Chapter One
Introduction

1.1 General

Weather means the state of atmosphere with respect to wind, temperature, cloudiness, lightness, moisture,pressure and rain. It will results wind, storms,rain,light,snow and etc.Now a day weather information is very important to researcher and many activities are weather dependent such as fishery, farming, traveling, industry and aviation.Weather or climate plays an important role in human life, so it is necessary that weather information must be available every time when they are required. Thus using the most reliable electronic sensors under control of the embedded systems and employing of the latest and fastest communications tools has proved to be a better approach for weather monitoring and forecasting.A weather station is a facility, either on land or sea, with instruments and equipment for measuring atmospheric conditions to provide information for weather forecasts and to study the weather and climate. The measurements takeninclude temperature, barometric pressure, lightness and humidity.

1.2 Problem Statement

Weather monitoring normally done by using Single Side Band (SSB) media from remote areas .The generation of exact SSB is rather difficult, complex detection, complex designed and cost of designing and receiver and take time.

1.3 Objectives

The objectives of the thesis is to design and sumilat meteorological central station to be connected with remote stations this can be achieved by;

1.Sensing important weather parameters (temperature, brightness, pressure and relative humidity) using electronic elements andsensors.

2. Applying sensors outputs to the microcontroller and developing an algorithm to process and transfer data uses remote Radio Frequency (RF)and display these weather data on Personal Computer (PC).

1.4Methodology

The thesis methodology is undertaken according to these stages:

1. Study and understand wireless weather station .
2. To model the wireless weather station using proteus8, Microcand labviewsoftware's.
3. Evaluate performance of the wireless weather station based on simulation results.

1.5Thesis layout

Chapter one giveun introduction to the thesis including general, objective, problem statement, and methodology.Chapter tow presents literature review and previous works. Furthermore, sensors, transducer, actuator, microcontroller, embedded system and radio frequency are briefly reviewed. Chapter three the main components to design weather station are discussed.Chapter four presents the simulation results.Chapter five draws general conclusion and recommendations.

Chapter Two

Literature Review and Previous Works

2.1 Previous Studies

Several works have been done in the area of weather station design among them this study undertaken during 2011 at the University of Khartoum, Faculty of Engineering, Department of Electrical and Electronic Engineering by AhmedJamalAldeen, AlaaAldeenAbdAlmjeed,MohammedKhalil and Mohammed AbdAlhameed. It depends on the type of microcontroller (ATMEGA16 microcontroller) andPC interface design (using Visual Basic) and use three sensors (pressure, temperature and humidity sensor) discussion and conclusion is the project was not implemented as proposed due to the unavailability of both (MXP4115A) and capacitive humidity sensor in the lab neither the agent Sudan. The circuit was designed to implement the (reading temperature process using lm35). On the other hand, the software was designed to simulate both reading pressure using MXP4115A and reading temperature using lm35[15].

P.Susmithadevelop an embedded system to design weather monitoring system which enables the monitoring of weather parameters in an industry. Such a system contains pair of sensors like temperature, Gus and humidity will be monitored and PIC1768 microcontroller (arm9). The data from the sensors are collected by the microcontroller and also it sends the sensors data in to the labview by using the serial communication and this module will keep the data in excel pageand also we can get the SMS in the mobile with the help of Global System Of Mobile (GSM)module, The system uses a compact circuitry built around lpc1768(arm9) microcontroller programs are developed in embedded C using the ide keiluvision4 jtag is used for loading program into microcontroller[16] .

G. V.StayarnaryanaandA.Mazaraddindevelovepeda wireless sensor networks can be used in monitoring various parameters in agriculture. Due to uneven natural distribution of rain water it is very difficult for farmers to monitor and control the distribution of water to agriculture field in the whole distribution or per the requirement of the crop. There is no ideal irrigation method for all weather conditions, soil structure and variety of crops cultures . Farmers suffer large financial losses because of wrong prediction of weather and incorrect irrigation methods .

In this context , with the evolution of miniaturized sensor devices coupled with wireless technologies it is possible remotely monitor parameter such as moisture, temperature and humidity. In this paper it is proposed to design,develop and implement a wireless sensor network connected to a central node using Zigbee, which in turn is connected to a central monitoring station through General Packet Radio Service (GPRS) or GSM technologies. The system also obtains global positioning system (GPS) parameters related to the field and sends them to a central monitoring station. This system is expected to help farmers in evaluating soil conditions and accordingly[17].

2.2 Sensors and Transducers

A sensor is a device that receives and responds to a signal. This signal must be produced by some type of energy such as heat, light, motion, or chemical reaction. Once a sensor detects one or more of these signals (input), it converts it into an analog or digital representation of the input signal, according to its output signal type. Figure 2.1 shows how sensor work. Based on this explanation of a sensor, are used in all aspects of life to detect and/or measure many different conditions. An observable variable y

(t) is obtained from the measured physical quantity x(t), where they are related in some determined way.

The sensor generated signal variable y(t) can be processed, transmitted or displayed . A sensor is calibrated by applying a number of known physical inputs, while recording its output signal. The sensor reading is modified by modifying inputs that change the behavior of the sensor, and hence the calibration curve. The figure 2.2 and 2.3 shows the sensor modifying inputand Calibration Curve respectively .

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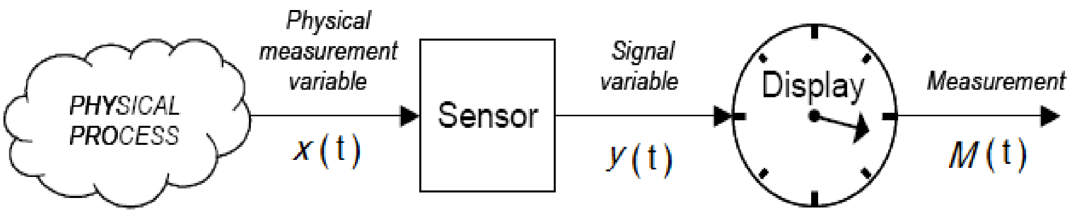

Figure 2.1:How sensor work

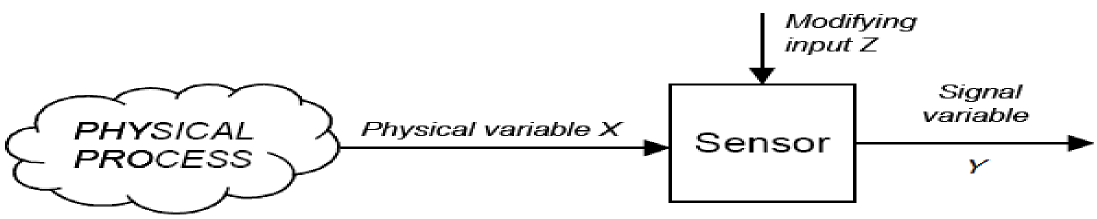

Figure 2.2:Modifying sensor input

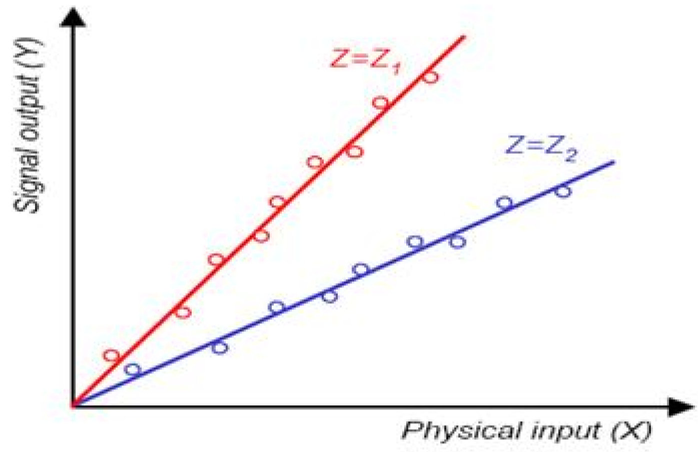

Figure 2.3: Calibration curve

The term transducer is often used in place of the term sensor. The transducer is a device that converts one physical quantity into anther [3,19].

2.2.1 Type of transducers

The main type of transducer are:

1. A microphone converts sound into electrical impulses and a loudspeaker converts electricalimpulses into sound (i.e., sound energy to electrical energy and vice versa).
2. A solar cell converts light into electricity and a thermocouple converts thermal energy into electrical energy.
3. An incandescent light bulb produces light by passing a current through a filament. Thus, a light bulb is a transducer for converting electrical energy into optical energy.
4. An electric motor is a transducer for conversion of electricity into mechanical energy or motion.

2.2.2 Primary and secondary transducer

1- Primary transducer changes real world parameter in to electrical signal.

2-Secondary transducer converts electrical signal in to analog or digital valuesFigure 2.4 shows the primary and secondary transducer [3].

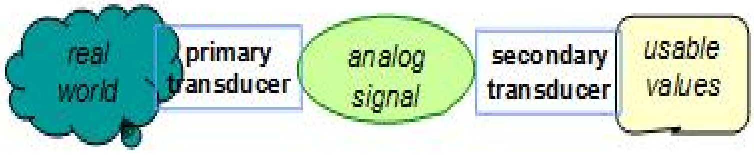

Figure 2.4: Primary and secondary transducer

2.2.3Sensor characteristics

The main characteristic of the sensor are:

1-Accuracy

- Accuracy is the capacity of a sensor (measuring instrument) to give a reading close to the true value of the measured quantity.
- Accuracy is related to the bias or partiality of a set of measurements.
- Accuracy is measured by absolute and relative errors, where:

Absolute Error = Reading- True Value (2.1)

Relative Error = Absolute Error/True Value (2.2)

2-Precision

Precision is the capacity of a sensor to give the same reading, when repetitively measuring the same quantity under the same conditions.

3-Resolution

Resolution, or the discrimination, is the minimal change in the input necessary to produce detectable change at the sensor output.When the increment is from zero, it is called the threshold.

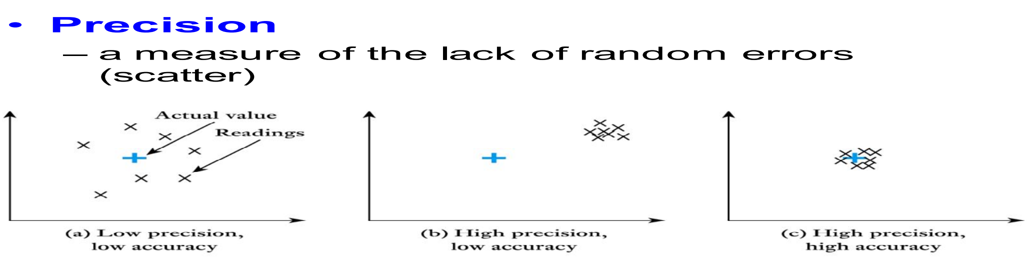

Figure 2.5:A Measure of the lack of random errors (scatter)

4- Sensitivity

The slope of the calibration curve $y=f(x)$.

5- Linearity

The closeness of the calibration curve to a specified straight line, which is the theoretical behavior[13].

6- Monotonicity

A monotonic curve is one in which the dependent variable $y(x)$ always increases or decreases as the independent variable x increases.

7-Input range

The maximum and minimum value of the physical variable that can be measured (e.g. -40°C/100°C in a thermometer). Output range can be defined similarly.

8- Hysteresis

The difference of two output values that correspond to the same input depending on the trajectory followed by the sensor.

2.2.4Sensor Errors

Errors of sensor reading are divided into two categories asshown in Figure2.6**.**

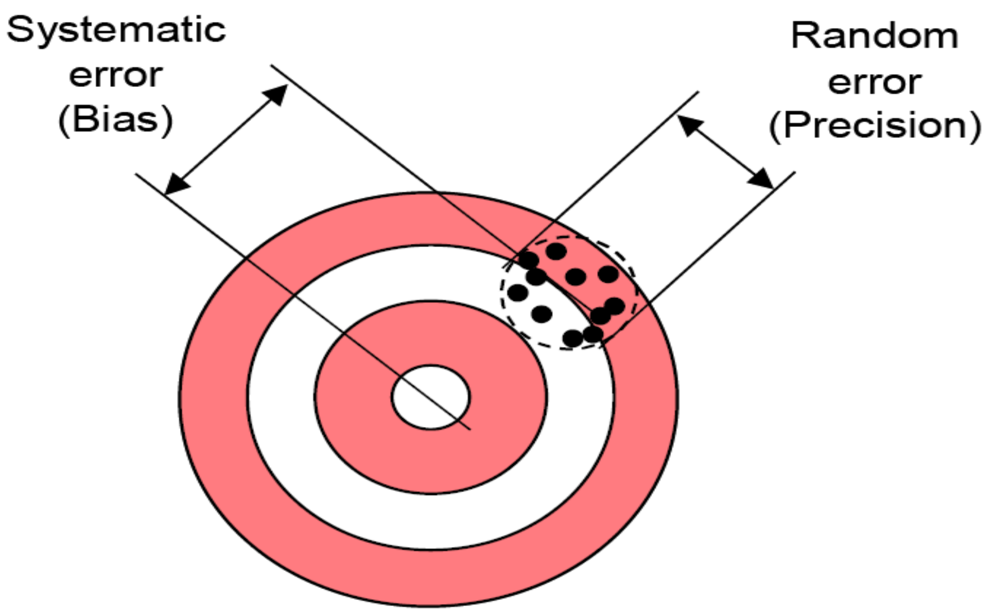

Figure 2.6: Type of error

a-Systematic Errors

Systematic errors can be compensated. They result from different factors such as:

1-Modifying variables, like temperature.

2-Drift , like changes in mechanical stress.

3-Sensor loading to the measuring.

4-Attenuation in the transmitted signal.

5-Human observation, like parallax errors.

b- Random errors

Random errors cannot be compensated, but could be reduced Random errors result from random processes that generates interfering noise signals, which can be divided in three classes.

1- Environmental noise, such as the background noise picked by a microphone.
2- Transmission noise, such as interference due to alternating current (AC) power lines and adjacent devices.
3- System noise, such as thermal or shot noise[3].

2.2.5Type OfUsed Sensors

1-Temperature Sensor

There are several devices used to measure temperature. several of the more practical designs are thermistor, resistance temperature detector, and integrated circuit temperature sensor.temperaturesensor is a transducer, which converts temperature energy into corresponding variation in resistance.

2-Humidity Sensor

Mainly, there are two types of sensors to measure the relative humidity are resistive humidity sensor and capacitive humidity sensor.The capacitive humidity sensor has a capacitance varying approximately proportionally with ambient humidity .The resistive humidity sensor measure the change in electrical impedance of a hygroscopic medium such as a conductive polymer, salt,or treated substrate. The impedance change is typically an inverse exponential relationship to humidity.

3- Pressure sensor

Pressure sensors either convert the pressure into mechanical movement or an electrical output.There are several devices used to measure atmospheric pressure. Some options are Mercury pressure, Digital pressure, and Analog pressure.

4- Light Sensor

A light sensor generates an output signal indicating the intensity of light by measuring the radiant energy that exists in a very narrow range of frequencies basically called light , and which ranges in frequency from infra-red to visible up to ultraviolet light spectrum.

The light sensor is a passive devices that convert this light energy whether visible or in the infra-red parts of the spectrum into an electrical signal output. light sensors are more commonly known as photoelectric devices or photo sensors because the convert light energy (photons) into electricity (electrons).the table 2.1and 2.2 show the parameters for choosing sensors and other types of sensors respectively [3].

Table 2.1: The parameters for choosing sensors

Environmental Factors	Economic Factors	Sensor Characteristics
Temperature Range Humidity Effects Corrosion Size Over Range Protection Susceptibility To Em Interferences Ruggedness Power Consumption Self-Test Capability	Cost Availability Lifetime	Sensitivity Range Stability Repeatability Linearity Error Response Time Frequency Response

Table2.2: Other type of sensors

SENSOR TYPE	Uses
Position sensor	To sense current position of moving device
Optical encoder	To produce digital out puts such as in digital micrometer and verniers
Strain gauge	Force or wight
Speed sensor (tacho)	Angular speed sensor
Attitude sensors	To sense and measure the inclination
Altimeter	To measure the altitude or height of an aircraft

2.3 Actuator

An actuator is a device that actuates or moves something. An actuator uses energy to provide motion. Therefore an actuator is a specific type of a transducer. An actuator is a type of motor that is responsible for moving or controlling a mechanism or system [3]. The example of a ctuater as fallows:

1- Piezoelectric actuator.
2- Hydraulic piston.
3- Electric motor.
4- Relay.
5- Servomechanism.
6- Pneumatic actuator.
7- Liquid crystal display

2.4 Method of Signal Filtering

Introduce elements into the instrument to block or reduce the interfering or modifying inputs .Figure 2.7 shows the method of the input filtering and Figure2.8 shows the method of the output signal filtring signal.

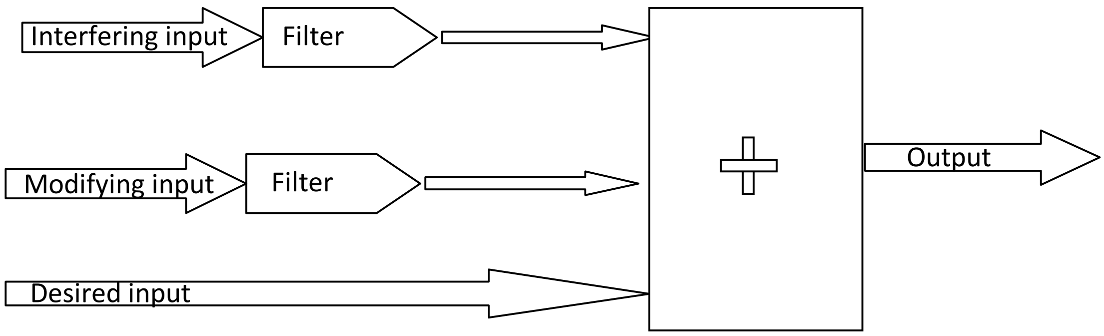

Figure 2.7: Method of Input signal Filtering

Output Filtering

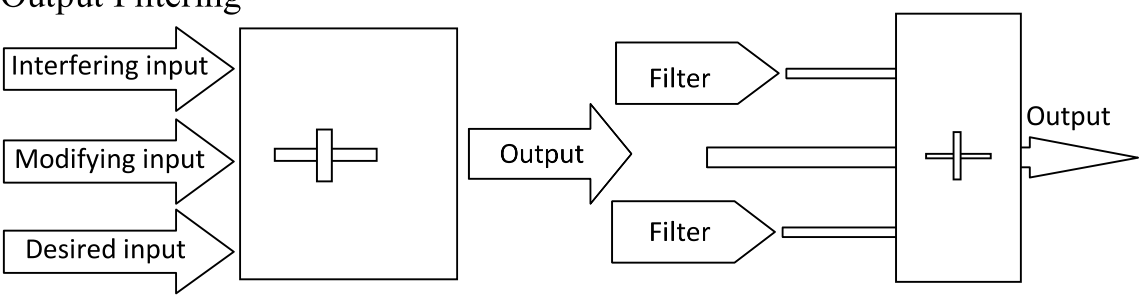

Figure 2.8: Method of the Output signal filtering

Interfering input: Quantities to which the instrument is unintentionally sensitive.

Modifying input: Quantities that cause a change in the input output relations of the instrument.

Desired input examples are: Temperature, atmospheric pressure, magnetic fields, humidity, etc [15].

2.5 Embedded System

Embeddedsystems are the electronic systems that contain a microprocessor or a microcontroller, but we do not think of them as computers, the computer is hidden or embedded in the system.A way of working, organizing or performing one or many tasks according to a fixed set of rules, program or plan also an arrangement in which all units assemble and work together according to a program or plan.In embedded systems, the microprocessor is a part of a final product and is not available for reprogramming to the end userAn embedded system is interfaced with other subsystems through its inputs and outputs.It is interfaced with digital subsystems through serial or parallel input/output ports, in order to convey data in and out. An embedded system is a system that has software embedded into computer-hardware, which makes a system dedicated for an application or specific part of an application or product or part of a larger system. An embedded system is one that has dedicated purpose software embedded in a computer hardware. It is a dedicated computer based system for an application(s) or product. It may be an independent system or a part of large system. Its software usually embeds into a Read Only Memory (ROM) or flash memory. It is any device that includes programmable computer but is not itself intended to be a general purpose computer. The main example of the embedded system are copying machine, washing machine.,Air conditioner[1].

2.6 The difference between a computer and embedded systems

A computer is a device that has the following or more components:

1. A microprocessor.

2. A large memory comprising the following two kinds.

(a) Primary memory (*semiconductor* memories Random access memory(RAM), Read Only Memoryrom(ROM) and fast accessible caches.

(b) Secondary memory (*magnetic* memory located in hard disks, diskettes and cartridge tapesand *optical* memory in CD-ROM).

3. Input units like keyboard, mouse, digitizer, scanner, etc.

4. Output units like video monitor, printer, etc.

5. Networking units like Ethernet card, etc.

6. I/O units like a modem, fax cum modem, etc.

An embedded system shownin Figure2.9 is one that has computer-hardware with software embedded in it as one of its most important component.

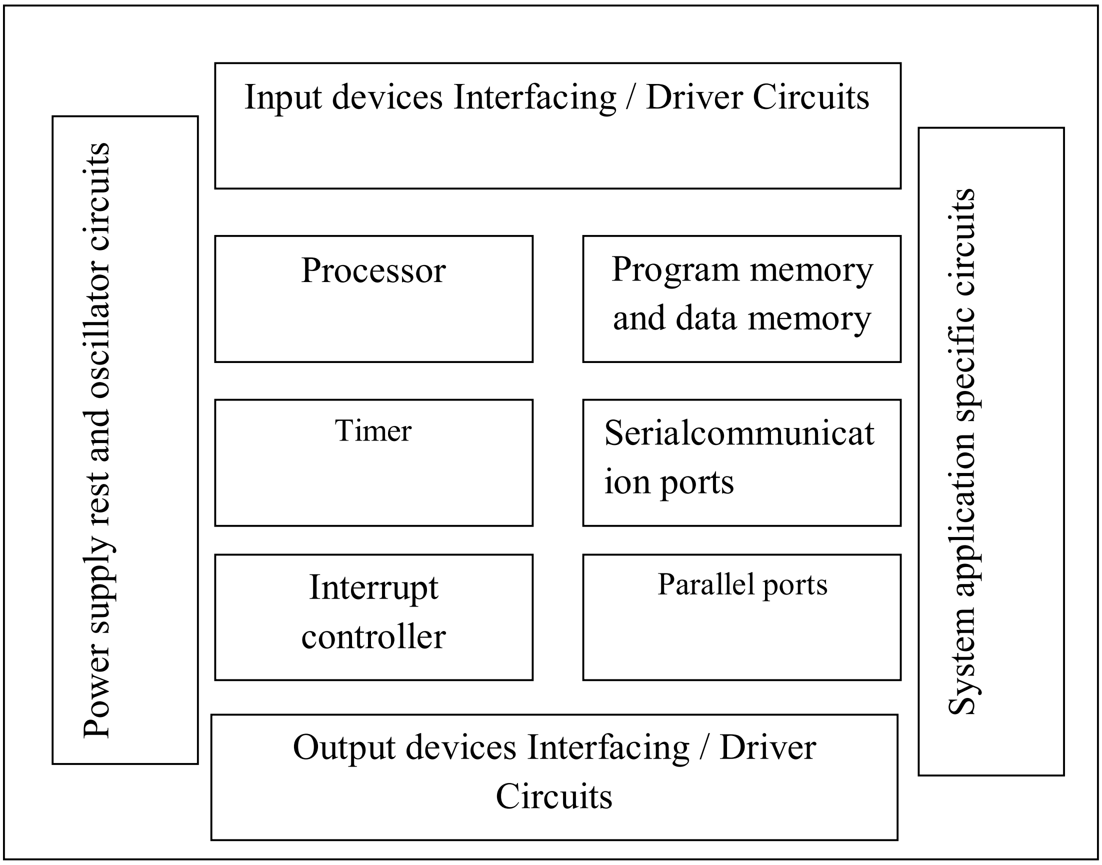

Figure2.9:The component of embedded system hardware

Anembedded system has three main components:

1-It has hardware as showenin Figure2.9.

2-It has main application software. The application software may perform concurrently the series of tasks or multiple tasks.

3. It has a Real Time Operating System (RTOS) that supervises the application software and provides a mechanism to let the processor run a process as per scheduling and do the context-switch between the various processes (tasks). RTOS defines the way the system works. It organizes access to a resource in sequence of the series of tasks of the system[1].

2.7 Microcontroller

A microcontroller (sometimes abbreviated µC, uC or MCU) is a small computer on a single integrated circuit containing a processor core, memory, and programmable input/output peripherals.Isalso often included on chip, as well as a typically small amount of RAM.Microcontrollers are designed for embedded applications, in contrast to the microprocessors used in personal computers or other general purpose applications.Microcontrollers are used in automatically controlled products devices, such as [1]:

1-Automobile engine control systems.

2-Implantable medical devices.

3- Remote controls.

4- Office machines.

5- Appliances.

6- Power tools.

7- Toys and other embedded systems.

2.7.1Microcontroller Features

1-Microcontrollers usually consistsof several to dozens of General Purpose input/output (GPIO)pins. GPIO pins are software configurable to either an

Input or an Output state.When GPIO pins are configured to an input state, they are often used to read sensors or external signals. Configured to the output state, GPIO pins can drive external devices such as LEDs or motors.

2-Many embedded systems need to read sensors that produce analog signals. This is the purpose of the Analog to Digital Converter (ADC). Since processors are built to interpret and process digital data, i.e. ones and zeros, they are not able to do anything with the analog signals that may be sent to it by a device. So the Analog to Digital Converter is used to convert the incoming data into a form that the processor can recognize. A less common feature on some microcontrollers is a digital-to-analog converter (DAC) that allows the processor to output analog signals or voltage levels.

3- In addition to the converters, many embedded microprocessors include a variety of timers as well. One of the most common types of timers is the Programmable Interval Timer (PIT). A PIT may either count down from some value to zero, or up to the capacity of the count register, overflowing to zero. Once it reaches zero, it sends an interrupt to the processor indicating that it has finished counting. This is useful for devices such as thermostats, which periodically test the temperature around them to see if they need to turn the air conditioner on, the heater on, etc.

4- A dedicated Pulse Width Modulation (PWM) block makes it possible for the central processing unit(CPU) to control power converters, resistive loads, motors, etc., without using lots of CPU resources in tight timer loops.

5- Universal Asynchronous Receiver/Transmitter (UART) clock makes it possible to receive and transmit data over a serial line with very little load on the CPU. Dedicated on-chip hardware also often includes capabilities to communicate with other devices (chips) in digital formats such as Serial Peripheral Interface (SPI) [1].

2.7.2 Criteria for choosing a microcontroller

the first and foremost criteria for choosing a microcontroller is that it must meet the task at hand efficiently and cost effectively,we must first see whether an 8bit ,16bit or 2bit.Microcontroller can best hand the computing needs of the task most effectively among other considerations in this category are [1].

1- Speed.
2- Power consumption.
3- The capacity of RAM and ROM on the chip.
4- The number of I/O pins and the timer on the chip.
5- Cost per unit.

2.8RadioFrequency

Electromagnetic wave: Travels freely through space in all directions at speed of light

Radio Wave: When electric current passes through a wire it creates a magnetic field around the wire as magnetic field radiates, creates an electromagnetic radio wave and spreads out through space in all directions . Also cantravel long distances also can penetrate non-metallic objects.

RF is a rate of oscillation in the range of around 3 KHZ to 300 GHz, which corresponds to the frequency of radio waves, and the alternating currents which carry radio signals.The table 2.3 shown the comparison of radio, light ,heat wave characteristics.

Table 2.3:Comparison of radio, light, heat Wave Characteristics

Type of Wave	Travels long Distances	Invisible	Imperceptible	Penetrates Solid Objects
Light	No	No	No	No
Heat	No	Yes	No	No
Radio	Yes	Yes	Yes	Yes

RF usually refers to electrical rather than mechanical oscillations; however, mechanical RF systems do exist. Although radio frequency is a rate of oscillation, the term RF is also used as a synonym for radio i.e. to describe the use of wireless communication, as opposed to communication via electric wires. RF signals are high frequency ACsignals composed of electromagnetic energy. Imagine dropping a rock into a still pond and watching the concentric ripples flow away from the point where the rock hit the water. This is how RF waves exit an antenna[5, 6].

2.8.1 RF Characteristics

1-Low power ,typically transmit less than 1mW of power.

2- Good operating range:Operate over distances of 3 to 30 meters.

3-Supports data rate up to 1-2 Mbps.

4-Penetrates walls.

5-Does not require a direct transmission path (as opposed to IR).

6-Wireless communication technology.

7-Cheap and widely used over40 millions systems manufactured each year utilizing low-power wireless RF technology for data links, telemetry, control and security.

8-Wide range of applications such as Cordless and cellular telephones, radio and television broadcast stations, hand-held computer andPersonal Digital Assistant (PDA) data links, wireless bar-code readers, wireless keyboards for PCs, wireless security systems, consumer electronic remote control, etc…[5].

2.8.2 Radio frequency module

An RF module is a usually small electronic device used to transmit and/or receive radio signals between two devices. In an embedded system it is often desirable to communicate with another device wirelessly. This wireless communication may be accomplished through optical communication or through RF communication. For many applications the medium of choice is RF since it does not require line of sight. RF communications incorporate a transmitter and/or receiver.

Several carrier frequencies are commonly used in commercially-available RF modules, including those in the Industrial, Scientific And Medical (ISM) radio bands such as 433.92 MHz, 315 MHz, 868 MHz, 915 MHz, and 2400 MHz. These frequencies are used because of national and international regulations governing the used of radio for communication.RF modules may comply with a defined protocol for RF communications such as Zigbee, Bluetooth low energy, or Wi-Fi, or they may implement a Proprietary protocol[6].

2.9 The Electromagnetic Spectrum

When an RF electrical signal radiates, it becomes an electromagnetic wave thatincludes not only radio signals, but also infrared, visible light, ultraviolet light,X-rays, gamma rays, and others. Before proceeding with RF electronic circuits,therefore, take a look at the electromagnetic spectrum.Table 2.4shows the electromagnetic spectrums from ELF to X-ray. The spectrum extends from the very lowest AC frequenciesand continues well past visible light frequencies into the X-ray and gammarayregion. The Extremely Low Frequency (ELF) range includes AC power-linefrequencies as well as other low frequencies in the 25 to 100-hertz region. TheUSA Navy uses these frequencies for submarine communications.

Table 2.4The Electromagnetic Sbectrum From VLF To X-RAY T

	AM			FM		MICROWAVES						
ELF	VLF	LF	MW MF	HF SW	VHF	UHF	SHF	EHF	IR	VISIBLE LIGHT	UV	X-RAY

100 Hz	10 Khz	100 Khz	1 Mhz	3 Mhz	30 Mhz	300 Mhz	1 Ghz	30 Ghz	300 Ghz	10^{14} Hz	10^{16} Hz	10^{17} Hz	10^{18} Hz

The Very Low Frequency (VLF) region extends from just above the ELF region,although most authorities peg it to frequencies of 10 to 100 KHZ. The Low Frequency (LF) region runs from 100 to 1000 KHZ or 1 MHZ. TheMedium-Wave (MW) or Medium-Frequency (MF) region runs from 1 to 3 MHz. TheAmplitude-Modulated (AM) broadcast band (540 to 1630 kHz) spans portions of theLF and MF bands.The High-Frequency (HF) region, also called the ShortWave bands (SW), runs .from 3 to 30 MHz. The VHF band starts at 30 MHz and runs to 300 MHz. This regionincludes the Frequency-Modulated (FM) broadcast band, public utilities, some televisionstations, aviation, and amateur radio bands. The UltraHigh Frequencies (UHF)run from 300 to 900 MHz and include many of the same services as Very HIGH Frequency VHF. The microwaveregion begins above the UHF region, at 900 or 1000 MHz, depending onsource authority.

You might well ask how microwaves differ from other electromagnetic waves.Microwaves almost become a separate topic in the study of RF circuits because atthese frequencies the wavelength approximates the physical size of ordinary electroniccomponents. Thus, components behave differently at microwave frequenciesthan they do at lower frequencies. At microwave frequencies, a 0.5-W metal film resistor,for example, looks like a complex RLC network with distributed inductors(L) andcapacitor (C)valuesand a surprisingly differentResistance(R) value. These tiniest of distributed componentshave immense significance at microwave frequencies, even though they can be ignoredas negligible at lower RFs[5].