F I N A L   Y E A R   P R O J E C T

Patient Monitoring Via Wireless Nodes and LAN

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بسم الله الرحمن الرحيم

In the name of Allah, the Beneficent, the Merciful

DEDICATION

This Project is dedicated to our parents, teachers and friends who were always there by our side to guide us and gave us the courage that we can do the best in our life and taught us the difference between the good and the evil, for this be our guide in our life.

CERTIFICATE OF APPROVAL

It is certified that the project work presented in this project report, entitled “**Patient Monitoring Via Wireless Nodes and LAN”** *was conducted by students of Bahria University under the supervision of Mr. S*haftab by *Raja Zeeshan Manzoor and Faizan Naseem*

______________________	____________________
Sir Shaftab	Sir Abid Ali Minhas
Advisor	H.O.D
Faculty of Electronic Engg.	Faculty of Electronic Engg.
Dated:__________________	Dated:__________________

Acknowledgement

All praises for Allah(The Almighty) who gave us the determination and enlightened us with the requisite knowledge on portion of this subject to complete this project.

Several people have had a significant impact, both directly and indirectly, on the material presented in this report. Our biggest debt of gratitude goes to our project supervisor Mr. Shaftab and Project Co-ordinator, Mr. Junaid Imtiaz from Bahria University ISLAMABAD. They have had the dual roles of supervisor and mentor for us. They have provided us with a model both for how to work on this project and how to report on it in a meaningful way. Their impact on both this project report, and our respective careers, has been profound.

Other people with whom we had the good fortune to collaborate and learn from include Mr. Abid Ali Minhas. These people have served as our teachers and more like our friends and we are grateful to them for their guidance and their support.

We greatly appreciate the generosity of our teachers and friends in devoting their time to help us with this project.

DECLARATION

The work that we did on this project is our own work and effort. It has not been submitted in any form for another degree. The information that we gathered in order to prepare our thesis is from published and unpublished work of others, it has been acknowledged and the list of references is being provided.

Faizan Naseem

Raja Zeeshan Manzoor

April 2011

Abstract

The classical patient monitoring system involves measurement of clinical parameters like blood pressure, heart beat and temperature.

The nurse measures all these parameters, writes it and reports it to the respective doctor periodically. Our project takes advantage of telecommunication where information acquisition and logging can be done automatically. This information is available anywhere, any time. It will reduce human effort and this system can b used for patients at home or patients in hospitals.

There has been an exponential increase in health care costs in the last decade. Patients have to make frequent visits to their doctor to get their vital signs measured. There is a huge market for non-invasive methods of measurement of these vital signs. The objective of this project is to design and implement a reliable, cheap, low powered, non-intrusive, and accurate system that can be worn on a regular basis and monitors the vital signs and displaying periodically. This data is also easily accessible by the physician through wireless network on computer system. This project specifically deals with the signal conditioning and data acquisition of three vital signs:

1. Heart Beat
2. Blood pressure
3. Body temperature

Contents

Chapter 1

INTRODUCTION

1 Our Project

Most of the developing countries are addressing challenges of the availability of better healthcare. The patient needs to visit a doctor once a week for inspection and it is some how difficult for the doctor to monitor all their patients Heartbeat, temperature and blood pressure control.

The main purpose of developing this project is to provide incentives is for doctors to work in remote areas. Due to the dramatic developments in the wireless scenario of the country, wireless monitoring of patients develop as a possible alternative solution to the problem of limited access to medical care.

Patients have to make frequent visits to their doctor to get their vital signs measured.
Regular monitoring of vital signs is essential as they are primary indicators of an individual's physical well-being. These vital signs include:

1. Pulse rate/Heart Beat,
2. Blood pressure,
3. Body temperature

The classical patient monitoring system involves measurement of clinical parameters like blood pressure, heart beat and temperature.

The nurse measures all these parameters, writes it and reports it to the respective doctor periodically. Our project takes advantage of telecommunication where information acquisition and logging can be done automatically. This information is available anywhere, any time.

Our project involves two important tasks which are

1. Patient Monitoring
2. Transfer of information using Wireless Technology

In this project, an electronic heart beat sensor, blood pressure sensor and temperature sensor is connected to a wireless local area network nodes and further connected with a computer devices via LAN. Wireless patient monitoring enables doctors and patients to access the medical information and ability to treat patients remotely, empowering patients and physicians with information that allows you to better care and control.

Motivation

Traditionally it was the custom of this vital measure to obtain during the visit of doctors. With advances in medicine and technology, this concept has changed. There are many devices on the market today that allows patients to monitor their health on a regular basis from the comfort of homes. These devices have an enormous impact on healthcare cost, the time and the resources of doctors and facilities needed by patients.
This is beneficial for both patients and doctors. Health professionals can access this information from computers on the wireless network and the vital information of their patients to check on anytime. If they notice abnormalities, they can always arrange to meet their patients.
There are very few in-home monitoring devices on the market that are accurate, secure and easy to use, while at the same time, lower costs for the customer. The goal of this project is to develop such devices.

Patient Monitoring System in Pakistan:

Patient Monitoring in Pakistan involves process of manual storage of information and the system it self has a lot of drawbacks. It is difficult for the doctor or a nurse to monitor a patient constantly and to provide equal time to all of them. The system that is followed in most of the Pakistani hospitals requires a lot of the human effort and is time consuming; this system has very low efficiency level.

Patients are increasing tremendously. Pakistan is one the developing countries which is facing problems in addressing the issues of availability of better health care to common man. Mostly every patient must have to visit doctor once a week for check up. In our country medical facilities are very limited and not so advanced and because of this limitation of resources doctors are forced to give dates after long gap and the treatment of the patient are not satisfactory. Even if the doctors check it's the entire patient, it would be very heretic routine for the doctor.

Technology has always helped humans in one way or the other. In this project we will take the help of technology to design a system that will be much accurate, much faster, will reduce human effort and will over all increase efficiency of current system in the hospitals.

To improve the current system that is followed in the hospitals of patient monitoring, in case of nurses which monitor patient by visiting them and asking them about the health and recording their blood pressure, temperature and checking their heart beat manually. We will be using different sensors which will collect patient's information e.g. (Blood Pressure, Heart Beat & Temperature) and these sensors will help to collect the information. Hence this system reduces human effort and nurses/doctors in this case won't have to visit patient constantly.

1.1 Objective

The main objective of this project is to provide incentives to the doctors to serve patients at remote communities for this a design is build for sensing and data conditioning system to acquire accurate heart beat, blood pressure and body temperature readings.

Due to dramatic development in the wireless scenario of country, wireless patient monitoring is evolving as a possible alternate to address the issue of limited access to health care.

The goal of this project is to develop low cost, low power, reliable, free from interference and non-invasive monitoring of vital information in the processing and analysis of data from the sensors to determine whether they are "normal" range, and further this data transfer wireless nodes and then displayed on the computer systems.

Methodology

The methodology adopted for this project is to use sensors to measure heart beat, blood pressure and body temperature. The sensors used are inexpensive and are easy to use by the patient. Signal conditioning circuits are designed to filter and amplify the signals to provide desired output. All the components used in these circuits are low powered and inexpensive. The acquired data is real time and is sent to through the analog-to-digital converter (ADC) and into the PIC microcontroller.

Heart Beat

Optical sensor measures the electrical activity of the heart. The activation of the heart starts at the sino-atrial node that produces the heart frequency, at about 70 cycles per minute. This activation propagates to the right and left atria muscle tissues. At the atria ventricular node, there is a delay to allow the ventricles to fill with blood from atria contraction. The heart beat or pulse rate is the frequency of this heart cycle, and more specifically, the number of heart cycles that occur every minute.

Blood Pressure

Same optical sensor measures the volume changes in an organ. Light from a Light Emitting Diode (LED) is shone through the skin and changes in light absorption are measured through a photodiode.

There are two types of techniques that can be used:

i) Transmission, which is shining light through the skin with LEDs on one side of the body part and placing the photodiode on the other side to obtain the characteristics of the light transmitted through the skin. This technique would work on finger or ear

ii) Reflection, which is shining light through the skin with LEDs on one side of the body part and placing the photodiode on the same side to obtain the characteristics of light reflected from the skin. This technique would work on forehead or chest.
In the resulting signal, the DC component refers to the absorption by the tissue, and the

AC component relates to the pulsatile component of blood volume that is directly related to the cardiac cycle.

Body Temperature

Human body temperature varies within a narrow range of values. Body temperature can be measured from different parts of the body. Temperature depends on many things, including level of activity, time of day, and psychological factors. It also depends on whether the person is eating

Project Goal

Basically, we just used the present resources and compile them to produce a very important device for patients as well as for doctor to monitor its respective patients.

In this project, sensor are connected with the body of the patient and they will send data to analog to digital converter (ADC) as the sensors will provide analog signals which will be converted by analog to digital converter (ADC) into digital signal. This digital signal is further send to the microcontroller which is programmed in such a way that the LCD will show the information about the patient like blood pressure, temperature and heart beat.

Displaying patient information on LCD is one of the important goal of this project.

The next aim would display patient information in computer system using wireless technology.

The use of wireless communication is very common mostly every body is familiar with it. In our project an electronic heart-beat, blood pressure and temperature counter is linked with a wireless nodes and LAN devices.

Wireless Patient Monitoring will enable doctors and patients to access medical information and doctors the ability to treat patients remotely, empowering patients and doctors with information that enables better care and control.

1.2 Aim of our Project

The main aim of our project is to ease both the patient and the doctor. This project aims to save time make things easier and much simpler for both the doctor and patient. The system designed, is much faster and accurate. It will reduce human effort and this system can b used for patients at home or patients in hospitals.

The procedure of this system is much simple and gives patients heartbeat blood pressure temperature details all the time. If an alarming situation arrives in order from respective patient, the doctor immediately comes to know about it without monitoring the patient as it is difficult for the doctor to keep an eye on the patient all the time. These technology advances are surely making an impact on the quality, cost and timely delivery of care.

Benefits of Patient Monitoring via Wireless Nodes & LAN:

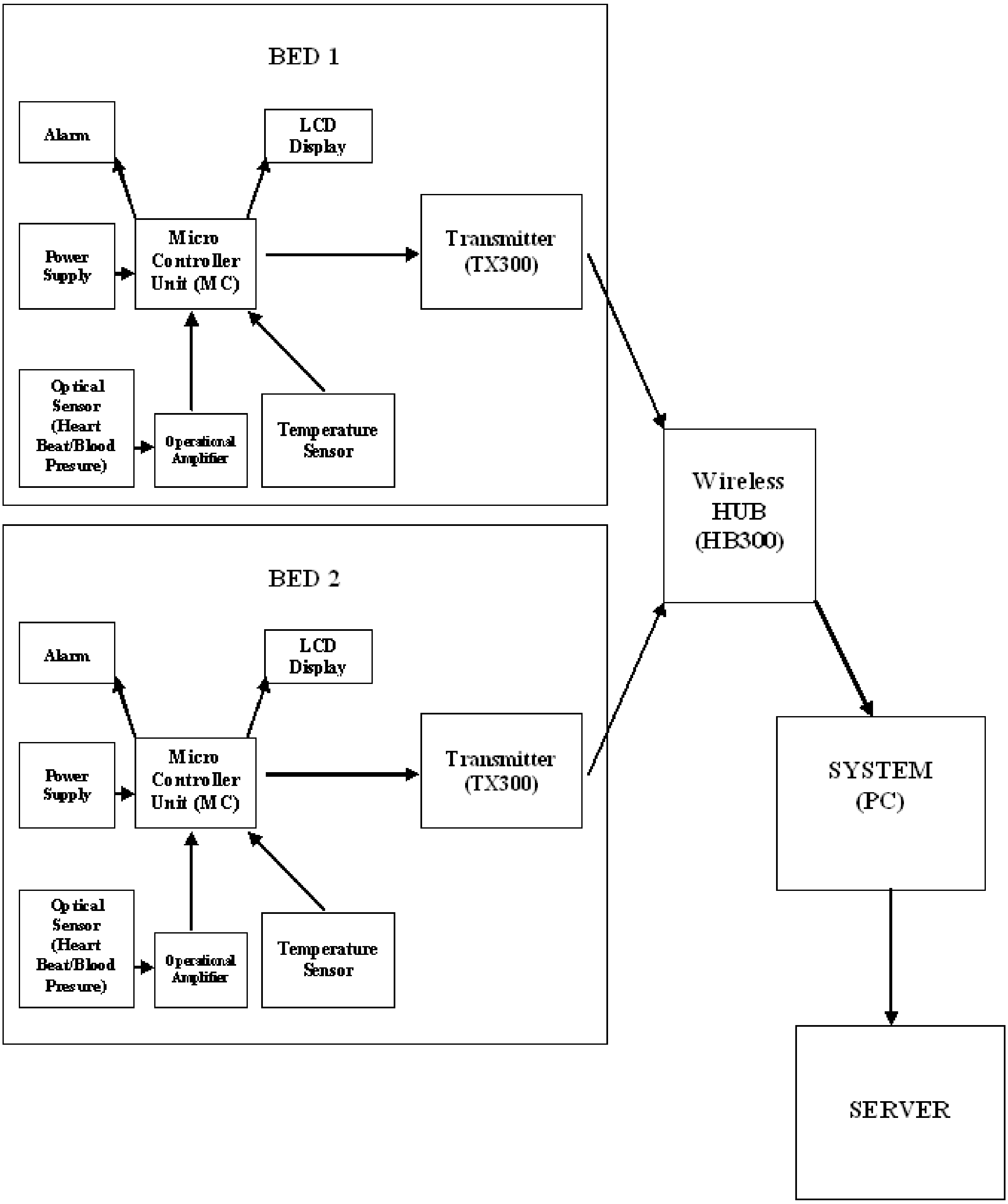
Patient Monitoring via wireless nodes and LAN will benefit the health care system in following key areas:

- Doctors and patients will have greater access to reliable health care information.
- This technology used will certainly result in a decrease in medical ambiguities
- automate and standardize decisions, identifying errors before they occur
- This Technology provides greater access to personal health care information being shared between patient and doctors. Heart beat blood pressure and temperature results will become available on LCD, as well as on computer.

- ❖ Doctors can get to know about patient’s condition and unnecessary visits by the doctors can come to an end by this system.
- ❖ Electronic thermometer can be used for monitoring the temperature parameter of the patient
- ❖ Three different parameters on the same system

PROJECT APPROCH

2.1 Block Diagram



The block diagram explains how the system works. The microcontroller is connected to a power supply and it will send data to the transceiver for wireless transmission. Data transferred wirelessly will be received by a receiver and will be displayed on computer screen which is connected to other computers via LAN. The microcontroller will also send data to the LCD and to the Alarm section .The LCD will display the information on its screen.

Chapter 3

REVIEW OF LITERATURE

3.1 Micro-Controller

Micro-Controller contains a processor memory programmable inputs and outputs peripherals Program memory in the form of OTP Read only memory is also usually include on chip as well as a typically small amount of Random access Memory.

Micro Controller is kind of a small computer on a single IC or an integrated circuit. Microcontrollers are planed, designed for embedded usage or applications such as automobile engine implantable devices used in medical remote controls machines in offices appliances power tools and toys.

Microcontrollers have become economical to control more devices and processes by reduction in the size and cost compared to a design that uses a separate microprocessor memory and input output devices.

Mixed signal microcontrollers are common integrating analog components needed to control non digital electronic system. Some microcontrollers may use 4 bit words and work at clock rate frequencies as low as 4 kHz. They will generally have the quality to regain functionality while waiting for an event such as a button press or other interrupt; power consumption while sleeping (CPU clock and most peripherals off) may be just nano-watts, making many of them well appropriate and acceptable for long lasting battery applications. Other microcontrollers may serve performance-crucial, critical roles.

The Role of Microcontroller System

In our system its is used to control all system that how data is send to user and the whole system Microcontroller consists of a powerful processor and memory are closely linked to the various input / output interfaces such as serial port, parallel port or timer, counter, interrupt controller, data collection interfaces, analog-digital converter, integrated digital / analog converter on a single die of silicon.

If the system is designed with a microprocessor, the designer for an external memory such as RAM, ROM, EPROM and peripherals. But the controller provided that all these items on a single chip. Development of micro-controller reduces the PCB size and cost of designing. One of the main differences between the microprocessor and the Micro-controller is that the controller often deals with the bits not bytes, as in the real world application. Intel Corporation today introduced a family of controllers called the Micro MCS-51.

Key Features of Microcontroller

Source	Description
INTO	Internal Request from P3.2 pin
Timer O	Overflow interrupts from timer O activated by flag TFO.
INT I	External request from P3.3pin
Timer I	Overflow interrupts from timer I
Serial Prot	Completion of transmission and reception of one serial frame activates TI and RI

Table 3.1.1 (Key Features of Microcontroller)

Features Description
▪ Compatible with MCS-51® Products
▪ 4K Bytes of In-System Programmable (ISP) Flash Memory
▪ Endurance: 1000 Write/Erase Cycles
▪ 4.0V to 5.5V Operating Range
▪ Fully Static Operation: 0 Hz to 33 MHz
▪ Three-level Program Memory Lock
▪ 128 x 8-bit Internal RAM
▪ 32 Programmable I/O Lines
▪ Two 16-bit Timer/Counters
▪ Six Interrupt Sources
▪ Full Duplex UART Serial Channel
▪ Low-power Idle and Power-down Modes

Table 3.1.2 (Features of Microcontroller)

More Description

Microcontroller consist of total 40 pin first 1 to 8 pin are connected with ULN 2803 which is used to step up a low power to high power and there is another unl 2803 with the controller pins no 12 to 15 and next pins no 16 and 17 are connected to the max 232 and pins no 18,19,20 is ground pin no 21 is connected with an LED and next pins no 22 to 28 are connected with the LCD pins and pins no 32 to 39 is connected with the LM 7805and pin no 40 have VCC.

3.2 MAX 232

General Description

MAX 232 is work at -15v to -3v on high and +3 to +15 at low node which is not normal for the logic of computers to understand it properly as computer work at 0v to +5v and now the new upcoming logic work at v to 3.3v or may lower then this.

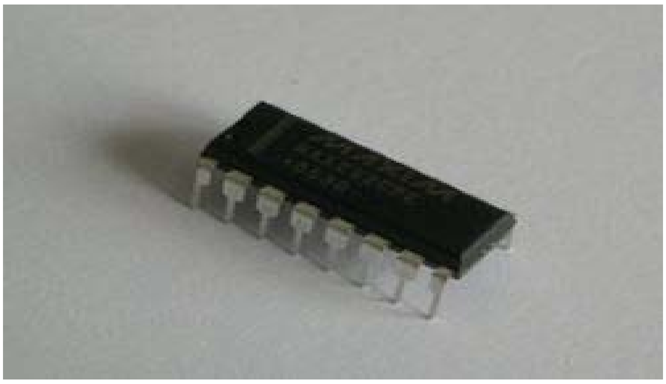


Figure 3.2.1, MAX 232

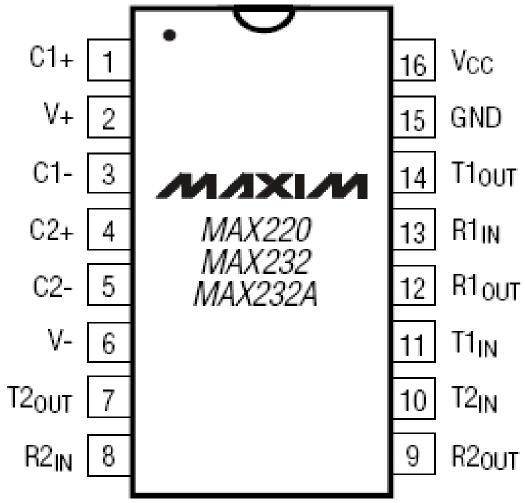
Packaging

Max 232 level of signal is too high to tackle by the computer logic and at negative voltage it is also high for it to understand by the computer logic as the information coming from serial port is to high so it has to be reduced so when a low voltage is coming it has to step up and a high voltage coming up is to step down to communicate with it or to avoid to short circuit of the circuit

Max 232 was first ic to be invented in which we have both function of sending and receiving and this ic become known ic because it can operate at 5v to give max 232 voltage levels and no voltage supply is required to tackle the max 232 ic and to give it just 5v supply to works

Function

Max 232 has the system inside which step up the charge of +5v to +_ 10 v to work with the circuitry. Working of the pin is that the c1 capacitor step up the 5v to +10 v and on other hand we have v+ at c3 and other capacitor c2 is used to convert +10 v to -10 v and with this c4 give v- output In max 232 there is drawback that it draw voltage when we go from +10v to -10 v output on the other hand max 225 and max 245 and max 247 do not do so because they don't have the v+ and v- so as the voltage drops it increases the load current and in our project it is used to convert the voltage to 5v to 10 to communicate with the serial port or DB9 connector and with the modem



DIP/SO

CAPACITANCE (µF)					
DEVICE	C1	C2	C3	C4	C5
MAX220	4.7	4.7	10	10	4.7
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1

Figure 3.2.2, MAX 232

3.3 Sensors

- **Optical Sensor:**

It has a laser red light which falls on the body of a patient. And it contains a photo diode. When blood intensity varies the variation is in form of weak signals are generated which are sent to operational amplifier.

- **Operational Amplifier:**

The pulse that is generated by the optical sensor is very weak hence it is amplified by the help of an operational Amplifier.

- **Temperature Sensor:**

The purpose of temperature sensor is to sense the temperature of the body. In this sensor the temperature varies with resistance giving different values of voltage hence the temperature is recorded in milli-Volts.

DB9 Male Connector

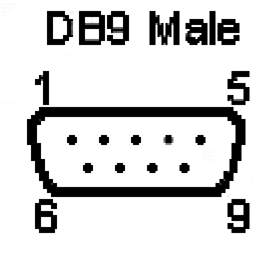
The db9 male connector that is used to make connection and it is used to make mouse based connection or parallel based data interference

Pin 1 is output that is parallel with TX LED on the board and it goes high when FIEHN EME program indicates that it is your transmit period

Pin 7 and 8 can be used to connect the hardware with the device when the low speed is not required and the line go low and allow the motors to run at full speed when tracking normally the motor will run slow all the time because the new target position will be achieved before the low speed condition are exceed .but when moving the antennae a large distance to initially achieve tracking and motor will be able to run at full speed and in our project db9 connector is used to connect the max232 and the GSM module to interface it with each other

Male DB9 - Auxillary Connector	
1	Tx LED output (for F1EHN sequencing)
2	Txd out (for mouse)
3	Rxd in (for mouse)
4	Processor reset
5	Ground
6	Parallel Load out and Processor RB7 (for programming)

7	Parallel Clock out and Processor RB6 (for programming). Also speed control for Elevation.
8	Parallel Data in, Mouse clock in or out, and Processor RB3 (for debugging). Also speed control for Azimuth.
9	VCC out (+5 vdc)



3.4 Crystal Oscillator

An oscillator is used to repeat the output regularly and this will be an electrical wave form often but not always the sine wave.

The most important property is its frequency the rate at which it repeats this is measured in hertz (HZ) one hertz is the one repetition per second .one MHZ is one million repetition per second

One of the problem in designing the oscillator is to maintaining the output the frequency at the required value there some method to maintain the oscillator is to control it by quartz crystal

A 12 MHz crystal oscillator is an electronic circuit that control its output at 12million times per second

Figure 3.4.1, Crystal Oscillator

3.5 DC Power Supply

An electronic circuit need a DC power supply which work as a battery as an power supply   as main power supply is AC but it has to be converted in DC to be useful in electronic circuit

This is what the power supply is

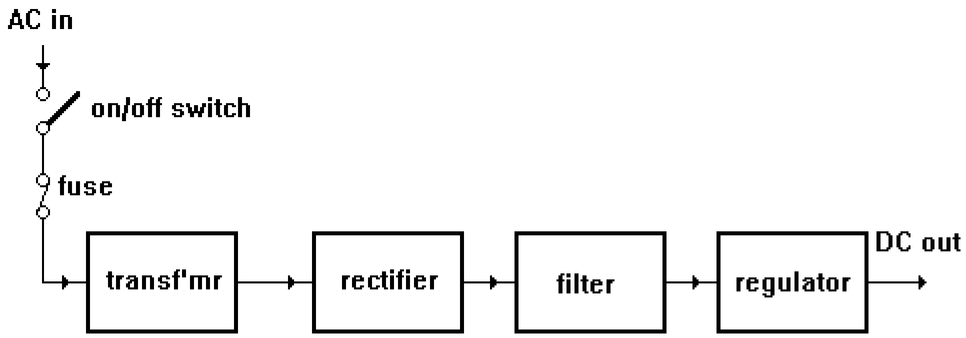


Figure 3.4.2, DC Power Supply

First the AC main supply passes through the switch and then it passes through the fuse and in most case the AC main supply is to high for the circuit therefore it is first stepped down to lower the value by mean of the transformer and the main AC power can be stepped up where high supply is need

Then the AC voltage is passes through the rectifier that consist one or more diodes the rectifier convert the AC to DC voltage. As the DC voltage is not smooth so to make it smooth we pass it from smoothing circuit called a filter and a filter may be a capacitor and resistor and the remaining small variation can be removed by a regulator circuit which also give the remaining variations and give out steady voltage. A regulator can also remove the variation in DC voltage and regulator is available in the form of integrated circuit

3.6 Relay and Function

Relay is an automatic switching component with isolation function which is widely used in remote control automatic control integration of the machinery and electrification and its generally used relays have ability to control the circuit on and off function between the input and the output part

Relay mainly has following functions

1) To enlarge the range of control e.g. when the controlling the signal a multiple relay reaches a certain value according to the different form of a function and it can be change over open or close circuit
2) Enlargement e.g. relays of the type sensitive and medium relays can control a high power circuit
3) Integrated signals e.g. several controlling signals are put into a multi relays in the starting form the relay can realize the expectance controlling function by the automatic function
4) Remote control and monitoring automatization e.g. in this circuit the relays and the ether electronic components can be program control circuit realizing the automatic operation

3.7 The Wireless Age

The doorway to the nowadays wireless communication systems was opened by Guglielmo Marconi when he transmitted the three-dot Morse code for alphabet ‘S‘ by the use of electromagnetic waves over a 3-KM link in 1895. This laid the foundation of modern communication systems ranging from broadcasting, satellite transmission and radio eventually progressing to nowadays cell phones. It wouldn’t be wrong to say that wireless communication has indeed revolutionized our present society

Wireless communications and the business products and services that are using the wireless communication have a number of functions that are motivated by specialized studies. First, the wireless connection based on the scarce resource - namely the radio spectrum - the property traditionally held by the state. To ensure the development of wireless communications (including telephony and broadcasting) to facilitate these assets privatized. Secondly, the use of spectrum for wireless communication is essential to the development of key technologies, in particular those whereby the higher frequencies which are used more efficiently. Finally, because of its special nature, efficient use of spectrum requires the coordinated development of standards. These standards play an important role in the dissemination of technologies based on use of spectrum

A sudden increase has been observed in the expansion of radio systems during the last two decades. We have seen great evolution in Wireless communication systems from 1G narrowband analog systems in the 1980s to the 2G narrowband digital systems in the 1990s. Now the existing 3G wideband multimedia systems are being deployed. In the meantime, research and progress in the future-generation wideband multimedia radio systems is vigorously being pursued worldwide.

To connect mobile users to the public switched network the United States introduced first radiotelephone service by the end of the 1940s. Improved Mobile Telephone Service was launched by Bell Systems in 1960s due to which lots of improvements like direct dialing and increase in bandwidth took place. IMTS formed the bases of the first analog cellular systems. The term cellular was used due to the fact that coverage areas were split cells, they had a low power transmitter and receiver.

Background

Marconi's pioneering works soon led to various commercial and government (especially military) developments and innovations. In the early 1900s, voice and then music was sent which move towards the modern radio. In 1920, commercial radio station WWJ was made in Detroit and KDKA in Pittsburgh. Wireless telegraphy was first used in the British military in South Africa in 1900 during the Boer War. The British fleet used equipment supplied by Marconi for communication between ships in the Delagoa Bay. Shipping is a major early customer for wireless telegraphy and radio was the norm for the navigation of the time the Titanic's radio distress calls released in 1912

Soon it was recognized that international coordination is necessary for wireless communication to be effective. Such coordination has two functions. First, the potential for interference in the radio broadcasting means that at least the local coordination was needed to prevent transmission of conflicting signals. Secondly, the spectrum of international communication and areas such as maritime safety and navigation, and coordination between countries are used it is necessary to ensure consistency in the approach to these services. It was the government who intervention to ensure the coordinated allocation of radio spectrum

Benefits of Wireless Technology

The four key benefits of wireless technology are:

1. **Increased efficiency** - improved communications leads to faster transfer of information within businesses and between partners/customers.
2. **You are rarely out of touch** - you don't need to carry cables or adaptors in order to access office networks.
3. **Greater flexibility and mobility for users** - office-based wireless workers can be networked without sitting at dedicated PCs.
4. **Reduced costs** - relative to 'wired', wireless networks are, in most cases, cheaper to install and maintain

3.8 Spectrum Allocation

Radio broadcast is concerning as the use of electromagnetic spectrum. Electromagnetic energy is transmitted at different frequencies and properties of energy independent of frequency. Example, visible light has a frequency of 4 and 7.5 × 1014 = 1.014 Hz.2 ultraviolet rays, X rays and gamma rays have higher frequencies (or equivalent shorter wavelengths) and infrared light, microwaves and radio waves have a lower frequency (longer wavelength).

Radio-frequency spectrum includes electromagnetic radiation with a frequency of 3000 Hz and 300 GHz.3
Even within the radio spectrum, different frequencies have different characteristics. The Cave (2001) notes as the higher the frequency the shorter will be the distance of signal which will travel, but most of the signal power are data transmission. The international coordination of radio spectrum management and the establishment of global standards were implemented by the International Telecommunication Union (ITU). ITU International Telecommunication Convention was founded in 1947 starting from about 1865. It is an agency of the United Nations more than 180 members.

ITU Radio Conference Division is coordinating as the global use of the spectrum by the Radio Regulations. The rules were first established in Berlin in 1906 International conference on wireless telegraphy. The distribution of radio-frequency spectrum occurs in three areas - frequency, geographical location and priorities for intervention. RSD is divided into eight bands, ranging from very low frequencies (3-30 kHz) to a very high frequency (30-300 GHz). Geographically, the world is divided into three areas. ITU has allocated certain frequencies for specific purposes by both global and regional basis. Individual countries may then divide the frequencies in the ITU international distribution.

3.9 The Range of Wireless Services

Radio frequency spectrum used a wide range of services. They can be divided into the following broad classes:

- **Broadcasting Services**

  The services like short wave, AM and FM radio as well as terrestrial television.

- **Mobile Communications of Voice & Data**

  It includes maritime and aeronautical services for communication between ships, aircraft and land, land mobile communication between a fixed base station and the relocation sites such as the taxi fleet, paging services and mobile communications between mobile users and fixed network or mobile users.

- **Fixed Services**

  Point to point or point to multipoint services are involved in fixed services.

- **Satellite:**

  It is used for broadcasting, telecommunications and internet, particularly over long distances.

3.10 Communication System

Block Diagram of Wireless Communication System

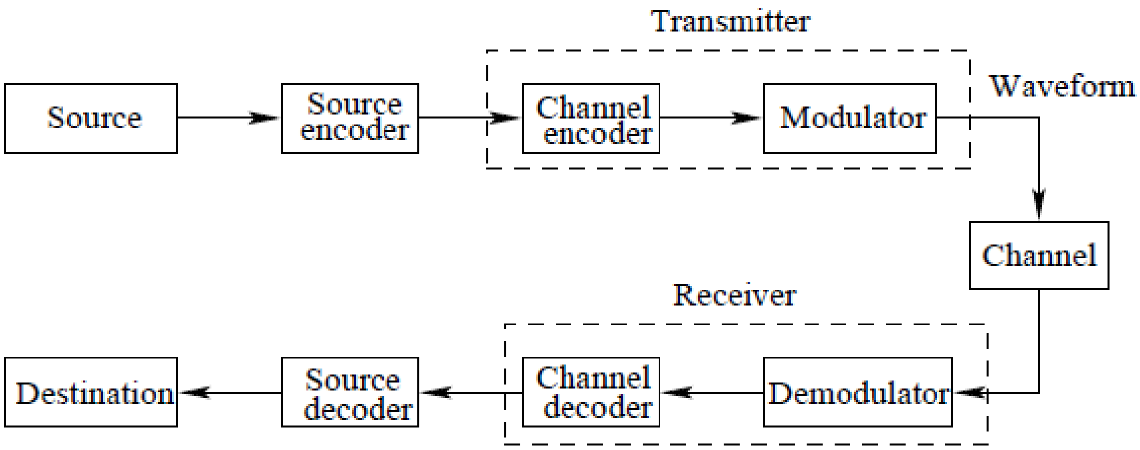


Figure 3.10.1, Communication System

3.11 Analog vs. Digital Communication System

3.11.1 Defining Digital

Digital describes electronic technology that generates, stores and processes the data with two states which are known as positive and non positive. Positive is expressed or represented by number 1 and non positive at 0. Thus, data transmitted or stored with digital technology is expressed as a string of 0 and 1. Each of these figures, a condition called bits (and a sequence of bits that a computer may apply individually, as a group of bytes).

3.11.2 Advantages of Digital

- Low-priced
- Reliable
- Easy to manipulate
- Flexible
- Compatible with other digital systems

- The information in digital form can only be transmitted without any degradation through a noisy channel
- Incorporated networks

3.11.3 Disadvantages of Digital

- Sampling Error
- As compared to analogue, larger bandwidth is required in digital communications for the transmission of the same information.
- Synchronization in the communications system is required to recognize the digital signals, but this is not the case with analogue systems.

3.11.4 Definition of Analogue

The electronic transmission is achieved by adding signals of different frequency or the amplitude of the carrier frequency of the alternating electromagnetic current. Broadcast and telephone transmissions are typically used in analog technology.
Analog also means any changes, evolving and changing process. Analog is usually presented as a series of sine waves. It is originated because the modulation of the carrier is similar fluctuations of voice itself.

One of the distinctive characters of between analog and digital wireless technology is their differences in modulation method.

For analog systems, we usually use FM, AM, DSB, SSB and VSB methods

Frequency Modulation (FM)

This is the most popular analog modulation technique. In FM carrier signal amplitude is kept constant while the frequency is changed by modulating signal. Thus the FM signals get all information in the phase or frequency of the carrier.

Amplitude Modulation (AM)

There is a linear relationship between the quality of the received signal and the received signal with AM signals impose precise relative to the amplitude of the modulating signal carrier. Thus these AM signals have all the information in their amplitude carriers.

Double Sideband AM (DSB)

This type of AM removes the carrier spectrum of the total signal to increase the efficiency of modulation.

Single Sideband AM (SSB)

Since both sides on the signal AM is using the same information. It uses one of them without loss information. SSB AM sends only one side of the sideband and thus occupy only half the bandwidth of conventional systems AM.

3.11.5 Advantages of Analogue

- Less bandwidth is required
- More Accurate

3.11.6 Disadvantages of Analogue

- Signal loss and distortion can be seen due to the effects of random noise which is impossible to recover

3.12 Design of a Communication System

3.12.1 The Transmitter

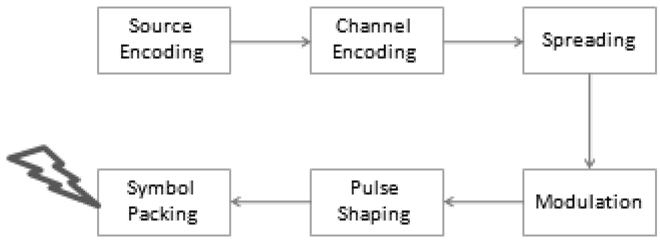


Figure 3.12.1, Transmitter

3.12.2 Source Encoding

In order to make incoming message compatible with the communication system source coding is used. In this project NRZ encoding scheme is used so that the incoming message signal becomes compatible with the walsh codes which are also in NRZ form. NRZ encoding provides a better utilization of the bandwidth, also if we compare it with AMI scheme it is more efficient because in that receiver has to distinguish between three different levels and it requires more signal power. While the Manchester and differential Manchester schemes have modulation rate twice or more than that of NRZ so hence they require greater bandwidth.

3.12.3 Channel Encoding

Channel encoding is performed so that bit errors can be reduced at the receiver; also it protects the data from channel noise and interference. In this project we have used Convolution Encoding technique and then have tried to upgrade our system using Low Density Parity Check (LDPC). LDPC improves channel capacity as it approaches to Shannon capacity limit. Both Convolution encoder and LDPC encoder form a codeword based on the incoming message signal. We have used ½ rate encoders that mean that we have two input bits and the output is going to be four bits. For Convolution encoder inbuilt mat lab trellis structure along with convent command has been used while in case of LDPC fecldpc.enc command is used to make LDPC object using sparse H matrix and then message is encoded using LDPC object by encode command.

3.12.4 Spreading

The fundamental criterion of spreading is cross correlation and auto correlation of message symbols. In case of a CDMA based communication system as there are many users that simultaneously transmit data so the system must have good cross correlation properties. This generates the need of orthogonal codes so Walsh codes are used. Walsh codes have good cross correlation properties. In this project direct sequence spread spectrum (DSSS) technique has been employed to spread the signal across the entire bandwidth.

3.12.5 Digital Modulation

Modulation is a technique that facilitates the message signal to be transmitted over the medium. In case of digital modulation, digital signal is modulated using amplitude shift keying, frequency shift keying and phase shift keying etc.

We have implemented Binary PSK, BPSK uses two symbols that have opposite phase to each other to modulate 0 and 1.Sampling frequency of 44 kHz and a data rate of 2 kHz has been used in this system. In case of LDPC modulate command has been used to modulate the signal.

3.12.6 Pulse Shaping

The effect of inter symbol interference (ISI) is minimized by the help of pulse shaping process. In this project Root Raised Cosine Filter has been used at the transmitter side to shape the pulse so as to limit the bandwidth of the modulated signal. By using this technique bandwidth is limited but the signal spreads in so there must be a threshold in order to counter this problem, this threshold is known as Nyquist limit. It is basically a low pass filter with a roll off factor 0.5 which has been used in this project.

3.12.7 Symbol Packing

At the start and end of the signal there is a Symbol Packing training sequence appended and also in addition to this about thousand zeros are inserted at the end and start of the signal. These are added so that even if the receiver fails to receive initial bits these bits are additional zeros and not the message signal.

Figure 3.12.2, Symbol Packing

3.13 The Channel

In a communication system channel could be wired or wireless. Different channels have different characteristics. When ever we talk about a channel we talk about noise, it is basically the unwanted electrical signal that confines the receiver ability to take correct decisions. Channel noise degrades the output very quickly. Small channel doesn't make much difference to the output signal but large channel noise considerably degrades the signal. In case of small channel noise the only noise that is present in the system is quantization noise. Another important factor in a communication system is Inter symbol interference (ISI). When the channel bandwidth is not much greater than signal bandwidth the spreading of the signal causes ISI.

Normally, the wireless channel is modeled with AWGN channel. A thermal noise source is used to spread an equal amount of noise power per unit bandwidth over all frequencies that is the reason why a simple model for thermal noise presumes that its power spectral density $G_n(f)$ is flat for all frequencies, as is denoted as:

$$G_n(f) = N_0/2 \qquad \text{watts/hertz}$$

3.13.1 The Receiver

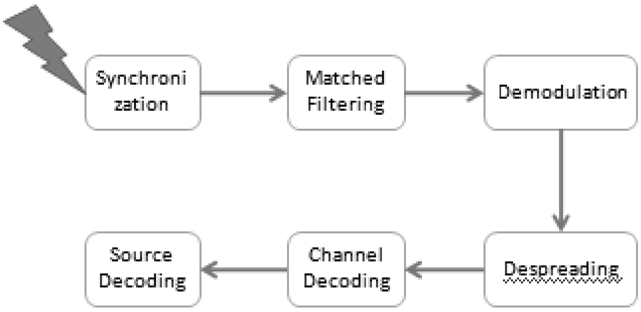


Figure 3.13.1, Receiver

3.13.2 Synchronization

It is assumed that the receiver is on all the time, in a system. Therefore whenever the transmitter will send the message signal, there should be some way through which the receiver can determine where its signal of interest is. This can be done by correlating the training sequence with the received signal. The part where the maximum correlation occurs would be the start of the signal and the second maximum in the correlation would give the end of the message signal.

3.13.3 Matched Filtering

The received signal is passed through root raised cosine filter in order to perform matched filtering and down sampling at the receiver end. Usually RC filter is divided into a root raised cosine (RRC) filter pair, with one at the transmitter end, which performs the pulse shaping in order to constrain the modulated signal bandwidth, and the other at the receiver end, that performs matched detection for optimizing SNR of a known signal in AWGN presence.

3.13.4 Demodulation

The signal is demodulated by multiplying it by the carrier signal. The output would be demodulated signal, but this demodulated signal would be sum of all the spreader signals.

3.13.5 Dispreading

In order to extract the individual message signal of each user, the spreaded signal is then again multiplied by the Walsh code and is then integrated over a symbol time

3.13.6 Channel Decoding

If the channel coding was not employed by the transmitter, then the despreaded messages would be the received signals. In the channel coding case, the signal will have to be decoded by using the viterbi decoding function in matlab.

3.13.7 Source Decoding

While performing source coding we had used NRZ encoding scheme, so now at the receiver this encoded message is again decoded back to its original form.

MATERIALS & WORK METHODS

4 Initial Hardware Design & Details:

4.1 Circuit Components and Working

First we started working on the power supply section. The transformer used as a power supply has voltage source providing an input voltage of 220volts and an output of 12 volts. On the power supply circuit we used four resistors having resistance of 220ohm which are connected to a capacitor having 1000 mico farad capacitance. Moreover LED is connected to check the current flow. As shown clearly in the figure.

Figure 4.1.1, Transformer

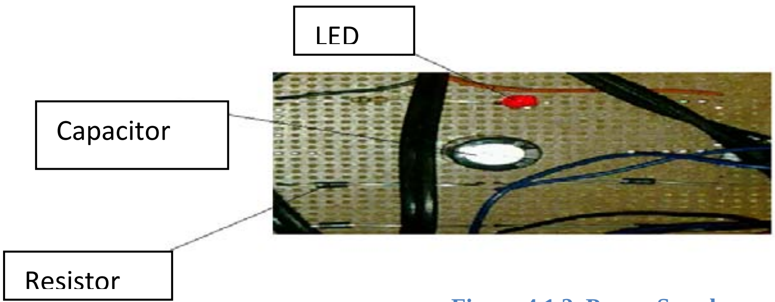


Figure 4.1.2, Power Supply

Applying Sensors to Detect Temperature, Blood Pressure, Heart Beat of Patient

We created a circuit for which we could measure the temperature, heart beat and blood pressure of human body which was one of the important works in our project.

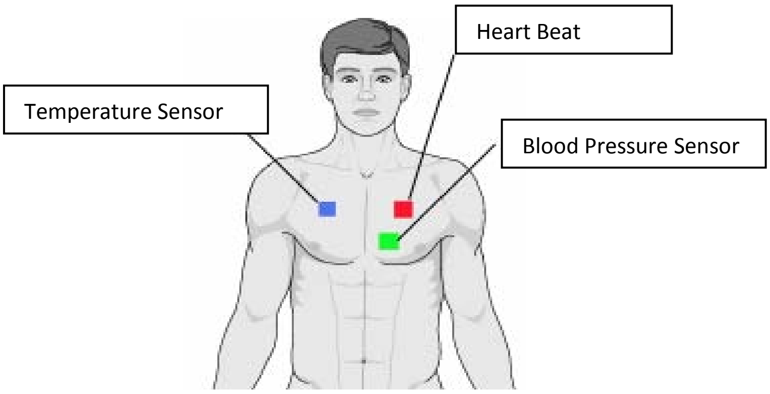


Figure 4.1.3, Sensor Attached

In this circuit we use **89S52** microcontroller, which has 40 pins and it is connected with different components. It has 8KB of memory and this memory can be used as storing and formulation of programs running on it. As it has 40 pins for different purposes, the configuration of 40 pin is described as that the 20th number pin is grounded and pin number 40 we are provide VCC (+5V). At pin number 19 and 18 a crystal is used, which is connected with two capacitors which are further grounded. We are using a voltage regulator to provide 5V to microcontroller. With voltage regulator we have connected noise filter capacitor of 10 pico farad. In the circuit we connected and LED to check the voltage levels. The LED tells whether the voltage is provided form the power supply to the voltage regulator. The raw voltage provide by the power supply is filtered by the capacitors, input and output filters. All the connection mentioned above are visible in the figures.

We have also connected a diode (IN4007) at the input of the voltage regulator. The purpose of the diode is that if the battery is not connected properly the diode won’t let the current to flow.

From pin 1-8, we have connected an 8bit input ADC (0804). The purpose of the ADC is that, as we receive blood pressure, temperature, heat beat in analog signal; the ADC converts it into digital.

The ADC (0804) contains 20 pins, 18 to 11 pins are connected with 1 to 8 pin of microcontroller for inputs and outputs. The pin number 20^{th} is used as VCC in the circuit. At pin number 19, we have connected a resister of 10 OHM which is grounded. 1 to 3 pin are grounded pin number 4 connected with a capacitor of 150 Pico Farad which is grounded, ADC in this particular circuit. At pin number four we have connected a resistor which is further grounded. Pin number 5 is connected to the microcontrollers pin number 12. pin number 7 and 8 of ADC are also grounded. At pin number 9 there is a potentiometer variable which is used for calibration for instance if the value is not correct it adjusts the value. In this circuit we have used two potentiometers .our temperature sensor is provided with a Vcc of +5V.

LCD. Liquid crystal display is also used in this circuit to display body temperature and blood pressure.

Pin number 1 to 3 of the LCD is grounded. We have provided Vcc of +5V.pin number 4 5 6. Pin number 4 is read, pin number 5 is used to write data. 8 bit data from the microcontroller is sent to the LCD. From pin number 32 to 39 are to connected pull up resistors. The data is sent to the LCD which is in form of binary digits (01010101). Pins of microcontroller are not high by default. Microcontroller from pin number 10 to 17 is Port 3. Pin number 10 and 11 are of serial port the data is received (RXD) and (TXD) through which controller transmits the data. Pin number 13 is connected to the wireless hub which will be used afterwards and we will be providing bit pulses by the help of a sensor. Pin number 12 of the microcontroller is connected with ADC pin number 5.when ADC receives an analog signal it generates an interrupt. After receiving the interrupt the controller starts picking data from the port 0 which is generally connected with an LCD. The data received by the microcontroller is displayed on the LCD after data is being converted to digital form. Crystal is connected to pin 19 and 18 to provide clock pulse.

At the bottom of the circuit we have used two relays by the help of relays we can use buzzers. Two relay switches are used which we will be using in the future

4.2 Main of Design Components

- Power Supply

Figure 4.2.1, PS

- Voltage Regulator

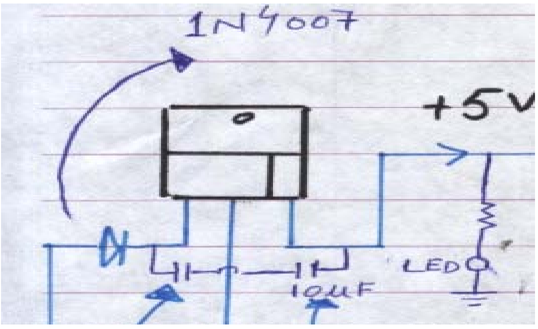


Figure 4.2.3, Voltage Regulator

- LCD

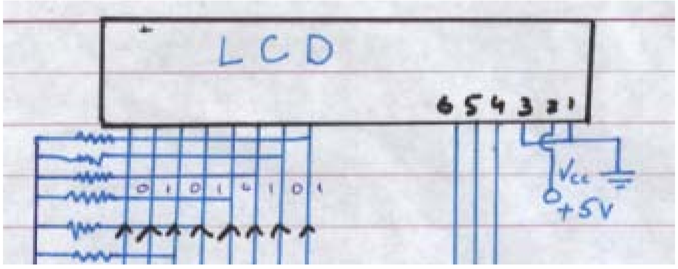


Figure 4.2.4, LCD

- Analog to Digital Convertor

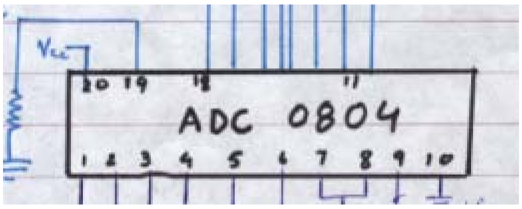


Figure 4.2.5, ADC

- Relays

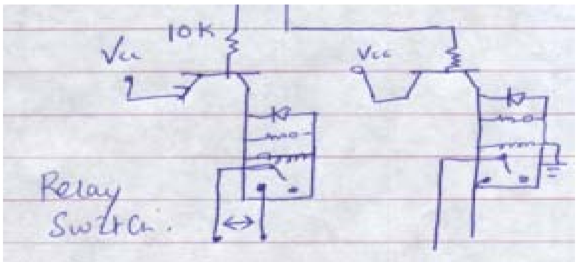


Figure 4.2.6, Relays

- Potentiometer

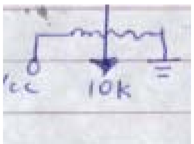


Figure 4.2.7, Potentiometer

- Sensors

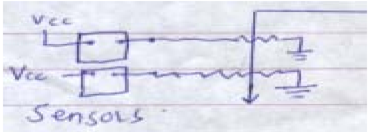
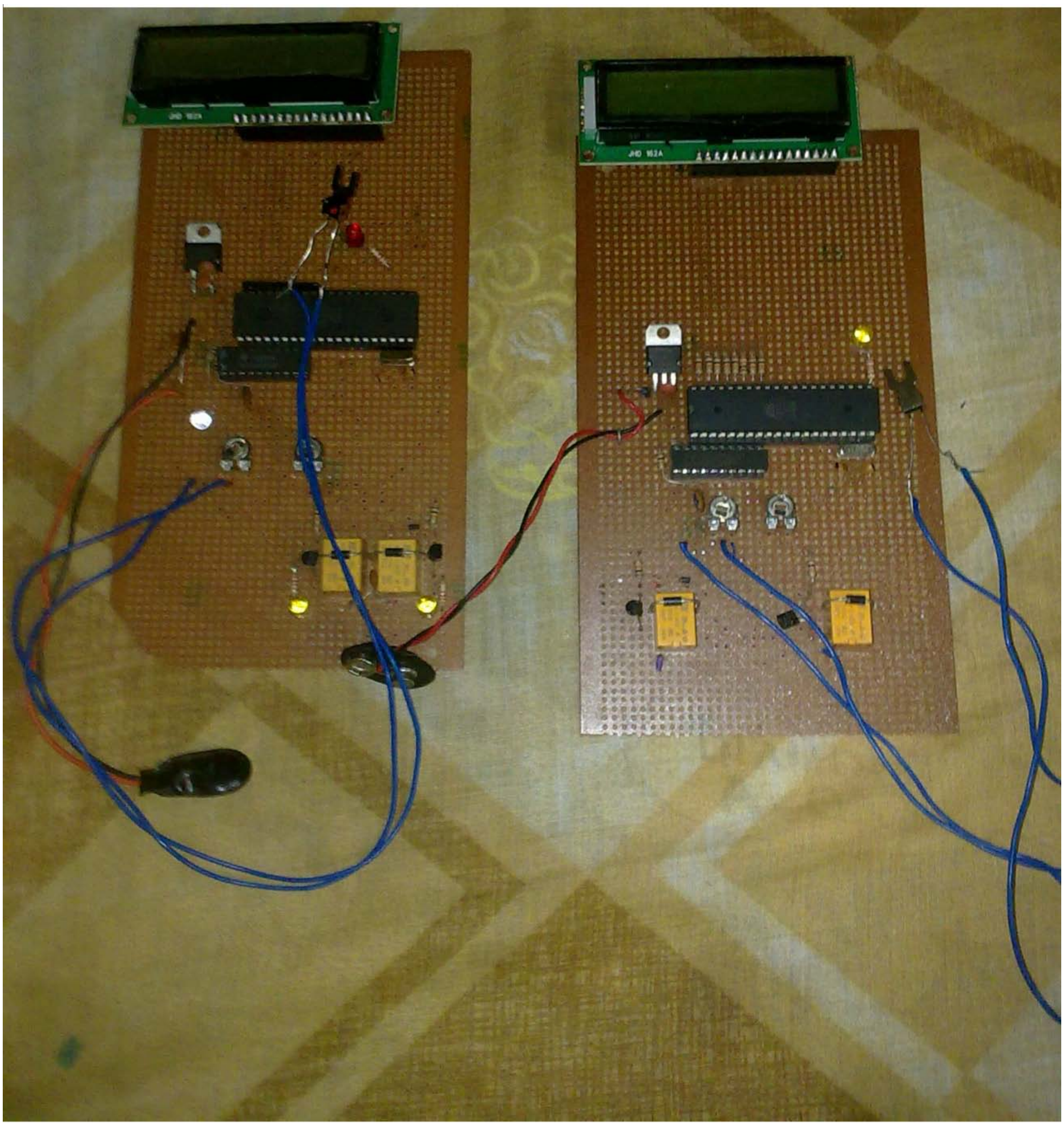
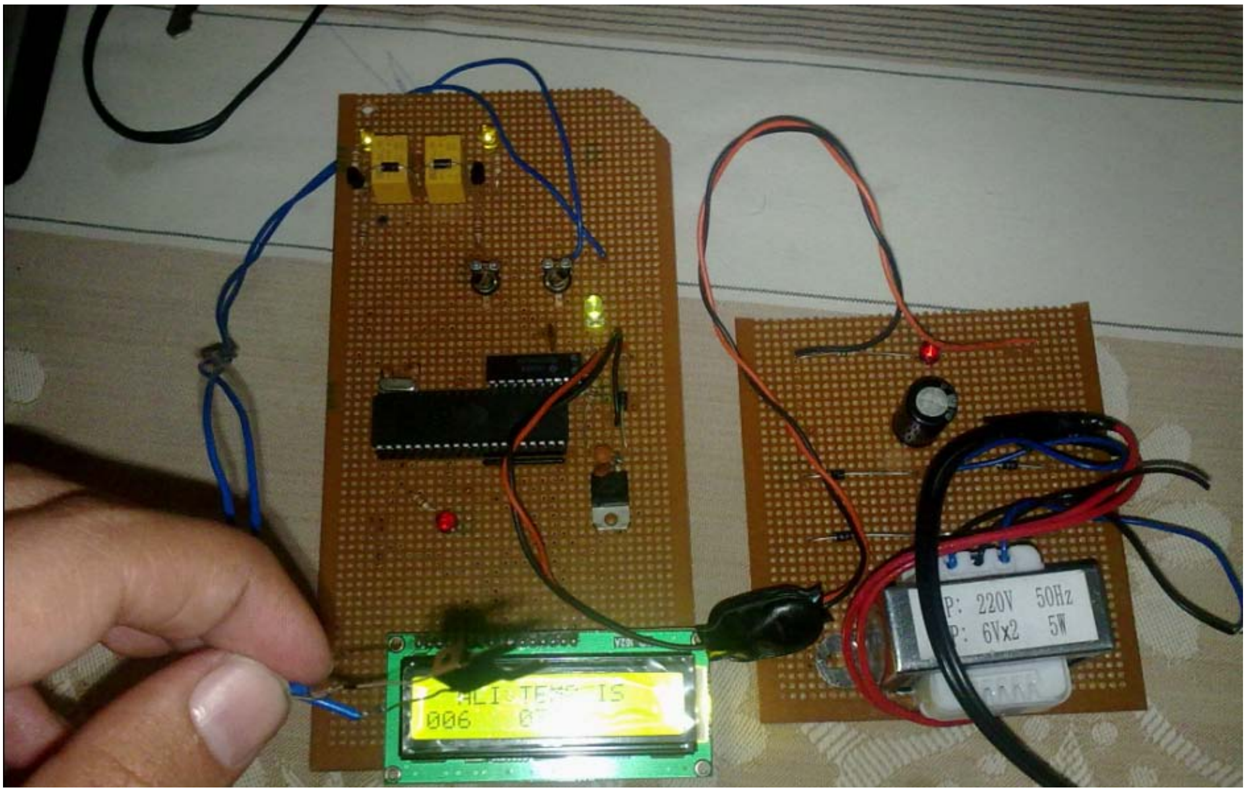


Figure 4.2.8, Sensors





In the second part of our hardware work the other milestone is to wirelessly transmit data and to display it on computer hence it imperative to study wireless communication understand and then implement it in our project

4.4 Wireless Scenario

4.4.1 Wireless Data Transmission

The pic controller we are using has 40 pins (16f877A). At pin 11 we are providing Vcc, pin number 12 is ground at pin number 13 and 14 apply capacitor we place a crystal apply capacitor (4MHz) and ground it.pin number 1 is used as a reset and we apply a capacitor and a resistor as it is given in the data sheet that a resistor and a capacitor is to be applied. At pin number 16 we have place an LED for the purpose of testing and we have grounded it and have connected a 100 ohm resistor to it .LED works at +5Volts.

We have used an LCD (16*2). At LCD part pin number 1, 2, 3 are grounded. At pin number 2 we provide a Vcc of +5Volts.pin number 5 is grounded. Pin number 4 of LCD is connected with pin number 19^{th} of LCD and pin number 16 is connected to pin number 20^{th} of the LCD. Pin number 6 is enabling and pin number 4 is used to READ data. The Pic controller sends data through theses pins and LCD reads it. The 7 8 9 10 pins are grounded and 11 12 13 and 14 number pin are used for data transfer. The data sent from the pic controller is in form of binary (0101).LCD 15 number pin is used as a Vcc and 16th number pin is used as a ground and for the purpose of providing back light to the LCD. Pic controller pins from pin number 2 to pin number 9 has an ADC (analog to digital convertor). At pin number 2 we have placed a potentiometer and we have connected a temperature sensor to it and have provide it with a Vcc of 5Volts.The temperature sensor is a 10 kilo ohm thermistor. When we provide heat to the thermistor its resistance gets low or resistance decreases. For instance when we provide heat the voltage increases and hence with the temperature also increases with it. Pic controller pin number 25 is used as a TX for serial data transmit .at pin number 34 we have provide a heart beat signal at pin number 33 we have placed a a SWITCH WHICH IS GROUNDED. 34 pin numbers is used as a push button and at pin number 34 we have provided a heart beat signal which goes high n low pulses. As it is a digital signal the LED glows after every high signal passes.

For the digital signal to pas we have a circuit of an operational amplifier. At once side of the operational amplifier we are using LDR (light dependent resistor) we have provided the LDR with 5 volts as described in the diagram. The operational amplifier is connected to a variable resistor. The operational amplifier is provided with a V reference as it is clear in the figure. The operational amplifier we are using is LMF358. In front of LDR we placed a 100 ohm resistor with Vcc and from above we are providing ground as it's clearly mentioned in the figure. The LDR is a laser one the light intensity varies as the intensity of blood varies the signal that is generated is of almost micro volts. The operation amplifier amplifies the signal and converts it to digital. At one end of the operational amplifier a digital signal is generated and at the other pin an analog signal is produced. The analog signal is provided at the 3rd pin of the pic controller and the digital signal is provided at the pin number 34th of the pic controller. The digital signal generated by the operational amplifier is used to measure the heart beat and the analog signal generated is used to measure the blood pressure of the human body. The 26th number pin of the controller is used as a RX and pin number 25 is used to send data which is further connected to transistor as we can see in the figure. The transistor is given Vcc of 5Volts. The Transistor used here is 25A1015 PNP. The transistor is used to amplify signal and is connected to the transceiver. The serial output of the controller is send to the transceiver via a transistor. The transistor produces an output in binary which is used as an input of the Transceiver. The transceiver (433 MHz Radio matrix) used for wireless data transfer it has a monopole antenna connected t o it. The Transceiver is provided by a Vcc and is grounded as well

At receiver end we will be having a module which is known as 433 RX. The receiver has an antenna placed at the top know as monopole antenna and has a length of 8inch. The receiver at one of the pin is provided with Vcc the other pin is grounded as shown in th figure. One of the pin is connected to the MAX 232 which is used for data output.

We have also used a db9 connector. It has 1-9 a pin .pin number 5 is grounded at pin number 2 is used to receives data. 3 number pin is used to send data.

The Receiver used will be used to receive carrier signal and it will convert data into binary (0101). The receiver will receive data which will be wirelessly transmitted by the transmitter. The bits produced by the Receiver will be TTL bits. In TTL 0 logic is equal to zero and one logic which is equal to +5Volts.

MAX 232 will send binary data to Db 9 connector from pin number 7. Max is also used in the circuit to convert voltage levels

4 capacitors are connected to MAX 232 from pin number 1-5. The voltage regulator is connected with both receiver and MAX 232 providing them a Vcc of % volts as we can see in the figure

Components List:

- PIC controller

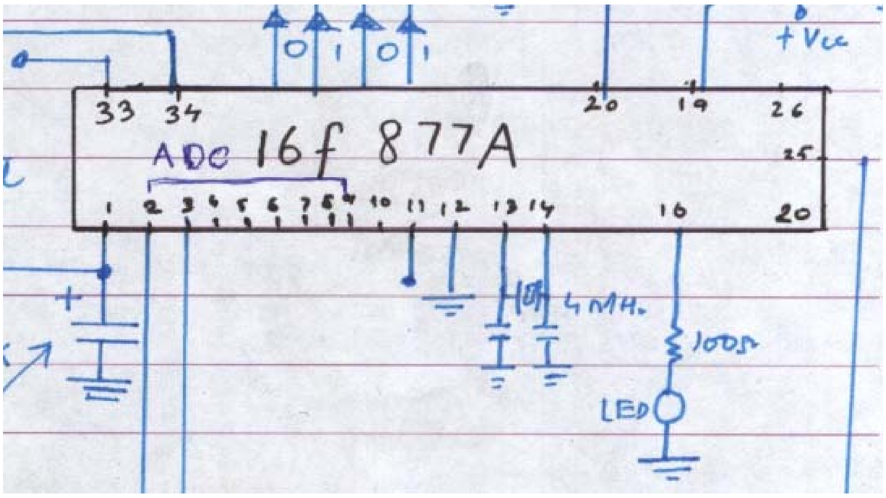


Figure 4.3.1, Pic Controller

- LCD

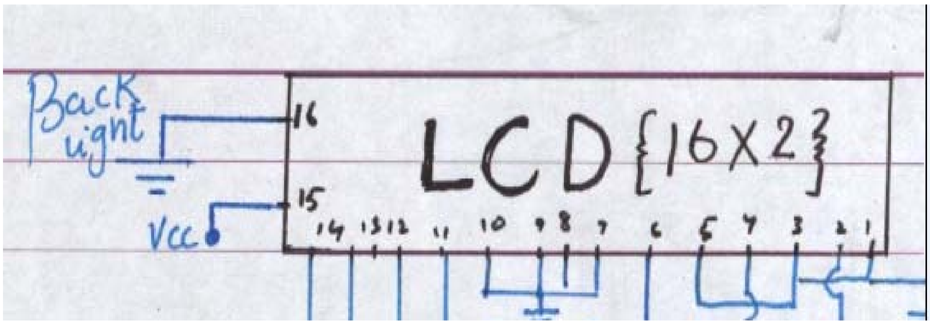


Figure 4.3.2, LCD

- Voltage Regulator

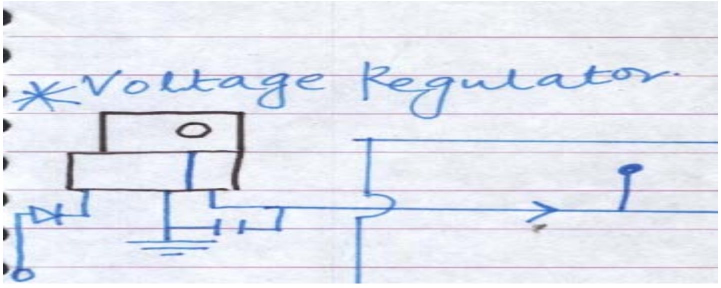


Figure 4.3.3, Voltage Regulator

- Thermistor

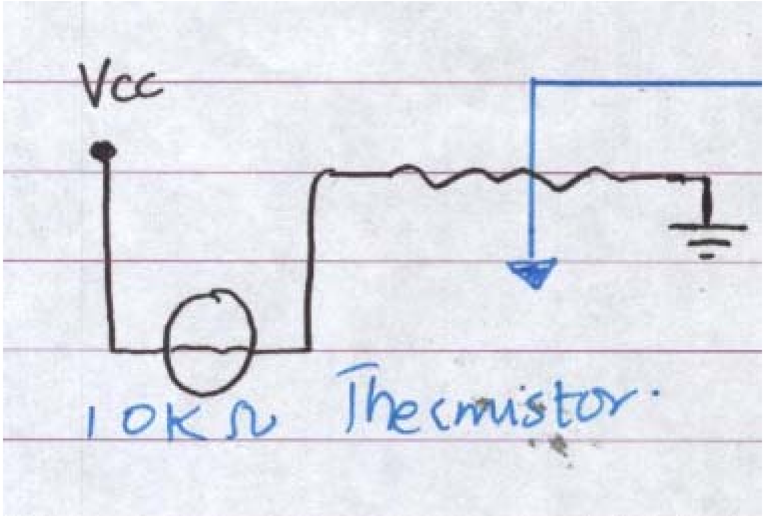


Figure 4.3.4, Thermister

- Transistor

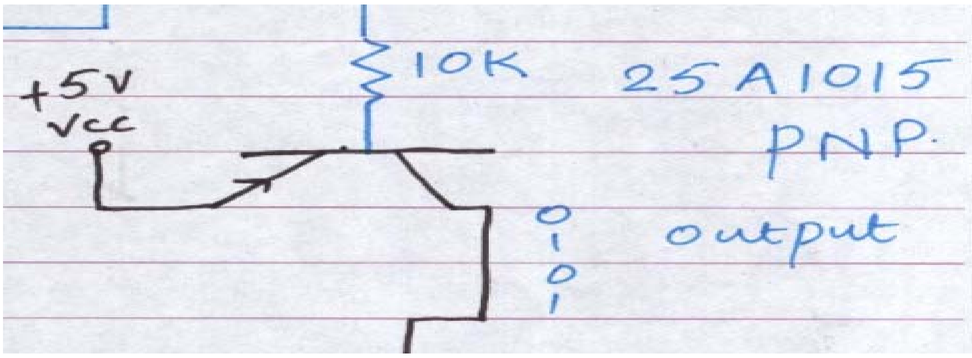


Figure 4.3.5, Transistor

- Operational Amplifier

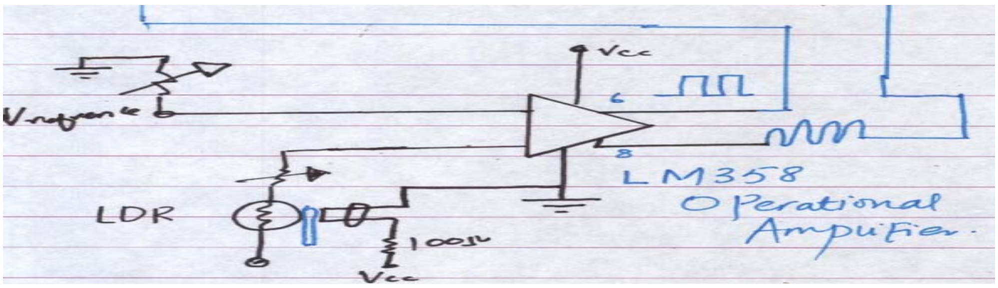


Figure 4.3.6, Omp Amp

Complete Connection

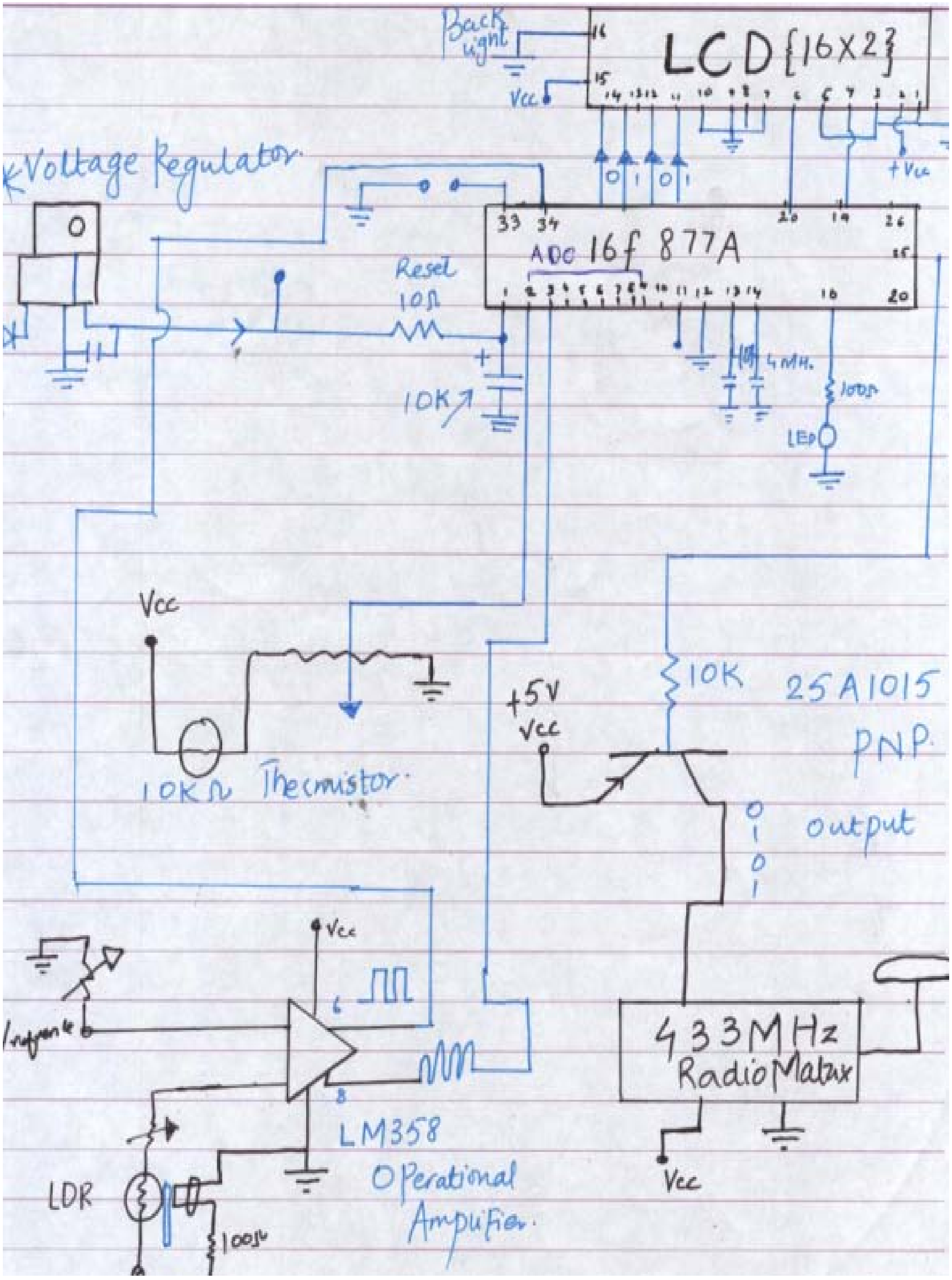


Figure 4.3.7, Internal Circuit

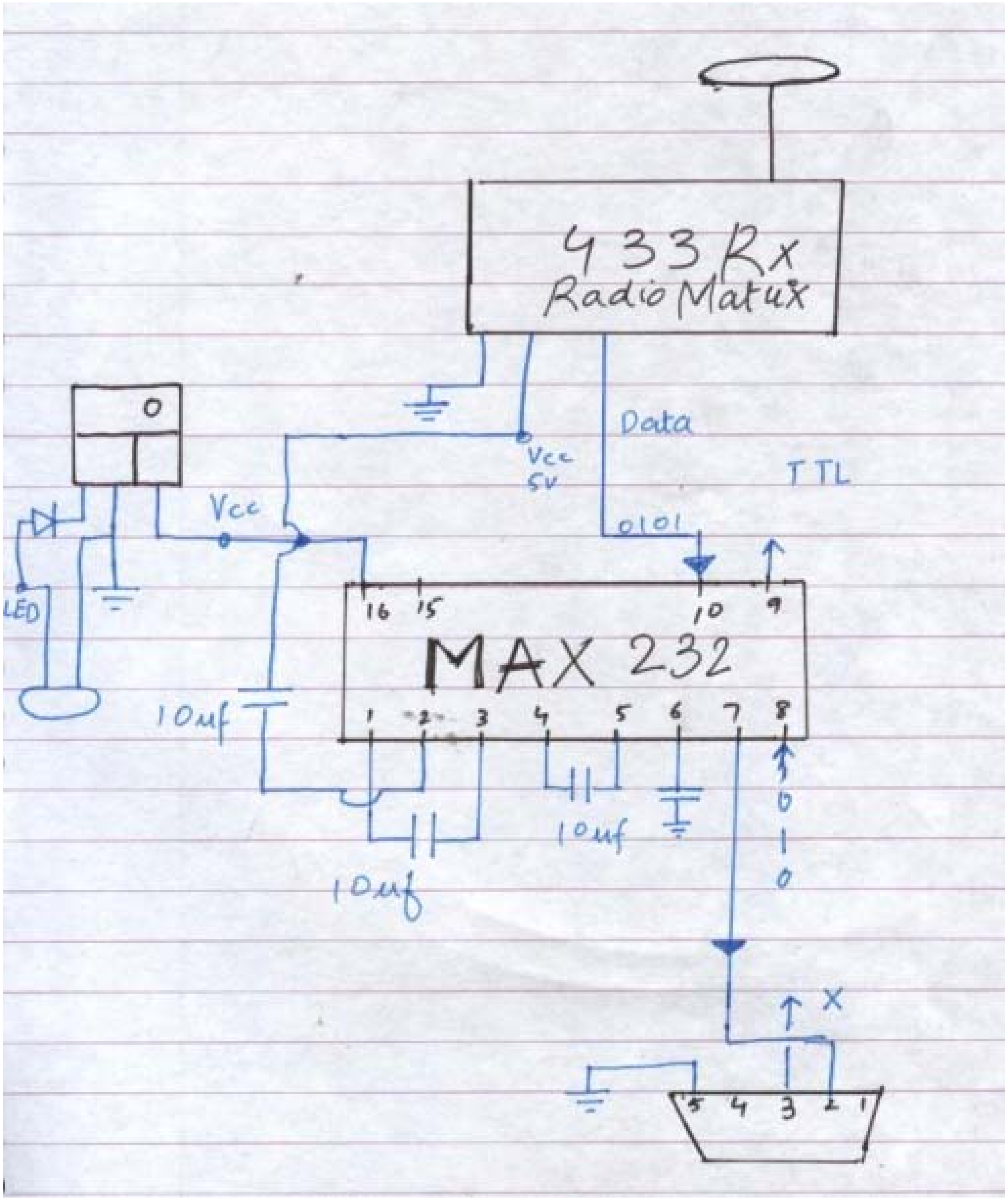


Figure 4.3.8, Transmitter

Chapter 5

Schematics and Project Data (Data Sheet)

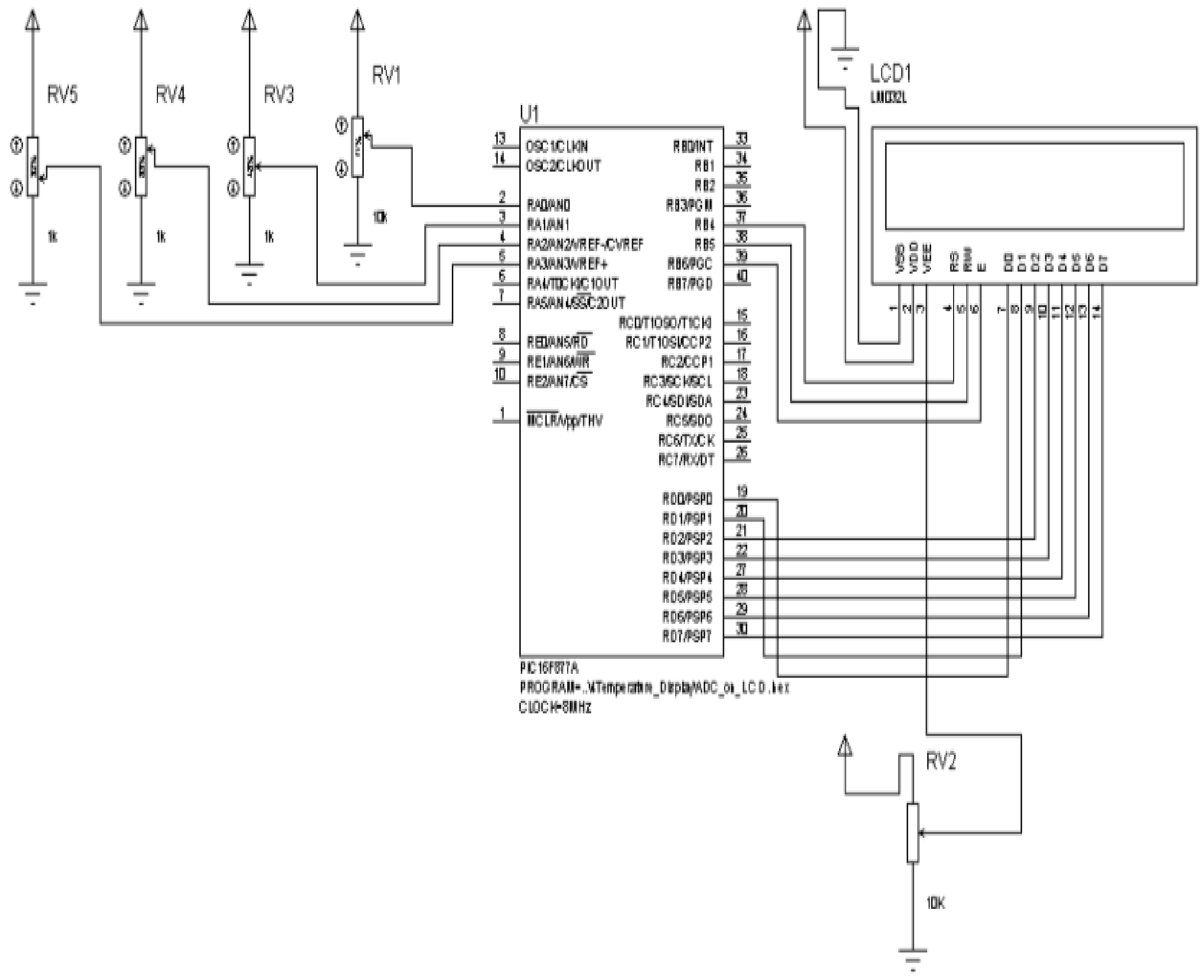


Figure 5.1, Data Sheet

5.1 CODING

```
'****************************************************************
'*  Name    : UNTITLED.BAS                                *
'*  Author  : [select VIEW...EDITOR OPTIONS]              *
'*  Notice  : Copyright (c) 2011 [select VIEW...EDITOR OPTIONS] *
'*          : All Rights Reserved                         *
'*  Date    : 4/19/2011                                   *
'*  Version : 1.0                                         *
'*  Notes   :                                             *
'*          :                                             *
'****************************************************************

Device 16F877A
XTAL 4
on_interrupt tick
'on_hardware_interrupt hardware
ALL_DIGITAL=true
''''''''''''''''''''''''''''''''''''
Declare LCD_TYPE 0  'in case we use alphanumeric then type 0 if graphical then 1
Declare LCD_DTPIN PORTD.4 'this show that 4 pin interface with lcd and 8 data pins will start from b0....b7
Declare LCD_RSPIN PORTD.2 'declaring lcd reset pin
Declare LCD_ENPIN PORTD.1 'declaring enable pin
```

```
Declare LCD_RWPIN PORTD.0 'declaring read write pin
Declare LCD_LINES 2  'telling how much rows lcd has
Declare LCD_INTERFACE 4 '
Declare LCD_COMMANDUS 50000
Declare LCD_DATAUS 200
'''''''''''''''''''''''''''''''''''''


PORTB_PULLUPS = true
''''''''''''''''''''''''''''''''''''
Symbol RBIF = INTCON.0
Symbol GIE INTCON.7
Symbol PSA OPTION_REG.3
Symbol PS0 OPTION_REG.0
Symbol PS1 OPTION_REG.1
Symbol PS2 OPTION_REG.2
Symbol T0CS OPTION_REG.5


Symbol a=PORTB.0
 Symbol b=PORTB.1
 Symbol c=PORTB.2
  Symbol d=PORTB.3
SERIAL_BAUD = 9600
RSOUT_PIN = PORTC.6
RSOUT_MODE = True
RSOUT_PACE = 1
RSIN_PIN = PORTC.7
RSIN_MODE = True
```

```
HSERIAL_BAUD = 9600            ' Set baud rate to 9600
HSERIAL_RCSTA = %10010000      ' Enable serial port and continuous receive
HSERIAL_TXSTA = %00100100      ' Enable transmit and asynchronous mode
HSERIAL_CLEAR = On
Dim minute_inc As Bit
Dim second As Byte
Dim minute As Byte
Dim eye_blink_counter As Byte
Dim detect As Bit
Dim eye As Byte
Dim second_inc As Bit
'TM0=0
Symbol T0IE INTCON.5
Symbol T0IF INTCON.2
Dim time_counter As DWord
Dim eye_blink_colunter As Byte
 Dim value As Byte
Dim value2 As Byte

Dim value3 As DWord
Dim timer_counter As DWord
Dim AD_RESULT As Word
Dim AD_RESULT1 As Word
Dim conter As DWord
  Dim i As Byte

ADCON1 = %10001101
```

```
value2 = 0

GoTo over_interrupt

tick:

If a = 0 Then
Inc eye_blink_counter
EndIf

TMR0 = 1
T0IF=0  'UNMASK TIMER INTERRUPT
Context Restore

over_interrupt:
GIE=0
PSA=0
PS0=1
PS1=1
PS2=1
T0CS=0
TMR0=0
T0IE=1
''''''''''''
'INTCON.4 = 1
GIE=1
Cls
Print " WELCOME TO THE"
```

```
Cursor 2,1

Print "    PROJECT"

DelayMS 2000



While 1=1




Cls

Print "Receiving....."

DelayMS 10000

Cls



     AD_RESULT = ADIn 0                                        ' Read the ADC


      value2 = AD_RESULT / 4 * 3 '*4.882


     If value2 > 0 Then

     AD_RESULT = ADIn 0

     AD_RESULT=AD_RESULT&65532

     value2 = AD_RESULT / 4 '*4.8828

     Cursor 2,1

     Print "Temperature ", Dec value2

     HRSOut "                    \r\n#Bed = 1 \r\nTemp ",Dec  value2,"\r\n"

     EndIf
```

```
If   eye_blink_counter>0 Then


HRSOut "Heart Beat/Minute ",Dec eye_blink_counter/3*7,"\r\n"

HRSOut "BLood Pressure ",Dec eye_blink_counter/3*7+25,"*\r\n"

Cursor 1,1

Print "HB/Min",Dec eye_blink_counter/3 *7

DelayMS 100

Print "-BP=",Dec eye_blink_counter/3*7+25

Else

 Cursor 1,1


HRSOut "Heart Beat/Minute =0\r\n"

HRSOut "BLood Pressure =0*\r\n"

Print "HB/Min=0"

Print "-BP=0"

End If



eye_blink_counter =0



DelayMS 2000

Wend

Stop
```

CONCLUSION

CONCLUSION AND FUTURE WORK

Rapid growth of wireless infrastructure in following years will allow a range of new medical applications that will significantly improve the quality of health care.

Recent advances in microcontroller and sensor technology, including low power consumption and good performance to cost ratio made possible a whole range of new applications using distributed sensors

In this project we used sensors which gave us information about the patient health and we were able to transmit patient's information wirelessly to the computer system. The project increased systems overall efficiency and communication became fast and more reliable. The communication system that we develop facilitates doctors and patients empowering and improving communication between them.

Present technological advances make possible development of intelligent wireless sensors that could be used for medical applications, such as heart rate monitors

There is considerable interest in using wireless and mobile technologies in patient monitoring in diverse environments including hospitals and nursing homes. However, there has not been much work in determining the requirements of patient monitoring and satisfying these requirements using wireless networks. In this project, we derive several requirements of patient monitoring and show how wireless technology could be used for patient monitoring.

The future work should address how to improve the reliability of patient monitoring under varying coverage of WLANs, wireless link variations and access point failures.

Some recommendations on future work would be to add the fourth vital sign monitor to this system, which is measuring the oxygen level in the blood and developing ECG. This can be achieved through PPG. Since the PPG is already being used to measure blood pressure, it can easily be extended to measure the oxygenation of blood. Adding this last sensing component would make this system a complete vital signs monitor

APPENDIX

MICROCHIP

PIC16F84A

18-pin *Enhanced* FLASH/EEPROM 8-Bit Microcontroller

High Performance RISC CPU Features:

- Only 35 single word instructions to learn
- All instructions single-cycle except for program branches which are two-cycle
- Operating speed: DC - 20 MHz clock input
  DC - 200 ns instruction cycle
- 1024 words of program memory
- 68 bytes of Data RAM
- 64 bytes of Data EEPROM
- 14-bit wide instruction words
- 8-bit wide data bytes
- 15 Special Function Hardware registers
- Eight-level deep hardware stack
- Direct, indirect and relative addressing modes
- Four interrupt sources:
  - External RB0/INT pin
  - TMR0 timer overflow
  - PORTB<7:4> interrupt-on-change
  - Data EEPROM write complete

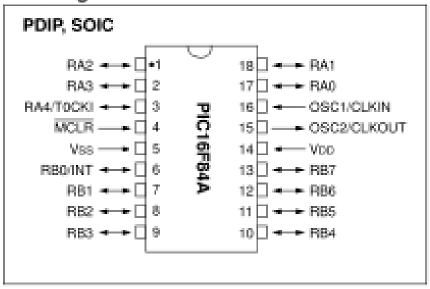
Peripheral Features:

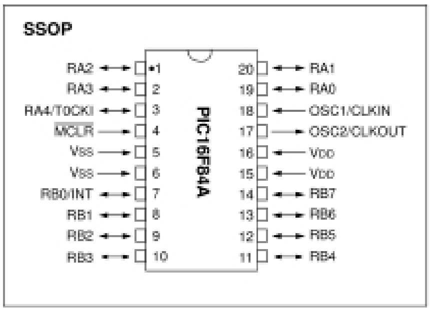
- 13 I/O pins with individual direction control
- High current sink/source for direct LED drive
  - 25 mA sink max. per pin
  - 25 mA source max. per pin
- TMR0: 8-bit timer/counter with 8-bit programmable prescaler

Special Microcontroller Features:

- 10,000 erase/write cycles *Enhanced* FLASH Program memory typical
- 10,000,000 typical erase/write cycles EEPROM Data memory typical
- EEPROM Data Retention > 40 years
- In-Circuit Serial Programming™ (ICSP™) - via two pins
- Power-on Reset (POR), Power-up Timer (PWRT), Oscillator Start-up Timer (OST)
- Watchdog Timer (WDT) with its own On-Chip RC Oscillator for reliable operation
- Code protection
- Power saving SLEEP mode
- Selectable oscillator options

Pin Diagrams





CMOS Enhanced FLASH/EEPROM Technology:

- Low power, high speed technology
- Fully static design
- Wide operating voltage range:
  - Commercial: 2.0V to 5.5V
  - Industrial: 2.0V to 5.5V
- Low power consumption:
  - < 2 mA typical @ 5V, 4 MHz
  - 15 μA typical @ 2V, 32 kHz
  - < 0.5 μA typical standby current @ 2V

 DS35007B-page 1

1.0 DEVICE OVERVIEW

This document contains device specific information for the operation of the PIC16F84A device. Additional information may be found in the PICmicro™ Mid-Range Reference Manual, (DS33023), which may be downloaded from the Microchip website. The Reference Manual should be considered a complementary document to this data sheet, and is highly recommended reading for a better understanding of the device architecture and operation of the peripheral modules.

The PIC16F84A belongs to the mid-range family of the PICmicro® microcontroller devices. A block diagram of the device is shown in Figure 1-1.

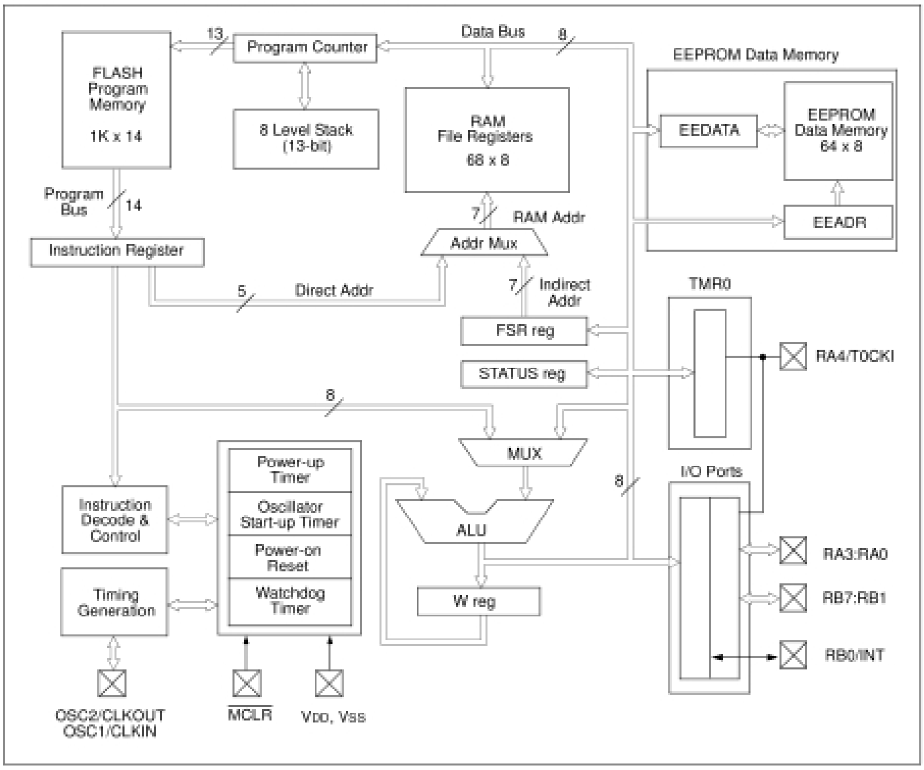
The program memory contains 1K words, which translates to 1024 instructions, since each 14-bit program memory word is the same width as each device instruction. The data memory (RAM) contains 68 bytes. Data EEPROM is 64 bytes.

There are also 13 I/O pins that are user-configured on a pin-to-pin basis. Some pins are multiplexed with other device functions. These functions include:

- External interrupt
- Change on PORTB interrupt
- Timer0 clock input

Table 1-1 details the pinout of the device with descriptions and details for each pin.

FIGURE 1-1: PIC16F84A BLOCK DIAGRAM



PIC16F84A

TABLE 1-1: PIC16F84A PINOUT DESCRIPTION

Pin Name	PDIP No.	SOIC No.	SSOP No.	I/O/P Type	Buffer Type	Description
OSC1/CLKIN	16	16	18	I	ST/CMOS(3)	Oscillator crystal input/external clock source input.
OSC2/CLKOUT	15	15	19	O	—	Oscillator crystal output. Connects to crystal or resonator in Crystal Oscillator mode. In RC mode, OSC2 pin outputs CLKOUT, which has 1/4 the frequency of OSC1 and denotes the instruction cycle rate.
$\overline{MCLR}$	4	4	4	I/P	ST	Master Clear (Reset) input/programming voltage input. This pin is an active low RESET to the device.
						PORTA is a bi-directional I/O port.
RA0	17	17	19	I/O	TTL	
RA1	18	18	20	I/O	TTL	
RA2	1	1	1	I/O	TTL	
RA3	2	2	2	I/O	TTL	
RA4/T0CKI	3	3	3	I/O	ST	Can also be selected to be the clock input to the TMR0 timer/counter. Output is open drain type.
						PORTB is a bi-directional I/O port. PORTB can be software programmed for internal weak pull-up on all inputs.
RB0/INT	6	6	7	I/O	TTL/ST(1)	RB0/INT can also be selected as an external interrupt pin.
RB1	7	7	8	I/O	TTL	
RB2	8	8	9	I/O	TTL	
RB3	9	9	10	I/O	TTL	
RB4	10	10	11	I/O	TTL	Interrupt-on-change pin.
RB5	11	11	12	I/O	TTL	Interrupt-on-change pin.
RB6	12	12	13	I/O	TTL/ST(2)	Interrupt-on-change pin. Serial programming clock.
RB7	13	13	14	I/O	TTL/ST(2)	Interrupt-on-change pin. Serial programming data.
V_{SS}	5	5	5,6	P	—	Ground reference for logic and I/O pins.
V_{DD}	14	14	15,16	P	—	Positive supply for logic and I/O pins.

Legend: I= input O = Output I/O = Input/Output P = Power
— = Not used TTL = TTL input ST = Schmitt Trigger input

Note 1: This buffer is a Schmitt Trigger input when configured as the external interrupt.
2: This buffer is a Schmitt Trigger input when used in Serial Programming mode.
3: This buffer is a Schmitt Trigger input when configured in RC oscillator mode and a CMOS input otherwise.

4.0 I/O PORTS

Some pins for these I/O ports are multiplexed with an alternate function for the peripheral features on the device. In general, when a peripheral is enabled, that pin may not be used as a general purpose I/O pin.

Additional information on I/O ports may be found in the PICmicro™ Mid-Range Reference Manual (DS33023).

4.1 PORTA and TRISA Registers

PORTA is a 5-bit wide, bi-directional port. The corresponding data direction register is TRISA. Setting a TRISA bit (= 1) will make the corresponding PORTA pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TRISA bit (= 0) will make the corresponding PORTA pin an output (i.e., put the contents of the output latch on the selected pin).

Note: On a Power-on Reset, these pins are configured as inputs and read as '0'.

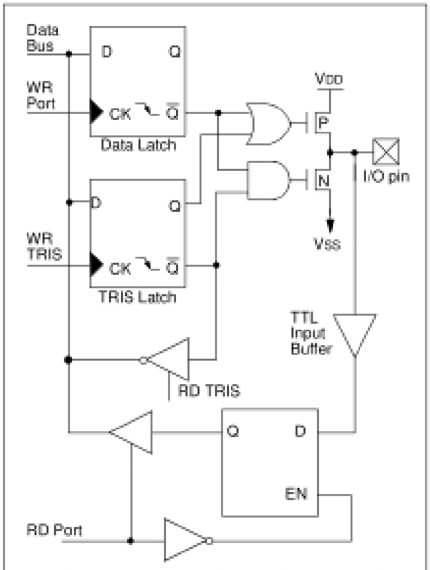
Reading the PORTA register reads the status of the pins, whereas writing to it will write to the port latch. All write operations are read-modify-write operations. Therefore, a write to a port implies that the port pins are read. This value is modified and then written to the port data latch.

Pin RA4 is multiplexed with the Timer0 module clock input to become the RA4/T0CKI pin. The RA4/T0CKI pin is a Schmitt Trigger input and an open drain output. All other RA port pins have TTL input levels and full CMOS output drivers.

EXAMPLE 4-1: INITIALIZING PORTA

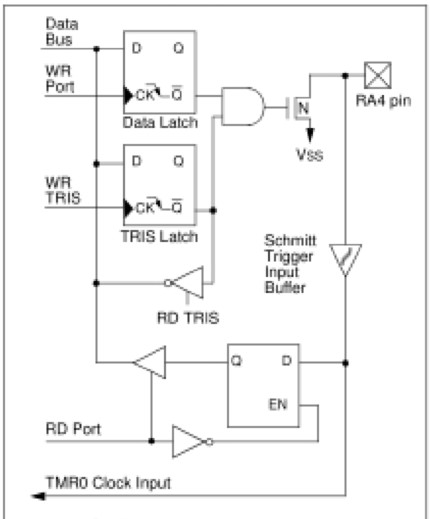
```
BCF     STATUS, RP0 ;
CLRF    PORTA       ; Initialize PORTA by
                    ; clearing output
                    ; data latches
BSF     STATUS, RP0 ; Select Bank 1
MOVLW   0x0F        ; Value used to
                    ; initialize data
                    ; direction
MOVWF   TRISA       ; Set RA<3:0> as inputs
                    ; RA4 as output
                    ; TRISA<7:5> are always
                    ; read as '0'.
```

FIGURE 4-1: BLOCK DIAGRAM OF PINS RA3:RA0



Note: I/O pins have protection diodes to VDD and VSS.

FIGURE 4-2: BLOCK DIAGRAM OF PIN RA4



Note: I/O pins have protection diodes to VDD and VSS.

4.2 PORTB and TRISB Registers

PORTB is an 8-bit wide, bi-directional port. The corresponding data direction register is TRISB. Setting a TRISB bit (= 1) will make the corresponding PORTB pin an input (i.e., put the corresponding output driver in a Hi-Impedance mode). Clearing a TRISB bit (= 0) will make the corresponding PORTB pin an output (i.e., put the contents of the output latch on the selected pin).

EXAMPLE 4-2: INITIALIZING PORTB

```
BCF     STATUS, RP0 ;
CLRF    PORTB       ; Initialize PORTB by
                    ; clearing output
                    ; data latches
BSF     STATUS, RP0 ; Select Bank 1
MOVLW   0xCF        ; Value used to
                    ; initialize data
                    ; direction
MOVWF   TRISB       ; Set RB<3:0> as inputs
                    ; RB<5:4> as outputs
                    ; RB<7:6> as inputs
```

Each of the PORTB pins has a weak internal pull-up. A single control bit can turn on all the pull-ups. This is performed by clearing bit $\overline{RBPU}$ (OPTION<7>). The weak pull-up is automatically turned off when the port pin is configured as an output. The pull-ups are disabled on a Power-on Reset.

Four of PORTB's pins, RB7:RB4, have an interrupt-on-change feature. Only pins configured as inputs can cause this interrupt to occur (i.e., any RB7:RB4 pin configured as an output is excluded from the interrupt-on-change comparison). The input pins (of RB7:RB4) are compared with the old value latched on the last read of PORTB. The "mismatch" outputs of RB7:RB4 are OR'ed together to generate the RB Port Change Interrupt with flag bit RBIF (INTCON<0>).

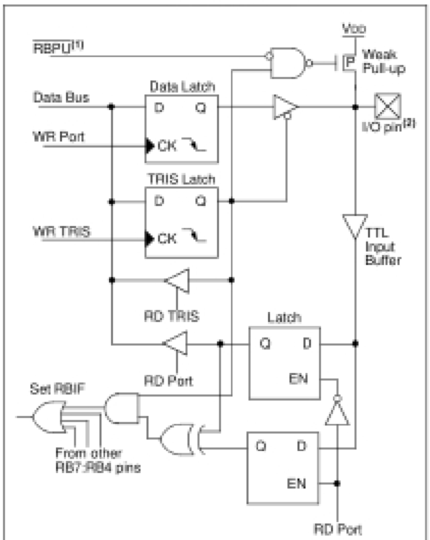
This interrupt can wake the device from SLEEP. The user, in the Interrupt Service Routine, can clear the interrupt in the following manner:

a) Any read or write of PORTB. This will end the mismatch condition.
b) Clear flag bit RBIF.

A mismatch condition will continue to set flag bit RBIF. Reading PORTB will end the mismatch condition and allow flag bit RBIF to be cleared.

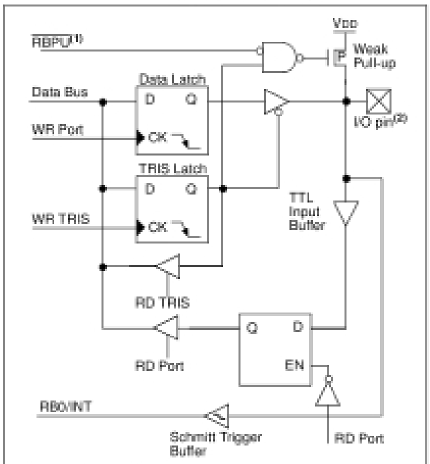
The interrupt-on-change feature is recommended for wake-up on key depression operation and operations where PORTB is only used for the interrupt-on-change feature. Polling of PORTB is not recommended while using the interrupt-on-change feature.

FIGURE 4-3: BLOCK DIAGRAM OF PINS RB7:RB4



Note 1: TRISB = '1' enables weak pull-up (if $\overline{RBPU}$ = '0' in the OPTION_REG register).
2: I/O pins have diode protection to VDD and VSS.

FIGURE 4-4: BLOCK DIAGRAM OF PINS RB3:RB0



Note 1: TRISB = '1' enables weak pull-up (if $\overline{RBPU}$ = '0' in the OPTION_REG register).
2: I/O pins have diode protection to VDD and VSS.

RADIOMETRIX

Hartcran House, 231 Kenton Lane, Harrow, Middlesex, HA3 8RP, England
Tel: +44 (0) 20 8909 9595, Fax: +44 (0) 20 8909 2233, www.radiometrix.com

TX2A/RX2A

Issue 1. 07th October 2010

UHF FM Data Transmitter and Receiver Modules

The TX2A and RX2A data link modules are a miniature PCB mounting UHF radio transmitter and receiver pair which enable the simple implementation of a data link at up to 64 kbps at distances up to 75 metres in-building and 300 metres open ground.

Figure 1: TX2A-433-64 & RX2A-433-

Features

- CE certified by independent Notified Body
- Verified to comply with harmonised radio standard EN 300 220-3 and EMC standard EN 301 489-3 by accredited Test Laboratory
- Data rates up to 64 kbps
- Usable range up to 300 m
- Versions available on 433.92MHz and 434.42MHz
- Fully screened

Available for operation at 433.92MHz or 434.42MHz in the UK and Europe, both modules combine full screening with extensive internal filtering to ensure EMC compliance by minimising spurious radiations and susceptibilities. The TX2A and RX2A modules will suit one-to-one and multi-node wireless links in applications including car and building security, EPOS and inventory tracking, remote industrial process monitoring and computer networking. Because of their small size and low power requirements, both modules are ideal for use in portable, battery-powered applications such as hand-held terminals.

Technical Summary

Transmitter - TX2A

- Crystal-locked PLL, FM modulated at up to 64 Kbps
- Operation from 2.2V to 16V (Dependent on version)
- +10dBm on 433.92MHz
- High efficiency, >30%, DC to RF
- Improved frequency and deviation accuracy
- 2nd harmonic, > -60dBc

Receiver - RX2A

- Single conversion FM superhet
- SAW front end filter gives >50dB image rejection
- Operation from 2.7V to 16V @ 12mA
- Built-in regulator for improved stability and supply noise rejection
- -101dBm sensitivity @ 1ppm BER, 64kb/s version
- -108dBm sensitivity @ 1ppm BER, 10kb/s version
- RSSI output with 60dB range
- Extremely low LO leakage, <-100dBm

Radiometrix Ltd, TX2A/RX2A Data Sheet *page 1*

Functional description

The TX2A transmitter module is a crystal based PLL controlled FM transmitter operating between 2.2V and 16V and is available in 433.92MHz. The TX2A module is type approved to EN 300 220-3 for European use and delivers nominally +10dBm at 11mA. The module measures 32 x 12 x 3.8 mm.

The RX2A module is a single conversion FM superhet receiver capable of handling data rates of up to 64kbps. It will operate from a supply of 2.7V to 16V and draws 10mA when receiving. The RX2A features a fast power-up time for effective duty cycle power saving and a signal strength (RSSI) output with 60dB of range. Full screening and a SAW front-end filter give good immunity to interference. The SIL style RX2A measures 48 x 17.5 x 4.5 mm excluding the pins.

TX2A transmitter

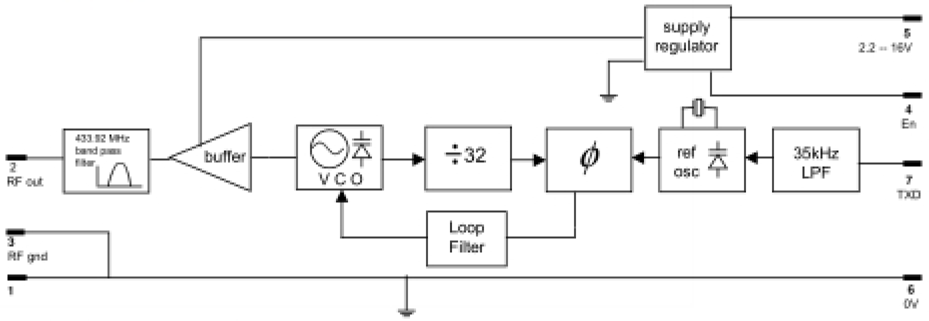


Fig. 2: TX2A block diagram

Pin description

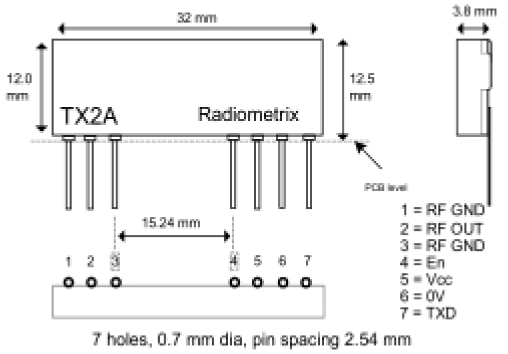


Fig 3: TX2A physical dimensions

RF GND *(pins 1&3)*
RF ground, internally connected to the module screen and pin 6 (0V). These pins should be directly connected to the RF return path - e.g. coax braid, main PCB ground plane etc.

RF OUT *(pin 2)*
50Ω RF output to the antenna. Internally DC-isolated. See antenna section of apps notes for details of suitable antennas.

En *(pin 4)*
Tx enable. <0.15V shuts down module (current <1µA). >1.7V enables the transmitter. Impedance ~1MΩ. Observe slew rate requirements (see apps notes).

Vcc *(pin 5)*
+2.2V to +16V DC supply. Max ripple content $0.1V_{p\text{-}p}$. Decoupling is not generally required.

0V *(pin 6)*
DC supply ground. Internally connected to pins 1 & 3 and module screen.

TXD *(pin 7)*
DC-coupled modulation input. Accepts serial digital data at 0V to 2.5V levels.
See applications notes for suggested drive methods. Input is high impedance (>100kΩ).

Notes: 1. The 3V and 5V supply variant TX2As intended for direct replacement to our SAW based TX2 modules and do not have internal regulator. They also have identical pin out as of TX2, hence lack pin 3 (GND) and pin 4 (Enable).
2. The TXD input of 3V and 5V versions require serial digital data at 0-Vcc levels. i.e. 0-3V and 0-5V respectively

Radiometrix Ltd, TX2A/RX2A Data Sheet *page 2*

RX2A receiver

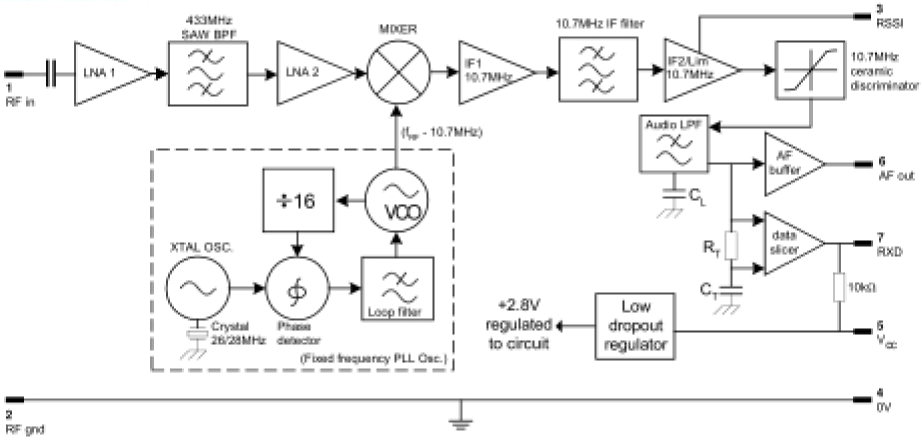


Figure 4: RX2A Block diagram

Pin description

RF IN *(pin 1)*
50Ω input from the antenna, DC isolated

RF GND *(pin 2)*
RF ground pin, internally connected to the module screen and pin 4 (0V). This pin should be connected to the RF return path (coax braid, main PCB ground plane etc.)

RSSI *(pin 3)*
Received signal strength indicator with 60dB range. See page 4 for typical characteristics.

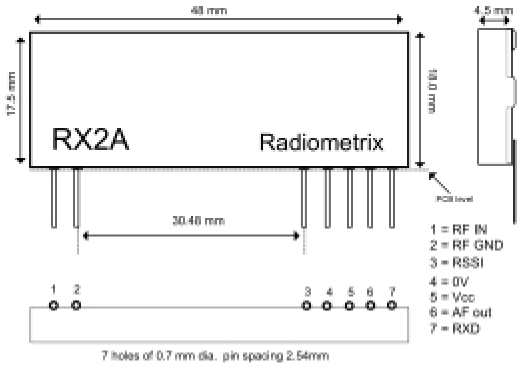


Figure 5: Physical dimensions

0V *(pin 4)*
DC supply ground. Internally connected to pin 2 and module screen.

Vcc *(pin 5)*
+2.7V to +16.0V DC supply. Max ripple content $0.1V_{p-p}$. Decoupling is not generally required.

AF out *(pin 6)*
Buffered and filtered analogue output from the FM demodulator. Standing DC bias 1.1V approx. External load should be >10kΩ // <100pF.

RXD *(pin 7)*
Digital output from the internal data slicer. The data is a squared version of the signal on pin 6 (AF) and is true data, i.e. as fed to the transmitter. Output is "open-collector" format with internal 10kΩ pull-up to Vcc (pin 5).

MAXIM

+5V-Powered, Multichannel RS-232 Drivers/Receivers

General Description

The MAX220–MAX249 family of line drivers/receivers is intended for all EIA/TIA-232E and V.28/V.24 communications interfaces, particularly applications where ±12V is not available.

These parts are especially useful in battery-powered systems, since their low-power shutdown mode reduces power dissipation to less than 5μW. The MAX225, MAX233, MAX235, and MAX245/MAX246/MAX247 use no external components and are recommended for applications where printed circuit board space is critical.

Applications

Portable Computers

Low-Power Modems

Interface Translation

Battery-Powered RS-232 Systems

Multi-Drop RS-232 Networks

Features

Superior to Bipolar

- **Operate from Single +5V Power Supply (+5V and +12V—MAX231/MAX239)**
- **Low-Power Receive Mode in Shutdown (MAX223/MAX242)**
- **Meet All EIA/TIA-232E and V.28 Specifications**
- **Multiple Drivers and Receivers**
- **3-State Driver and Receiver Outputs**
- **Open-Line Detection (MAX243)**

Ordering Information

PART	TEMP. RANGE	PIN-PACKAGE
MAX220CPE	0°C to +70°C	16 Plastic DIP
MAX220CSE	0°C to +70°C	16 Narrow SO
MAX220CWE	0°C to +70°C	16 Wide SO
MAX220C/D	0°C to +70°C	Dice*
MAX220EPE	-40°C to +85°C	16 Plastic DIP
MAX220ESE	-40°C to +85°C	16 Narrow SO
MAX220EWE	-40°C to +85°C	16 Wide SO
MAX220EJE	-40°C to +85°C	16 CERDIP
MAX220MJE	-55°C to +125°C	16 CERDIP

Ordering Information continued at end of data sheet.

**Contact factory for dice specifications.*

Selection Table

Part Number	Power Supply (V)	No. of RS-232 Drivers/Rx	No. of Ext. Caps	Nominal Cap. Value (μF)	SHDN & Three-State	Rx Active in SHDN	Data Rate (kbps)	Features
MAX220	+5	2/2	4	4.7/10	No	—	120	Ultra-low-power, industry-standard pinout
MAX222	+5	2/2	4	0.1	Yes	—	200	Low-power shutdown
MAX223 (MAX213)	+5	4/5	4	1.0 (0.1)	Yes	✓	120	MAX241 and receivers active in shutdown
MAX225	+5	5/5	0	—	Yes	✓	120	Available in SO
MAX230 (MAX200)	+5	5/0	4	1.0 (0.1)	Yes	—	120	5 drivers with shutdown
MAX231 (MAX201)	+5 and +7.5 to +13.2	2/2	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; same functions as MAX232
MAX232 (MAX202)	+5	2/2	4	1.0 (0.1)	No	—	120 (64)	Industry standard
MAX232A	+5	2/2	4	0.1	No	—	200	Higher slew rate, small caps
MAX233 (MAX203)	+5	2/2	0	—	No	—	120	No external caps
MAX233A	+5	2/2	0	—	No	—	200	No external caps, high slew rate
MAX234 (MAX204)	+5	4/0	4	1.0 (0.1)	No	—	120	Replaces 1488
MAX235 (MAX205)	+5	5/5	0	—	Yes	—	120	No external caps
MAX236 (MAX206)	+5	4/3	4	1.0 (0.1)	Yes	—	120	Shutdown, three state
MAX237 (MAX207)	+5	5/3	4	1.0 (0.1)	No	—	120	Complements IBM PC serial port
MAX238 (MAX208)	+5	4/4	4	1.0 (0.1)	No	—	120	Replaces 1488 and 1489
MAX239 (MAX209)	+5 and +7.5 to +13.2	3/5	2	1.0 (0.1)	No	—	120	Standard +5/+12V or battery supplies; single-package solution for IBM PC serial port
MAX240	+5	5/5	4	1.0	Yes	—	120	DIP or flatpack package
MAX241 (MAX211)	+5	4/5	4	1.0 (0.1)	Yes	—	120	Complete IBM PC serial port
MAX242	+5	2/2	4	0.1	Yes	✓	200	Separate shutdown and enable
MAX243	+5	2/2	4	0.1	No	—	200	Open-line detection simplifies cabling
MAX244	+5	8/10	4	1.0	No	—	120	High slew rate
MAX245	+5	8/10	0	—	Yes	✓	120	High slew rate, int. caps, two shutdown modes
MAX246	+5	8/10	0	—	Yes	✓	120	High slew rate, int. caps, three shutdown modes
MAX247	+5	8/9	0	—	Yes	✓	120	High slew rate, int. caps, nine operating modes
MAX248	+5	8/8	4	1.0	Yes	✓	120	High slew rate, selective half-chip enables
MAX249	+5	6/10	4	1.0	Yes	✓	120	Available in quad flatpack package

+5V-Powered, Multichannel RS-232 Drivers/Receivers

ABSOLUTE MAXIMUM RATINGS—MAX220/222/232A/233A/242/243

Supply Voltage (V_{CC})..-0.3V to +6V
Input Voltages
T_{IN}..-0.3V to (V_{CC} - 0.3V)
R_{IN} (Except MAX220)..±30V
R_{IN} (MAX220)..±25V
T_{OUT} (Except MAX220) (Note 1)..±15V
T_{OUT} (MAX220)..±13.2V
Output Voltages
T_{OUT}..±15V
R_{OUT}..-0.3V to (V_{CC} + 0.3V)
Driver/Receiver Output Short Circuited to GND........Continuous
Continuous Power Dissipation (T_A = +70°C)
16-Pin Plastic DIP (derate 10.53mW/°C above +70°C)....842mW
18-Pin Plastic DIP (derate 11.11mW/°C above +70°C)....889mW
20-Pin Plastic DIP (derate 8.00mW/°C above +70°C)..440mW
16-Pin Narrow SO (derate 8.70mW/°C above +70°C)...696mW
16-Pin Wide SO (derate 9.52mW/°C above +70°C)......762mW
18-Pin Wide SO (derate 9.52mW/°C above +70°C)......762mW
20-Pin Wide SO (derate 10.00mW/°C above +70°C)....800mW
20-Pin SSOP (derate 8.00mW/°C above +70°C)..........640mW
16-Pin CERDIP (derate 10.00mW/°C above +70°C).....800mW
18-Pin CERDIP (derate 10.53mW/°C above +70°C).....842mW
Operating Temperature Ranges
MAX2_ _AC_ _, MAX2_ _C_ _..0°C to +70°C
MAX2_ _AE_ _, MAX2_ _E_ _..-40°C to +85°C
MAX2_ _AM_ _, MAX2_ _M_ _..-55°C to +125°C
Storage Temperature Range..-65°C to +160°C
Lead Temperature (soldering, 10sec)..+300°C

Note 1: Input voltage measured with T_{OUT} in high-impedance state, $\overline{SHDN}$ or V_{CC} = 0V.
Note 2: For the MAX220, V+ and V- can have a maximum magnitude of 7V, but their absolute difference cannot exceed 13V.

Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243

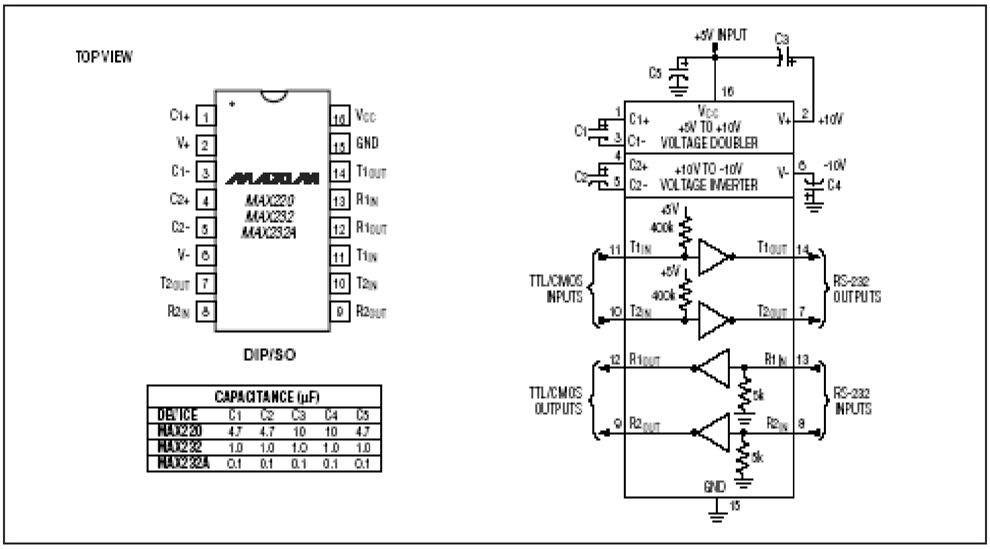
(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
RS-232 TRANSMITTERS						
Output Voltage Swing	All transmitter outputs loaded with 3kΩ to GND		±5	±8		V
Input Logic Threshold Low				1.4	0.8	V
Input Logic Threshold High			2	1.4		V
Logic Pull-Up/Input Current	All except MAX220, normal operation			5	40	µA
	$\overline{SHDN}$ = 0V, MAX222/242, shutdown, MAX220			±0.01	±1	
Output Leakage Current	V_{CC} = 5.5V, $\overline{SHDN}$ = 0V, V_{OUT} = ±15V, MAX222/242			±0.01	±10	µA
	V_{CC} = $\overline{SHDN}$ = 0V, V_{OUT} = ±15V			±0.01	±10	
Data Rate	All except MAX220, normal operation			200	116	kbits/sec
	MAX220			22	20	
Transmitter Output Resistance	V_{CC} = V+ = V- = 0V, V_{OUT} = ±2V		300	10M		Ω
Output Short-Circuit Current	V_{OUT} = 0V		±7	±22		mA
RS-232 RECEIVERS						
RS-232 Input Voltage Operating Range					±30	V
RS-232 Input Threshold Low	V_{CC} = 5V	All except MAX243 $R2_{IN}$	0.8	1.3		V
		MAX243 $R2_{IN}$ (Note 2)	-3			
RS-232 Input Threshold High	V_{CC} = 5V	All except MAX243 $R2_{IN}$		1.8	2.4	V
		MAX243 $R2_{IN}$ (Note 2)		-0.5	-0.1	
RS-232 Input Hysteresis	All except MAX243, V_{CC} = 5V, no hysteresis in shdn.		0.2	0.5	1	V
	MAX243			1		
RS-232 Input Resistance			3	5	7	kΩ
TTL/CMOS Output Voltage Low	I_{OUT} = 3.2mA			0.2	0.4	V
TTL/CMOS Output Voltage High	I_{OUT} = -1.0mA		3.5	V_{CC} - 0.2		V
TTL/CMOS Output Short-Circuit Current	Sourcing V_{OUT} = GND		-2	-10		mA
	Shrinking V_{OUT} = V_{CC}		10	30		

ELECTRICAL CHARACTERISTICS—MAX220/222/232A/233A/242/243 (continued)

(V_{CC} = +5V ±10%, C1–C4 = 0.1µF, MAX220, C1 = 0.047µF, C2–C4 = 0.33µF, T_A = T_{MIN} to T_{MAX}, unless otherwise noted.)

PARAMETER	CONDITIONS		MIN	TYP	MAX	UNITS
TTL/CMOS Output Leakage Current	$\overline{SHDN}$ = V_{CC} or $\overline{EN}$ = V_{CC} ($\overline{SHDN}$ = 0V for MAX222), 0V ≤ V_{OUT} ≤ V_{CC}			±0.05	±10	µA
$\overline{EN}$ Input Threshold Low	MAX242			1.4	0.8	V
$\overline{EN}$ Input Threshold High	MAX242		2.0	1.4		V
Operating Supply Voltage			4.5		5.5	V
V_{CC} Supply Current ($\overline{SHDN}$ = V_{CC}), Figures 5, 6, 11, 19	No load	MAX220		0.5	2	mA
		MAX222/232A/233A/242/243		4	10	
	3kΩ load both inputs	MAX220		12		
		MAX222/232A/233A/242/243		15		
Shutdown Supply Current	MAX222/242	T_A = +25°C		0.1	10	µA
		T_A = 0°C to +70°C		2	50	
		T_A = -40°C to +85°C		2	50	
		T_A = -55°C to +125°C		35	100	
$\overline{SHDN}$ Input Leakage Current	MAX222/242				±1	µA
$\overline{SHDN}$ Threshold Low	MAX222/242			1.4	0.8	V
$\overline{SHDN}$ Threshold High	MAX222/242		2.0	1.4		V
Transition Slew Rate	C_L = 50pF to 2500pF, R_L = 3kΩ to 7kΩ, V_{CC} = 5V, T_A = +25°C, measured from +3V to -3V or -3V to +3V	MAX222/232A/233A/242/243	6	12	30	V/µs
		MAX220	1.5	3	30	
Transmitter Propagation Delay TLL to RS-232 (normal operation), Figure 1	t_{PHLT}	MAX222/232A/233A/242/243		1.3	3.5	µs
		MAX220		4	10	
	t_{PLHT}	MAX222/232A/233A/242/243		1.5	3.5	
		MAX220		5	10	
Receiver Propagation Delay RS-232 to TLL (normal operation), Figure 2	t_{PHLR}	MAX222/232A/233A/242/243		0.5	1	µs
		MAX220		0.6	3	
	t_{PLHR}	MAX222/232A/233A/242/243		0.6	1	
		MAX220		0.8	3	
Receiver Propagation Delay RS-232 to TLL (shutdown), Figure 2	t_{PHLS}	MAX242		0.5	10	µs
	t_{PLHS}	MAX242		2.5	10	
Receiver-Output Enable Time, Figure 3	t_{ER}	MAX242		125	500	ns
Receiver-Output Disable Time, Figure 3	t_{DR}	MAX242		160	500	ns
Transmitter-Output Enable Time ($\overline{SHDN}$ goes high), Figure 4	t_{ET}	MAX222/242, 0.1µF caps (Includes charge-pump start-up)		250		µs
Transmitter-Output Disable Time ($\overline{SHDN}$ goes low), Figure 4	t_{DT}	MAX222/242, 0.1µF caps		600		ns
Transmitter + to - Propagation Delay Difference (normal operation)	t_{PHLT} - t_{PLHT}	MAX222/232A/233A/242/243		300		ns
		MAX220		2000		
Receiver + to - Propagation Delay Difference (normal operation)	t_{PHLR} - t_{PLHR}	MAX222/232A/233A/242/243		100		ns
		MAX220		225		



DEVICE	C1	C2	C3	C4	C5
MAX220	4.7	4.7	10	10	4.7
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1

Figure 5. MAX220/MAX232/MAX232A Pin Configuration and Typical Operating Circuit

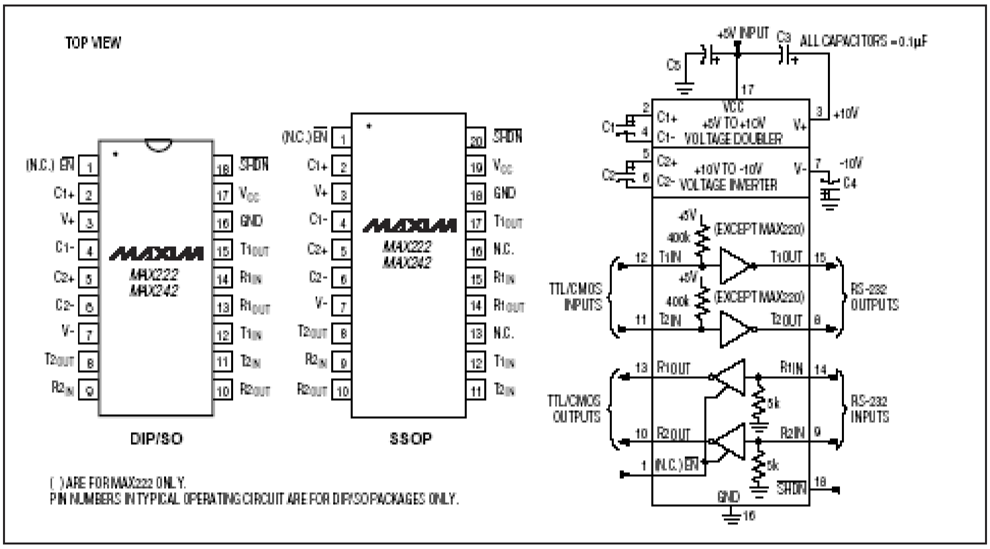
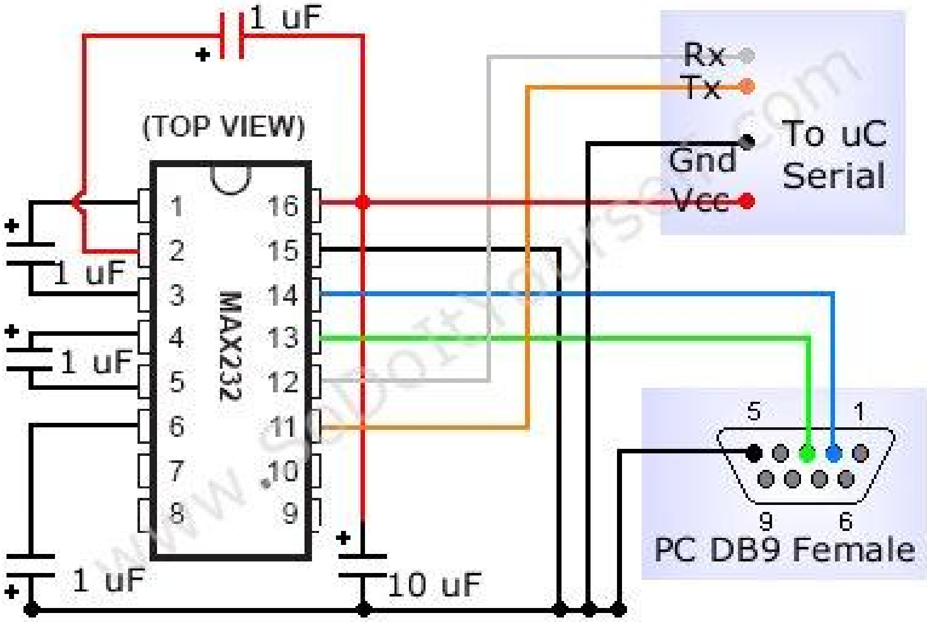


Figure 6. MAX222/MAX242 Pin Configurations and Typical Operating Circuit



intel®

PRELIMINARY

T-49-19-07

MCS®-51
8-BIT CONTROL-ORIENTED MICROCOMPUTERS
8031/8051
8031AH/8051AH
8032AH/8052AH
8751H/8751H-8

- **High Performance HMOS Process**
- **Internal Timers/Event Counters**
- **2-Level Interrupt Priority Structure**
- **32 I/O Lines (Four 8-Bit Ports)**
- **64K Program Memory Space**
- **Security Feature Protects EPROM Parts Against Software Piracy**
- **Boolean Processor**
- **Bit-Addressable RAM**
- **Programmable Full Duplex Serial Channel**
- **111 Instructions (64 Single-Cycle)**
- **64K Data Memory Space**

The MCS®-51 products are optimized for control applications. Byte-processing and numerical operations on small data structures are facilitated by a variety of fast addressing modes for accessing the internal RAM. The instruction set provides a convenient menu of 8-bit arithmetic instructions, including multiply and divide instructions. Extensive on-chip support is provided for one-bit variables as a separate data type, allowing direct bit manipulation and testing in control and logic systems that require Boolean processing.

The 8051 is the original member of the MCS-51 family. The 8051AH is identical to the 8051, but it is fabricated with HMOS II technology.

The 8751H is an EPROM version of the 8051AH; that is, the on-chip Program Memory can be electrically programmed, and can be erased by exposure to ultraviolet light. It is fully compatible with its predecessor, the 8751-8, but incorporates two new features: a Program Memory Security bit that can be used to protect the EPROM against unauthorized read-out, and a programmable baud rate modification bit (SMOD). The 8751H-8 is identical to the 8751H but only operates up to 8 MHz.

The 8052AH is an enhanced version of the 8051AH. It is backwards compatible with the 8051AH and is fabricated with HMOS II technology. The 8052AH enhancements are listed in the table below. Also refer to this table for the ROM, ROMless, and EPROM versions of each product.

Device	Internal Memory		Timers/ Event Counters	Interrupts
	Program	Data		
8052AH	8K x 8 ROM	256 x 8 RAM	3 x 16-Bit	6
8051AH	4K x 8 ROM	128 x 8 RAM	2 x 16-Bit	5
8051	4K x 8 ROM	128 x 8 RAM	2 x 16-Bit	5
8032AH	none	256 x 8 RAM	3 x 16-Bit	6
8031AH	none	128 x 8 RAM	2 x 16-Bit	5
8031	none	128 x 8 RAM	2 x 16-Bit	5
8751H	4K x 8 EPROM	128 x 8 RAM	2 x 16-Bit	5
8751H-8	4K x 8 EPROM	128 x 8 RAM	2 x 16-Bit	5

T-49-19-07

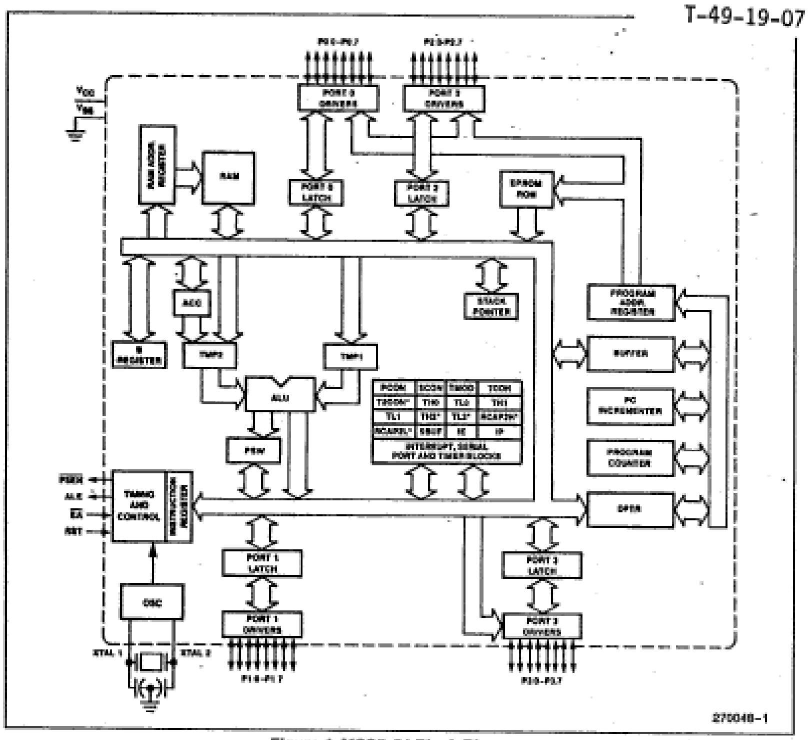


Figure 1. MCS®-51 Block Diagram

PACKAGES

Part	Prefix	Package Type
8051AH/ 8031AH	P D N	40-Pin Plastic DIP 40-Pin CERDIP 44-Pin PLCC
8052AH/ 8032AH	P D N	40-Pin Plastic DIP 40-Pin CERDIP 44-Pin PLCC
8751H/ 8751H-8	D R	40-Pin CERDIP 44-Pin LCC

PIN DESCRIPTIONS

V_{CC}: Supply voltage.

V_{SS}: Circuit ground.

Port 0: Port 0 is an 8-bit open drain bidirectional I/O port. As an output port each pin can sink 8 LS TTL inputs.

Port 0 pins that have 1s written to them float, and in that state can be used as high-impedance inputs.

Port 0 is also the multiplexed low-order address and data bus during accesses to external Program and Data Memory. In this application it uses strong internal pullups when emitting 1s and can source and sink 8 LS TTL inputs.

Port 0 also receives the code bytes during programming of the EPROM parts, and outputs the code bytes during program verification of the ROM and EPROM parts. External pullups are required during program verification.

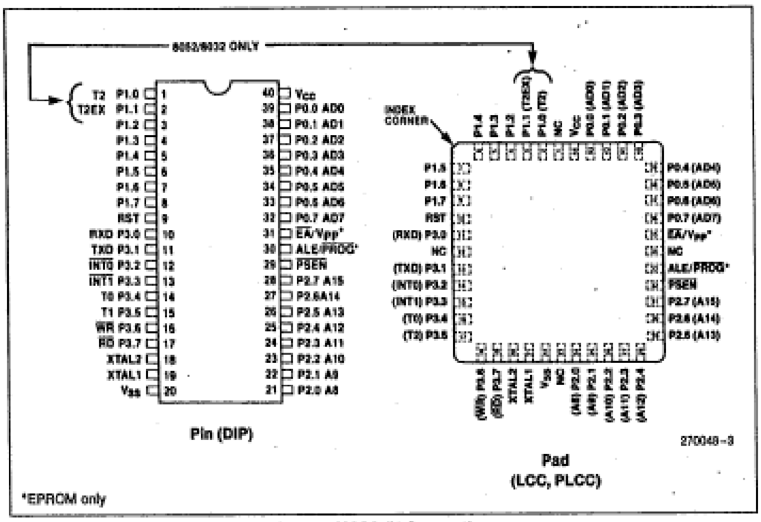


Figure 2. MCS®-51 Connections

Port 1: Port 1 is an 8-bit bidirectional I/O port with internal pullups. The Port 1 output buffers can sink/source 4 LS TTL inputs. Port 1 pins that have 1s written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source current (I_{IL} on the data sheet) because of the internal pullups.

Port 1 also receives the low-order address bytes during programming of the EPROM parts and during program verification of the ROM and EPROM parts.

In the 8032AH and 8052AH, Port 1 pins P1.0 and P1.1 also serve the T2 and T2EX functions, respectively.

Port 2: Port 2 is an 8-bit bidirectional I/O port with internal pullups. The Port 2 output buffers can sink/source 4 LS TTL inputs. Port 2 pins that have 1s written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source current (I_{IL} on the data sheet) because of the internal pullups.

Port 2 emits the high-order address byte during fetches from external Program Memory and during accesses to external Data Memory that use 16-bit addresses (MOVX @DPTR). In this application it uses strong internal pullups when emitting 1s. During accesses to external Data Memory that use 8-bit addresses (MOVX @Ri), Port 2 emits the contents of the P2 Special Function Register.

Port 2 also receives the high-order address bits during programming of the EPROM parts and during program verification of the ROM and EPROM parts.

Port 3: Port 3 is an 8-bit bidirectional I/O port with internal pullups. The Port 3 output buffers can sink/source 4 LS TTL inputs. Port 3 pins that have 1s written to them are pulled high by the internal pullups, and in that state can be used as inputs. As inputs, Port 3 pins that are externally being pulled low will source current (I_{IL} on the data sheet) because of the pullups.

Port 3 also serves the functions of various special features of the MCS-51 Family, as listed below:

Port Pin	Alternative Function
P3.0	RXD (serial input port)
P3.1	TXD (serial output port)
P3.2	$\overline{INT0}$ (external interrupt 0)
P3.3	$\overline{INT1}$ (external interrupt 1)
P3.4	T0 (Timer 0 external input)
P3.5	T1 (Timer 1 external input)
P3.6	$\overline{WR}$ (external data memory write strobe)
P3.7	$\overline{RD}$ (external data memory read strobe)

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