Chapter Three

System Design

٣.١ Project Description

The project is a combination of analogue and digital electronic devices; it designed so as to fulfill the requirement of industry, home and environment applications. It consists of parameter monitoring and storage beside PC interface in which various data and parameters are sent to personal Computer wirelessly via radio frequencies.Microcontroller has been used as a main component of the project. . Also Liquid Crystal Display (LCD) and labview is used on major basis for the display and storage purpose. So the project is consists of two basis modules, The “Data Monitoring” and “Data Storage”. The display unit shows the value of parameters. It helps the person to know the values, after connecting of various sensors to ADC.The other module is named as parameter storage. It can be used to store the parameter values in the (PC). Labview software well be used. These values can later be seen using a switch provided on the front panel. This system operate automatically and may give accurate results. Figure 3.1 shows the block diagram of the system to be designed .Figure 3.2 shows the system design flowchart.

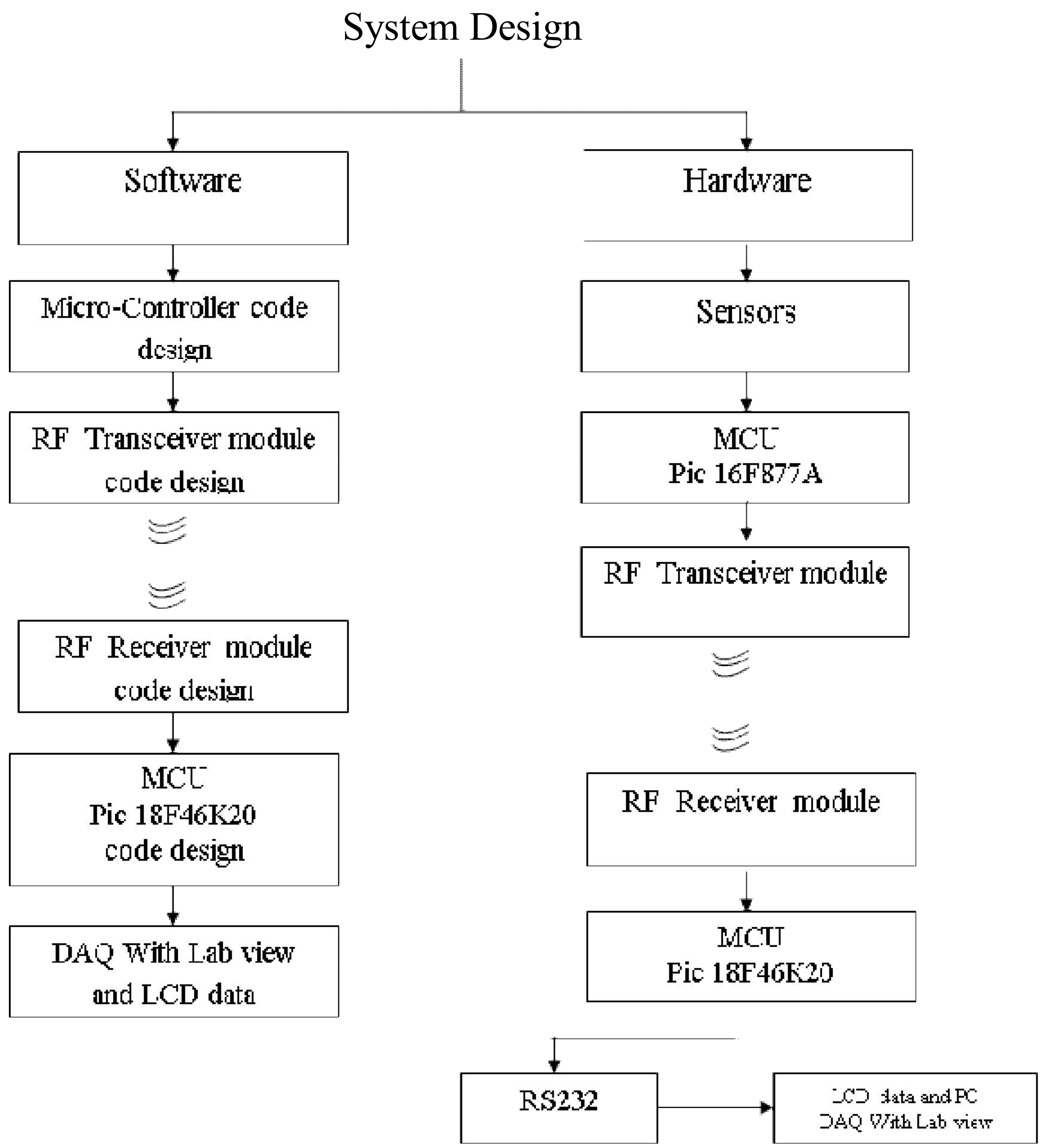

Figure 3.1:System block diagram

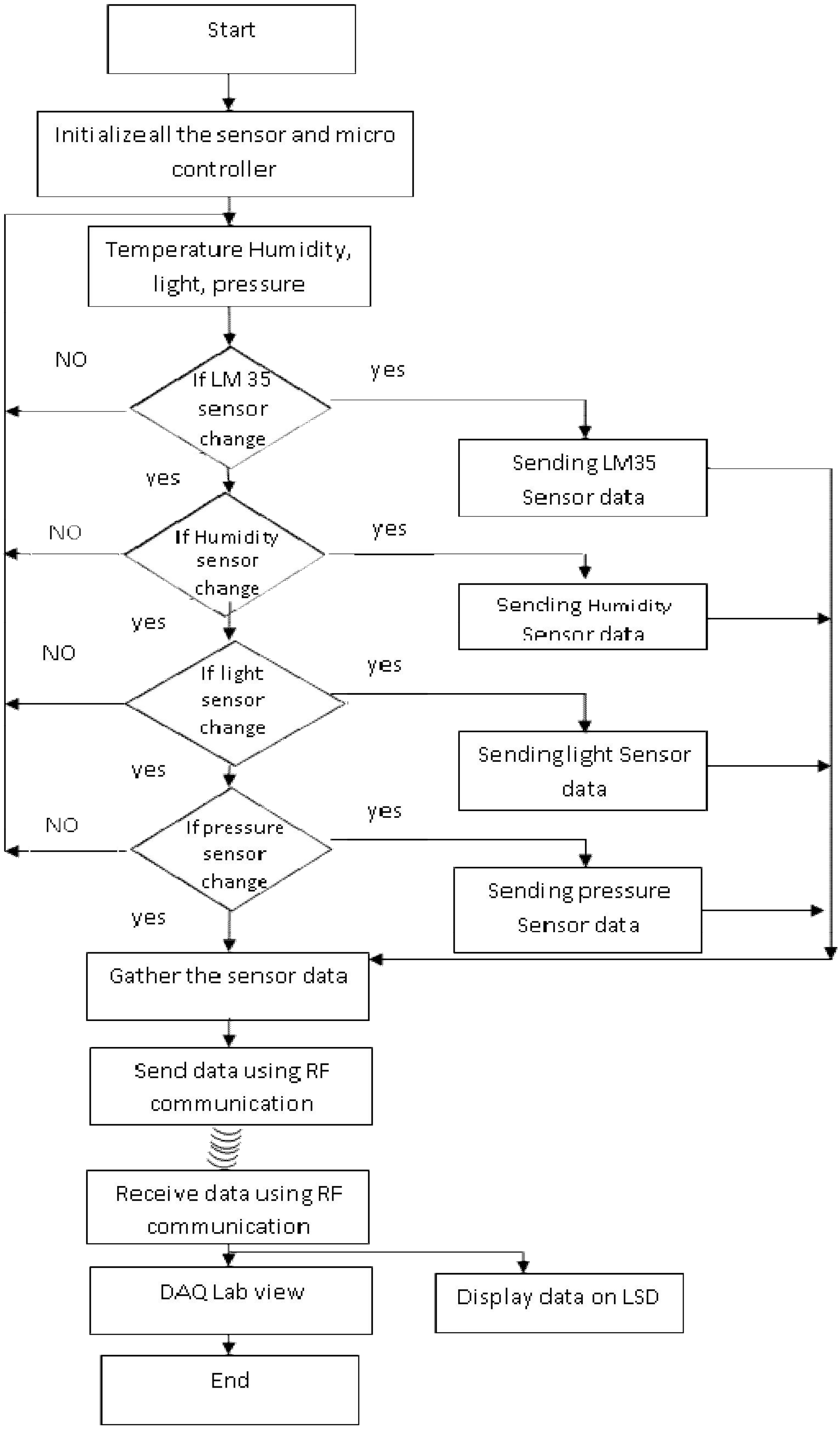

Figure 3.2: Flow chart of system design

3.2 System Hardware

The system consists ofsubstationsand the central station (transmitter and receiver) as show in the figure 3.3 and 3.4 respectively. The meteorology system is a PIC-based (16F877A) designed to take readings of temperature, pressureHumidity and light sensors. All of the readings are taken to the PIC in transmitting station and then they are transmitted to receivingcentral stationsdisplayedon a 16 x 2 LCDand the reading also displayed on personal computer using labview.

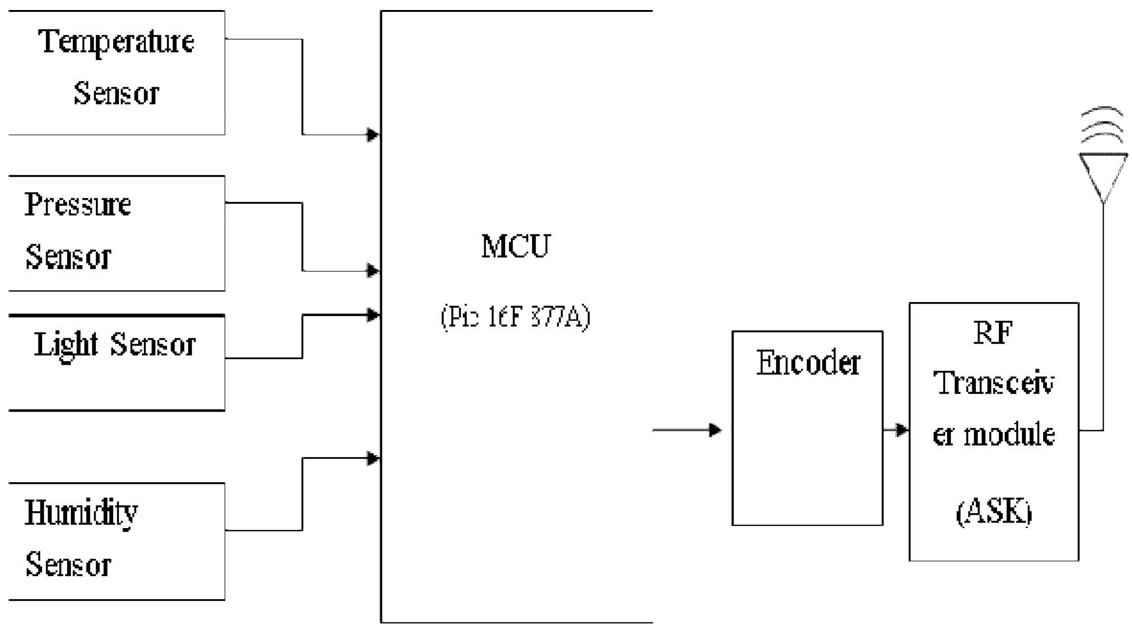

Figure 3.3: Block diagram of transmitting station

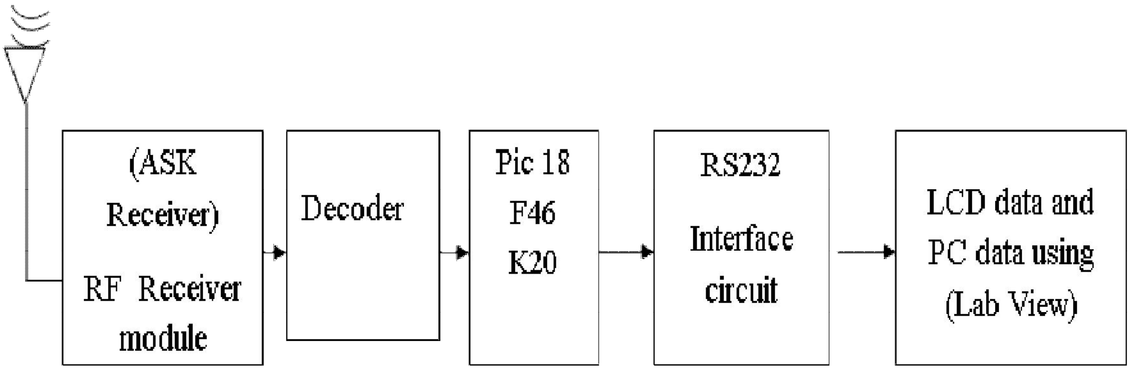

Figure 3.4: Block Diagram of Receiver Station

3.3LM35 Temperature Sensor

Several temperature sensing techniques are currently in widespread usage. Suitable type and feature of temperature sensors can be used depends on the required temperature range, linearity, accuracy, cost, features, and ease of designing the necessary support circuitry. The temperature sensor that used here is LM35 is one of PN junction type which is a semiconductor device with the properties of diode.The LM35 is a precision integrated-circuit temperature sensor, whose output voltage is linearly proportional to the Celsius (Centigrade) temperature.Figure 3.5 shows the lm35 temperature sensor.

Figure 3.5:LM35 temperature sensor

This sensor is rated for full range from -55°C to +150°C with linear +10.0 mV/°C scale factor, it operates from 4 to 30 V.LM35 temperature sensor is used here to give an analog output voltage that is proportional to the ambient temperature; this analog voltage signal is applied to a one channel of the ADC module of the microcontroller as shown in Figure 3.6. The signal is converted into to digital value and calibrated according to the high and low ADC voltage references. Since the resolution of the sensor is 10 mV/˚C , the obtained value must be multiplied by 100 in order to give an actual temperaturereading[3,13] .

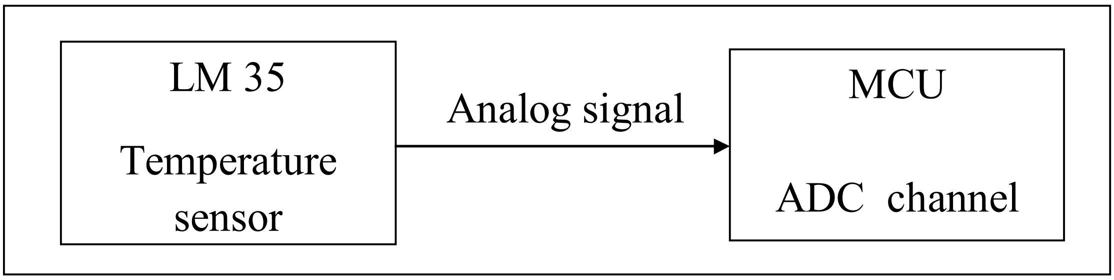

Figure3.6: LM 35 Temperature sensor interface to MCU

The out put of this device is equal to absolute temperature in degres Kelvin divided by 100 or:

$$Vout = Temperature(k)/100 \qquad (3.1)$$

To determine the temperature in degrees Celsius use the equation 3.2 below

$$C° = 100 \times Vout - 273 \qquad (3.2)$$

The determine the temperature in degrees Fahrenheit it use the Equation 3.3.

$$F° = 1.8 \times C° - 32.2 \qquad (3.3)$$

$$F° = 1.8 \times (100 \times Vout - 273) + 32. \qquad (3.4)$$

$$F° = 180 \times Vout - 459. \qquad (3.5)$$

3.4 Capacitive humidity sensor

The capacitive atmospheric humidity sensor shown in Figure 3.7consists of non-conductive foil which is covered on both sides with a layer of gold. The dielectric consists of the foil changes as a function of the relative humidity of the ambient atmosphere and accordingly the capacitance value of the sensor is a measure for the relative humidity.

Figure3.7: HS1101 sensor

This sensor measures the Relative Humidity(RH) in the range of 10 to 90 %, with sensitivity of 0.4±0.05 pF/%RH between 12 and 75% RH. The sensor operates with 15 V as maximum AC or DC voltage. Since the sensor used here is capacitive humidity sensor (i.e. the sensor has a capacitance varying approximately proportionally with the ambient relative humidity), so a certain way must be found to measure this variable capacitance as an indirect indication of the ambient relative humidity. The most efficient way is to convert this capacitance into frequency (digital signal) so as this frequency can be measured by the microcontroller and then calibrated to an actual relative humidity reading [14].

3.5.The Timer NE555

The NE555 is a highly stable controller capable of producing accurate timing pulses. Figure 3.8.shows the NE 555timer stable operation connection Figure 3.9 shows the pin configuration of the NE555 timer.

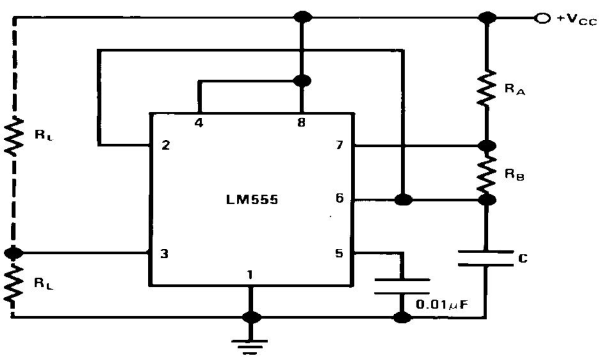

Figure 3.8: NE555 timer with a stable circuit

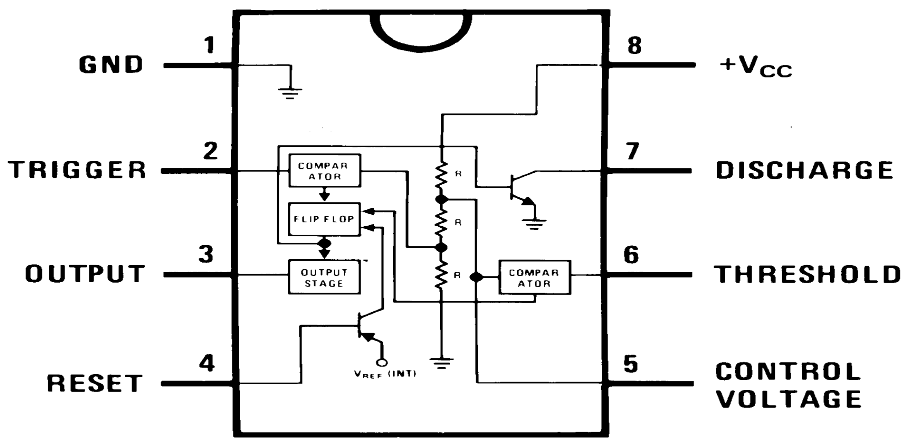

Figure 3.9:TheNE555 timer pin configuration

The frequency and duty cycle are accurately controlled by two external resistors and one capacitor, so by keeping the two resistors constant the frequency is controlled only by one capacitor which will be the humidity sensor. The frequency is given by the following equation[14].

$$f=\frac{1.44}{(R2+R3)C1} \quad (3.6)$$

where :

R2=49.9KΩ

R3=576KΩ

C1=HS1101 Capaceter value

f= freguncy which represent the humidity

Figure 3.10 shows the connection between HS11XX and 555timer. The interface between capactive sensor and MCU as shown in Figure 3.11.

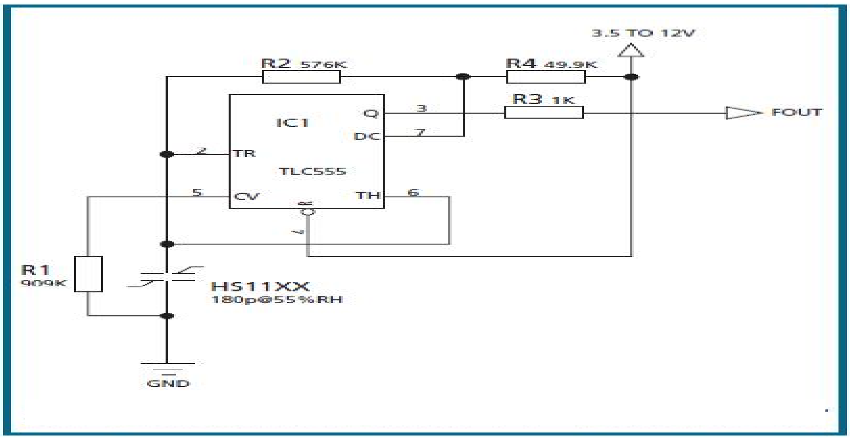

Fig 3.10:Connecting Hs110xx To 555timer

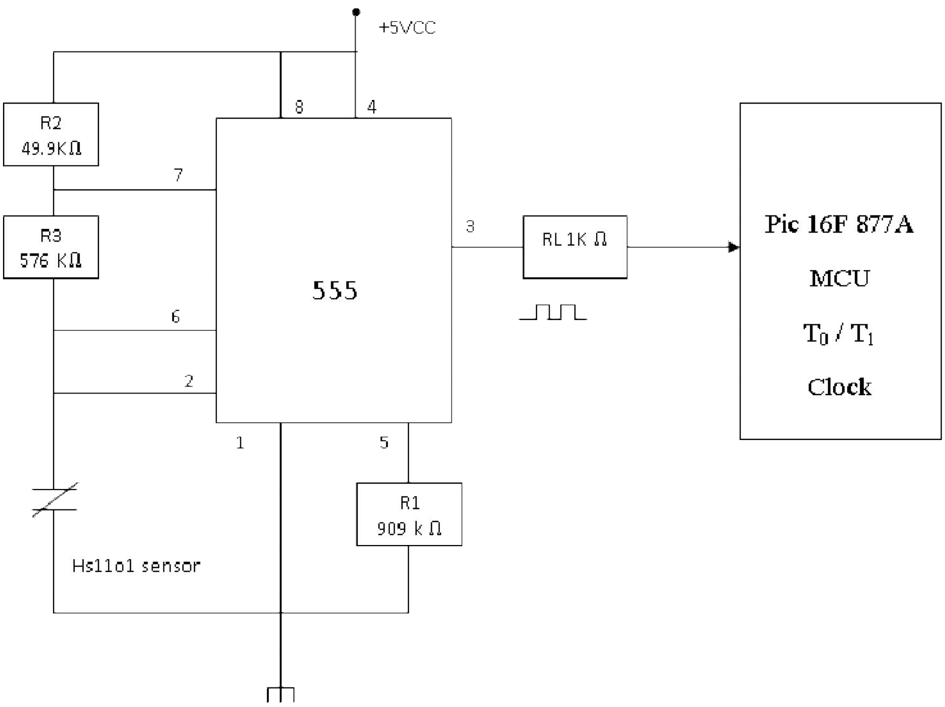

Figure 3.11:Capacitive sensor interface toMCU

3.6 Pressure Sensor

There are several devices used to measure atmospheric pressure.such as mercury pressure, digital pressure, and analog pressure.The MPX4115 series is designed to sense absolute air pressure in an altimeter orbarometer (BAP) applications. Motorola's BAP sensor integrates on–chip, bipolar opamp circuitry and thin film resistor networks to provide a high level analog output signaland temperature compensation. The small form factor and high reliability of on–chipintegration makes the Motorola BAP sensor a logical and economical choice forapplication designers[3.11]. Figure 3.12 shows the MPX4115A air pressure sensor.

Figure 3.12:MPX4115A air pressure sensor

This sensor measures the air pressure in the range of 15 to 115 kPa, with supply voltage of 5.1 V. The sensor outputs is an analog voltage that is proportional to the pressure with minimum scale of 0.204 VDC and full scale of 4.794 VDC, so the sensitivity is 45.9 mV/kPa. MPX4115A air pressure sensor is used here to give an analog output voltage that is proportional to the air pressure; this analog voltage signal is applied to a one channel of the ADC module of the microcontroller as shown in Figure 3.13. The signal is converted into digitalform and calibrated according to the high and low ADC voltage references. The algorithm inside the microcontroller converts this obtained value into an actual pressure reading in term of (kPa) by the following equation [11].

Pressure (Kpa) = $\frac{x+Vcc*0.095}{(Vcc-0.009)}$ (3.7)

Where: x is the obtained value. Vcc is the supply voltage = 5 V.

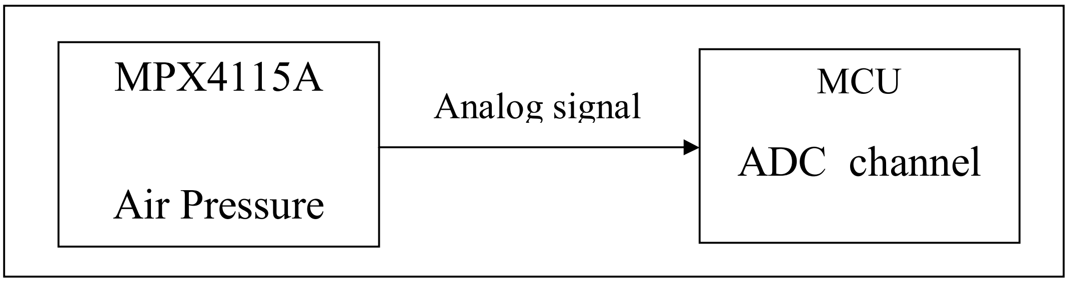

Figure 3.13 :MPX 4115A sensor interface to MCU

3.7 Light Depended Resistance

A light sensor, as its name suggests, is a device that is used to detect light.Light sensors are much similar to temperature sensors. They are photo cells, photo resistors, photo diodes and transistors.The supply voltage can be from 3.3Vor 5V.A 5V DC. The output is an analog voltage that ranges from 0V to 5V based on the brightness (luminance)[12].

This sensor has many good properties such as:

- Low energy requirements.
- Sensitivity; spectral response.
- Small, lightweight.
- Inexpensive.
- Easy to construct.
- Versatile[12].

Figure 3.14 shows the light sensor.

Figure3.14: Light sensor

3.8PIC16F877A Microcontroller

The PIC16F877A microcontroller will be used. It is the major part of the system which controls all the operation of the circuit such as LCD interfacing, square wave generation and interface with RF module .It also decides the messages to be displayed on the LCD along with the time duration for which they should be displayed on the LCD. It also interfaced with labview to save and monitor data.The Figure 3.14 shows the pin configuration, of PIC16F877A Microcontroller chip.

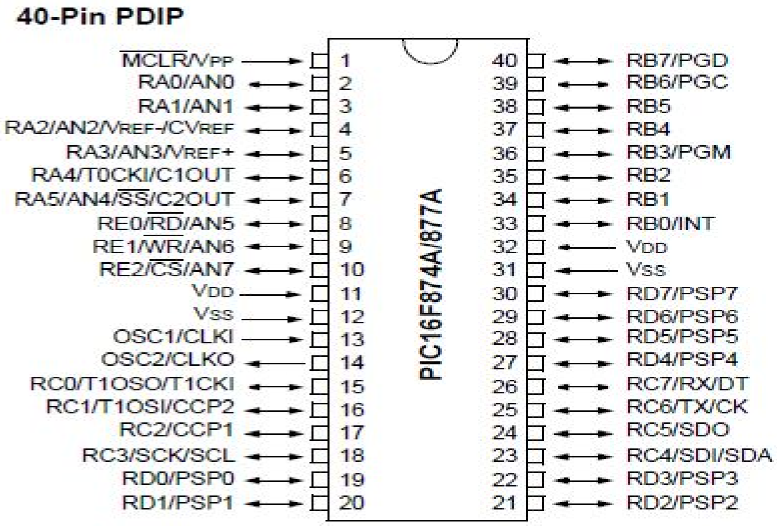

Figure 3.15 : PIC16F874A/877A microcontroller chips

The main features of the PIC16F877A Microcontroller as follows[1,9]:

1-Program Memory 14.3k.

2-Data static random access memory (SRAM)Is 368 Byte.

3- Erath able electric program read only memory (EEPROM)256 bytes.

4-I/O IS 33.

5-10-bit A/D (CH) is 8 Pin.

6-Two pwm

7-Operating frequency is 20 MHz.

8-Flash program memory (14-bit words) is 8k.

9-Data memory 368 bytes.

10-EEPROMdata memory is 256bytes.

11-Interrupts 15.

12-I/Oport (a,b,c,d,e).

13-Three timers.

14-10-bit analog to digital module 8input channels.

15-Analog Comparators 2.

16- 35 instructons set.

17-Packages 40-pin pdip, 44-pin plcc,44-pin tqfp and44-pin qfn[1][9].

3.9 PIC18F46K20 Microcontroller

The Figure 3.16shows the PIC18F46K20 microcontrolle pin configuration.

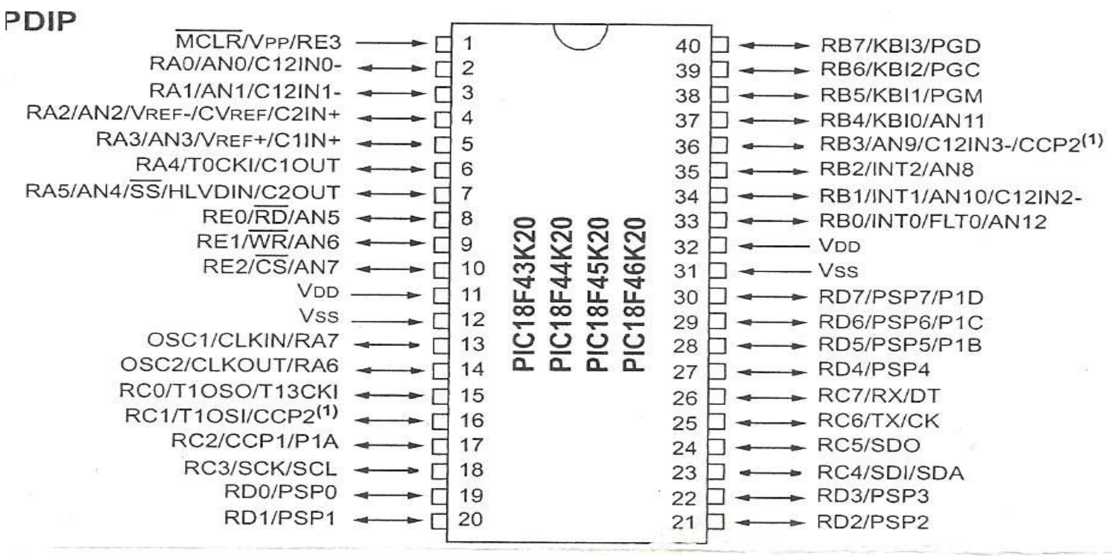

Figure 3.16.:PIC18F46K20 MCU pin configuration

in the receiver circuit we prefer to use PIC18F46K20 because the memory is big than pic16f877a but it has the sam features of PIC16F877A microcontroller .

1-Operating frequency from 0Hz-64MHz.

2-Programmemory (byte)is 65536.

3-Programmemory instruction 32768.

4-Data Memory (byte) 3936.

5-Interrupt Source 20.

6- I/O port A,B,C,D,E.

7-Timer 4.

8-Instruction set 75 And 83 with extended instruction set enable .

9- Data EEPROM memory byte 1024.

10- Packages 40-pinPDIP, 44pin QFN and 44PIN TQP[1][8].

3.10Liquid Crystal Display (LCD)

The liquid crystal display revolutionized the modern display technology with its compactness and versatility. Today it is seen embedded in various electronic gadgets and devices like T.V., computers, laptops, watches, etc. A Liquid crystal coating is the heart of the display which is sandwiched between two polarized glasses. LCD's are available in various shapes and sizes depending on the configurations. A 16x2 LCD shown in the Figure 3.17 can display 32 characters with 16 characters in each row. It is capable to display any character with ASCII values ranging from 0 to 255.

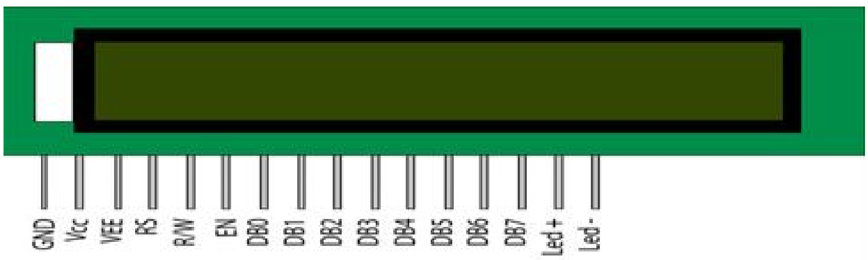

Figure 3.17:The 16×2 liquid crystal display

The LCD has many features such as:

1-LCDs are economical.

2- Easily programmable.

3-Animations[15].

3.11 RF Based Wireless Remote using RX-TX Modules

This radio frequency transmission system employs Amplitude Shift Keying (ASK) with transmitter/receiver (Tx/Rx) pair operating at 434 MHz. The transmitter module takes serial input and transmits these signals through RF. The transmitted signals are received by the receiver module placed away from the source of transmission. The system allows one way communication between two nodes, namely, transmission and reception. The RF module has been used in conjunction with a set of four channel encoder/decoder ICs. Here HT12E and HT12D have been used as encoder and decoder respectively. The encoder converts the parallel inputs (from the remote switches) into serial set of signals. These signals are serially transferred through RF to the reception point. The decoder is used after the RF receiver to decode the serial format and retrieve the original signals as outputs. These outputs can be observed on corresponding LEDs [5]Figure 3.18 shows the based wireless remote using RX-TX module..

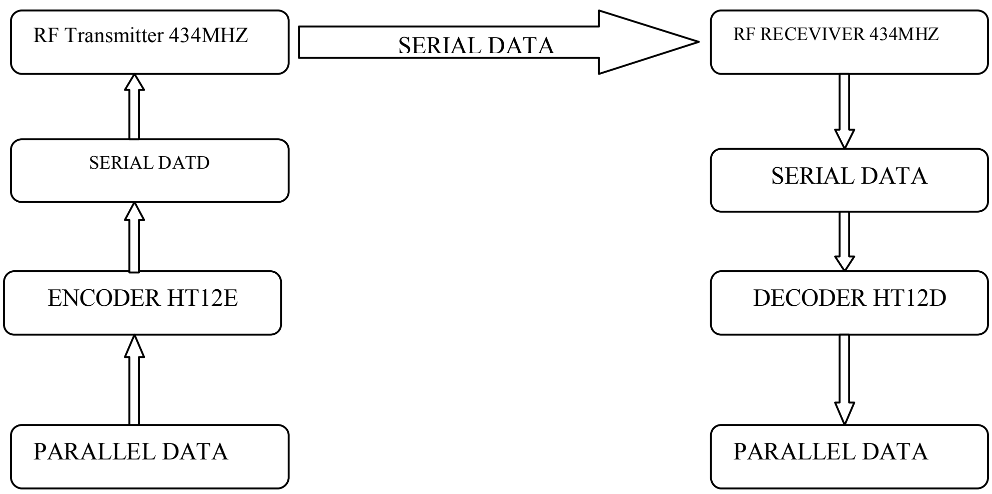

Figure 3.18: RF based wireless remote using rx-tx modules.

Encoder IC (HT12E) receives parallel data in the form of address bits and control bits. The control signals from remote switches along with 8 address bits constitute a set of 12 parallel signals. The encoder HT12E encodes these parallel signals into serial bits. Transmission is enabled by providing ground to pin14 which is active low. The control signals are given at pins 10-13 of HT12E. The serial data is fed to the RF transmitter through pin17 of HT12E [5][21].Figure 3.19 shows the encoder HT12E interface with RF transmitter.

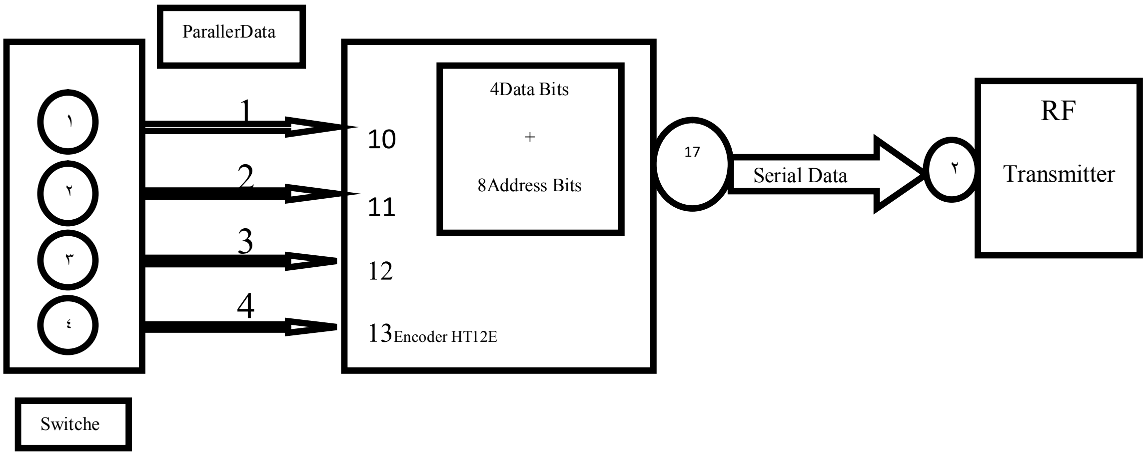

Figure 3.19: Encoder HT12E interface with RF transmitter

Transmitter, upon receiving serial data from encoder IC (HT12E), transmits it wirelessly to the RF receiver. The receiver, upon receiving these signals, sends them to the decoder IC (HT12D) through pin2 in RF receiver. The serial data is received at the data pin (DIN, pin14) of HT12D. The decoder then retrieves the original parallel format from the received serial data[5].Figure 3.20 shows the decoder HT12D.

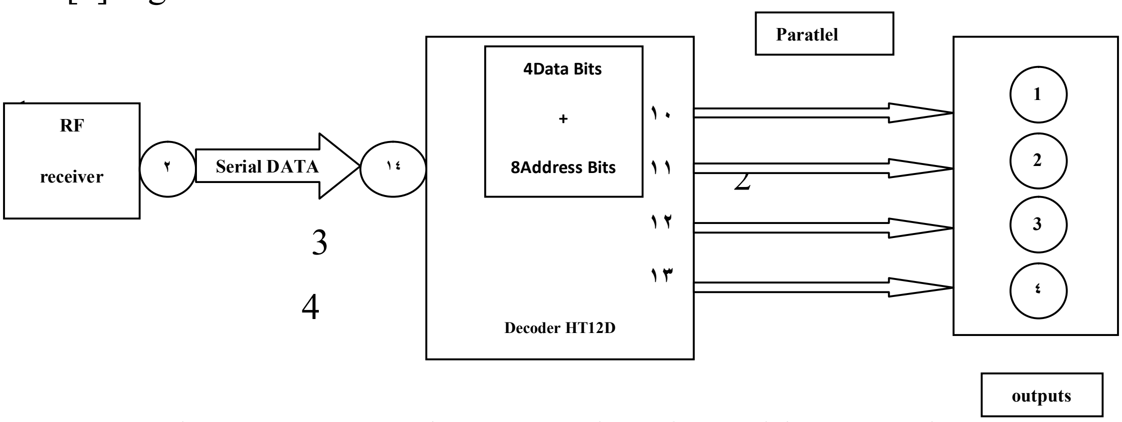

Figure 3.20:Decoder HT12E interface with RF receiver

When no signal is received at data pin of HT12D, it remains in standby mode and consumes very less current (less than 1μA) for a voltage of 5V.

When signal is received by receiver, it is given to DIN pin (pin14) of HT12D. On reception of signal, oscillator of HT12D gets activated. IC HT12D then decodes the serial data and checks the address bits three times. If these bits match with the local address pins (pins 1-8) of HT12D, then it puts the data bits on its data pins (pins 10-13) and makes the VT pin high. An LED is connected to VT pin (pin17) of the decoder. This LED works as an indicator to indicate a valid transmission. The corresponding output is thus generated at the data pins of decoder IC. A signal is sent by lowering any or all the pins 10-13 of HT12E and corresponding signal is received at receiver's end (at HT12D). Address bits are configured by using the by using the first 8 pins of both encoder and decoder ICs. To send a particular signal, address bits must be same at encoder and decoder ICs. By configuring the address bits properly, a single RF transmitter can also be used to control different RF receivers of same frequency.

To summarize, on each transmission, 12 bits of data is transmitted consisting of 8 address bits and 4 data bits. The signal is received at receiver's end which is then fed into decoder IC. If address bits get matched, decoder converts it into parallel data and the corresponding data bits get lowered which could be then used to drive the LEDs. The outputs from this system can either be used in negative logic or NOT gates (like 74LS04) can be incorporated at data pins[5].

3.12 HT12D DECODER

HT12D IC comes from HolTek Company. HT12D is a decoder integrated circuit that belongs to 2^{12} series of decoders. This series of decoders are mainly used for remote control system applications, like burglar alarm, car door controller, security system etc. It is mainly provided to interface RF and infrared circuits. They are paired with 2^{12} series of encoders. The chosen pair of encoder/decoder should have same number of addresses and data format. In simple terms, HT12D converts the serial input into parallel outputs. It decodes the serial addresses and data received by, say, an RF receiver, into parallel data and sends them to output data pins. The serial input data is compared with the local addresses three times continuously. The input data code is decoded when no error or unmatched codes are found. A valid transmission in indicated by a high signal at VT pin. HT12D is capable of decoding 12 bits, of which 8 are address bits and 4 are data bits. The data on 4 bit latch type output pins remain unchanged until new is received[5].The figure 3.21. Shows HT12D decoder Pin configuration.

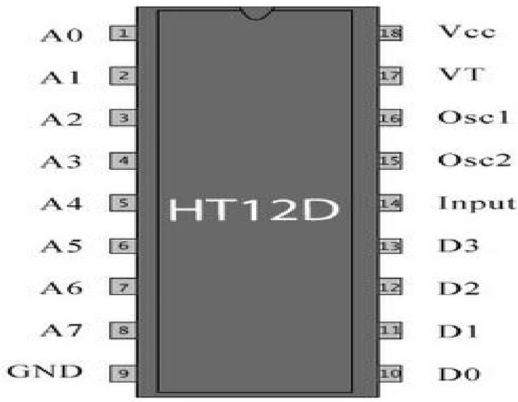

Figure 3.21:HT12D decoderpin configuration

3.13HT12E Encoder

HT12E is an encoder integrated circuit of 2^{12} series of encoders. They are paired with 2^{12} series of decoders for use in remote control system applications. It is mainly used in interfacing RF and infrared circuits. The chosen pair of encoder/decoder should have same number of addresses and data format. Simply put, HT12E converts the parallel inputs into serial output. It encodes the 12 bit parallel data into serial for transmission through an RF transmitter. These 12 bits are divided into 8 address bits and 4 data bits. HT12E has a transmission enable pin which is active low. When a trigger signal is received on TE pin, the programmed addresses/data are transmitted together with the header bits via an RF or an infrared transmission medium. HT12E begins a 4-word transmission cycle upon receipt of a transmission enable. This cycle is repeated as long as TE is kept low. As soon as TE returns to high, the encoder output completes its final cycle and then stops [5].The figure 3.22 Shows HT12E ENCODER Pin configuration.

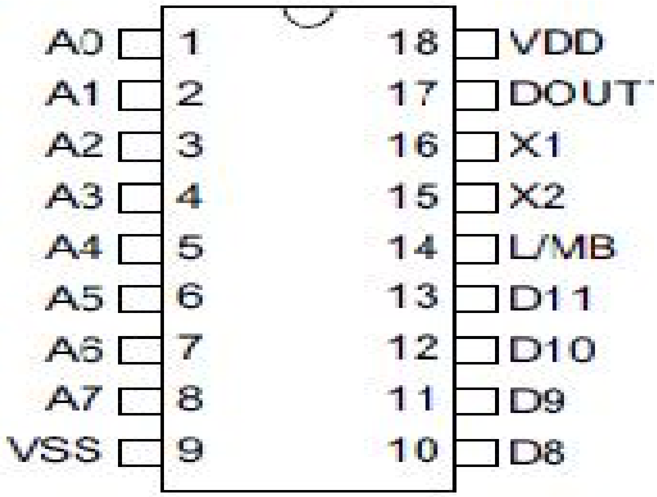

Figure 3.22 : HT12E Encoder pin configuration

3.14 RF Modules

Figure 3.23 shows the transmitter and receiver RF module.

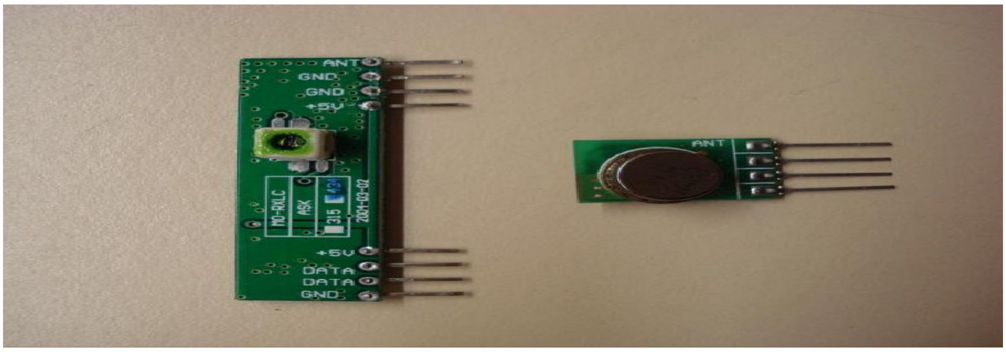

Figure 3.23: Transmitterand receiver RF module

The RF module, as the name suggests, operates at radio frequency. The corresponding frequency range varies between 30 kHz and 300 GHz. In this RF system, the digital data is represented as variations in the amplitude of carrier wave. This kind of modulation is known as (ASK). Transmission through RF is better than InFrared(IR) because of many reasons. Firstly, signals through RF can travel through larger distances making it suitable for long range applications. Also, while IR mostly operates in line-of-sight mode, RF signals can travel even when there is an obstruction between transmitter and receiver. Next, RF transmission is more strong and reliable than IR transmission. RF communication uses a specific frequency unlike IR signals which are affected by other IR emitting sources. This RF module comprises of an RF transmitter and an RF receiver. The transmitter/receiver (Tx/Rx) pair operates at a frequency of 434 MHz. An RF transmitter receives serial data and transmits it wirelessly through RF through its antenna connected at pin4. The transmission occurs at the rate of 1Kbps - 10Kbps.The transmitted data is received by an RF receiver operating at the same frequency as that of the transmitter. The RF module is often used along with a pair of encoder/decoder. The encoder is used for encoding parallel data for transmission feed while reception is decoded by a decoder. HT12E-HT12D, HT640-HT648, etc. are some commonly used encoder/decoder pair ICs [5].Figure 3.24 and 3.25 show the receiver model an transmitter module, respectively.

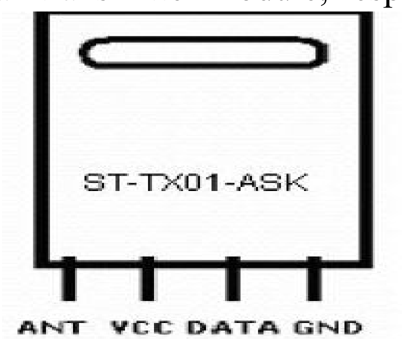

Figure 3.24:Receiver module

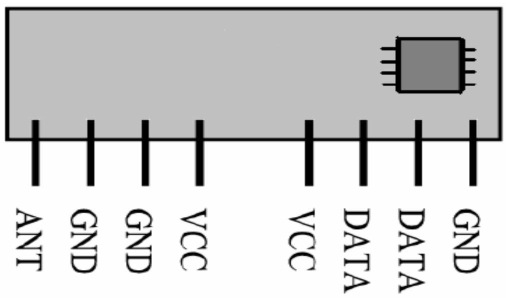

Figure 3.25:Transmitter module

We select this wireless link RF 433MHz according to followings[5,6]:

1- It is suitable for our project from its range(up to 60 m) and data rate(10Kbps).

2- It is easy to obtained(available on our workshop).

3- Low cost.

4- No need for Light of Sight Propagation(LOS).

5- Point to multi-point.

3.15Antenna

An antenna is a component that radiates and receives the RF or microwave power. It is a reciprocal device, and the same antenna can serve as a receiving or transmitting device. Antennas are structures that provide transitions between guided and free-space waves. Guided waves are confined to the boundaries of a transmission line to transport signals from one point to another , while free-space waves radiate unbounded. A transmission line is designed to have very little radiation loss, while the antenna is designed to have maximum radiation. The radiation occurs due to discontinuities (which cause the perturbation of fields or currents), unbalanced currents, and so on.The antenna is a key component in any wireless system. TheRF and microwave signal is transmitted to free space through the antenna. The signal propagates in space, and a small portion is picked up by a receiving antenna. The signal will then be amplified, down converted, and processed to recover the information.There are many types of antennas can be classified based on[6].

1. Shapes or geometries:

a. Wire antennas: dipole, loop and helix.

b. Aperture antennas: horn, slot.

c. Printed antennas: patch, printed dipole, spiral.

2. Gain:

a. High gain: dish.

b. Medium gain: horn.

c. Low gain: dipole, loop, slot, patch.

3. Band width :Wideband and narrowband.

4. Beam shapes:

a. Omni directional: dipole.

b. Pencil beam: dish.

c. Fan beam: array.

3.16MAX232

Figure 3.26 show the max232 adapter. It has input pins for RX, TX, CT, RT as well as GND and 5V. The RX and TX pins can be directly connected to your PIC.

Figure 3.26: Max232 adapter

The MAX232 is a very popular chip. It converts your 5Vto the 12V required for serial communication [10].The Figure 3.27 shows the MAX232pin configuration.

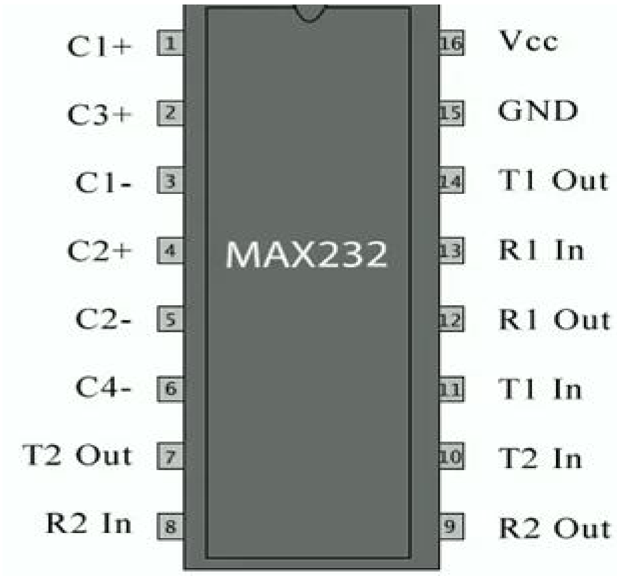

Figure 3.27:The MAX232pin configuration

3.17 RS232 Cable

In telecommunications, RS-232 is a standard for serial communication transmission of data. It formally defines the signals connecting between a data terminal equipment such as a computer terminal, and a Data Circuit-Terminating equipment(DTE), originally defined as Data Communication Equipment(DCE), such as a modem. The RS-232 standard is commonly used in computer serial ports[17].

The Figure 3.28 shows the RS232 cable. Figure 3.29 shows the female connector.

Figure 3.28: RS232 cable

Figure 3.29:DB9 Female Connector

The main feature of the Rs232 cable are:

1-DB9 female to DB9 male .

2-Connects 9 pin serial port to a serial printer .

3-Can be used for PC-PC file transfer.

3.18 Circuit Diagram

The Figure 3.30 shows the circuit diagram of transmitter and receiver module with RF communication and the Figure 3.31 shows the wireless weather station circuit using Radio frequency (RF) .

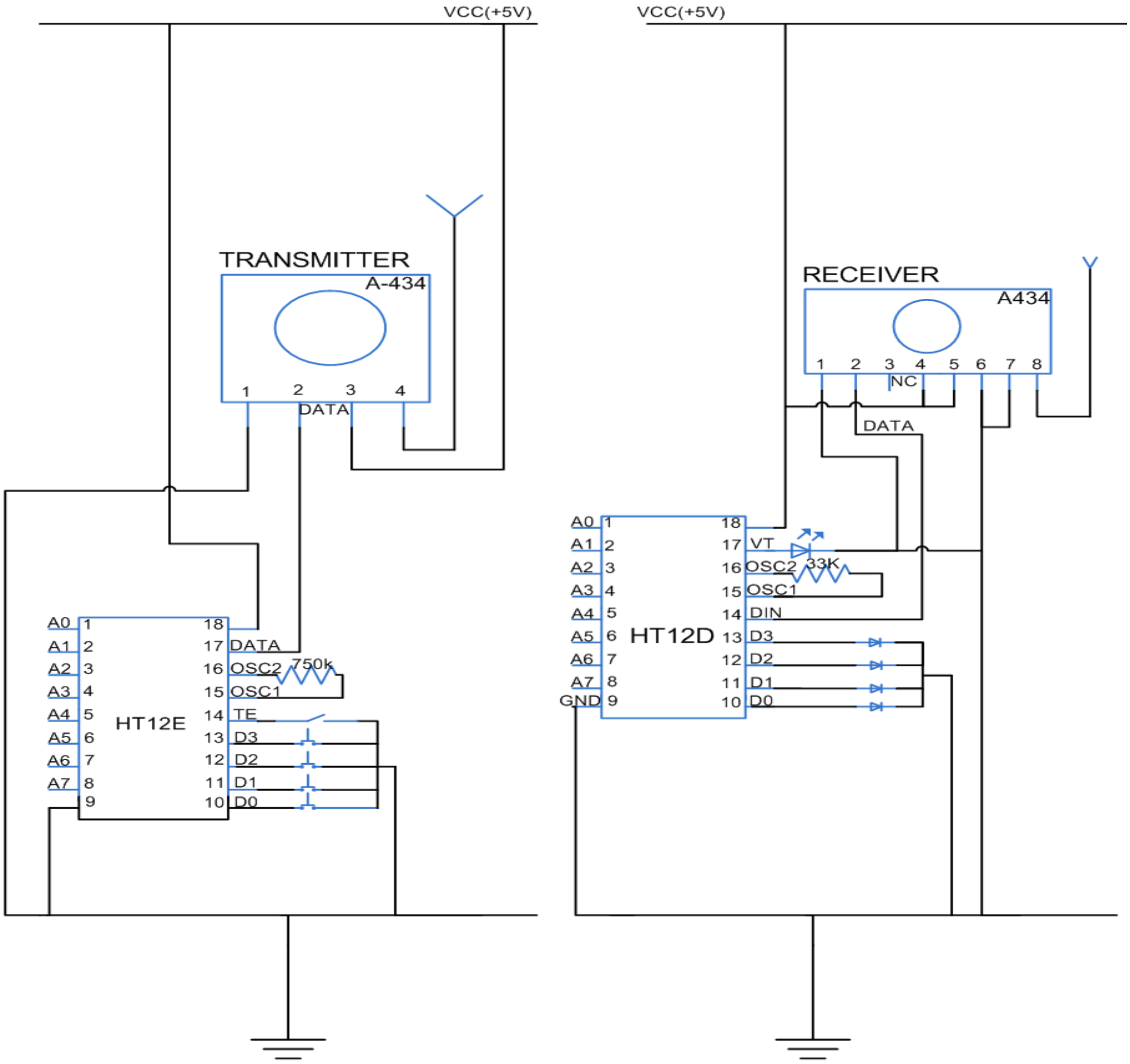

Figure 3.30 Circuit diagram of transmitter and receiver with RF

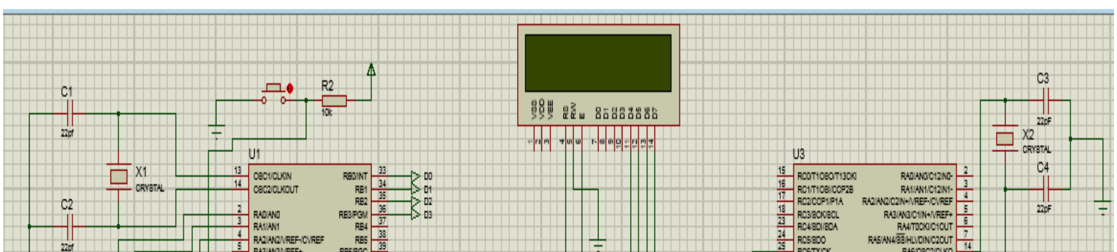

Figure 3.31:Wireless weather station circuit using radio frequency .