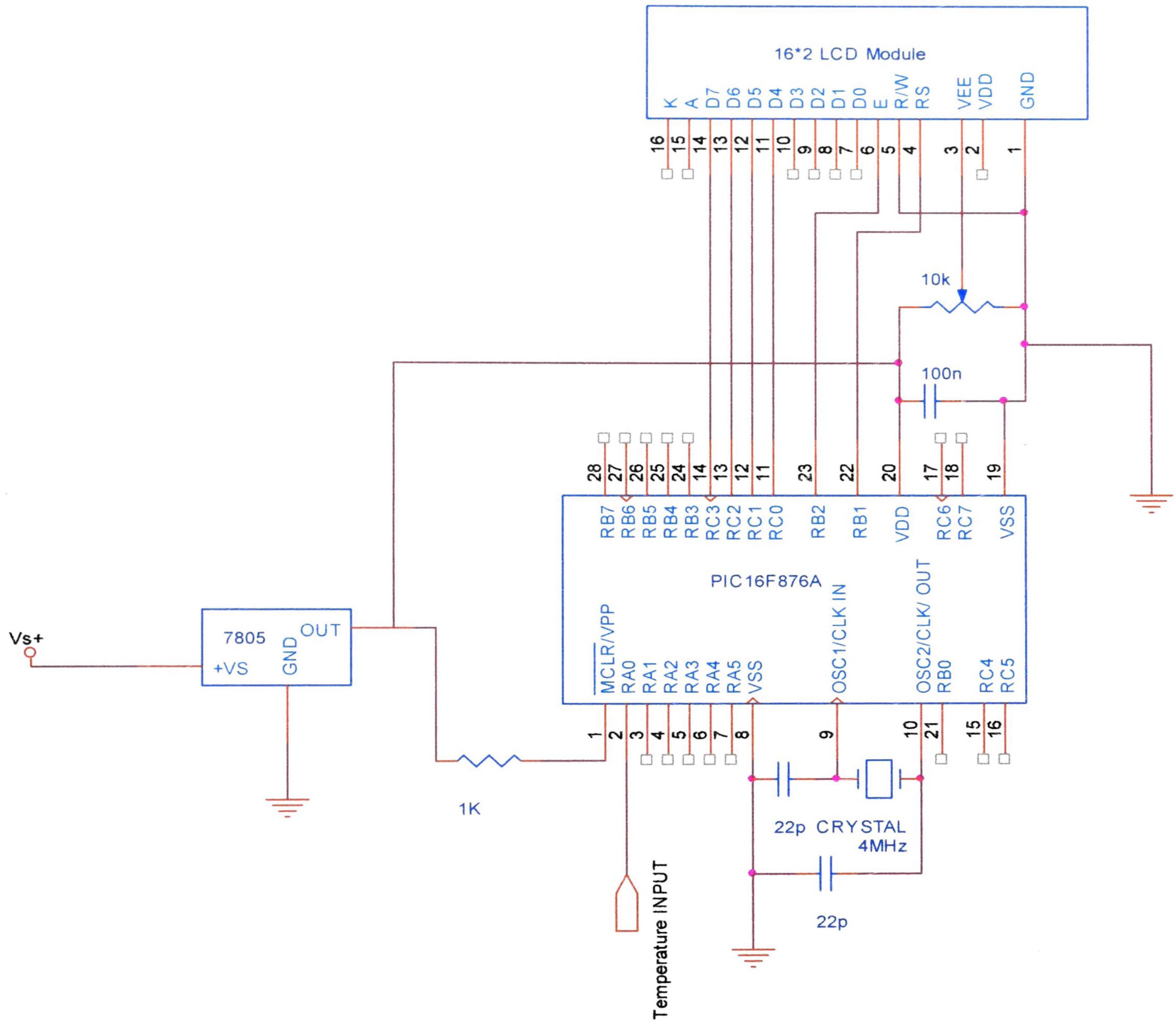


Figure 3.20 LCD Interface To PIC16F876A Circuit

3.4.2 Firmware Programming using C language

PIC16F876A is programmed using Hi-Tech C, a Microchip supported C compiler which can be integrated in to the MPLAB IDE, is available from http://www.htsoft.com/. Other than the Hi-Tech compiler there are numerous others available such as CSS, CC5X, etc. Once we installed the Hi-Tech C compiler in our computer using the Hi-Tech C installations, we have to instruct MPLAB where to find the Hi-Tech C compiler

3.5 FLOW CHART OF FUNCTIONS

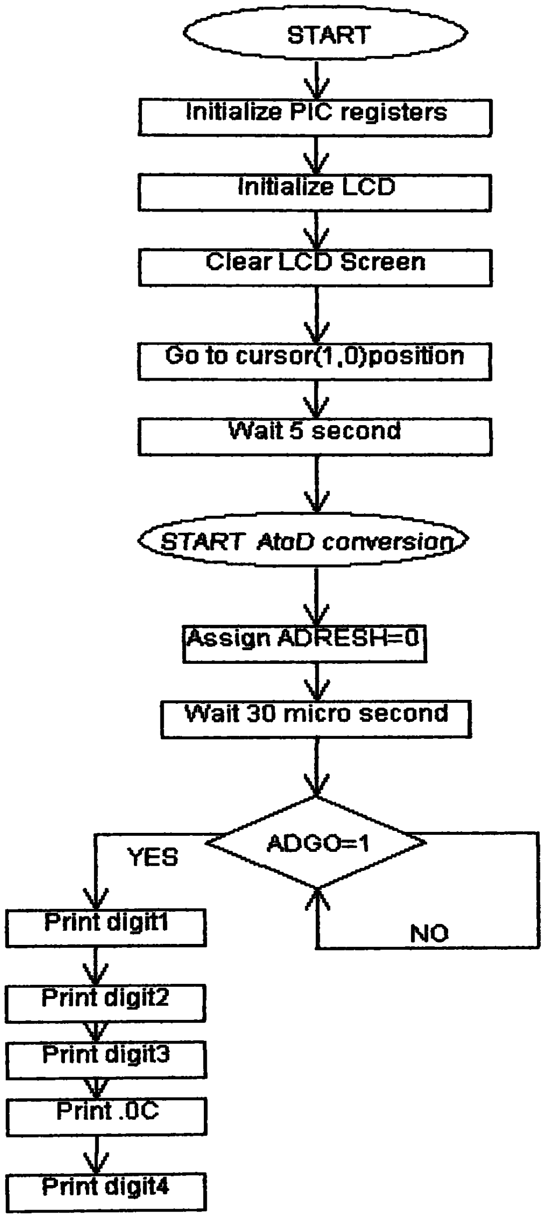


Figure 3.21 Flow Chart of Functions

Programming codes:

```
# include <pic.h>                                    //Header files
#include <lcd.h>
# include <delay.h>
# include <stdio.h>
static bit LCD_RS      @ ((unsigned)&PORTB*8+1);  // Register select
static bit LCD_EN      @ ((unsigned)&PORTB*8+2);  // Enable
#define LCD_STROBE ((LCD_EN = 1),(LCD_EN=0))
unsigned char lcd_add@ 0x140, lcd_wr@ 0x141 ;
void Initialize(void);                            //Initialize PIC register
void lcd_init();                                  //Initialize LCD
void Address(void);
void lcd_clear(void);                             //Clear LCD
void Line_1(void);
void Line_2(void);
void Cursor_Right(void);                          //Move to the cursor right
void lcd_gotoxy (char row, char col);             //Go to position
void writeInt(int int_i_want_converting);         //Print value on LCD
void start_a2d(void);                             //Start A/D conversion
void forconversion(void);
void lcd_putch(char c);                           //LCD print character
int Digit1,Digit2,Digit3,Digit4;                  //Initialize the digits
int temp;
//Start main function
void main()
{
Initialize();
lcd_init();
    while(1)
{
```

```
lcd_clear();                    //Clear the LCD before printing
lcd_gotoxy (1,0);               //Go to Position 1,0
lcd_puts("TEMP=");              //Print TEMP
DelayMs(100);                   //Delay
DelayMs(200);
start_a2d();
}
}



void Initialize()
{
// Initialize PIC registers
    OPTION = 0x80;     // setting bit7 is disabling all weak internal pull-ups.
     INTCON = 0x00;
    TRISB = 0x00;              // RA1 - RA2 (outputs to LCD, RA0-register select,
                                         RA1-Enable))
    TRISC=0x00;            // RC0 -RC3  are outputs (to LCD)
    PORTB=0x00;
    TRISA=0xFF;
}
void lcd_init(void)
{
LCD_RS = 0;                      // write control bytes
        DelayMs(15);             // power on delay
        PORTC = 0x3;             // attention!
```

```
LCD_STROBE;
        DelayMs(5);
        LCD_STROBE;
        DelayUs(100);
LCD_STROBE;
        DelayMs(5);
        PORTC = 0x2;            // set 4 bit mode
        LCD_STROBE;
        DelayUs(40);
        lcd_write(0x28);        // 4 bit mode, 1/16 duty, 5x8 font
        lcd_write(0x08);        // display off
        lcd_write(0x0F);        // display on, blink curson on
        lcd_write(0x06);        // entry mode
}
void lcd_puts(const char * s)   //Print character
{
        LCD_RS = 1;             // write characters
        while(*s)
                lcd_write(*s++);
}
void lcd_putch(char c)
{
LCD_RS=1; //- write characters
lcd_write(c);
}
void Address(void)
{
LCD_RS = 0;
        DelayUs(160);
```

```
        lcd_write(lcd_add);
}
void
DelayMs(unsigned char cnt)
{
#if     XTAL_FREQ <= 2MHZ
        do {
                DelayUs(996);
        } while(--cnt);
#endif
#if  XTAL_FREQ > 2MHZ
        unsigned char   i;
        do {
                i = 4;
                do {
                        DelayUs(250);
                } while(--i);
        } while(--cnt);
#endif
}
void lcd_write(unsigned char c)
      {
        PORTC = (PORTC & 0xF0) | (c >> 4);
        LCD_STROBE;
        PORTC = (PORTC & 0xF0) | (c & 0x0F);
        LCD_STROBE;
        DelayUs(40);
        }
}
```

```
void Line_1(void)
{
        lcd_write(0x80);
}
void Line_2(void)
{
        lcd_write(0xC0);
}
void Cursor_Right(void)
{
        lcd_write(0x14);
}
void
lcd_clear(void)
{
LCD_RS = 0;
lcd_write(0x1);                 //Clear the Display
DelayMs(2);
lcd_write(0x02);                // Home the display
DelayMs(2);
}
void writeInt(int int_i_want_converting)          //Print integer
{
        char str[16];
        sprintf (str, "%d", int_i_want_converting);
        lcd_puts(str);
}
void lcd_gotoxy (char row, char col){
int i;
```

```
        if (row == 1)
        Line_1();
        if (row == 2)
        Line_2();
        for ( i = 0; i < col; i++)
        Cursor_Right();
}
void start_a2d(void)              //Start A/D Conversion
{
ADCON1 = 0x00;
ADCON0 = 0x00;  // AN1
ADON = 1;
ADRESH = 0x00;                    //Put 0 to ADRESH Register

DelayUs(30);
forconversion();                  //For print Digit
temp=((ADRESH*100)/255);
temp=temp*10;
Digit1=temp/1000;
DelayMs(2);
writeInt(Digit1);                 //Print Digit 1
DelayMs(200);
DelayMs(200);
temp=temp%1000;
```

```
DelayMs(2);
Digit2=temp/100;
writeInt(Digit2);          //Print Digit2
DelayMs(100);
DelayMs(200);
temp=temp%100;
DelayMs(2);
Digit3=temp/10;
writeInt(Digit3);          //Print Digit3
DelayMs(200);
lcd_puts(".");             //Print .
temp=temp%10;
Digit4=temp;
writeInt(Digit4);          //Print Digit4
DelayMs(100);
lcd_putch(0xDF);           //for print degree
lcd_putch(0x43);           //for print capital "C"
DelayMs(200);
DelayMs(200);
lcd_clear();               //LCD clear
}
void forconversion(void) {
ADGO=1;
        while(ADGO)
        continue;
}
```

CHAPTER 4 RESULTS AND DISCUSSION

4.1 DISCUSSION

When design this Data Display system mainly I used PIC16F876A Microcontroller and 16×2Character LCD (which has PCD8544 LCD controller).

The PCD8544 interfaces to microcontrollers through a serial bus interface. So SPI mode of the microcontroller can be easily used to drive the LCD.

The PCD8544 is a very low power CMOS LCD controller/driver and it has designed to drive a graphic display of 48 rows and 84 columns. Due to low power consumption this LCD is very suitable for the battery operated systems like Data Display System for a Data Logger.

Economically more benefits Nokia 3310 phone LCD than 16×2 Character LCD.But it can not be directly interface the bread board because it Pins small than the 16×2 Character LCD .And another disadvantage of this LCD is this is physically small.

When design the Temperature sensor circuit I was used LM 35 Temperature Sensor as my Sensing device. It output is a voltage signal which is very weak signal so an amplifier was use to amplify this voltage here I used OPA 340 as my Operational Amplifier. But it is not the local market to buy.LM741 is most common Operational amplifier and can buy easily in the local market. But its Supply voltage is higher than the OPA 340.This system is battery operated so OPA340 is more suit than the LM741 Operational Amplifier.

4.2 RESULTS

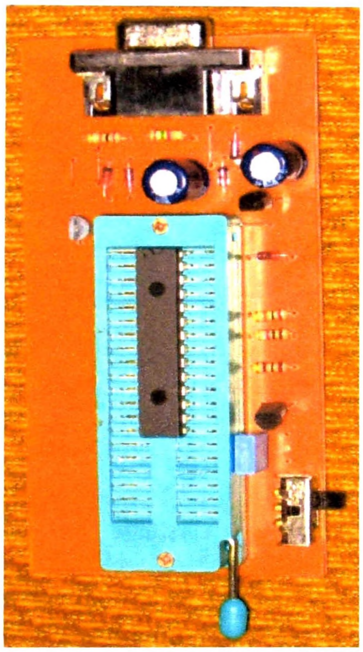


Figure 4.1 Demonstration Board of PIC Programmer

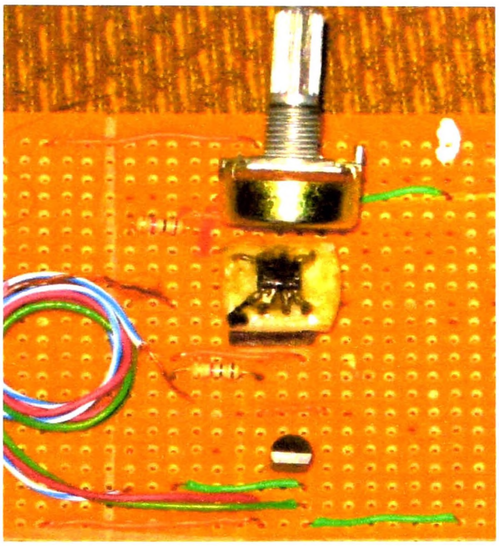


Figure 4.2 Demonstration Board of Temperature Sensor circuit

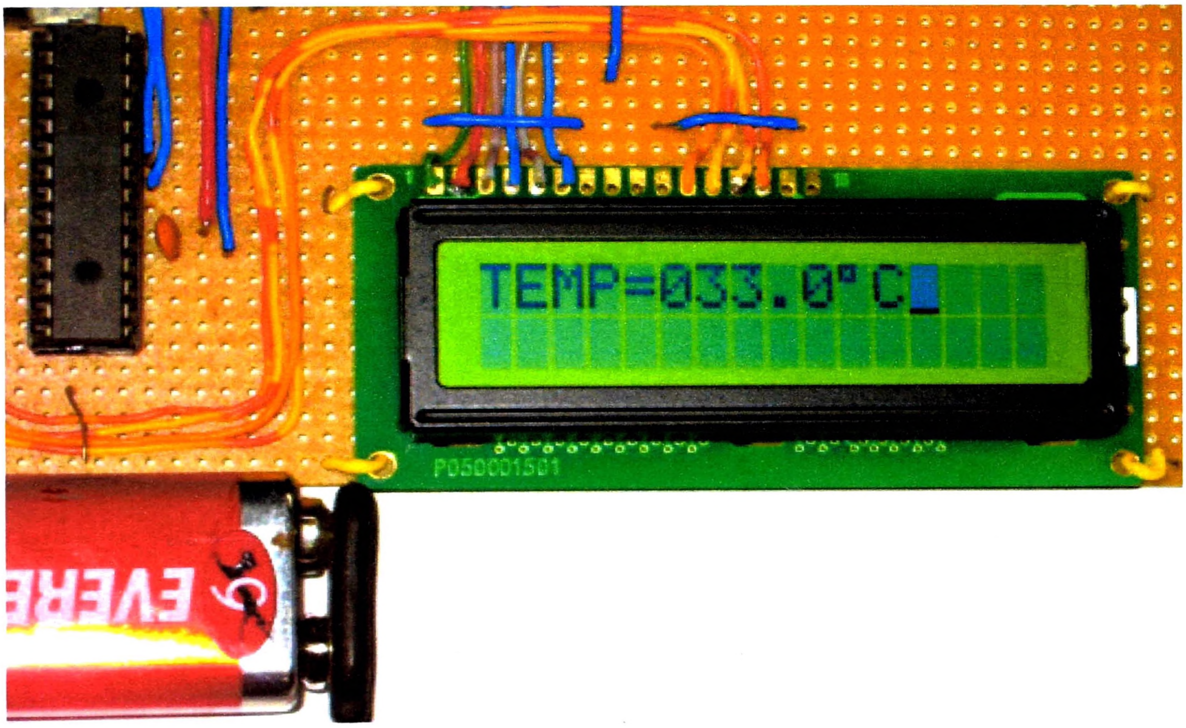


Figure 4.3 Demonstration Board of Data Display System

CHAPTER 5 CONCLUSION AND FURTHER STUDIES

5.1 CONCLUSION

Temperature sensing unit was designed & tested successfully. The successful operation of the unit was also carried out in the presence of numerous tests. We have done for two parameter, but the same can also be done for 3 or more parameters like pressure, viscosity .This system is cost-effective and time efficient in its operation.

5.2 FURTHER STUDIES

Some of the future developments could also be discussed as follows. We were successful in sensing the temperature as one of the data and displaying the same on the LCD.We can add other parameters like voltage, pressure, Viscosity etc.To the existing work done in this project. This system can be calibrate and used as a display system for a data logger.

The graphical LCD can also replace the typical LCD so that the user can know the status of the parameter being measured using the graphical LCD rather than the typical LCD, so that the designed unit can be more user friendly and user interactive.

REFERENCES

Alexander.C.K,Sadiku.M.N.O (2002) Fundamentals of electric circuits,173-191,249-285pp In: Published by McGraw-Hill,a business unit of the Mc Graw-Hill Companies,Second edition,904p

Andreu.D,Bialko.M,Carmpagne.R (1995) Basic methods for microcomputer-Aided analysis of electronic circuits,1-25,233-303pp In: Prentice Hall International(UK)Limited,455p.

Antonic,V.(1990) Embedded Control Handbook,2-139pp In: Microchip Technology,1074p.

Clements.A(1992) Microprocessor system design,1-41,629-664pp In:Pws publishing company is adivision of wadsworth,895p.

Horn,D.T. (1994) Basic Electronics Theory, 1-239pp In:TAB Books is a division of McGraw-Hill, Fourth edition,647p.

Keown.J.(1991) PSPice and circuit analysis, 7-74,81-110pp In: Collier Macmillan Canada,331p.

Wilmshurst.T.H.(2001) Analog circuit techniques,240-251pp,ingreat Britain publisher,311p.

Introduction to temperature sensor or Homepage, URL: http://www.capgo.com, 14th February 2009 – [www1}

Temperature sensor or Homepage, URL: www.temperatures.com, 16th February 2009 – [www2]

Introduction to Humidity sensor or Homepage, URL: www.sensorsmag.com/, 16th February 2009 –[www3]

Operational amplifier or Homepage, URL: http:// en.wikipedia.org, 17th February 2009 – [www4]

Operational amplifier or Homepage,URL: http://research.cs.tamu.edu, 17th February 2009 – [www5]

Introduction to NE555 or Homepage,URL: http://en.wikipedia.org, 17th February 2009 – [www6]

Introduction to Regulator or Homepage, http://en.wikipedia.org, 19th February 2009 – [www7]

Introduction to CD74HC4060E or Homepage,URL: http://parts.digikey.com, 19th February 2009 – [www8]

Introduction to LCD display or Homepage,URL: http://en.wikipedia.org, 19th February 2009 – [www9]

Introduction to IC PROG or Homepage,URL: http://www.best-microcontroller-projects.com, 19th February 2009 – [www10]

16F87XA microcontroller data sheet,URL: http://www.robotics-bg.com, 21st February 2009 – [www11]

PCD 8544 LCD controller data Sheet,URL: http://www.datasheetcatalog.com,21st February 2009 – [www12]

National Digitization Project

National Science Foundation

Institute : Sabaragamuwa University of Sri Lanka

1. Place of Scanning : Sabaragamuwa University of Sri Lanka, Belihuloya
2. Date Scanned : ..2017-09-22..
3. Name of Digitizing Company : Sanje (Private) Ltd, No 435/16, Kottawa Rd, Hokandara North, Arangala, Hokandara
4. Scanning Officer

Name : .....S. A. C. Gandaruwan.....................................

Signature : ....

Certification of Scanning

I hereby certify that the scanning of this document was carried out under my supervision, according to the norms and standards of digital scanning accurately, also keeping with the originality of the original document to be accepted in a court of law.

Certifying Officer

Designation : LIBRARIAN..

Name : T.N. NEIGHSOOREI..

Signature : ....

Date : ....2017-09-22.........

Mrs. T.N. NEIGHSOOREI
(MSSc.PGD.ASLA,BA)
Librarian
Sabaragamuwa University of Sri Lanka
P.O.Box 02,Belihuloya,Sri Lanka
Tele:0094 45 2280045
Fax:0094 45 2280045

"This document/publication was digitized under National Digitization Project of the National Science Foundation, Sri Lanka"