

MU'TAH UNIVERSITY WEATHER STATION DESIGN

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ABSTRACT

Weather forecasting and prediction have a great importance in the modern science and technology, because of its impact on other fields such as aviation and navigation fields.

Weather stations may not cover large area and may have huge size, but wireless communication solves this problem by using sensors in far place which sends the data to the center. This center is connected directly to a server and then this server publishes this information to the whole world. This web pages will that display the current weather conditions and also any archived weather measurements the user would like to see.

The main goal of this project is to design and implement a weather station for Mu'tah University, The measurements and calculations are displayed on a webpage that is accessible to the public. The webpage will also be able to display previously stored data. The stored data will be available for anyone who needs the measurements for research.

Intelligent device or may be called microcontroller is used in this project in order to perform some processing on the data collected from the sensors. This device can be used in other application and it is smaller and cheaper than a computer.

DEDICATION

*This project is dedicated with affection, to the
dearest people, to our parents who helped us to
reach this point...*

And to everybody help us in our work,

ACKNOWLEDGEMENTS

We would like to express our profound gratitude to **Allah** who give us excellence and diligence, and guide us to the correct path to get to this point.

We also offer great thanks and appreciation to our supervisor **Dr. Yazeed Al-Sbou.**

We thank our teachers who have dedicated themselves to help us and provide everything possible for us as students.

Qusai, Abdel-Karim and Tariq

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ABBREVIATIONS

BAUD	Baud rate
CIP	Channel Interface Processor
DCE	Data Communications Equipment
DTE	Data Terminal Equipment
EEPROM	Electrically Erasable Programmable Read-Only Memory
EIA	Electronics Industry Association
HTML	Hyper Text Markup Language
IRQ	Interrupt Request
LDR	Light Dependant Resistors
LCD	Liquid Crystal Display
MPU	Micro Processor Unit
NOAA	National Oceanic Atmospheric Administration
PIC	Programmable Interface Controller
PSP	Parallel Slave Port
RXD	Receive Data
SCI	Serial Communications Interfaces
SFR	Special Function Registers
SPP	Standard Parallel Port
TA	Terminal Adapter
TXD	Transmit Data
TE	Transmitter Enable
UART	Universal Asynchronous Receiver Transmitter

CHAPTER ONE

INTRODUCTION

On an everyday basis, people use weather forecasts to determine what to wear on a given day. Since outdoor activities are severely curtailed by heavy rain, snow and the wind chill, forecasts can be used to plan activities around these events, and to plan ahead and survive them.

Weather can be described as the overall effect of what is happening in the air around us. Weather includes rain, snow, and other types of precipitation, plus humidity, temperature, wind direction, wind speed, cloudiness, and air pressure. All of these factors added together give us the term “weather.” Weather is constantly changing in all parts of the world. This is due to the earth’s rotation, position of the sun, land formations, and air masses [1].

1.1 Aims and objectives

The objectives of our senior project is to implement a general purpose weather system based on wireless sensors station using some basic components like PIC (Programmable Interface Controller) 16F877A, sensors, transmitter and other components. In addition it gives solution of some problems such of how to properly integrate and use the serial transmitter in the used circuit. It provides the reader with the basics about connecting multiple weather sensors to the PIC in order to form a simple weather forecast. It aims also on identifying more of important ICs such as CIP-8Encoder and CIP-8Decoder. There are, however, many alternatives for designing and implementing the weather station itself.

In general our weather system which will take many measurements and store them on a database. Then eventually the system will provide these measurements on the website of the University of Mu’tah to be available for the visitors of the website of the university.

The weather station consists of two physical parts: sensor station and server. The sensor station acquires data and then sends the data to the server. The server performs any necessary calculations and then stores all the data. The university webpage is then provided with the current and archived weather conditions and measurements.

1.2 Motivation

The project motivation comes from the idea that the students and also the employees of the university need to know the weather conditions so that they can properly ready themselves to the weather conditions which may be unexpected and/or dangerous like a very cold weather. In addition to that the neighbor population of the university or any visitors to the university or its region may refer to the website of the university to know the weather conditions.

In general, the website will provide its visitors with the weather measured conditions and in addition to that it may provide them with weather expectation for a week ahead.

1.3 History

Weather forecasting is defined as the application of science and technology to predict the state of the atmosphere for a future time and a given location. Human beings have attempted to predict the weather informally for millennia, and formally since at least the nineteenth century. Weather forecasts are made by collecting quantitative data about the current state of the atmosphere and using scientific understanding of atmospheric processes to project how the atmosphere will evolve [2].

Over the years, there have been many different implementations and designs for weather systems. One implementation was by Dallas Semiconductors and Texas Weather Instruments. The goal of their design was to reduce the cost of weather systems and make them more efficient. They have achieved that by transmitting both power and bi-directional data over a single twisted wire cable [2].

This cable acts as a bus for any sensor. This allows for easy addition or removal of sensors without needing to add or remove wires. Additionally, multiple weather stations are capable and have the option of using the same bus depending on their application. In this implementation, the sensors used were specifically designed to work with the bus (i.e. the sensors must be compatible with this bus) [3]. Therefore, if a new sensor needed to be added, it either had to work with the bus or an intermediate circuit needed to be designed to interface with the bus (i.e. to organize the using of the shared bus among of the different sensors that are used).

Another implementation was by Purdue University. They purchased an entire weather station made by Davis Instruments and focused on using the data measured to create an informational web page. Their implementation was to read data every five seconds using a Visual Basic script. Then, every five minutes they would transfer the data to a web page server. They would then use a PERL script to generate the web page from the data every time the web page was loaded [4].

Jerry Wasinger designed an implementation, which is more closely related to our planned design. Wasinger's system consists of a remote station that includes sensors to take measurements of the weather conditions. The remote station is solar powered and wakes up once a minute to collect and transfer data. The data is sent through an RF circuit card to a base station. The base station receives and buffers the data and transfers it to a personal computer. Wasinger uses a simple program in Visual Basic to collect data, perform calibration corrections, and display it on the screen [5].

CHAPTER TWO

THEORY AND BACKGROUND

2.1 Introduction

Over the years, weather forecasting has gone from simple observation to a modern form that uses technology, science, and advanced math to accurately predict the weather. Gathering of information is always the first step needed in weather forecasting.

Some of the tools used today to gather information include computers, radar, satellites, and weather balloons. Twice a day weather balloons are launched all over the world. These balloons record data such as temperature, pressure, humidity, and wind speed at different heights in the atmosphere. Satellites allow meteorologists to see what the earth and clouds look like from space. Doppler radar looks into clouds with radio waves to see how rain or snow is acting and how it might change. All of this information is then loaded into computers. The computers put the information on maps, then meteorologists read the maps and make a weather forecast according to the data presented [5].

Many different people forecast the weather such as local television meteorologists and scientists at the National Oceanic Atmospheric Administration (NOAA). Anyone can be a weather forecaster even if they don't have technical monitoring equipment available.

2.2 Weather Forecasting

Weather is a collection factors contact with each other to make something in the air which effect in the overall things happen around us, these factors can be determined as the following:

2.2.1 Clouds

One of the best and easiest ways to forecast the weather is by observing clouds. Clouds give clues about what is happening in the atmosphere and how the weather might change in the hours or even days to come. Each type of cloud forms in a different way, and each brings its own kind of weather [6].

Clouds are formed when particles of dust, dirt, or salt are in the air. Water vapor condenses onto these particles and rises into the air to make clouds. There are three basic types of clouds: Cumulus, Stratus, and Cirrus. Clouds form at different levels in the atmosphere and have a prefix attached to their name that identifies the level. High clouds have the prefix “cirro”, middle clouds have the prefix “alto” and low clouds do not have a prefix. If a cloud produces rain or snow it has either “nimbo” added at the beginning or “nimbus” at the end [5].

Cumulus clouds are the large, billowy clouds that look like heaps of cotton balls. They are as tall as they are wide and are considered low level clouds. They form on sunny days from rising pockets of air. Cumulus clouds usually signal fair weather, but if they rise to the middle or high levels of the atmosphere they become cumulonimbus clouds. The clouds usually bring severe weather that includes lightening, thunder, damaging winds, and even tornadoes [5].

Stratus clouds are layered and cover the sky. They are much wider than they are tall. If the clouds are in puffy or broken layers, they are stratocumulus clouds. If they are in high layers that turn the sky solid white, they are cirrostratus clouds. Cirrostratus clouds are formed by ice crystals high in the atmosphere. When stratus clouds are very thick, they become dark nimbostratus clouds, which can produce rain, drizzle, or snow.

Cirrus clouds are found at the highest level and are formed by ice crystals. They are often referred to as “Mare’s Tails” because of their thin, wispy look. Cirrus clouds are a sign of warm moist air rising up over cold air. They are sometimes an early signal that thickening clouds could bring light rain or snow within one or two days [5].

We can sense the clouds by our eyes, but for weather forecasting and prediction the satellite images shall give an exact prediction for the clouds and its motion also these images can determine the height of this clouds.

2.2.2 Air Pressure

Barometric pressure, otherwise known as air pressure, is directly involved with weather changes. Air pressure is the force exerted by the weight of a column of air above a particular location. It can be compared to the weight of water pressing down on a person as they dive deep into a pool of water. The weight of the atmosphere decreases as you go up in the atmosphere. People can feel the effect of air pressure as they hike up and down mountains or fly up and down in airplanes [4].

A barometer is used to measure air pressure. It indicates whether the pressure is rising or falling. A rising barometer indicates increasing (or high) air pressure and means sunny and dry conditions. A falling barometer indicates decreasing (or low) air pressure and means stormy or wet conditions.

Several different barometers exist; two of the most common are the mercury barometer and the aneroid barometer. The mercury barometer is a tube with a reservoir of mercury at one end. Under average sea level conditions, the atmosphere exerts enough pressure to push a column of mercury up to the height of 29.92 inches, figure 2.1 shows the mercury barometer and how it is work the aneroid barometer uses an *aneroid* or *sylphon* cell to measure pressure. The aneroid cell is a metal chamber that expands and contracts with changing air pressure.

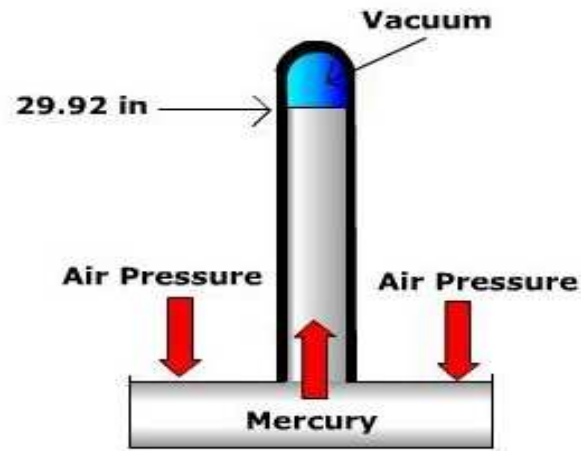


Figure 2.1: Mercury barometer.

Average sea level pressure serves as the division between what we call "high pressure" and "low pressure" at the surface. High pressure is defined as values greater than 1013.2 mb and low pressure is below 1013.2 mb [7].

When air is warmed by the sun, it expands, gets lighter and rises. In a low pressure center warm, moist air rises and favors the development of clouds and precipitation. A high pressure center suppresses the upward movement of air that is needed to support the development of clouds and precipitation. This is why fair weather is commonly associated with an area of high pressure.

Since cold air weighs more than warm air, the pressure of cold air is greater. Cooler, heavier air blows to where the warmer and lighter air was, or in other words, wind usually blows from areas of high pressure to areas of low pressure. If the high pressure center is very close to the low pressure center, or if the pressure difference (or temperature difference) is very great, the wind can blow very fast [4].

2.2.3 Wind Speed

Depending on the speed of wind, air masses can frequently be pushed together causing warm and cold fronts. When two fronts collide it can cause severe storms. From

October through May different air masses often come in contact over Lake Erie causing storms. During this period storms can occur one out of every four days. The most violent storms occur in the fall and spring when winds have been measured at over 62 miles per hour. In July, average wind speeds at Lake Erie vary from 9 to 14 miles per hour. In the other three seasons the wind speeds are higher, averaging 11 to 16 miles per hour. The most common wind direction is from the south/southwest with the most severe winds moving from the west at speeds up to 45 miles per hour [8].

Many devices are designed to determine the speed of the wind, but all of these depend on the same technique that can be described as follows: The lightweight three or four cups anemometer is directly coupled to a slotted disc chopper wheel. Figure (2.2) shows the wind speed sensor with three cups. The chopper rotates and interrupts the light path of an optical link. The signal is amplified and produces pulsed frequency output proportional to wind speed. Typically, the pulsed output signal is applied to Met One Instruments' Wind Speed Translator Module for conversion to analog voltage/current output signals [5].



Figure 2.2: three cups wind speed sensor.

2.2.4 Wind Direction

Wind direction can also predict if there will be a change in the weather. Wind moving from the south usually brings warm, moist air and wind from the north brings cold, dry air. Winds moving from the west are called “westerlies” and these are the winds that move across North America. Winds from the northwest, west, and southwest tend to bring good weather. Winds from the east, southeast, and south often bring stormy weather.

We can determine the wind direction by using wind vane, figure 2.3 shows the typical wind vane and the wind map, where both of them are complemented to other.

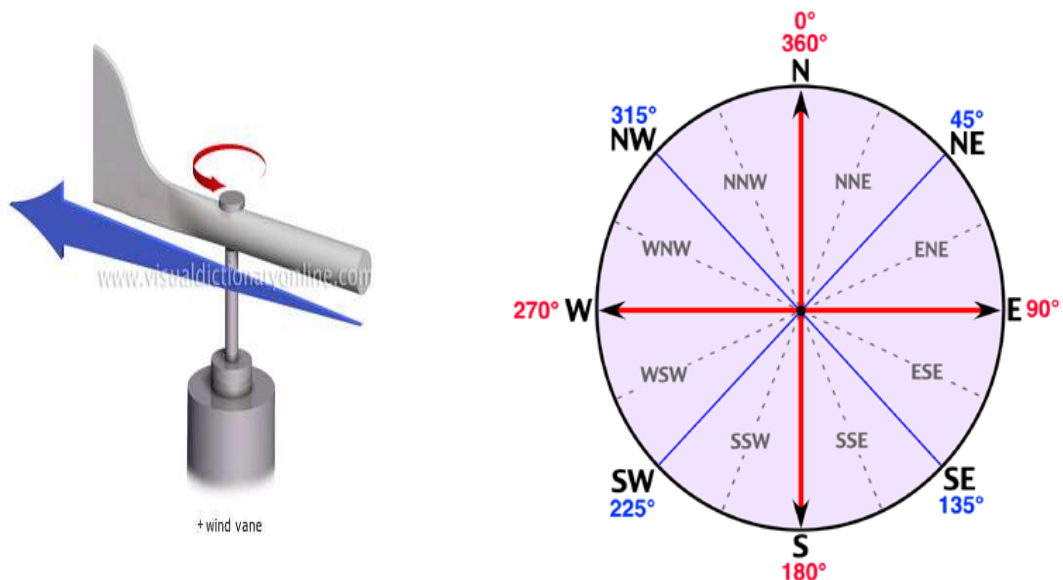


Figure 2.3: Wind vane and map

2.2.5 Temperature

Temperature is a measure of heat content. The air temperature at any place is determined by:

1. Radiation and heat transfers between the surface and the air above.
2. The location relative to a large body of water
3. The movement of vast pools of air called air masses.

The immediate source of energy that heats the air is the surface of the earth. The sun heats the land and the land gives off radiation that warms the air. Clouds have an impact on the radiation balance and air temperature of a place. Clouds can block incoming solar radiation by reflection off their tops. Clouds also act to spread out the light as it penetrates towards the surface [3].

Both of these would act to cool the air. In reverse, clouds and water vapor absorb the radiation given off by the land and send it back down to the earth, warming the air. The coldest evenings occur during cloudless conditions. When days and nights are both cloudless, the earth warms significantly during the day raising the air temperature but at night the heat radiation escapes into space dropping the temperature significantly [3].

Air temperature is also greatly affected if it is close to a large body of water such as Lake Erie. Air temperature near or over bodies of water are much different from that over land due to differences in the way water and land cools. Water is transparent and land is not. Water allows light to penetrate deep, leaving the surface layers cooler than they would be if the surface was not transparent. A cooler water temperature results in cooler air temperatures above. Much of the heat on land is transferred into the air but on water most of the heat is used for evaporation [3].

With little energy used for heat transfer into the air, the air over water remains cooler than that over land. Air masses influence temperature depending on the source of the air mass. If you live in Canada which is the source of the continental polar air mass, you can expect temperatures to remain somewhat constant ranging from cool to cold temperatures. Erie is subject to a greater variation in temperature because it is in a zone that experiences several different air masses [3].

In general, accurate weather predictions are not always possible because of the large number of variables involved. No one is ever certain what the exact weather will be at a particular time, but careful observation of the environment can provide clues as to what may happen in the near future.

CHAPTER THREE

HARDWARE SPECIFICATIONS

To build the weather system various components are needed, some components are needed for acquisition of the measurements from the sensors, other components needed to transmit these measurements and deliver them eventually to the computer. In this project the following components have been used:

1. PIC16F877A.
2. Special Decoder and Encoder.
3. Transmitter and Receiver.
4. Sensors.
5. LCD.
6. Serial Port (RS232).

3.1 PIC16F877A

At first we should generally define the PIC microcontroller. The PIC stands for **Programmable Interface Controller** which is a low cost and powerful IC (Integrated Circuit) used in many applications such as robots controlling, motors, connecting several analog or digital inputs and for other applications. There are various types of PICs such as PIC16F873A, PIC16F874A, PIC16F876A and PIC16F877A. We have chosen PIC16F877A for the following characteristics:-

- It has 5 I/O ports that enable interfacing with the outer world.
- It includes 15 interrupts.
- It has 8 A/D input channels that accept analog data and translate it into ten bits of digital data.
- The parallel slave port is implemented in it.

- Have 8k 14-bit words of flash program memory.
- The operating frequency is up to 20 MHz DC.
- Have 40 pins.
- Have three timers. [9]

Figure 3.1 shows the pin out of the PIC16F877A.

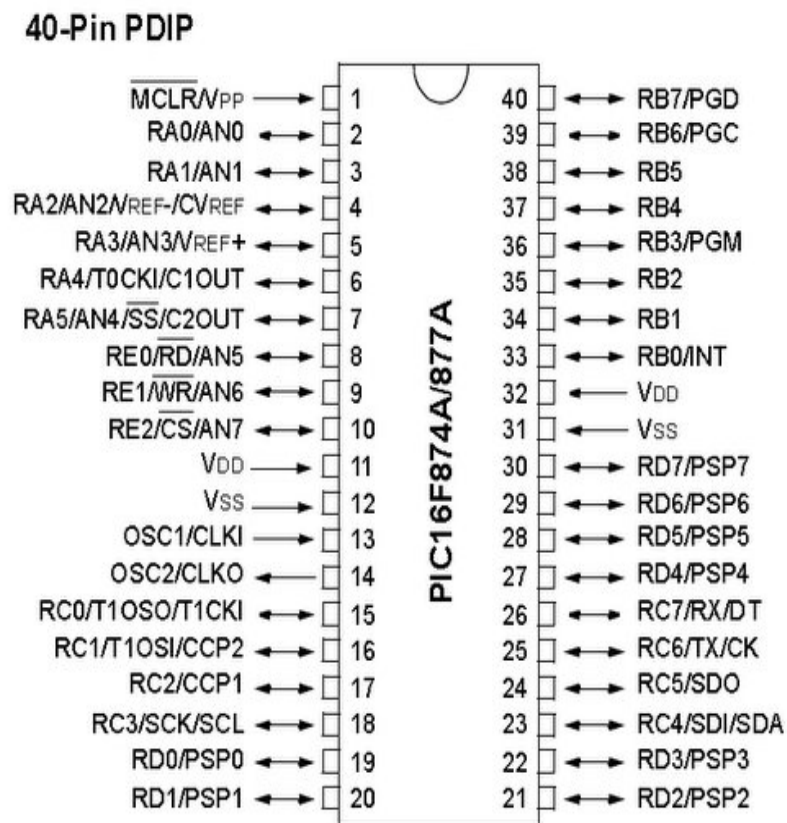
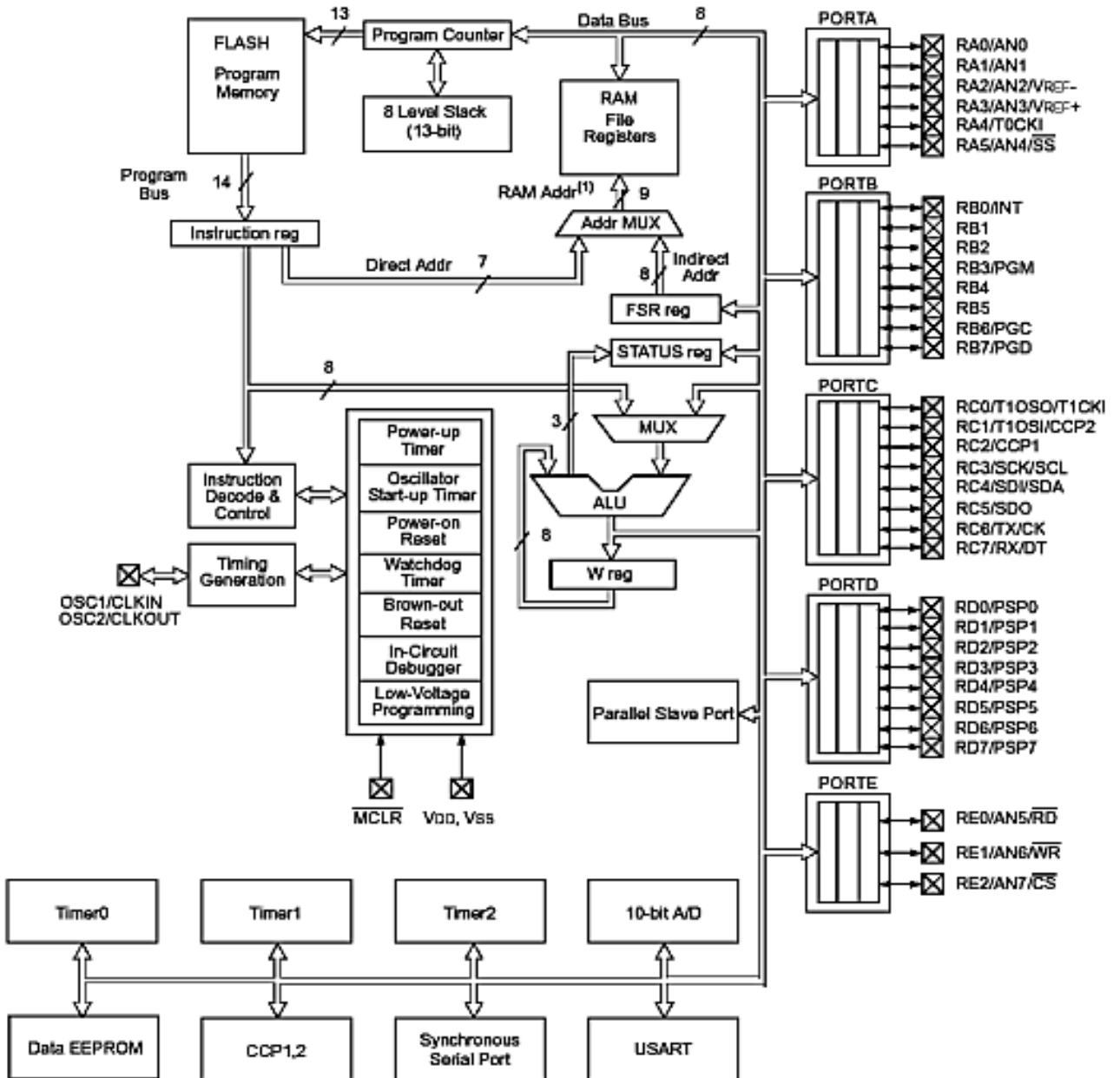


Figure 3.1: The Pin out of the PIC16F877A

These features and other is viewed in figure 3.2 which shows the block diagram of the PIC16F877A.

Device	Program FLASH	Data Memory	Data EEPROM
PIC16F874	4K	192 Bytes	128 Bytes
PIC16F877	8K	368 Bytes	256 Bytes



Note 1: Higher order bits are from the STATUS register.

Figure 3.2: The internal block diagram of the PIC16F877A

3.1.1 PIC Pin Out Description

PIC16F877A pin out is as follows:-

- #MCLR: It's either an active low Master Clear input used to reset the PIC. [9]

Port A pins: It is composed from 6 pins that function as digital I/O pins or analog input:

- RA0: Digital I/O or analog input 0
- RA1: Digital I/O or analog input 1
- RA2: Digital I/O or analog input 2
- RA3: Digital I/O or analog input 3
- RA4: Digital I/O.
- RA5: Digital I/O or analog input 4 [9]

Port B pins: It is composed from 8 pins that function as digital I/O pins.

- RB0, RB1, RB2, RB3, RB4, RB5, RB6, RB7. [9]

Port C pins: It is composed from 8 pins that function as the following:

- RC0, RC1, RC2, RC3, RC4 & RC5 all used for digital I/O.
- RC6: used for digital I/O or as USART asynchronous transmit (TX).
- RC7: used for digital I/O or as USART asynchronous receive (RX).

Port D pins: It is composed from 8 pins that function either as digital I/O or as Parallel slave port.

- RD0, RD1, RD2, RD3, RD4, RD5, RD6, RD7. [9]

Port E pins: It is composed from 3 pins that function as the following:

- RE0/#RD/AN5: It is used for digital I/O, read control for the parallel slave port or for analog input 5 respectively.
- RE/#WR/AN6: It is used for digital I/O, write control for the parallel slave port or for analog input 6 respectively.
- RE/#CS/AN7: It is used for digital I/O, chip select control for the parallel slave port or for analog input 7 respectively. [9]

VSS & VDD: VSS correspond to ground connection and VDD correspond to 5 volt connection. There are others uses for these pins, return to the datasheet for extra reading.

3.1.2 Memory Organization

The PIC 16f877a contains three types of memory blocks as follows:

I. Program memory:

It is an 8K words memory with each word composed of 14 bits. For accessing any word of this memory the PIC contains a 13-bits program counter. Figure 3.3 shows the common structure of the Program memory. [9]

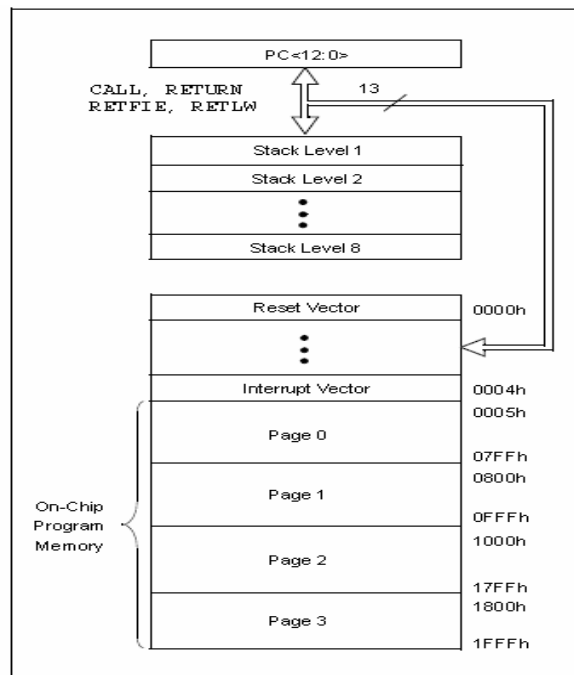


Figure 3.3: Program memory structure

II. Data memory:

It is divided into multiple banks that contain special function and general purpose registers, with each bank of 128 bytes, where RP0 and RP1 (STATUS 6 and STATUS

5 respectively) are used to select the required bank (see table (3.1)). The special function registers take the lower locations of these banks. [9]

Table (3.1): Bank selection of in the data memory

RP1:RP0	Bank
00	0
01	1
10	2
11	3

The register file can be accessed directly or by using File Select Register (FSR). Figure 3.4 shows the structure of the data memory registers with the corresponding address in hexadecimal. [9]

and when to write data) you need the control signals #RD, #WR and #CS. So you need to configure the TRISE register so that RE0, RE1 and RE2 function as inputs [9].

3.2 8-Bit Remote Control Encoder/Decoder IC's

3.2.1 Description

The Channel Interface Processor (CIP) series 8-bit encoder/decoder IC's is easy to use, low-cost solution for simple remote control applications in a convenient industry standard 20-pin. Figure 3.6 illustrates the pin out of the decoder and the encoder [10].

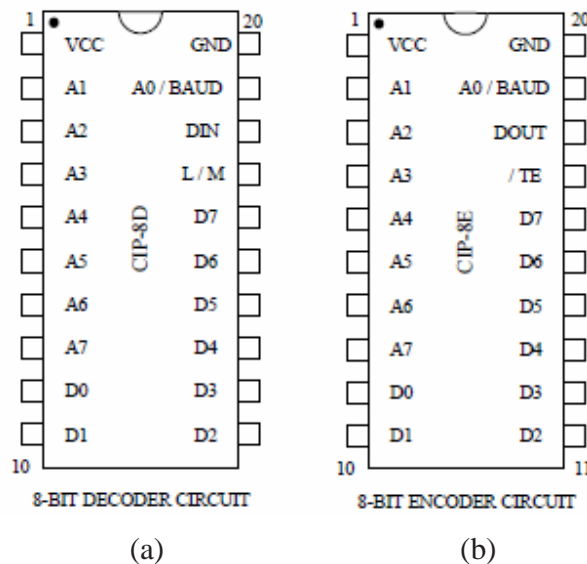


Figure 3.6: The pin out of both the a) decoder and b) the encoder

3.2.2 How does The Encoder Operate?

When we power-up the encoder it will be enter low power sleep mode. When the transmit enable pin is pulled to ground, the encoder will wake up and begin the transmit process.

The encoder will record the state of the 8-bit address/data lines, encode for error correction and assemble the packet. It will then sample the A0/BAUD pin to fix the data

rate, and then output the address and encoded data packet on DOUT. The encode/transmit process will continue for as long as the /TE pin is low, and return to low power sleep mode when /TE returns high. It will update the state of the address and data lines with each packet and finish the current transmission even after the /TE pin is released from ground. [10]

3.2.3 Encoded Data Packet

Each data packet consists of seven bytes of information to be transmitted.

- The preamble
- The synchronization byte
- The 1st address byte
- The 1st data byte
- The 2nd address byte
- The 2nd data byte
- The address/data checksum

A 10mS guard time is inserted between each encoded packet transmission to allow the decoder time to receive, decode, verify, and process each packet. The encoder returns to low power sleep mode for power conservation immediately once /TE returns to logic 1, and the packet transmission is complete [10].

3.2.4 Applications

This is some examples of Encoder Applications:

- Simple remote control
- Wire elimination
- Remote status monitoring
- Remote lighting control [10]

3.2.5 How does the Decoder Operates?

The decoder enters a timed loop waiting for the synchronization byte. An internal 16-bit timer is used to force an exit from the receive loop, and reset the output pins (in momentary mode) every 65.5mS if no valid synch byte is received during this time period.

Once a valid synch byte is received, the timer is disabled, and the remainder of the data packet is received and stored for the verification process. Immediately after receiving a valid data packet it begins the process of verifying the data, and checking it for errors.

Once data has been verified, the decoded data will be placed on the output pins, and the decoder re-enters the timed loop waiting for the next valid packet. If the decoder is operating in latch mode, the last valid 8-bit binary data value received will remain on the decoder outputs until a different valid binary data packet is received. [10]

3.2.6 8-Bit Decoder/Encoder circuit

Figure 3.7 illustrates an example connection of the 8-bit decoder.

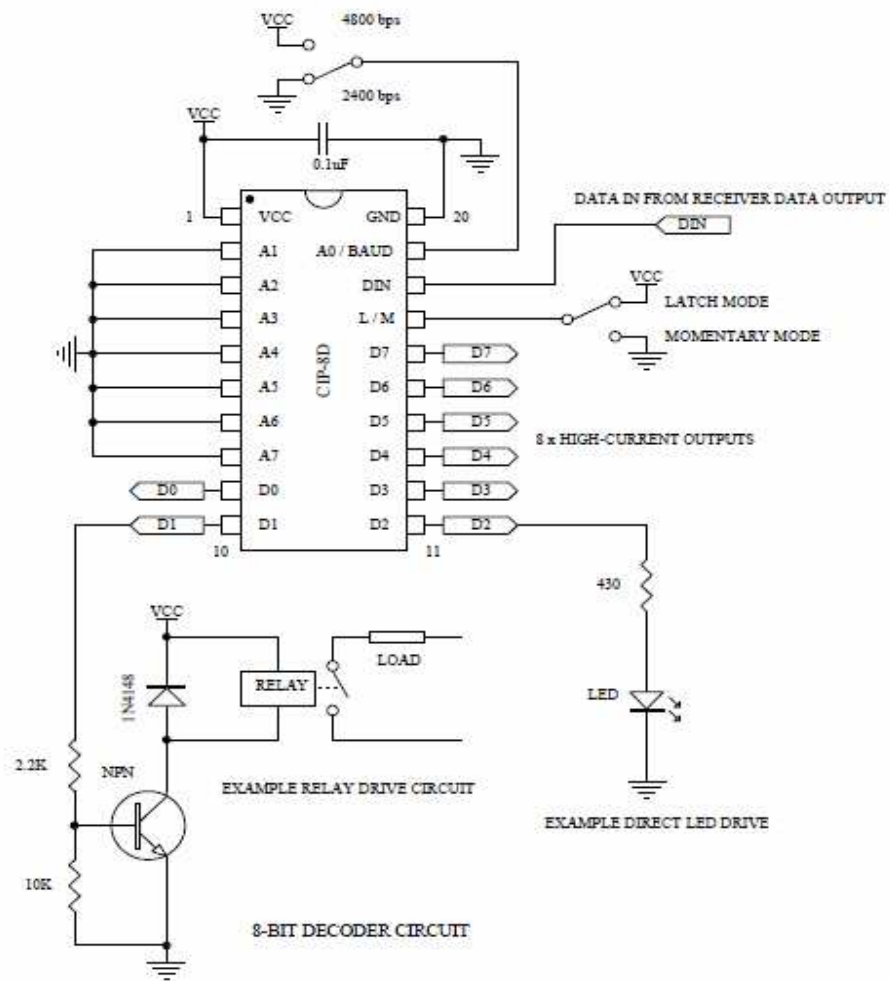


Figure 3.7: The CIP 8-bit decoder circuit [10]

Figure 3.8 illustrate an example of connection of the 8-bit encoder, in order to use in this project with 2400 Baud rate.

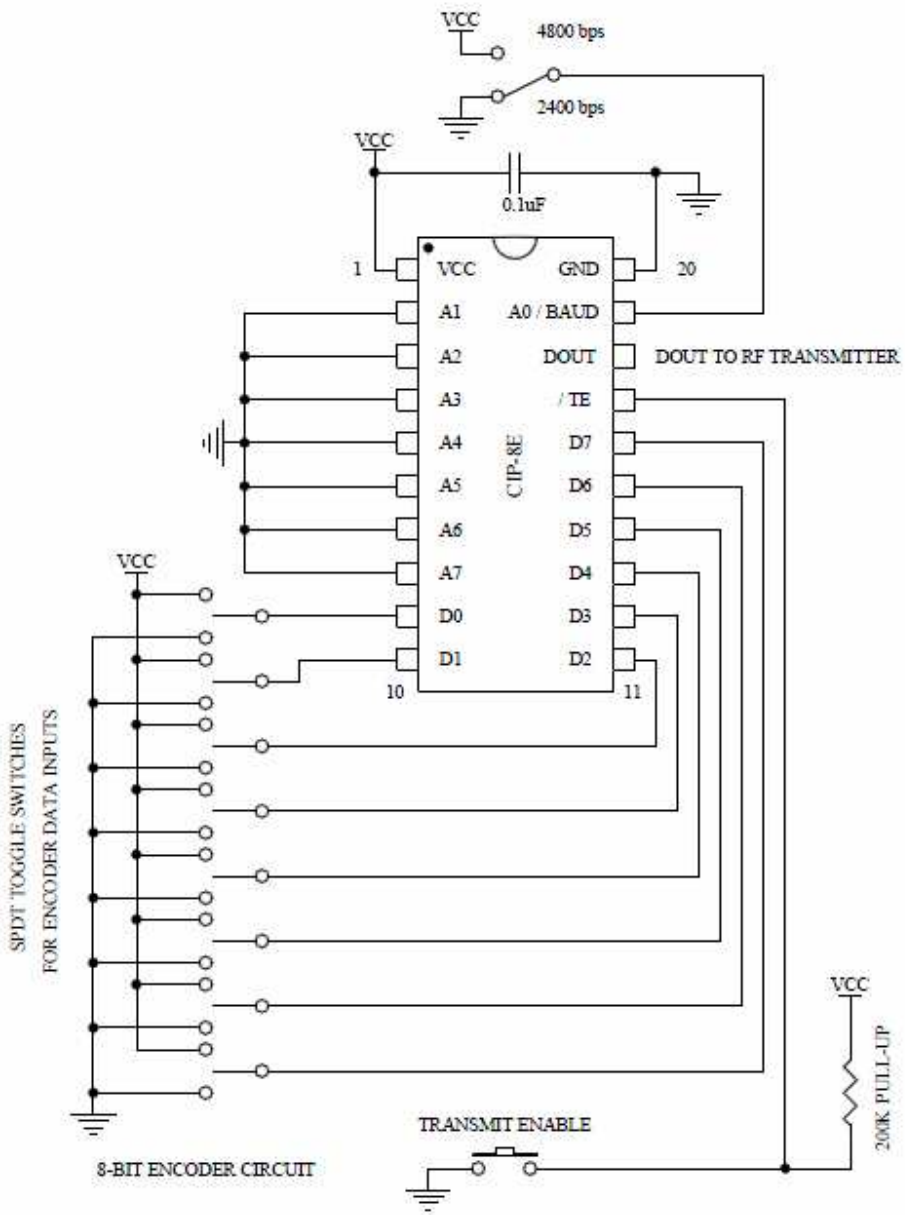


Figure 3.8: The CIP 8-bit encoder circuit [10]

3.3 The RF Transmitter and Receiver

3.3.1 Transmitter TX-4MSIL:

TX-4MSIL is a Small dimension and low consumption transmitter module with external antenna ideal for application when we need to modulate ON-OFF RF carrier with digital signals [11].

It uses voltage between 3 to 5 volt and must be supplied with at least 3 mA current. The carrier frequency for its signal is 433.92 MHz. To keep this transmitter in true operation and right work you must use it in the nature environment which means the temperature should be limited from -20°c to $+80^{\circ}\text{c}$. This factor and other are summarized in table 3.2 [11].

Table (3.2): TX-4MSIL transmitter characteristics.

Characteristics		Minimum value	Typical	Maximum value	Unit
V_s	Supply Voltage	3		5	Vdc
I_s	Supply Current	3		6	mA
F_C	Carrier Frequency		433.92		MHz
	Data transfer rate		9600		Bit/sec
F_m	Square wave modulation			4	KHz
L_1	Input logic level		V_s		
T_{op}	Operating temperature range	-20		+80	$^{\circ}\text{C}$
P_o	Effective Radiated Power (E.R.F)		2		dBm

Figure 3.9 shows the mechanical dimensions and the pins arrange on this transmitter.

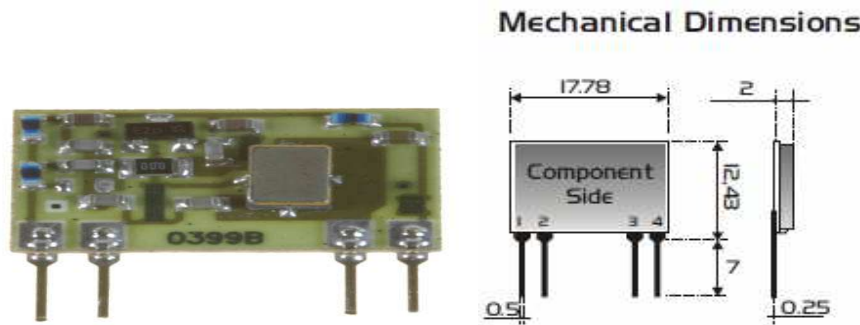


Figure 3.9: Mechanical Dimensions and the pin out of the TX-4MSIL.

Now, we describe the connection for the TX-4MSIL in the Table 3.3 as follows.

Table (3.3): TX-4MSIL transmitter pin out.

Pin number	description
1	RF output
2	Data input
3	Ground
4	+V

3.3.2 Receiver BC-NBK

BC-NBK it's a receiver can briefly describes by Digital RF receiver high-miniaturization SIL thick-film hybrid circuit. Low cost, low consumption, narrow bandwidth, high noise immunity and low antenna radiation. The 300 MHz version has a RF -3dB bandwidth at ± 2 MHz and can be used in conjunction with LC oscillator transmitters [6].Pin out of this receiver is shown in Figure 3.10:

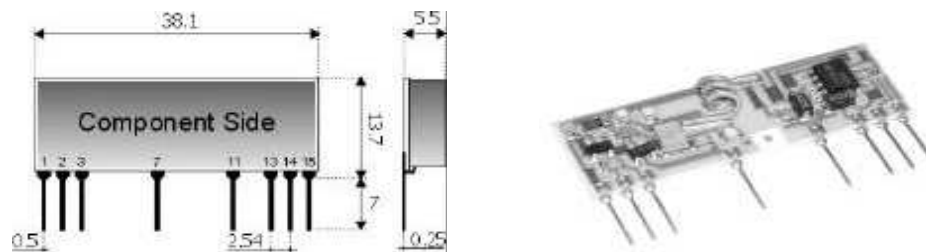


Figure 3.10: BC-NBK Pin out.

To connect this transmitter we should know the connections and the meaning for each pin which are described in the Table 3.4 as follows [12]:

Table (3.4): BNC-NBK Receiver connections

Pin 2-7-11	Ground	GND Connections: Internally connected to a single ground plate.
Pin 3	Antenna	50W impedance, antenna connection
Pin 1-15	+V	Connection to the positive pole of supply (+5V \pm 10%)
Pin 13	Test Point	Analog output of the demodulated signal. By connecting an oscillograph, the entity and quality of the received RF signal can be seen.
Pin 14	Data Out	Receiver digital output. Apply loads over 1 KW

Important notes:

1. Keep the receiver separate from all other components of the circuit (more than 5 mm).
2. Keep particularly far away and shielded all microprocessors and their clock circuits.
3. Do not fit components around the 50 Ohm line. At least keep them at 5 mm distance.
4. If the Antenna Connection is directly used for a radiating whip connection, keep at least a 5 cm radius free area. In case of coaxial cable connection, then 5 mm radius will suffice.

BC-BNC used voltage between 4.5 to 5.5 volt and must absorb maximum current of 3mA. The carrier frequency is as the carrier frequency for the transmitter and it is equal 433.92 MHz. This factor and other are summarized in Table 3.5. [12]

Table (3.5): BC-NBC Technical Features.

CHARACTERISTICS		MIN	Typical	MAX	Unit
V _s	Supply Voltage	4.5	5	5.5	Vdc
I _s	Supply current			3	mA
F _w	Reception frequency	220		434	MHz
S _I	RF sensitivity		-97		dBm
B _w	- 3dB RF bandwidth		+1.2		MHz
S _o	Square wave output			2	KHz
S _L	Spectrum emitted level		-65	-60	dBm
H _o	Output high voltage	VS-0.4			V
L _o	Output low voltage			GND + 0.4	V
T _{ON}	Switch on time			2.5	s
T _{OP}	Operating temperature range	-20		+80	oC

3.4 The sensors

In this project three types of sensors have been used, and they are:

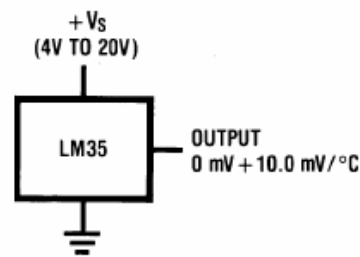
3.4.1 LM35

The LM35 series are precision integrated-circuit temperature sensors, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature. The output is Calibrated directly in Celsius, every 10.0 mV = 1 Celsius.

The LM35 thus has an advantage over linear temperature sensors calibrated in Kelvin, as the user is not required to subtract a large constant voltage from its output to obtain convenient Centigrade scaling [13].

The LM35's low output impedance, linear output, and precise inherent calibration make interfacing to readout or control circuitry especially easy. It can be used with single power supplies, or with plus and minus supplies as in Figure 3.11 and Figure 3.12 respectively [13].

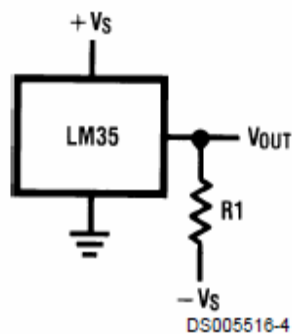
Typical Applications



DS005516-3

Basic Centigrade Temperature Sensor (+2°C to +150°C)

Figure 3.11: LM35 with Single power supply.



DS005516-4

Choose $R_1 = -V_S/50 \mu\text{A}$
 $V_{\text{OUT}} = +1,500 \text{ mV at } +150^\circ\text{C}$
 $= +250 \text{ mV at } +25^\circ\text{C}$
 $= -550 \text{ mV at } -55^\circ\text{C}$

Full-Range Centigrade Temperature Sensor

Figure 3.12: Positive and negative power supplies are both used.

The LM35 can be applied easily in the same way as other integrated-circuit temperature sensors. It can be glued or cemented to a surface and its temperature will be within about 0.01 C of the surface temperature. When the LM35 is applied with a 200 Ω load resistor it is relatively immune to wiring capacitance because the capacitance forms a bypass from ground to input, not on the output. However, as with any linear circuit connected to wires in a hostile environment, its performance can be affected adversely by intense electromagnetic sources such as relays, radio transmitters, motors with arcing brushes, SCR transients, etc, as its wiring can act as a receiving antenna and its internal junctions can act as rectifiers. [13]

3.4.2 LDR (Light Dependent Resistance)

Figure 2.13 shows an example of an LDR.

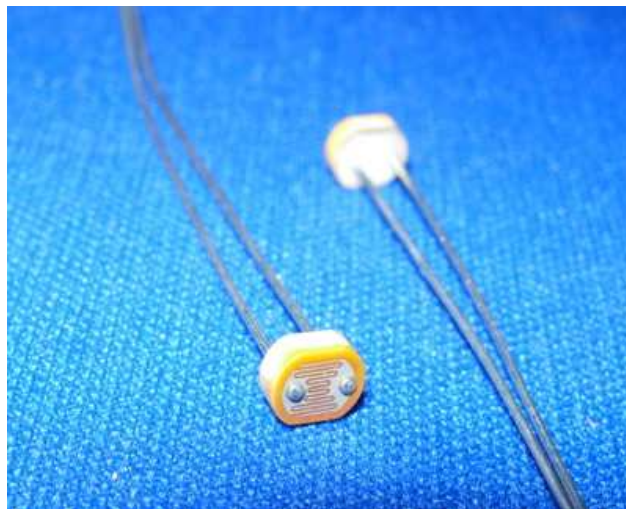


Figure 3.13: Light Dependent Resistance.

Light Dependant Resistors or **photo resistors** or **photocells** are devices that their resistance changes when light fall on them. When there is **no light**, it will have very high resistance. As the light intensity increases, its resistance decreases. So for example, a LED can be used to focus light on to the surface that you want to detect. Then place an LDR in the path of reflection. Thus, depending on the intensity of the reflected light, we will have different resistance. Figure 2.14 is an example of a circuit that uses LDR [14].

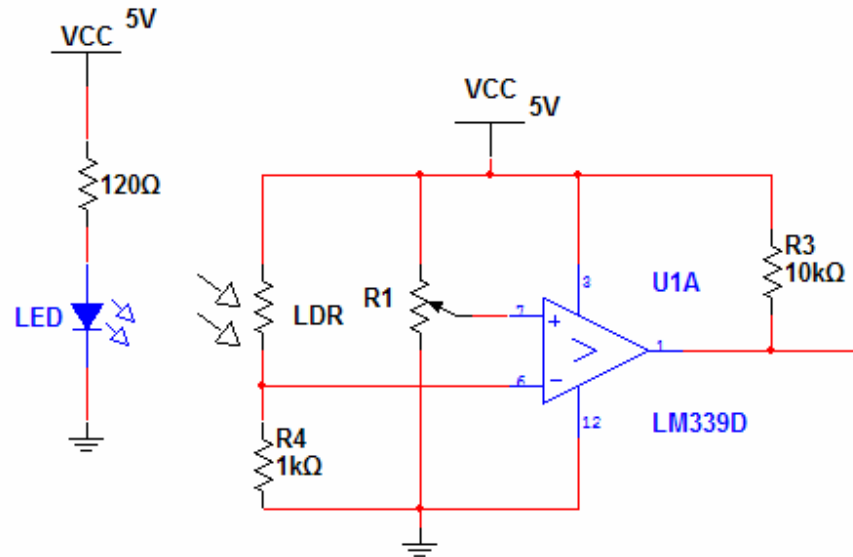


Figure 3.14: Example of an LDR circuit

The circuit in Figure 15 shows a simple design of sensor circuit. Towards the left is the emitter part. Resistance is to limit current through the diode. You can make the LED grow brighter or dimmer by changing the value of resistance. In this kind of apparatus, continuous light or pulsed light can be used. Continuous light is used in common spectroscopic apparatus [14].

LDR's are made of semiconductors as light sensitive materials, on an isolating base. The most common semiconductors used in this system are cadmium sulphide, lead sulphide, germanium, silicon and gallium arsenide [14].

The LDR circuit used in this project is based on voltage division. There are just two ways of constructing the voltage divider, with the LDR at the top, or with the LDR at the bottom as in Figure 3.15:

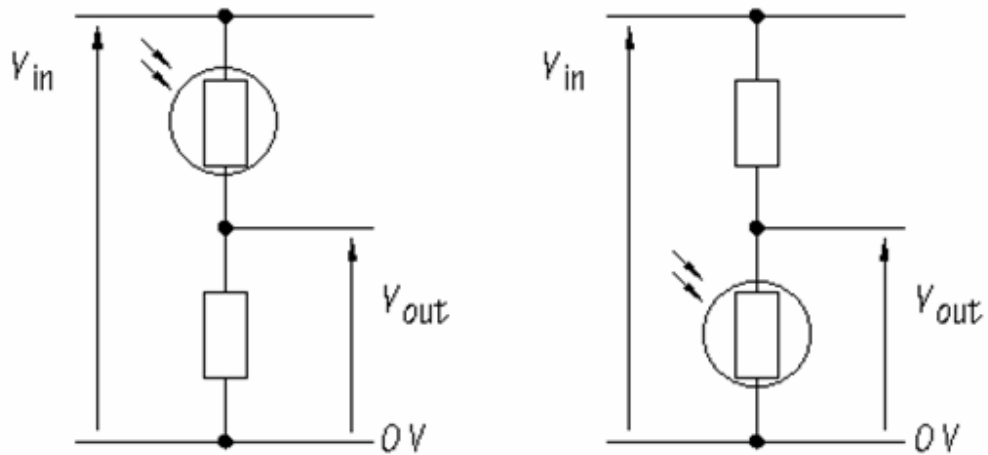


Figure 3.15: Voltage divider circuit with LDR

3.4.2 RHK1AN Humidity sensor

This RHK1AN humidity sensor is designed to measure relative humidity in the ambient air [15].



3.16: RH1AN Humidity sensor

Mechanical characteristics of the RHK1AN:-

- Soldering heat resistance: The Humidity Sensor should be kept the original appearance and electrical characteristics after soldering the lead for 3 seconds at $270 \pm 5^\circ\text{C}$ temperature condition [16].
- Termination strength: Lead terminal should be safe after pulling with it by 500g force for 10 seconds.

- Shock resistance: The Humidity Sensor should be kept the original appearance and electrical characteristics after falling down 5 times on the hard place from 70cm height.
- Vibration resistance: The Humidity Sensor should be kept the original appearance and electrical characteristics after testing the vibration for 2 hours in each direction (X.Y.Z) 10-55Hz frequency in the box (10x 60x 10).

Reliability:

1. Humidity resistance:

Put it for 1000 hours at 40%RH and 90%RH; put it more for hour in usual humidity and temperature conditions. After that, the value is changed within +/-3%RH from the initial value.

2. Humidity cycle:

One cycle should be to put for 30 minutes at 25°C and 30%RH-I continue to put it for 30 minutes while raising to 90%RH-I, put it for 30 minutes at 90%RH-II and put it more [or 30 minutes while lowering to 30%RH. Repeat 500 these cycles, and then put it for 1 hour in the usual humidity and temperature conditions. After that, the value is changed within +/-5%RH value [16].

3. Temperature cycle:

One cycle should be to put for 30 minutes at -30°C continue to put it for 30 minutes while raising the temperature to 85°C, put it for 30 minutes at 85°C and put it more for 30 minutes while lowering the temperature to -30°C. Repeat 100 these cycles, then put it for 1 hour in the usual condition. After that, the value is changed within +/-5%RH from the initial value.

4. Heat resistance:

Put it for 1000 hours at 80°C and 30%RH more for 1 hour in the usual humidity and temperature conditions. After that the value is changed within +/-5%RH from the initial value.

5. Cool Resistance:

Put it for 1000 hours at $\sim 30^{\circ}\text{C}$, and put it more for 1 hour in the usual humidity and temperature conditions. Alter that the value is changed within $\pm 5\% \text{RH}$ from the initial value.

3.5 Liquid Crystal Display (LCD)

The LCD used in this project is the LM032L which has the following characteristics:

- LCD has two lines each of 20 characters.
- The controller LSI HD44780 is built in the LCD.

Some of the power characteristics of the LCD:

- Master voltage is +5V (VDD).
- Input high voltage is 2.2V minimum
- Input low voltage is 0.6V maximum
- output high voltage is 2.4V minimum
- output low voltage is 0.4V maximum

Pin out of the LM032L is shown in figure 3.17:

Pin No.	Symbol	Level	Function
1	V _{SS}	—	0V
2	V _{DD}	—	+5V
3	V _O	—	—
4	RS	H/L	L: Instruction code input H: Data input
5	R/W	H/L	H: Data read (LCD module→MPU) L: Data write (LCD module←MPU)
6	E	H, H→L	Enable signal
7	DB0	H/L	Data bus line Note (1), (2)
8	DB1	H/L	
9	DB2	H/L	
10	DB3	H/L	
11	DB4	H/L	
12	DB5	H/L	
13	DB6	H/L	
14	DB7	H/L	

Notes:

In the HD44780, the data can be sent in either 4-bit 2-operation or 8-bit 1-operation so that it can interface to both 4 and 8 bit MPU's.

- (1) When interface data is 4 bits long, data is transferred using only 4 buses of DB₄~DB₇ and DB₀~DB₃ are not used. Data transfer between the HD44780 and the MPU completes when 4-bit data is transferred twice. Data of the higher order 4 bits (contents of DB₄~DB₇ when interface data is 8 bits long) is transferred first and then lower order 4 bits (contents of DB₀~DB₃ when interface data is 8 bits long).
- (2) When interface data is 8 bits long, data is transferred using 8 data buses of DB₀~DB₇.

Figure 3.17: The pin out description of the LM032L LCD.

The Figure 3.18 represents the block diagram of the LM032L:

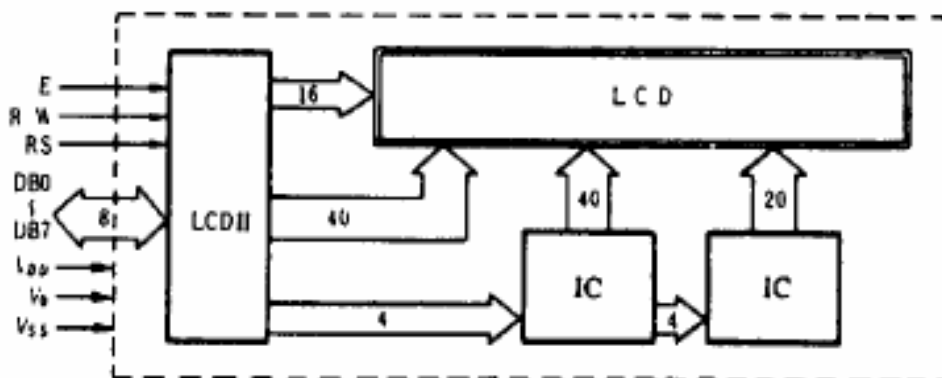


Figure 3.18: The internal block diagram of the LM032L LCD

3.6 Serial Port

The Serial Port is harder to be interfaced than the Parallel Port. In most cases, any device you connect to the serial port will need the serial transmission converted back to parallel so that it can be used. This can be done using a UART (Universal Asynchronous Receiver Transmitter). On the software point of view, there are many registers that have to be attended to than on a Standard Parallel Port (SPP).

3.6.1 The Advantages of the serial port

The serial port is used rather than parallel and this is because the followings:-

- Serial Cables can be longer than Parallel cables. The serial port transmits a '1' as -3 to -25 volts and a '0' as +3 to +25 volts where as a parallel port transmits a '0' as 0v and a '1' as 5v. Therefore the serial port can have a maximum swing of 50V compared to the parallel port which has a maximum swing of 5 Volts. Therefore cable loss is not going to be as much of a problem for serial cables as they are for parallel [17].
- We don't need as many wires as parallel transmission. If our device needs to be mounted a far distance away from the computer then 3 core cables (Null modem Configuration) is going to be a lot cheaper than running 19 or 25 core cable. However you must take into account the cost of the interfacing at each end [17].
- Microcontrollers have also proven to be quite popular recently. Many of these have in built Serial Communications Interfaces (SCI) which can be used to talk to the outside world. Serial Communication reduces the pin count of these MPU's. Only two pins are commonly used, Transmit Data (TXD) and Receive Data (RXD) compared with at least 8 pins if you use an 8 bit Parallel method (You may also require a Strobe) [17].

3.6.2 Hardware Properties of the serial port

Devices which use serial cables for their communication are split into two categories. These are Data Communications Equipment (DCE) and Data Terminal Equipment (DTE), where DCE are devices such as modem, Terminal Adapter (TA), plotter etc, while DTE is your Computer or Terminal [17].

The electrical specifications of the serial port is contained in the Electronics Industry Association (EIA) RS232C standard. It states many parameters such as -

1. A "Space" (logic 0) will be between +3 and +25 Volts.
2. A "Mark" (Logic 1) will be between -3 and -25 Volts.
3. The region between +3 and -3 volts is undefined.
4. An open circuit voltage should never exceed 25 volts. (In Reference to GND)
5. A short circuit current should not exceed 500mA. The driver should be able to handle this without damage.

Serial Ports come in two "sizes", there are the D-Type 25 pin connector and the D-Type 9 pin connector both of which are male on the back of the PC, and thus you will require a female connector on your device. Below is a table of pin connections for the 9 pin and 25 pin D-Type connectors.

Because this project uses 9 pin D-Type, Figure 3.19 and Table 3.6 show the pin out and the function for each pin:

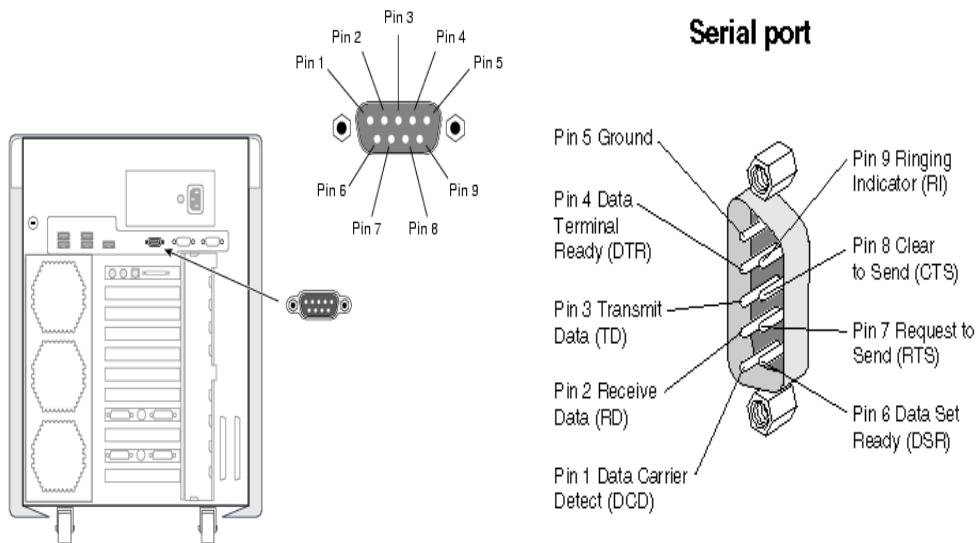


Figure 3.19: Serial port location and pin out.

Table (3.6): 9 pin D-Type Serial port pin out and function.

Pin No.	Abbreviation	Full Name	Function
Pin 1	CD	Carrier Detect	When the modem detects a "Carrier" from the modem at the other end of the phone line, this Line becomes active.
Pin 2	RD	Receive Data	Serial Data Input (RXD)
Pin 3	TD	Transmit Data	Serial Data Output (TXD)
Pin 4	DTR	Data Terminal Ready	This is the opposite of DSR. This tells the Modem that the UART is ready to link.
Pin 5	SG	Signal Ground	
Pin 6	DSR	Data Set Ready	This tells the UART that the modem is ready to establish a link.
Pin 7	RTS	Request To Send	This line informs the Modem that the UART is ready to exchange data.
Pin 8	CTS	Clear To Send	This line indicates that the Modem is ready to exchange data.
Pin 9	RI	Ring Indicator	Goes active when modem detects a ringing signal from the PSTN.

3.6.3 Port Addresses & IRQ's (Interrupt Request)

Below is the standard port addresses. These should work for most PC's. If you just happen to be lucky enough to own an IBM P/S2 which has a micro-channel bus, then expect a different set of addresses and IRQ's. Just like the LPT (Line Print Terminal) ports, the base addresses for the COM ports can be read from the BIOS Data Area. Table 7 gives the standard port addresses.

Table (3.7): Standard Port Addresses

Name	Address	IRQ
COM1	3F8	4
COM2	2F8	3
COM3	3E8	4
COM4	2E8	3

CHAPTER FOUR

EXPERIMENTAL PROCEDURE

4.1 Introduction

In this chapter we will discuss the procedure that is followed on building the system with details and the problem that are faced during the work. Also, we will discuss the solutions for these problems. The software programs used in parallel with the procedure will be discussed such as the Proteus that has been used to pre-simulate circuits. The outcomes that have been perceived will also be discussed.

4.2 Procedure

The circuit has been built, programmed and tested step by step so that faults are avoided as much as possible, this is illustrated as follows:-

Two PICs have been used; the first PIC was connected to the LCD (used to view the measurements) via port B. The sensors were connected to the analog channels (i.e. port A) so that the analog input is to be converted to digital signals to be processed (in order to get meaningful measurements to be considered in the conversion ratio of each sensor, e.g. 10mV to 1C for temperature sensor). This result will be viewed on the LCD and then sent to the encoder which in turn is connected to port D of the PIC. The encoder takes the outputs from port D and then converts it to serial data output that is connected to the serial input of the RF transmitter.

The transmitter then prepares the data to be transmitted through the antenna to the receiver. The receiver accepts the data through and prepares the output data and deliver it to the decoder with it's serial input pin is connected to the serial output pin of the receiver. The decoder converts the serial data into parallel and delivers it to the port B of

the second PIC. The second PIC accepts the parallel data and converts it to serial then send it to a computer through the serial port.

These steps can be summarized as follows:

1. Intelligent device1 reads the analog data from the sensors and converts it to digital.
2. Intelligent device 1 sends the data to the LCD to be viewed and to the encoder to be transmitted to the receiving circuit.
3. The encoder converts the data (i.e. from intelligent device1) from parallel to serial and sends it to the transmitter, then the transmitter send the data to the receiver.
4. The receiver receives the data then delivers it to the decoder, and then the decoder converts the serial data to parallel and sends it to intelligent device2.
5. Intelligent device2 accepts the data then send it serial to the computer through the serial port.

These steps are illustrated in Figure 4.1. In this Figure we can see “Manipulation 1” and “Manipulation 2”. Manipulation 1 includes converting inputs from the sensors from analog to digital and delivering it to the encoder, and Manipulation 2 includes convert data from parallel to serial.

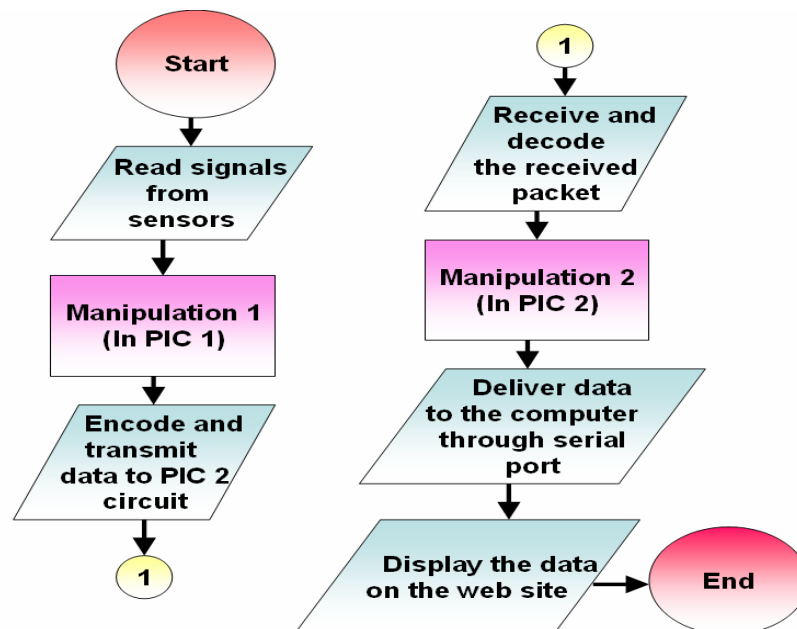


Figure 4.1: The flow chart of the system process

The block diagram of our weather system is shown in Figure 4.2 where you can clearly see two subsystems one for acquisitioning data that collect the data from the sensors, and the other for finally displaying data on the web site, Where the wireless transmission circuit composed of the encoder and the serial RF transmitter, and the wireless receiving circuit composed of the decoder and the serial RF receiver.

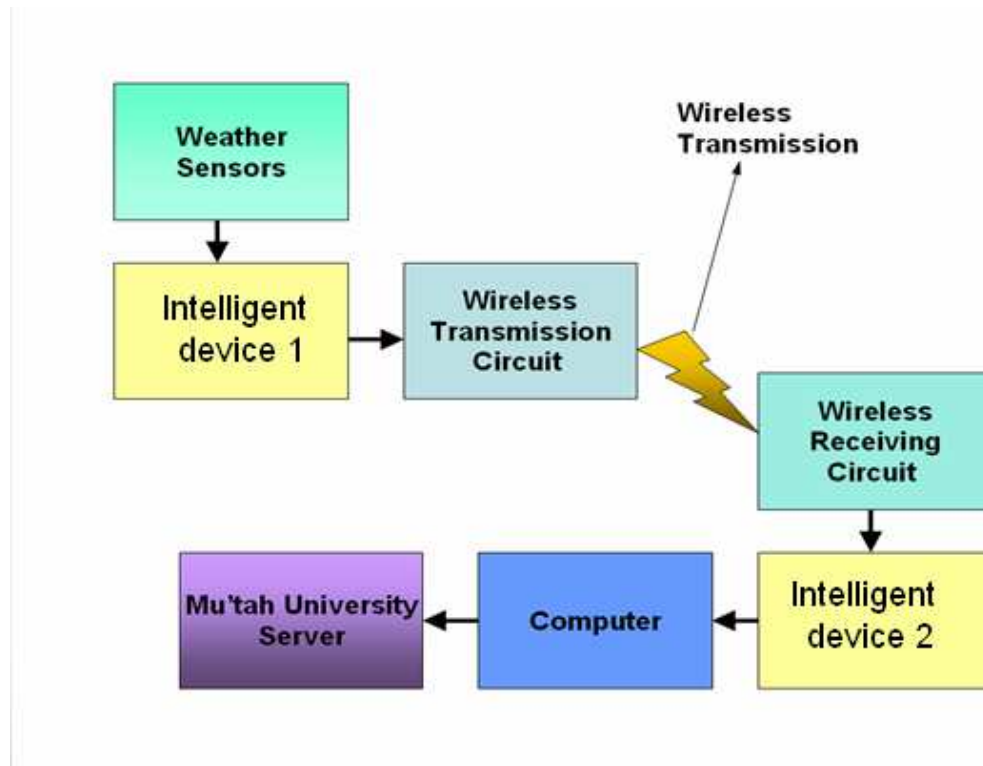


Figure 4.2: Weather system block diagram

There was a problem faced in the project that the data received was meaningless. This problem had risen from the fact that the transmitter and the receiver are not working on the same oscillation frequency. The problem has been solved by using the encoder and the decoder. These IC's achieve the synchronization between the transmitter and the receiver. The encoder deliver the first data packet to the transmitter then wait for a 10ms to enable the decoder to receive, decode and verify the transmitted packet, and this procedure is replayed every time a packet is intended to be transmitted.

The detailed connection of our weather system circuit is shown in Figure 4.3. This Figure shows the connection of the acquisition circuit and the wireless transmission circuit. Figure 4.4 shows the wireless receiving circuit and the serial port connection.

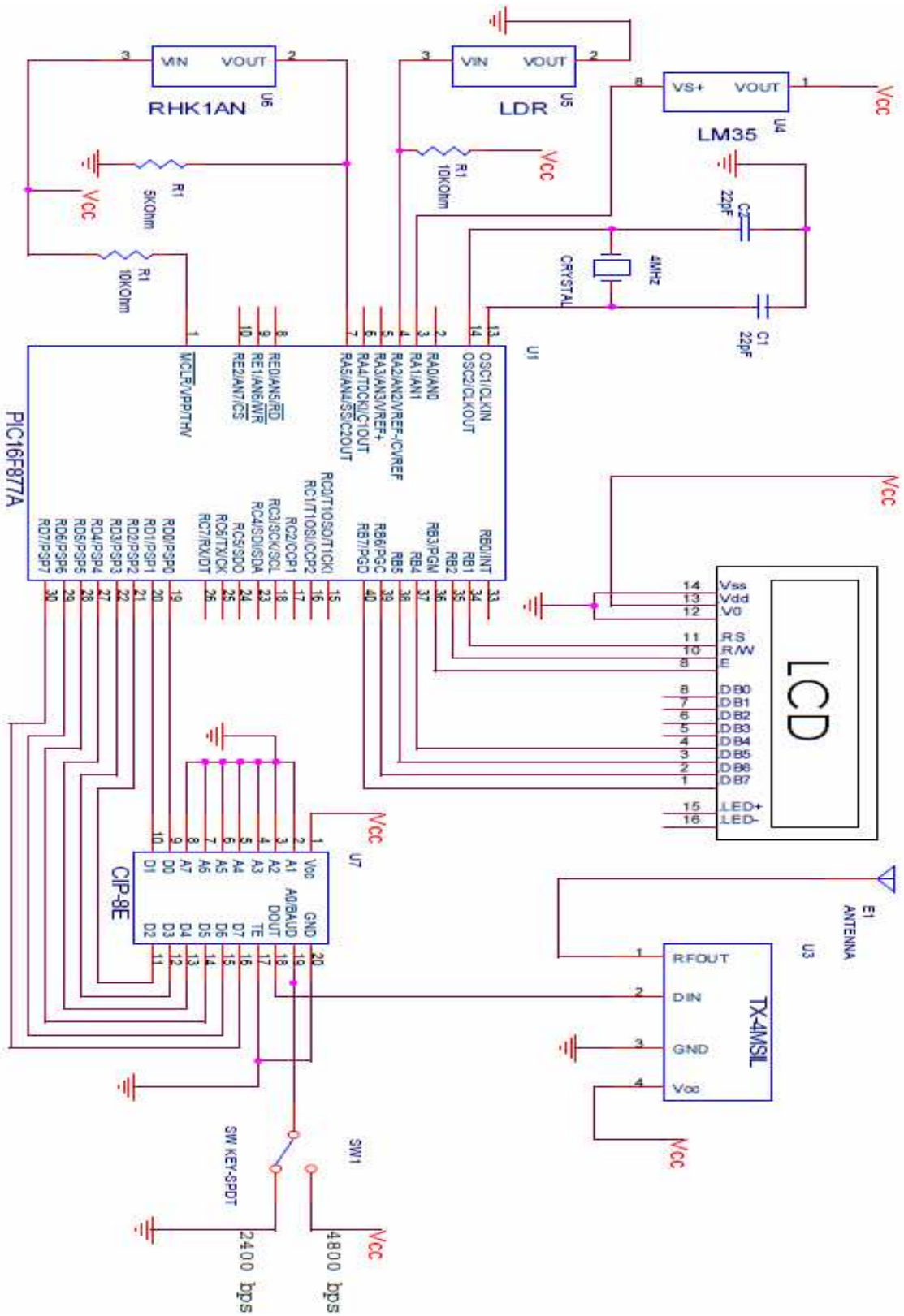


Figure 4.3: Sensors and wireless transmission circuit.

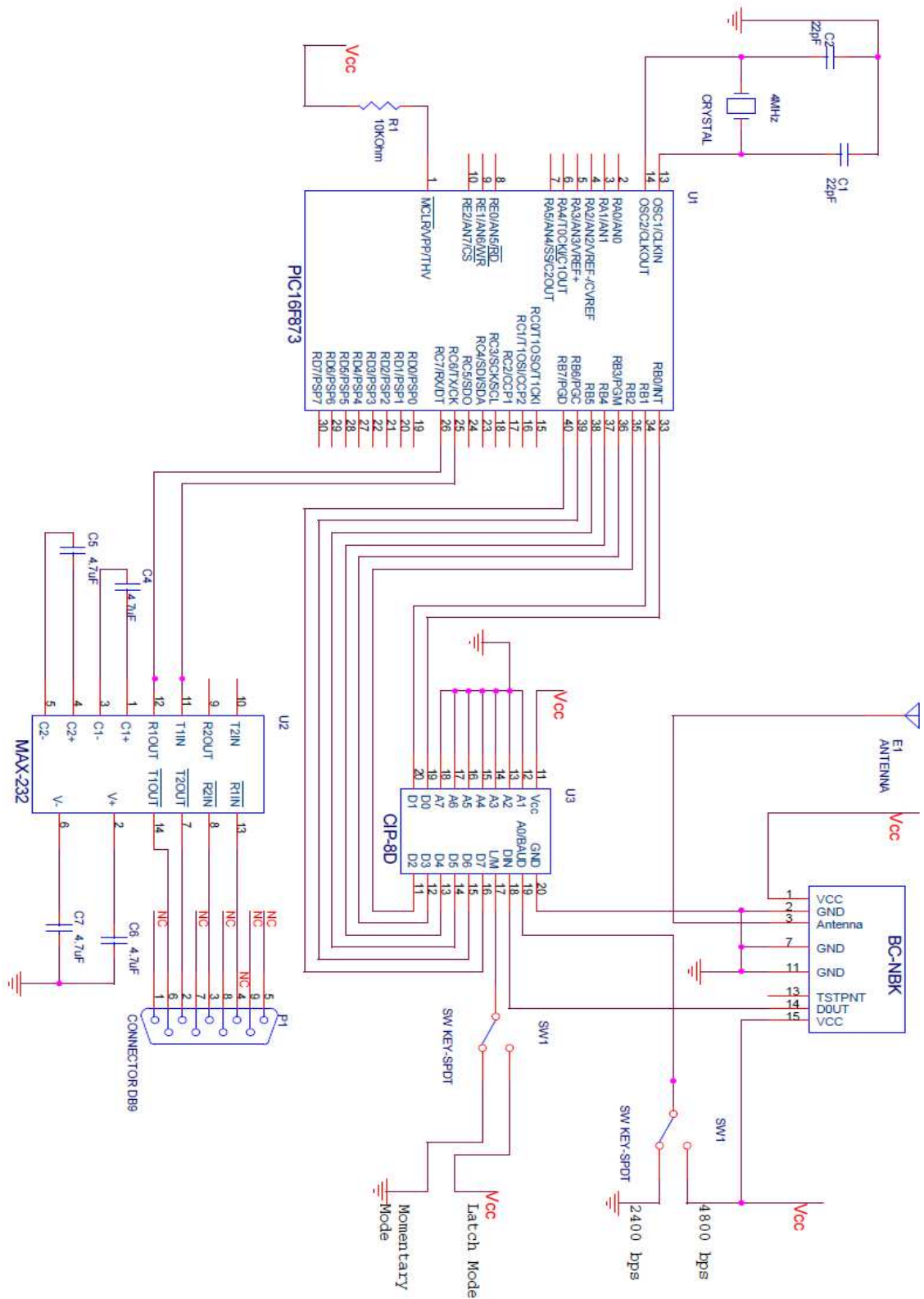


Figure 4.4: Wireless receiving and serial port circuits

4.3 Software

In this project there are various programs used to support various operation such as simulation and programming. These programs are as follows:

I. MicroBasic:

This program is used to program PIC1 and PIC2 used in the system by writing the required code then using the micro boot loader in this program you can download the written program to the PIC by using the serial port (The PIC must at first contain the boot loader that enable serial programming) .

This program support PIC high level programming language, PIC assembly programming language and hexadecimal programming. Here are some examples:

Dim ldr as byte	High level language
Bcf status, rp1	Assembly language
BFF3FFF3FFF3	Hexadecimal representation

Figure 4.5 shows the main window of the MicroBasic program, where you can see the white panel where you can write the code using the MicroBasic high level language. In the left side window of the program you can specify the type of the PIC that is used and the clock of the PIC to program it properly.

All the results of building the written code will be summarized in the message table (below the writing panel) where the used and free size of the internal RAM memory of the PIC is computed. The debugging output will also be listed in the message table.

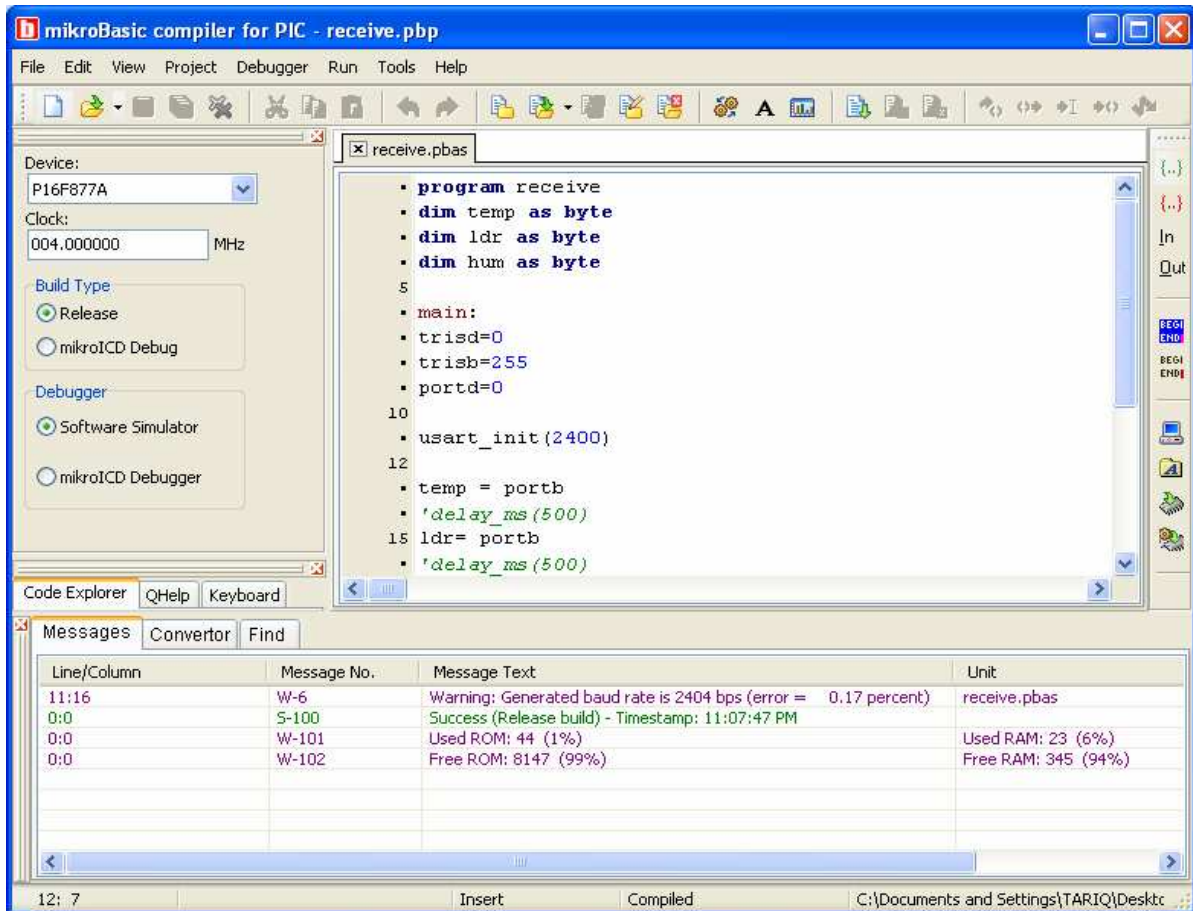


Figure 4.5: The main window of MicroBasic program.

II. Proteus:

It is a powerful simulator that support many electrical and electronic components, it enable the user to build it's own circuit then simulate it as it is in real operation. In this project the Proteus is used to test some PIC circuits and programs. One of these circuits is shown in Figure 4.6.

MATLAB is also a programming language that currently is widely used as a platform for developing tools for many topics such as Machine Learning, Electrical Engineering...etc.

Why it is useful for prototyping artificial intelligence projects:

- Large toolbox of numeric/image library functions.
- Very useful for displaying, visualizing data.
- High-level: focus on algorithm structure, not on low-level details.
- Allows quick prototype development of algorithms.

The MATLAB provides a very powerful Mathematical Function Library. This is a vast collection of computational algorithms ranging from elementary functions, like sum, sine, cosine, and complex arithmetic, to more sophisticated functions like matrix inverse, matrix eigenvalues, Bessel functions, and fast Fourier transforms [20].

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Introduction

In this chapter we will discuss the outcomes and the results of the project. The results appear on the LCD of the acquisitioning circuit where the readings of PIC1 from the sensors are forwarded and displayed on the LCD. The readings appear on the LCD as in Figure 5.1.

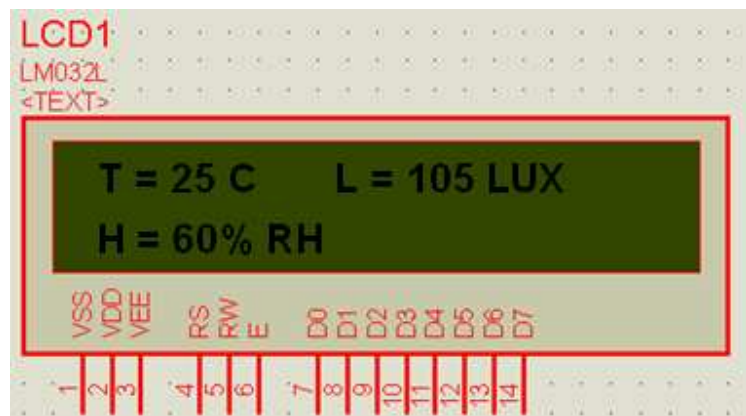


Figure 5.1: Readings on the LCD.

The readings also appear on the computer on the receiving side by which PIC2 is connected. PIC2 forwards the reading received to the computer. These Readings appear on the USART Terminal in the MicroBasic program as in the Figure 5.2.

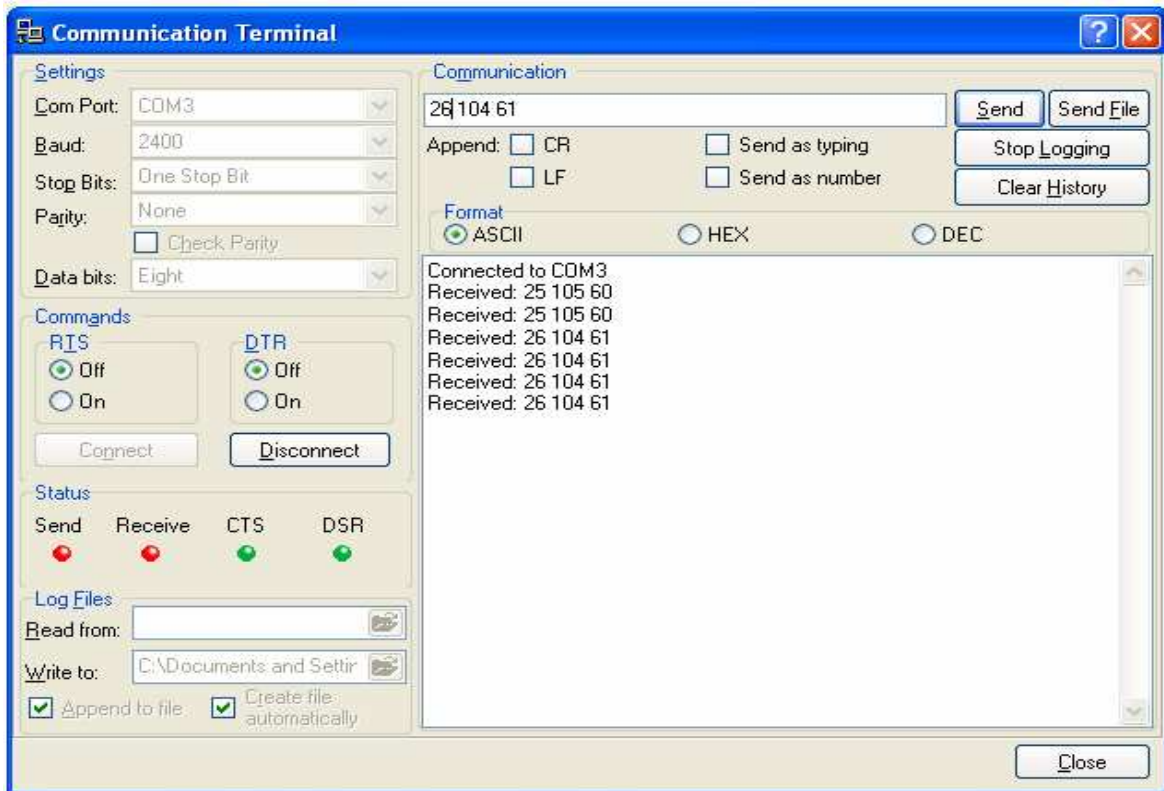


Figure 5.2: The results on the communication (USART) terminal in MicroBasic.

CHAPTER SIX

CONCLUSIONS AND FUTURE WORK

The project utilizes many areas that were covered in both electrical engineering courses, computer engineering courses, and communication engineering courses. Some of the skills needed were not covered and had to be researched and understood before implementing into the design of the system.

Researching and design skills were used initially to determine the actual implementation of the weather station. Skills from the electrical engineering curriculum were used for the signal conditioning circuitry and digital communication. Communication engineering curriculum gives how to send radio frequency signals from the station then how to receive these signals in proper form. The computer engineering curriculum provided the skill in microcontroller interfacing and Visual Basic programming. In addition, skills in Adobe flash, HTML needs to be acquired in order to complete the project. Teamwork played a very large and important role in the design, implementation, and completion of the system. Oral presentation skills were also utilized.

After conducting our research, we feel that a wireless connection will be the best approach to the system. This will allow us to place our sensors in a desired location without running wires from the computer to the system. Even though we will transmit the data using a wireless connection, we will power our system by using a wired power source. This allows for us to focus on other issues because it is a reliable source of power.

The Weather Station project will successfully display and store weather measurements for many years to come. The system has the ability to be upgraded or expanded. Additional sensors can be relatively easy because the system is already established. New sensors can be integrated by modeling them after the already existing

ones. Those that could be added are snow depth, acid rain, visibility, and carbon dioxide sensors.

Since the measurements are stored in files, there is the possibility of adding software that will graph and chart the measurements. This implementation not only succeeds in creating a weather station for Mu'tah University, but it also provides a solid base in which improvements and upgrades can be made.

Also this system can be used in many applications such as security system by using student cards. Also by connecting camera with students' picture database we can eliminate the number of employee on the gate of the university.

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- 9) <http://ww1.microchip.com/downloads/en/DeviceDoc/39582b.pdf>
- 10) <http://www.rentron.com/Files/CIP-8.pdf>
- 11) http://www.soselectronic.com/a_info/resource/c/pdf/tx4msil.pdf
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