Explosive Detection Using Ultrasonic Waves

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Certificate

We accept the work contained in this report as a confirmation to the required standard for the partial fulfillment of the degree of BS(ETM).

Head of Department	Supervisor
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Dedication

We dedicate this project to all the martyrdoms of the suicide blasts that have taken place all over the world and especially in Pakistan. We hope that our step in this direction opens door to new grounds which will help to save many precious lives.

This is also dedicated to all the teachers who taught us throughout the degree and helped us gain shear knowledge and played their vital role in building our character and academia.

Dedication cannot be completed without mentioning our parents & friends who provided us with all the necessary back end support to accomplish our degree and make us what we are today.

Acknowledgements

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We also like to thank our project co-coordinator **Ma'am Saima Jawad** who encouraged us throughout the project and helped us in the best possible way.

Abstract

The aim of this project is to develop a system that will be capable of detecting explosives/metal detection from a remote distance; this system would be installed on security checkpoints and walkthrough security points. By the help of ultrasonic sensor the sensor will extract the signal and MATLAB will be used for signal processing and classification algorithm. The ability of this system will surpass the prior technology of detecting metals that is by electromagnetic interference. Hence allowing the user to remotely scan the subject from a safe distance without any close contact and enabling the security personal to maintain a distance with the suspect. This allows a crucial small time window in which a security measure can be initiated to ensure the safety.

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Chapter # 1

Introduction

1.1 Project Background/Overview

Our country is located at a very strategically important place. Especially after the twin tower attack in September 9.11 Pakistan has played a key role as an ally of USA. This alliance did not come without a price; there has been a great hype in the security threats to Pakistan.

One of the major security threats are the suicide blasts. Therefore scientific communities are focusing on finding a technique that will enable an accurate detection of explosives on a person's body.

Currently, the technologies that have been applied to detect explosives (Weapons) are X-Rays (at the airport check points) and Walkthrough gates.

It is observed that the suicide bomber mostly detonate themselves during the security check in, as a security officer is checking him/her. The idea came in our mind that would it be possible to detect and raise an alarm prior to close contact with any suspect. In this regard our research showed that ultrasounds can offer an alternative to these two techniques, if a remote detection needs to be carried out.

There are numerous advantages of using ultrasound over metal detectors. Metal detectors have multiple limitations; metal detectors require the material to be ferromagnetic. Therefore if the explosives are concealed in a non-magnetic thing there can be deviation in the detection behavior of the metal detectors and walkthrough gates. On the other hand X-Rays use ionizing of the material hence they are costly and require a huge setup, in terms of cost and space.

When talking in terms of cost ultrasonic offer a great deal of cost reduction as the equipment used to build the system is less costly as compared to walkthrough gates and x-ray machines.

1.2 Problem Description

Security is one of the biggest concerns now a days. With increasing security threats an elevation in the safety measures needs to be considered. Explosives have a tendency to deliver catastrophic damage, therefore strict monitoring and effective detection is vital. It is to be noted that current techniques require a very upfront and a close contact with the suspect/object. Security personal are appointed at the security check in which put their life in danger to scan the suspect by bare hands/detectors or walkthrough gates.

Apart from this there are some limitations of the current systems that have been discussed earlier.

1.3 Project Objectives

The main objective of this project is to deal with security issue by deploying a remote detection unit which will assist in achieving a higher level of security.

The overall objective of the project can be sub divided into different parts
First our basic aim is to deliver and acquire the ultrasonic signal. To detect any sorts of material the system must know what to look for inside the reflected signal. The crux of the complete project was to figure out that which part of the returning signal contains the information that whether the suspect is armed or unarmed.

For this a control test was to be carried out, in which only samples of explosive material was placed in environment containing minimal noise. After successful detection, the benchmark will be set and all the further test will be conducted accordingly with the extracted sample of explosive signal.

Chapter # 2

Literature Review

2.1 Background:

Explosives are the reactive materials which have the tendency to produce an explosion along with light, heat and pressure. The potential energy that is stored in the explosives can be of different types:

- Pressurized Gas
- Nuclear Energy.
- Chemical Energy (Explosive Compounds).

2.2 History:

50 B.C:
There was a common use of seismoscope in China.

1200 A.D:
Abdullah of Arab first used saltpeter as a core ingredient of black powder.

13th Century:
"Roman Candles" were used by Chinese. They used it in wars. To confine

The ingredients of explosive were first derived by English and later they were implemented by German. They used it in machine guns etc.
Blasting in mines was done in 1670
First mill for the manufacturing of powder was built in U.S in 1675
Then later black powder was used in construction of roads in Switzerland in 1696.

Now let us give an overlook to the past years of explosive and black powder and other materials which were used in different wars. In 1749 miners of Hungary used chisel bit to make their way through. Compression of powder in cartridges was done by an American scientist Benjamin Franklin in 1750. Black powder was used in making roads in Pennsylvania. Some other uses of black powder were that they were used in Electric firing. Then a major invention was done late in 1832 by Dr. Robert Hare. He invented a blasting cap using bridge wire.

In the field of Explosives Alfred Nobel is known as "The Father of Explosives". He mixed two compounds comprising kieselguhr and nitroglycerine. And he was able to make dynamite in 1866. After a few months a plant for manufacturing nitroglycerine was installed in U.S.

Trade association was formed in U.S of gunpowder in round about 1872.

From 1884, the manufacturing of dynamites began. Ammonium Nitrate became a common compound in the production of dynamite. Alfred invents a powder which was having no smoke. A cord was developed in Europe in 1902, used for detonating. Black powder was then used on the large scale in U.S. Almost 280m pounds was used. Testing of different explosive began in 1908. They were mostly tested underground in mines. Mean time many accidents happened.

There was an institute formed in 1913. It was known as the "Institute of Makers of Explosives". It was installed in Chicago. In 1914, the largest engineering project to that date took place. Nearly 60 million pounds of dynamite was used.

The world's biggest blast up to that date occurred in California in 1924. Up to 328000 pounds of dynamite was used.

A major invention came after a lot of study and experiments. United States used Oxygen in its liquid state for explosions. It can be done under the radar. Export and import of dynamite began in 1931. Another pioneer DuPont commercially used non-nitroglycerin ammonium nitrate. He used it as a blasting agent in 1935.

During World War 2, some advanced weaponry was used. Explosives were used in plastics. This was the most advanced technology used in 1939. Then in 1940, tungsten was also started been used in the form of carbide bits. In 1946, the concept of time bomb came into being. Usage of underground explosives reached 100 million pounds in U.S.

In the middle of 1959, there were almost 39 plants which were using dynamite as the operator.

In late 1950's, dynamite was becoming extinct. Prilled Ammonium Nitrate was used instead. By now all the dirty work under the tunnels was done by the explosives. Boring machines were not needed. Emulsion explosives were widely used in 1969.

Explosives were also used to demolish the buildings. In Oklahoma city, a 26 story hotel was brought down with the help of explosives. It was the tallest steel structure. Computers were introduced to make the blast patterns efficient. Electronic delays detonators were invented in late 1980's.

And then in 2001, the members of International Society of Explosives Engineering assisted the anti-terrorism efforts in Afghanistan.

Explosives are basically categorized in two classes on basis of their explosion speed:

- High Explosives
- Low Explosives

2.2.1 High Explosives

High explosives are the type of explosives which expand (blast) at supersonic speed. They are often used in military and civil mining sector. They can also be further divided into:

- Primary Explosives
- Secondary Explosives.

Few examples of high explosives are:

- Nitroglycerin
- Dynamite

2.2.2 Low Explosives:

These types of explosives blast at a sub sonic speed, their heat transfer is more over a subsonic combustion rather than a high speed, high volume blast.

Use of explosives other then military and legalized fields they are prohibited. In wrong hands explosives can be a cause of catastrophic incident therefore a strict monitoring of the explosives need to be carried out.

2.3 Ultrasounds:

Any sound that occurs beyond the human hearing limit of 20khz is said to be ultrasonic in nature. A very interesting use of ultrasonic sound can be seen in bats. They are blind and use ultrasonic waves to detect prey. In this detection phenomenon bats can also determine the shape and size along with distance of the target.

Ultrasonic waves have the tendency to bounce off from any object and return to its source and the reflected signal contains the information which can be processed to acquire desired results.

2.3.1 How ultrasound are generated:

The phenomenon of piezoelectric effect is used for the generating waves of ultrasonic nature. Basically when an alternating potential difference is applied across a quartz crystal, it starts a to and fro motion.

2.3.2 History of ultrasonic:

In World War 2 (ww2) a concept of sonar (sound navigation and ranging) was used it was basically for the purpose of identifying the distance of the object from the station. Mid 19's it was also used for the purpose of testing material, it was generally a non destructive method. For the purpose of diagnosing tumor, in 1942 it was used. From 1965 onwards ultrasound were started to be used to produce real time images.

2.3.3 Applications:

Ultrasonic waves are in nature very non-destructive, as they don't contaminate or affect the properties of any material through which they pass, contrary to x-rays which can ionize the material through which they pass. Therefore they can be easily used for different purposes. For medical imaging ultrasonic waves are used.

One of the major application of ultrasonic waves is in ranging. By the help of Doppler shift a transmitter can compute the distance along with the speed of any moving object.

Plastic welding industry uses low ultrasonic waves.

2.3.4 Advantages of Ultrasonic:

One of the major advantages of ultrasonic is that the equipment for building ultrasonic sensor is very cost effective and safe. They have no side effects due to zero radiation. Real time imaging can be carried out without any harm [15]. These waves have no hazards related to environment. They can propagate through many materials including hard & rigid materials.

They have small wavelength hence enabling them to be transmitted up to long distance and without much energy loss.

Chapter # 3

Requirement Specifications

The following section reviews the shortcomings of the existing systems and an analysis of our system design.

3.1 Existing System

The existing techniques which are deployed in this domain are metal detectors and walkthrough gates, which use electromagnetic interference to detect any metal. This requires the detected material to be magnetic in nature, thus limiting the domain of material which can be detected. Metal detector require a close contact with the suspect which can be dangerous. Apart from this on airport high frequency X-Rays are being used for detection of material and they have the tendency to ionize the material. Latest technology deployed is the Tera Hz frequency which is extremely expensive.

3.2 Proposed System

The system we proposed utilizes non ionizing ultrasonic waves and it can detect materials irrespective of their magnetic property. We explored ultrasonic as an alternative to electromagnetic detection which can enable a distant remote detection of target material. Our system will focus on comparing and contrasting the backscatter of different signal which is being reflected back from different material in order to uniquely identify the specific material.

3.3 Requirement Specifications

The requirement specification for our system include

- Ultrasonic Sensors
- Resistors

- Capacitors
- Ics
    - 555 timer
    - LM 741
- Battery
- Transistor
- Microcontroller
- Computer
- MATLAB
- Serial ports
- Serial protocols

3.3.1 Ultrasonic Sensor:

A transducer basically is an electrical component that when an alternating pulses are applied at its base it generates ultrasonic waves as output. We can say that it's a device that converts electrical energy and into electrical form and can do vice versa. [2]

The main components are the

- Active element
- Backing

3.3.1.1 The Active Element:

This element consists of a material which is piezo or ferroelectric in nature, thus converts electrical energy into ultrasonic energy. Depending upon the structure of the material different wave modes can be generated. New materials can also be used for application where they can be beneficial to transducer and system performance.[17]

3.3.1.2 Backing

It's the second component of the Ultrasonic Sensors. Backing is a material of high density that is used to control the vibration of the transducer. Due to its high attenuation property, it absorbs the energy radiating from the active element [11]. The relationship between the acoustic impedances of both the backing material and the active element is reciprocal, in terms of amplitude. But when their impedances match it will result in a very heavily damped transducer. It will show good resolution. If there is a mismatch in acoustic impedance between the active element and the backing material, more energy will be reflected forward into the test material. [2]

3.3.2 Resistors:

First you should know what a resistor is. It's an electronic device whose function is to create specified values of current and voltage in a circuit. In this circuit we are using different types of resistors. 4.7k, 10k, a variable resistor of 10k, 100k, 47k, 1k. In the circuit diagram you can see where these resistors are used.

Fig 3.1 Resistor

3.3.3 Capacitors:

It’s an electronic device which is used to store electric charge. It is also used in timer circuits. A capacitor may be used with a resistor to produce a timer. A simple capacitor can be made by placing two conductors together, but don’t join them. The conductor plates should be separated and a dielectric material should be in between them. Now in our circuit we are using different capacitors. 680p, 103, 104, 10u.

Fig 3.2 Capacitor

3.3.4 Timer IC (555)

It’s an electronic device consisting of eight legs. Basic purpose of this device is to generate time delays. Now this device can perform it so accurately that time delay is changed from hours to microseconds. Other purpose of this device is to produce oscillations. In the time delay mode, controlling of time is done by one external capacitor plus resistor. Resistors and one capacitor is used for controlling the frequency and oscillation in stable mode. The circuit may be triggered and reset on falling waveforms, and the output circuit can source up to 200mA or drive TTL circuits. [5]

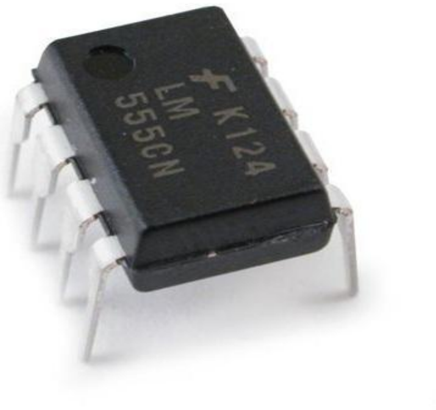


Fig 3.3 555 timer IC

3.3.5 OP AMP LM 741

The LM741 is an operational amplifier Integrated Circuit which is mostly utilized in a circuit topology having a negative feedback. It can be used as summing amplifier, integrators, active filters and circuit buffers. It is readily available in the market at a very cheap price. It can be used in multiple ways for the feedback purpose it can be used for a positive feedback and for negative feedback. [13]

Fig 3.4 741 Op-Amp

To establish a negative feedback circuit the voltage is provided at the inverting terminal and vice versa for positive feedback. It is to be noted that op-amp is a linear amplifier which means that it doesn’t changes the frequency response of the input signal making it easy to use without incorporating extra problems.

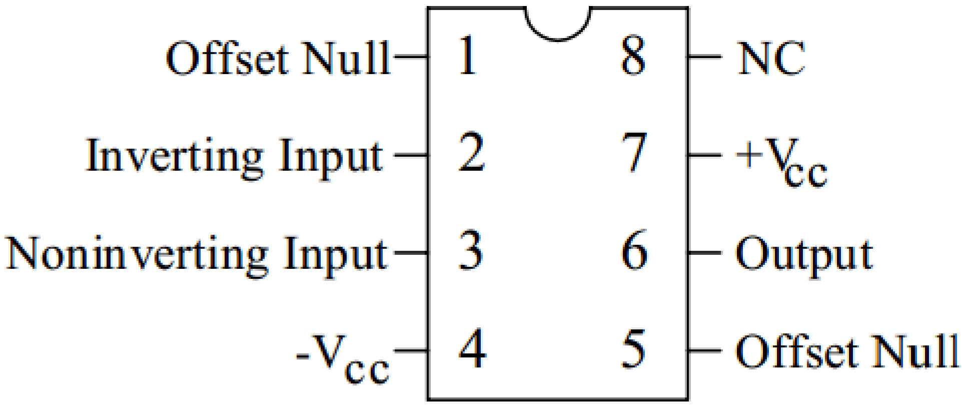


Fig 3.5 Pin Layout Op-Amp

3.3.6 Microcontroller

In our project we are using 16F676 Microcontroller. This device can act as small computer. It consists of a processor, memory and input/output peripherals. Microcontrollers are designed for embedded applications, whereas microprocessors are used in personal computers or other general purpose applications. The hardware used for controlling remote devices is now decreased due to microcontroller. Microcontrollers are used in machinery, such as automobiles, telephones, appliances, and other computer systems. The most famous type of microcontroller is PIC Microcontroller. [5]

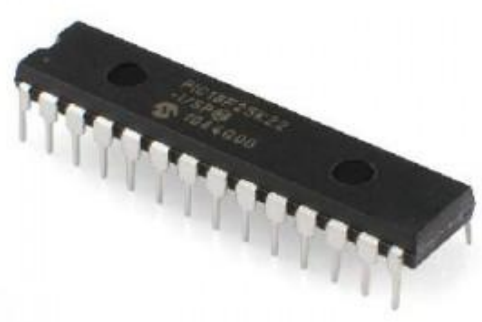


Fig 3.5 PIC Microcontroller 16F676

3.3.7 Transistor:

A three legged electrical device whose basic function is to act as a switch. Another use of this device is amplification. The two main types of transistor are NPN and PNP. Different transistors work on different voltage levels. The three legs told earlier are known as Collector, Base and Emitter.

Collector is the positive lead of the Transistor. Base is responsible for activating the transistor. And Emitter is the negative lead of the transistor.

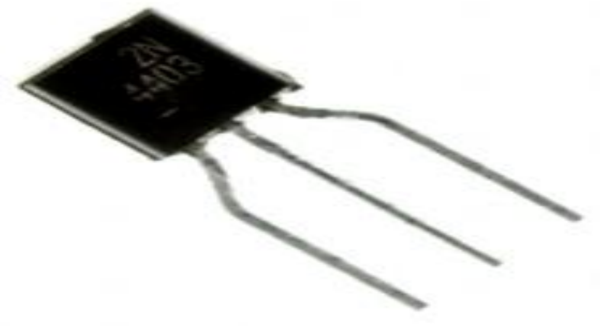


Fig 3.6 Transistor

3.3.8 Max 232

This IC is used for serial communication. It consists of dual transceiver. Max 232 can work under very high and very low temperature levels. Max 232 is used in applications, which require processing systems and control devices of wide applications. It is also used in battery systems, terminals, modems, and computers. In this project we are using this IC, so that microcontroller can communicate with the computer.

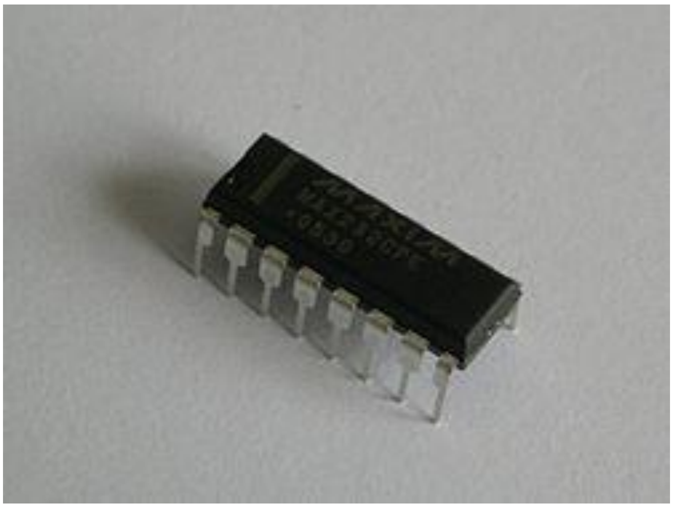


Fig 3.7 Max 232

Microcontroller cannot directly send data into the computer, so we have used max 232 because it can take the output of microcontroller and convert it into multiple ports and going in DB9, which is directly connected with the computer.

Chapter # 4

System Design

This chapter include the system architecture its component its module, interfaces, and data for the system which specified requirements regarding system.

4.1 System Architecture

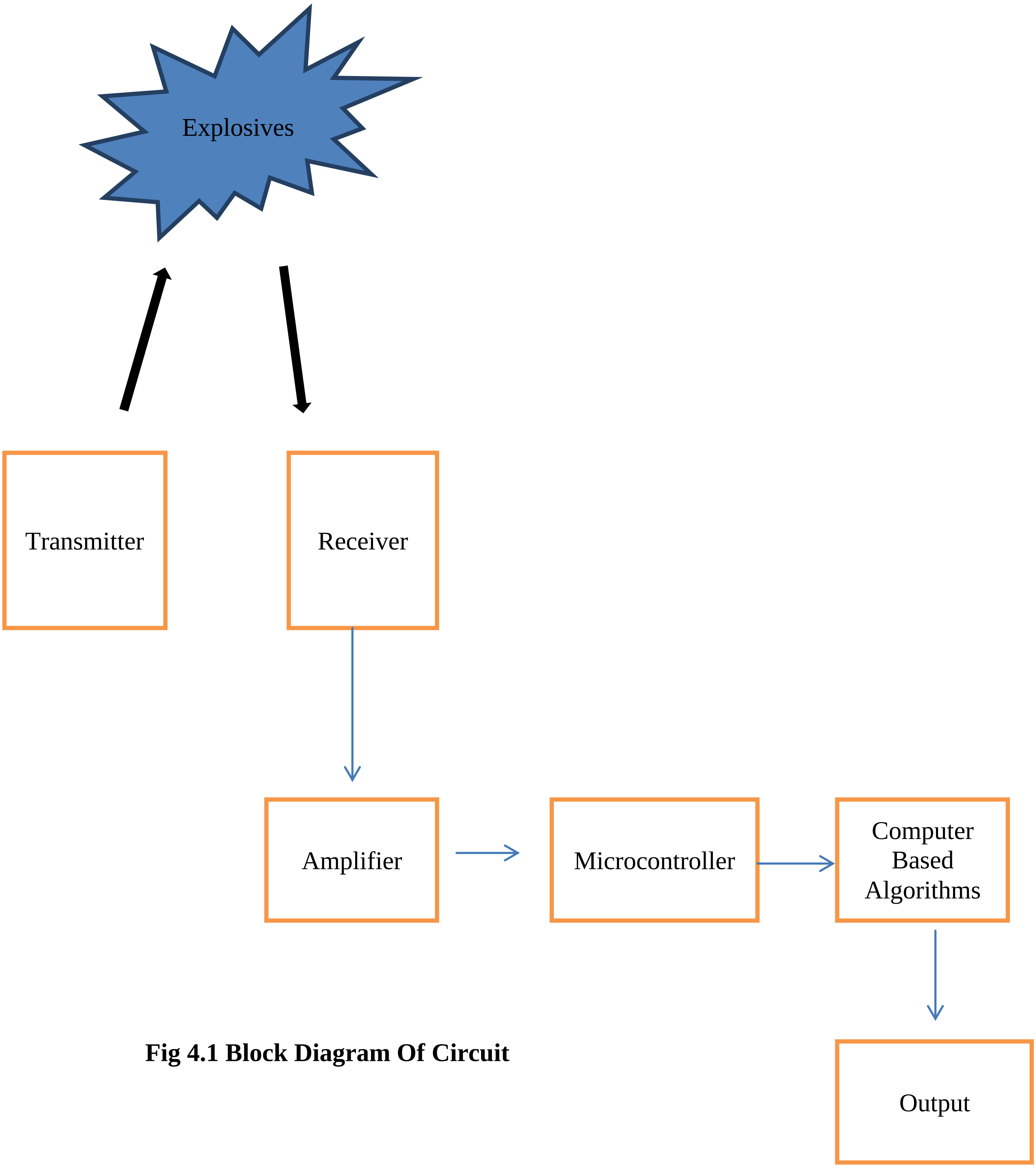


Fig 4.1 Block Diagram Of Circuit

System Architecture

The overall system is designed in two phases

- Hardware
- Software

4.2 Design Constraint:

On the hardware part our system was having the constraint of noise. In order to avoid noise we had to double the soldering. By doing this minimum noise shall penetrate the system. And the components on the bread board or Vera board are to be placed very closely. By doing so we shall encounter very less noise.

The second constraint of this system was the lack of availability of accurate sensor equipment in local market. Hence due to the non-availability of the desired components we were unable to increase the distance or the range of the system.

4.3 Hardware Design:

4.3.1 Ultrasonic Transducer:

Transducer is a device which transmits or receives ultrasonic waves. It works on the principle of piezo-electric conversion. It’s a device which works on high frequency. It is a very useful device, when it comes to transmit a signal over a long distance. So it best suits our project requirement.

Transducer takes voltage and produces ultrasonic waves when the crystal moves to and fro. This produces ultrasonic waves which travel in a longitudinal fashion in the air. They travel toward the target. On striking the target some of the energy is reflected back. And the receiver receives that energy.

The second component of the transducer which completes the pair is the receiver ultrasonic transducer. The function of this transducer is to generate signal voltages in term of electric signals. This happens when the sound waves, which are reflected from the material, strike the receiving transducer. In the similar fashion the receiving transducer crystal vibrates and produces equivalent electric signals by converting mechanical energy into electric energy.

In this system it is to be noted that the transmitting transducer will transmit ultrasonic waves if alternating pulses are applied as input driving source to the transducer. The amplitude of the input signal can vary according to need. But the frequency must be kept such that it resonates with the internal frequency of the ultrasonic transducer

4.3.2 Explosive

Explosive means explosion something dangerous it has tendency to explode in a very little time basically explosive is a reactive substance which contain a huge amount of potential energy which suddenly release and react in a form of explosion, usually accompanied by the combination of light, heat sound and pressure.

4.3.3 Transmitter:

In our system we designed the ultrasonic transmitter which can transmit ultrasonic waves. It uses a 555 timer IC which is used to generate oscillating voltage, which is applied across the transducer. There are two moods of 555 Timer IC

- A-stable
- Mono-stable

So in our circuit we are using 55 Timer IC in A-stable mood it has numerous advantage, because one the 555 Timer IC is triggered it produces continuous alternating pulses which is amplified and applied at the base of the transistor.

4.3.4 Receiver

In our system we designed the Ultrasonic receiver which can receive Ultrasonic signal the receiving transducer works on the same phenomena of piezoelectric. When the Ultrasonic waves strike the receiving transducer after reflecting back from the target it oscillates and converts the wave energy in to equivalent electric signal. This signal is then amplified by transistors. The resistors serve the same purpose of keeping the current in control.

4.3.5 555 Timer IC

Before telling the uses of this ic, first we will see what is this ic made of. This IC consists of transistors, resistors and diodes. 555 timer IC provides functions of controlling, triggering, level sensing, comparison, discharge and power output. Some
of the features of the 555 timer are: Supply voltage between 4.5 and 18 volt, supply current 3 to 6 mA, and a Rise/Fall time of 100 nsec. [1]
The supply current, when the output is 'high', is typically 1 milli-amp (mA) or less. The initial mono stable timing accuracy is typically within 1% of its calculated value, and exhibits negligible (0.1%/V) drift with supply voltage[1]. Thus long-term supply variations can be ignored, and the temperature variation is only 50ppm/°C (0.005%/°C). All IC timers rely upon an external capacitor to determine the off-on time intervals of the output pulses. It takes a finite period of time for a capacitor (C) to charge or discharge through a resistor (R). Those times are clearly defined and can be calculated given the values of resistance and capacitance.

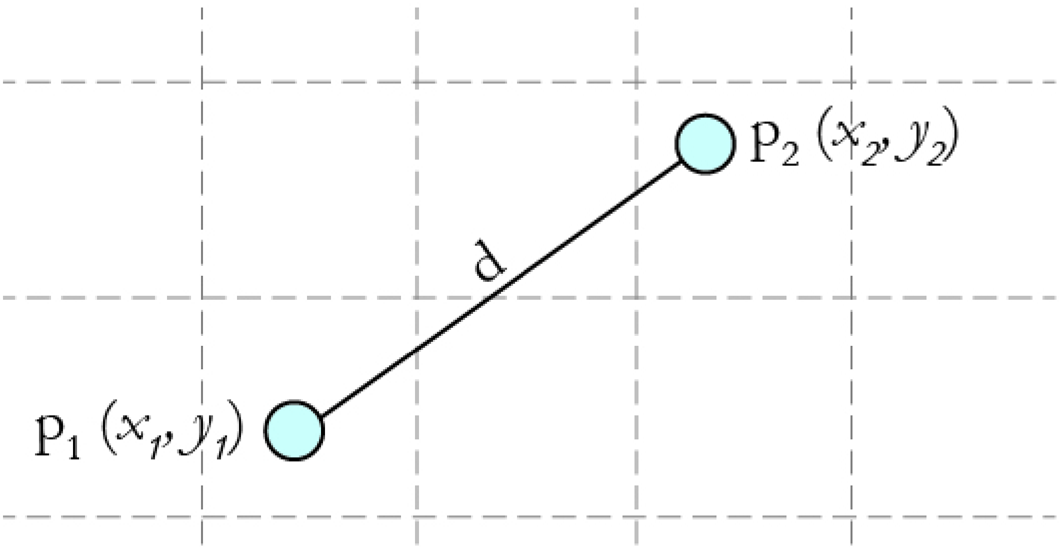
In this project the work of 555 timer IC is to generate pulses. It is used to derive the Ultrasonic Transducers. Pulses of desired magnitude are generated. The ultrasonic transmitter uses a 555 based a-stable multi-vibrator. It oscillates at a frequency of 40-50 kHz.

4.4 Software Design:

4.4.1 Computer based Algorithms

Nearest Neighbor

Nearest Neighbor technique is a function that is used for the classifying of objects on nearest training points in the feature space. By measuring the Euclidean distance an object is set to belong to a specific class on the bases of least distance from its neighbor. By assigning the property for a particular average value of its nearest neighbor this can be utilized for the purpose of regression.



$$\text{Euclidean distance (d)} = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Fig 4.2 Representation Of Euclidean Distance

A more generic n dimensional row or column vector x and y can be given as

$D(x,y)= ||x-y||= ||y-x|| = [(x_1 – y_1)^2 + ………………..+ (x_n-y_n)^2]^{-1/2}$

In our case explosive signal sample set will be held against the non explosive sample space, distance will be calculated from each point and it will be classified as explosive or non explosive.

Chapter # 5

System Implementation

System Architecture

System was implemented in two separate portion and then integrated to form a one working unit.

5.1 Hardware Implementation:

Hardware part of the circuit comprises of the sensor which is used for transmission and acquisition of ultrasonic signal along with A→D conversion.

5.1.1 Sensor unit:

Building of the sensor was the most challenging part of the project as there are numerous problems faced when building hardware. These problems range in variety from accurate components to the lack of availability of equipment.

Our main problem with the circuit design was to reduce the level of noise.
In the daily routine there are numerous sources of ultrasonic noise which can interfere with our subject signal. Some major sources of ultrasonic noises are:

- Vehicle noise
- People talking
- Noise from different household objects

Another problem with the signal detection was the distance as we increased the distance of the explosives from the sensor the noise incorporation increased exponentially, for this reason we kept our detection distance to 1m only.

- Transmitter.
- Receiver.

5.1.2 Transmitter Circuit

The start point for ultrasonic band is above 20 kHz. The circuit is designed to work at an ultrasonic frequency of 40 kHz to 50 kHz.

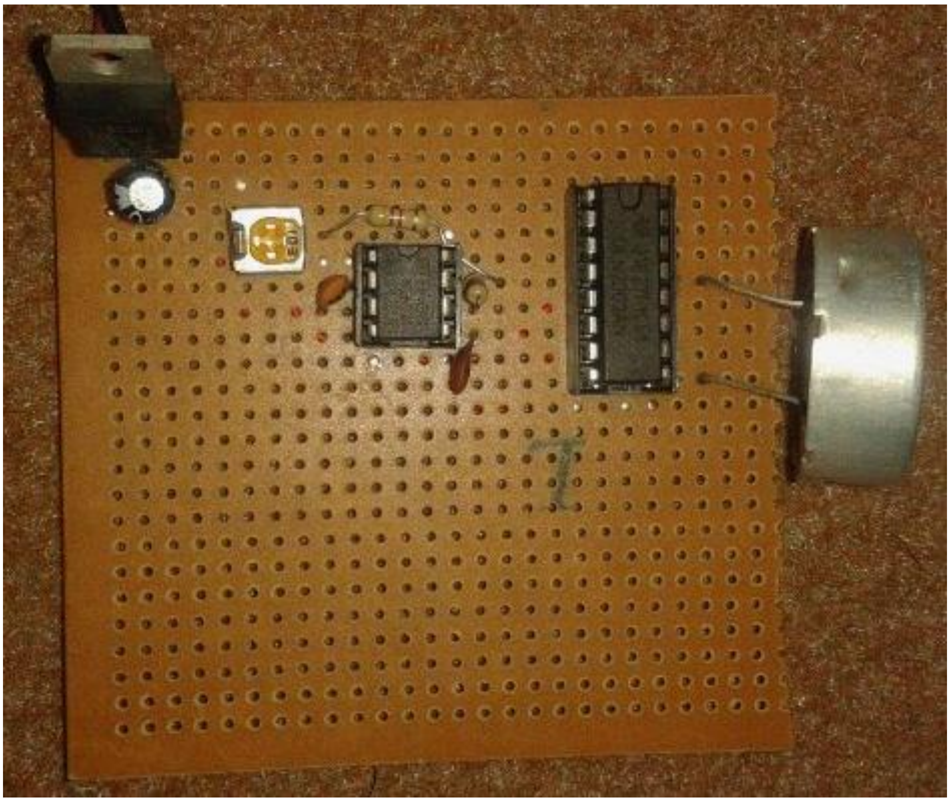


Fig 5.1 Transmitter Circuit

The circuit is driven by a 9-volt battery. In the transmitter part 555 timer IC is used in a-stable multi-vibrator mode. At its output an alternating pulse of 40 kHz is produced.

After the production of the pulses a main driving source for the transducer was required. Couple of transistor could do the job which could amplify the input voltage and apply it to the base of transducer, but instead we opted for ULN2003 Darlington pair IC. It can be used to drive stepper motors and relays and provided sufficient amount of current and voltage for the driving of the ultrasonic transducer.

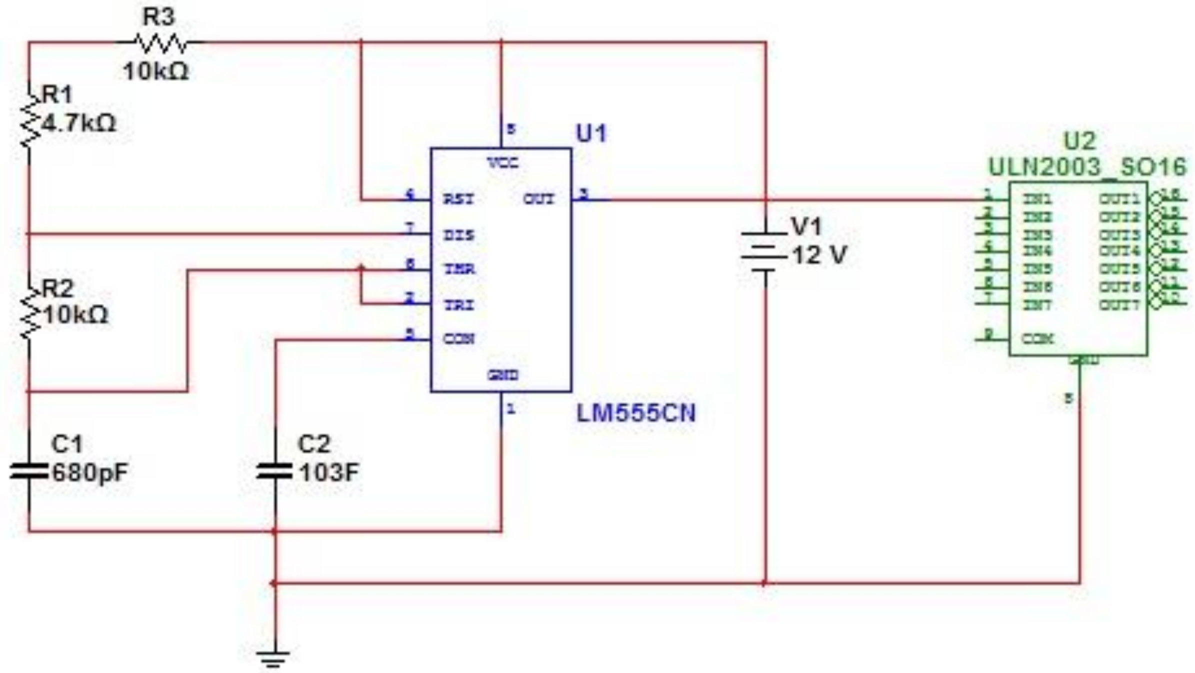
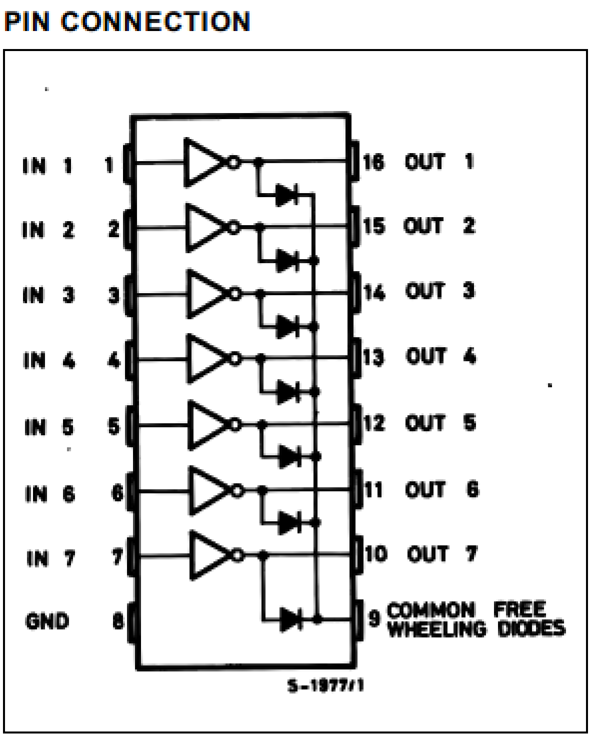


Fig 5.2 Transmitter Circuit- Schematic



ULN2003 Darlington Array IC Fig 5.3

5.1.3 Receiver Circuit

The receiver circuit is made to oscillate at a frequency of 40-50 kHz. This Ultrasonic transducer senses the ultrasonic signal. When the signal strikes the sensor it vibrates and converts the mechanical signal into electrical signal.

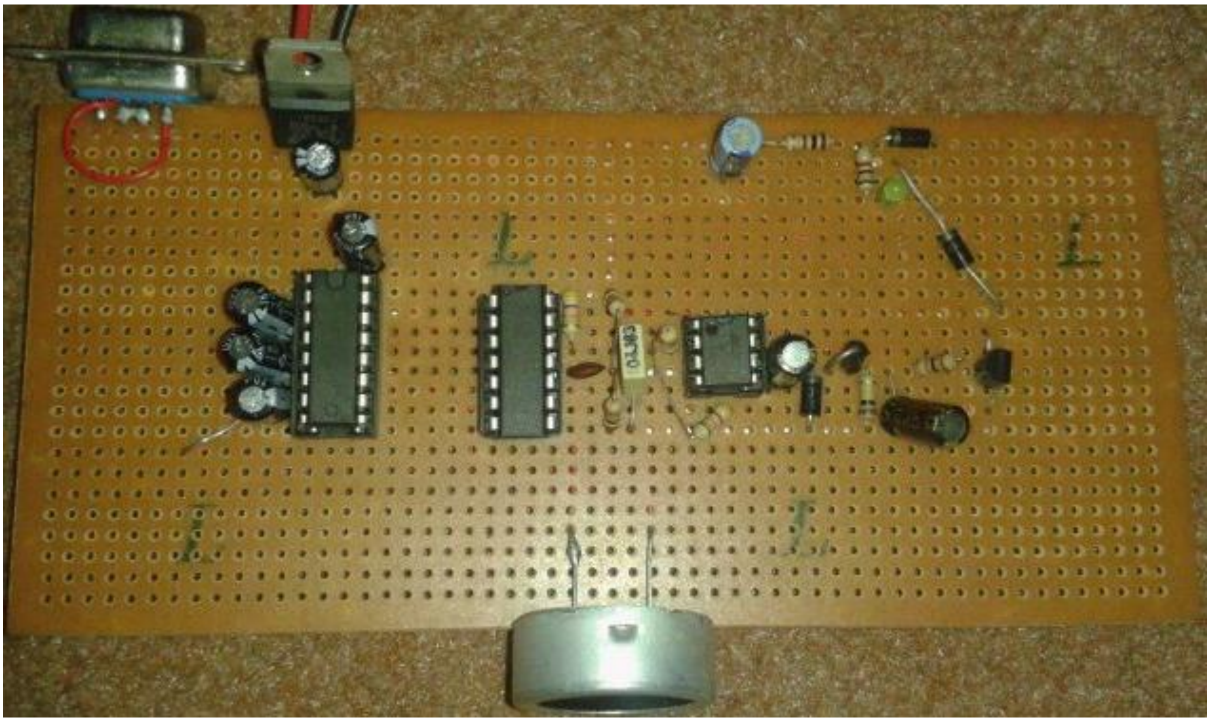


Fig 5.4 Receiver Circuit

On receipt the signal is very weak for that reason amplification needs to be carried out, for this purpose op-amp is used to amplify the received signal in order to make it readable for the microcontroller. Op amp is used in a non inverting configuration with a high gain of +500. This enables adequate amount of amplification necessary in order to achieve digitization of the signal in the microntroller.

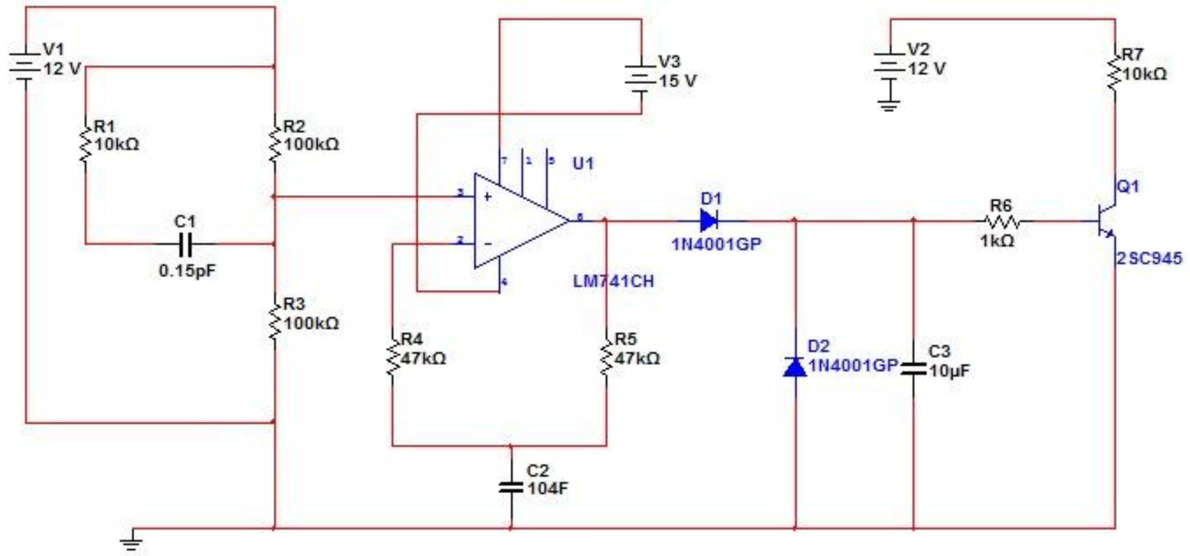


Fig 5.5 Receiver Circuit - Schematic

5.1.4 Interfacing with Microcontroller & PC

Microcontroller is used for the purpose of serial communication with the computer in order to apply the computer based algorithms the data needed to be fed into the PC through serial port.

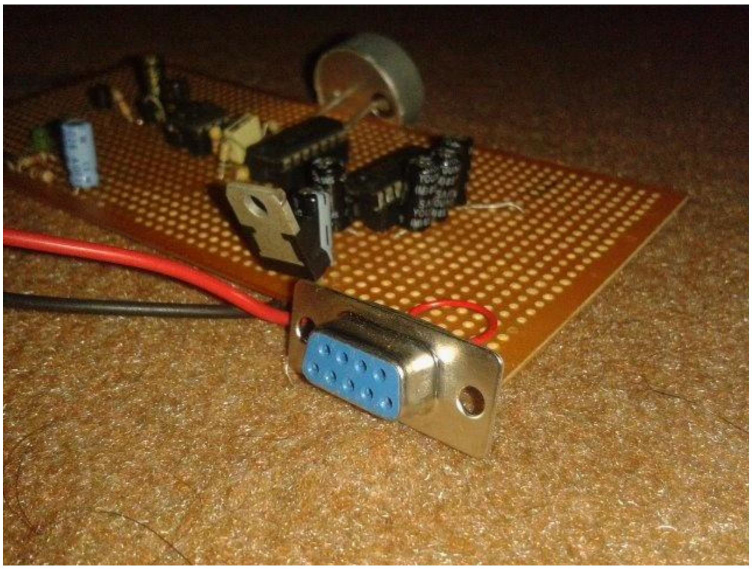


Fig 5.6 Serial Output of the Receiver

Max 232 is the IC which is used to connect the DB-9 serial Communication cable with the output port of the microntroller. 13th pin of the microntroller is connected with the output of the amplification and rectification circuit. Max232 enables the interpretation of the RS-232 port signal into TTL signals which are understandable for the microcontroller. MAX-232 has the output voltage level of almost 7 to 7.5 for the RS-232, and takes the input of a normal TTL signal of 5 volts.

Fig 5.7 Serial port of Pc

5.1.5 Circuit Adjustment

As our experiment were to be conducted various environment so it was really important to enable the option of dynamic adjustment in the operating frequency of the circuit for this purpose we are one is used.

5.2 Software Implementation

Before we move onto the signal processing we need to understand that the raw signals that were being received at the serial port of the computer cannot be directly fed into MATLAB for signal processing. Therefore we need computer software that can record that incoming data into a MATLAB compatible file, so from there on further signal processing could be carried out.

Using VB 6.0 platform we had to create small software that can read the serial data and translate that data into .dat file which is compatible with MATLAB. The .Dat file simply contains the signal data inform of sample arrays.

In order to communicate with the serial port certain parameter needed to be incorporated into the software for efficient extraction of the data. These parameters were

- Start bit
- Stop bit
- Baud rate
- Parity bit

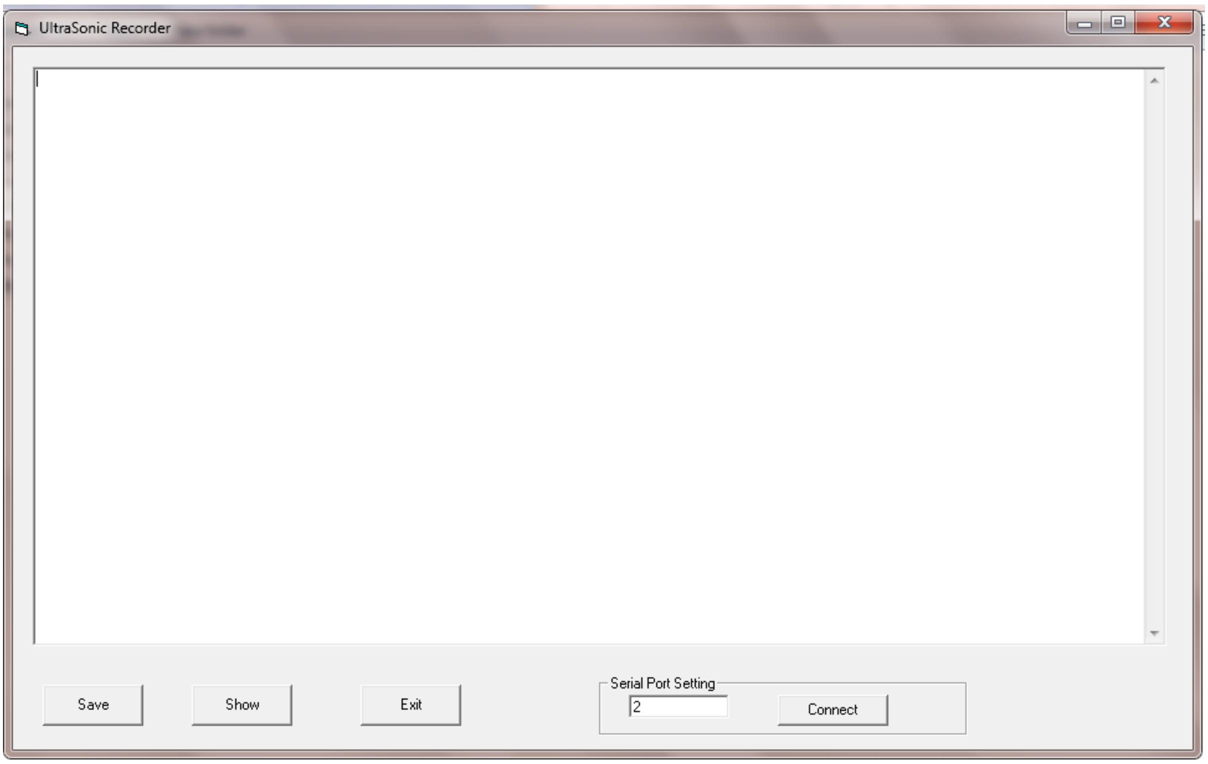


Fig 5.8 Software Interface

This custom build software helps the data acquisition from the serial port.

Once the data is acquired and saved MATLAB is used to apply further digital signal processing.

The file is saved in a .DAT format in the computer which is MATLAB compatible file.

Chapter # 6

System Testing and Evaluation

6.1 Hardware Testing

Sensor unit is supplied with a 9v battery which is sufficient to drive the complete circuit. Voltage dropped is checked on every node ensuring that every component has its required voltage and current supply.

For the testing of the explosive samples we need to create a very enclosed environment and take special care that least amount of noise in the form of sound or any disturbance gets closer to the circuit. This can contaminate the signal that is bouncing back from the target.

6.2 Software Testing:

The major work was needed to be completed on the basis of Software. The user interface is presented on the computer. Which allows to track the input values that are being received at the serial port.

When the circuit is first started the software on the screen shows garbage values that are received at the serial port.

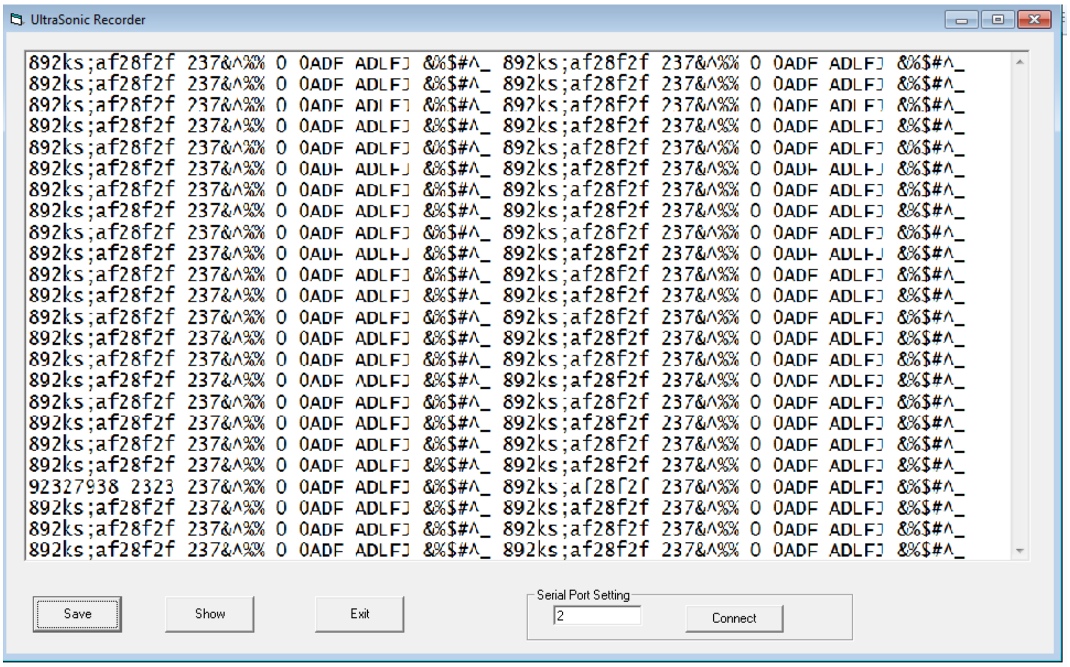


FIG 6.1 Garbage Values

The system takes some time before its completely initialized. After the initializing is completed the system will start working. This interface has the options of

- Save
- Show
- Connect

The save option is used to save the data to a file. While the show button utilizes that file and displays the data. The most important button is the connect button which is used to start the connection between the serial interface and the data recording software.

On the pc the software will start showing the inputs on the basis of the received input at the serial end these files are saved as .dat file on the computer.

To start the processing the file is first imported into the MATLAB by the following steps:

1.)

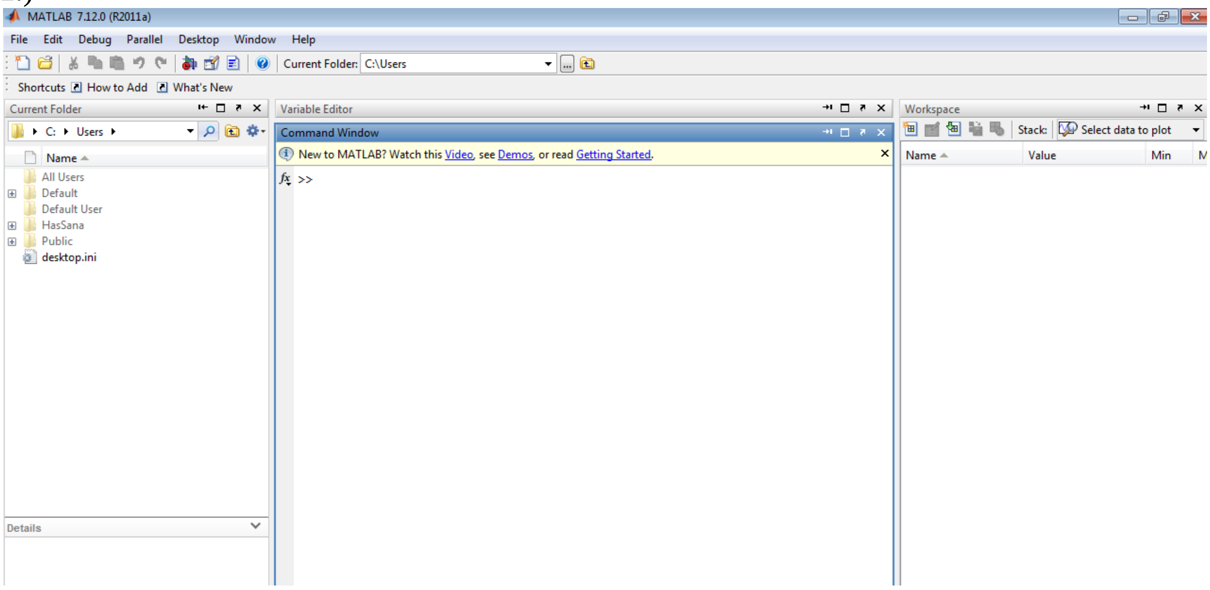


FIG 6.2 Command Windows

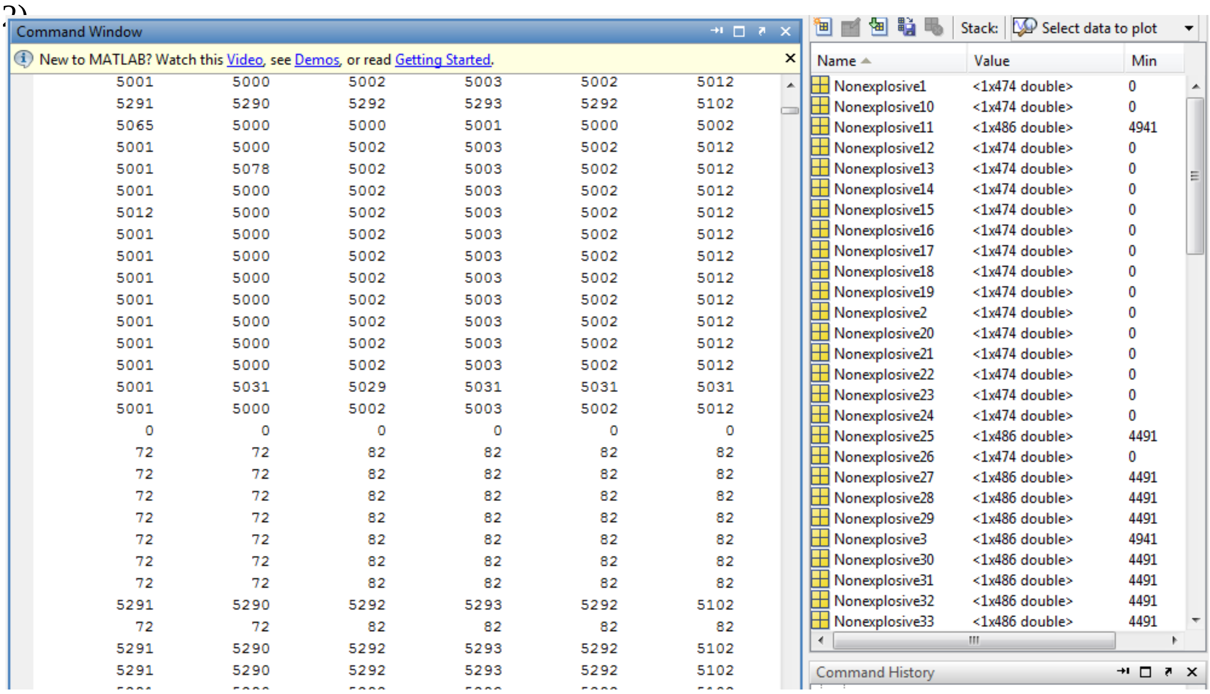


FIG 6.3 Data being loaded

Sample set of both explosive and non explosive are loaded. The array string is concatenated in order to represent the complete array with one string. After that using the Euclidean distance formula we can calculate the distance between the samples of the both.

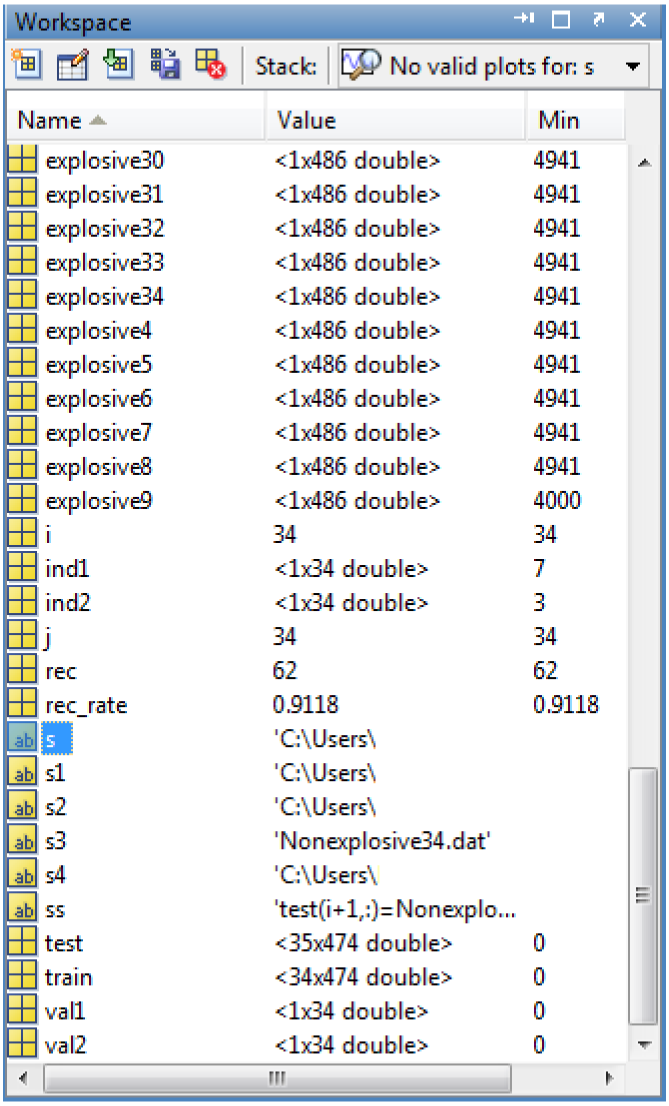


Fig 6.4 Variables

The two different data of explosive and non explosive are loaded as train and test sample after that every point is measured against the value of the training sample and using the nearest neighbor it is classified as explosive or non explosive.

In the end the detection output is presented on the basis of the difference between the two sample set and is shown as percentage. The record rate variable displays the detection rate that whether or not the two sample sets are successfully classified as distinct signals on the basis of nearest neighbor and distance measurement.

```
        1027        1022        1028        1029        1023        1025
        1027        1022        1028        1029        1023        1025
        1027        1022        1028        1029        1023        1025
        5100        5200        5200        5200        5200        5204
        1027        1022        1028        1029        1023        1025
        5100        5200        5200        5200        5200        5204
        5100        5200        5200        5200        5200        5204
        5100        5200        5200        5200        5200        5204
        5100        5200        5200        5200        5200        5204
        5100        5200        5200        5200        5200        5204
        5100        5200        5200        5200        5200        5204
        5100        5200        5200        5200        5200        5204
        5100        5200        5200        5200        5200        5204


rec_rate =

    0.9118

>>
```

Fig 6.5 Final Output

Chapter # 7

Conclusion

Our aim to test and evaluate the use of ultrasonic as a cheap and a remote detection alternative to orthodox explosive/metal detection has been successful. We explored a new dimension which can be enhanced and implemented to a fully useable model to strengthen the security measures and to help re-enforce them.

In order to fully develop a functional unit a lot work needs to be done in this field. By setting up our system we proved that ultrasonic can offer a good solution in terms of remote detection. We also laid down basis of this detection technique which can be further taken to a whole new level with enhanced features. There are a lot of parameters and situation that need to be dealt with.

There were a lot of challenges that we faced during this project and we had to come up with new design solution every now and then to coop with the problem. But these challenges helped us explore our strengths and weaknesses and made us to link our learned theory with the practical work.

This field of remote detection of explosive has endless possibilities and much work is can be done in this field. Our work can be taken further with a lot of enhancements. By incorporating multiple receivers for the bouncing back signal the detection can be enhanced the distance can be further increased.

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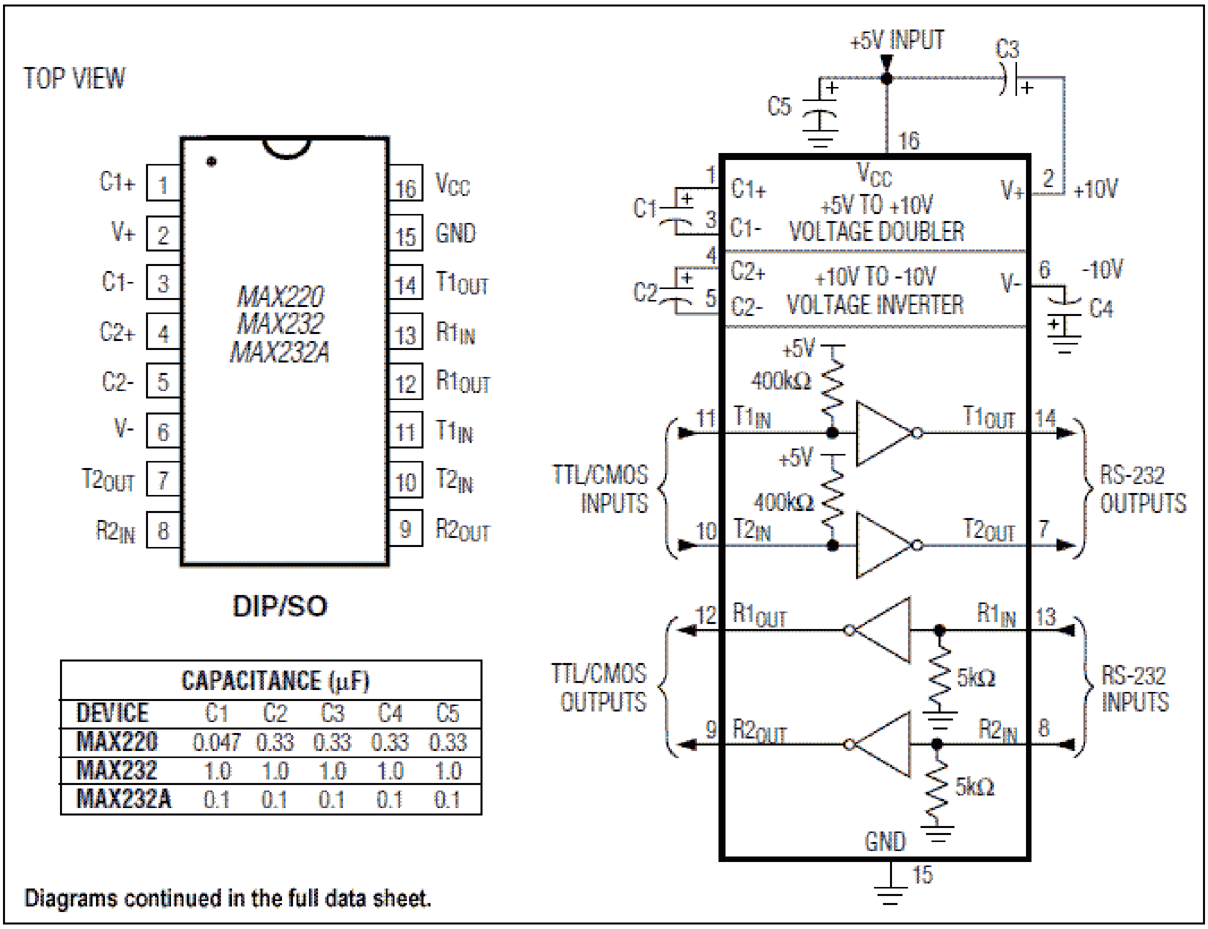
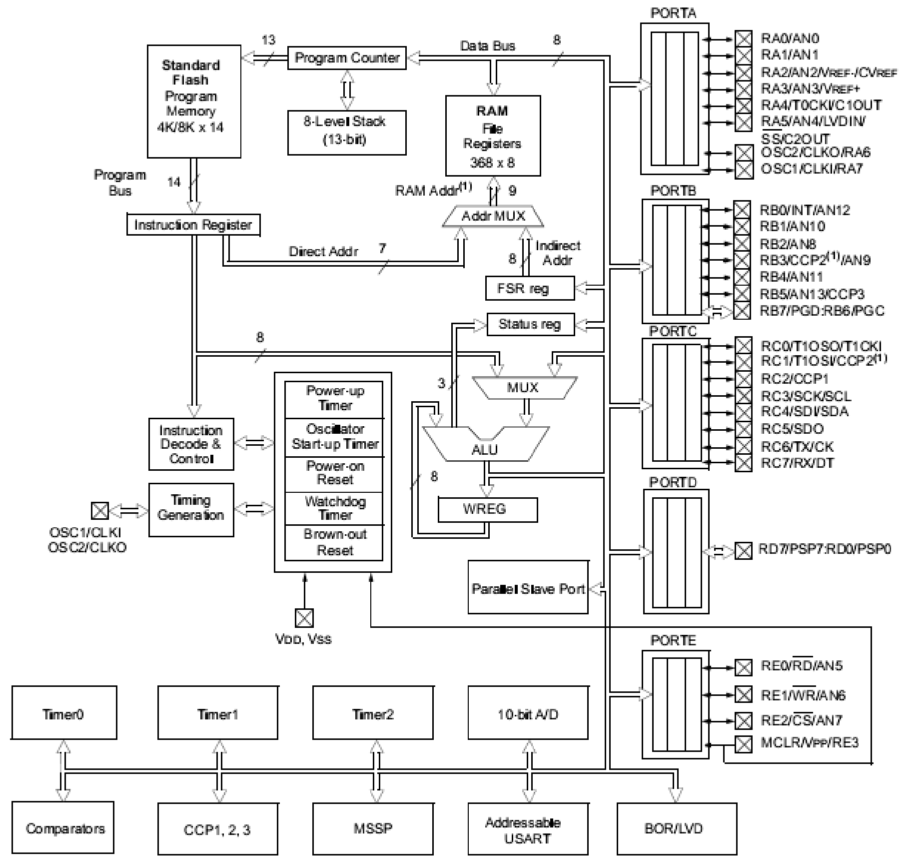
Appendices

Data Sheet



CAPACITANCE (μF)					
DEVICE	C1	C2	C3	C4	C5
MAX220	0.047	0.33	0.33	0.33	0.33
MAX232	1.0	1.0	1.0	1.0	1.0
MAX232A	0.1	0.1	0.1	0.1	0.1

FIGURE 1-2: PIC16F747 AND PIC16F777 BLOCK DIAGRAM

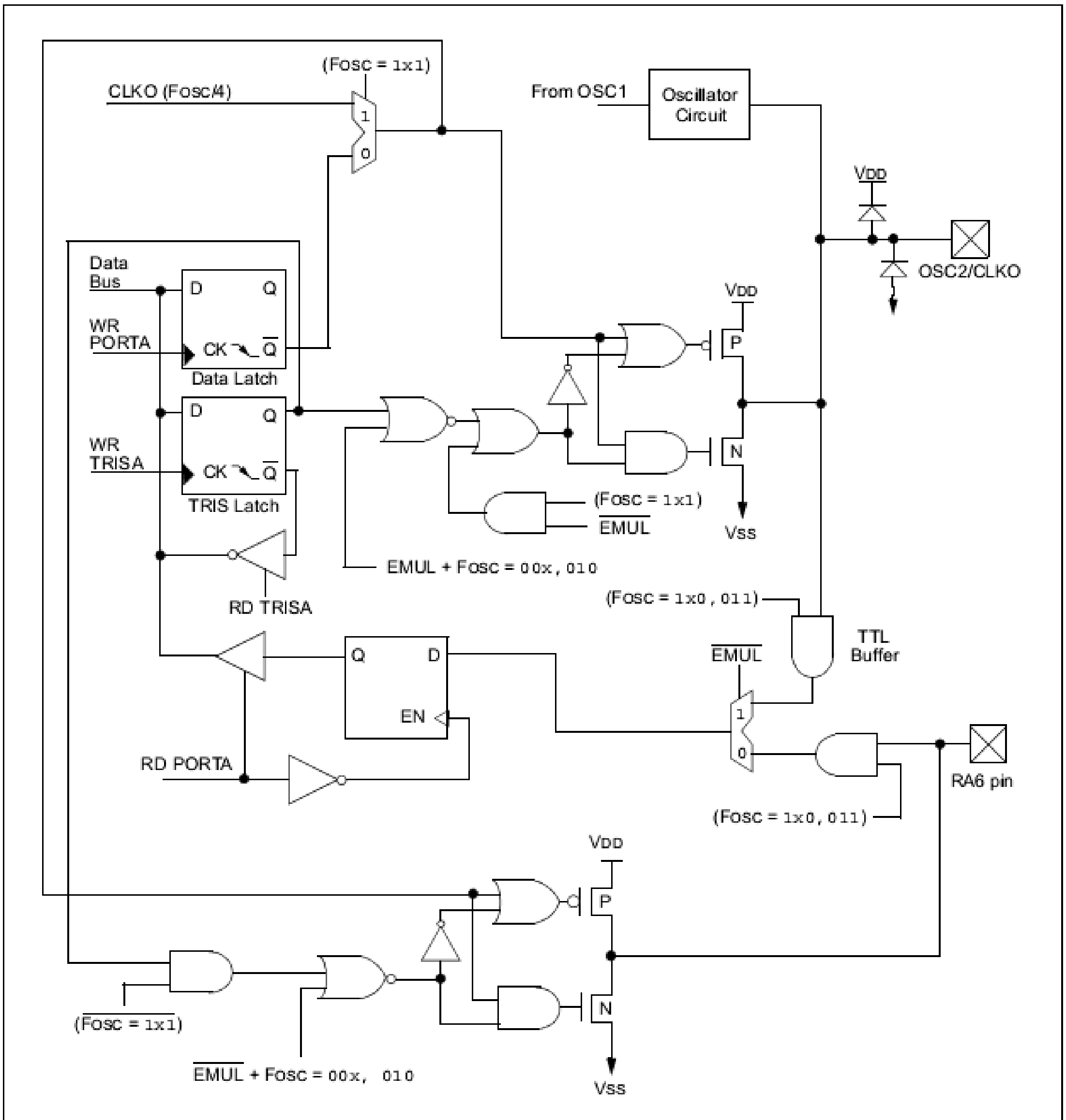


Note 1: Pin location of CCP2 is determined by the CCPMX bit in Configuration Word Register 1.

TABLE 1-3: PIC16F747 AND PIC16F777 PINOUT DESCRIPTION (CONTINUED)

Pin Name	PDIP Pin #	QFN Pin #	TQFP Pin #	I/O/P Type	Buffer Type	Description
						PORTD is a bidirectional I/O port or Parallel Slave Port when interfacing to a microprocessor bus.
RD0/PSP0	19	38	38		ST/TTL(3)	
RD0				I/O		Digital I/O.
PSP0				I/O		Parallel Slave Port data.
RD1/PSP1	20	39	39		ST/TTL(3)	
RD1				I/O		Digital I/O.
PSP1				I/O		Parallel Slave Port data.
RD2/PSP2	21	40	40		ST/TTL(3)	
RD2				I/O		Digital I/O.
PSP2				I/O		Parallel Slave Port data.
RD3/PSP3	22	41	41		ST/TTL(3)	
RD3				I/O		Digital I/O.
PSP3				I/O		Parallel Slave Port data.
RD4/PSP4	27	2	2		ST/TTL(3)	
RD4				I/O		Digital I/O.
PSP4				I/O		Parallel Slave Port data.
RD5/PSP5	28	3	3		ST/TTL(3)	
RD5				I/O		Digital I/O.
PSP5				I/O		Parallel Slave Port data.
RD6/PSP6	29	4	4		ST/TTL(3)	
RD6				I/O		Digital I/O.
PSP6				I/O		Parallel Slave Port data.
RD7/PSP7	30	5	5		ST/TTL(3)	
RD7				I/O		Digital I/O.
PSP7				I/O		Parallel Slave Port data.
						PORTE is a bidirectional I/O port.
RE0/$\overline{RD}$/AN5	8	25	25		ST/TTL(3)	
RE0				I/O		Digital I/O.
$\overline{RD}$				I		Read control for Parallel Slave Port.
AN5				I		Analog input 5.
RE1/$\overline{WR}$/AN6	9	26	26		ST/TTL(3)	
RE1				I/O		Digital I/O.
$\overline{WR}$				I		Write control for Parallel Slave Port.
AN6				I		Analog input 6.
RE2/$\overline{CS}$/AN7	10	27	27		ST/TTL(3)	
RE2				I/O		Digital I/O.
$\overline{CS}$				I		Chip select control for Parallel Slave Port.
AN7				I		Analog input 7.
V_{SS}	—	31	—	P	—	Analog ground reference.
V_{SS}	12, 31	6, 30	6, 29	P	—	Ground reference for logic and I/O pins.
V_{DD}	—	8	—	P	—	Analog positive supply.
V_{DD}	11, 32	7, 28	7, 28	P	—	Positive supply for logic and I/O pins.
NC	—	13, 29	12, 13, 33, 34	—	—	These pins are not internally connected. These pins should be left unconnected.

FIGURE 5-6: BLOCK DIAGRAM OF OSC2/CLKO/RA6 PIN



Note 1: CLKO signal is 1/4 of the Fosc frequency.

DRIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature range (see Note 4)

PARAMETER			TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	T1OUT, T2OUT	R_L = 3 kΩ to GND		5	7		V
V_{OL}	Low-level output voltage‡	T1OUT, T2OUT	R_L = 3 kΩ to GND			−7	−5	V
r_o	Output resistance	T1OUT, T2OUT	$V_{S+} = V_{S-} = 0$,	V_O = ±2 V	300			Ω
I_{OS}§	Short-circuit output current	T1OUT, T2OUT	V_{CC} = 5.5 V,	V_O = 0		±10		mA
I_{IS}	Short-circuit input current	T1IN, T2IN	V_I = 0				200	µA

† All typical values are at V_{CC} = 5 V, T_A = 25°C.
‡ The algebraic convention, in which the least-positive (most negative) value is designated minimum, is used in this data sheet for logic voltage levels only.
§ Not more than one output should be shorted at a time.
NOTE 4: Test conditions are C1−C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Note 4)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
SR	Driver slew rate	R_L = 3 kΩ to 7 kΩ, See Figure 2			30	V/µs
SR(t)	Driver transition region slew rate	See Figure 3		3		V/µs
	Data rate	One TOUT switching		120		kbit/s

NOTE 4: Test conditions are C1−C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

RECEIVER SECTION

electrical characteristics over recommended ranges of supply voltage and operating free-air temperature range (see Note 4)

PARAMETER			TEST CONDITIONS		MIN	TYP†	MAX	UNIT
V_{OH}	High-level output voltage	R1OUT, R2OUT	I_{OH} = −1 mA		3.5			V
V_{OL}	Low-level output voltage‡	R1OUT, R2OUT	I_{OL} = 3.2 mA				0.4	V
V_{IT+}	Receiver positive-going input threshold voltage	R1IN, R2IN	V_{CC} = 5 V,	T_A = 25°C		1.7	2.4	V
V_{IT-}	Receiver negative-going input threshold voltage	R1IN, R2IN	V_{CC} = 5 V,	T_A = 25°C	0.8	1.2		V
V_{hys}	Input hysteresis voltage	R1IN, R2IN	V_{CC} = 5 V		0.2	0.5	1	V
r_i	Receiver input resistance	R1IN, R2IN	V_{CC} = 5,	T_A = 25°C	3	5	7	kΩ

† All typical values are at V_{CC} = 5 V, T_A = 25°C.
‡ The algebraic convention, in which the least-positive (most negative) value is designated minimum, is used in this data sheet for logic voltage levels only.
NOTE 4: Test conditions are C1−C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.

switching characteristics, V_{CC} = 5 V, T_A = 25°C (see Note 4 and Figure 1)

PARAMETER		TYP	UNIT
$t_{PLH(R)}$	Receiver propagation delay time, low- to high-level output	500	ns
$t_{PHL(R)}$	Receiver propagation delay time, high- to low-level output	500	ns

NOTE 4: Test conditions are C1−C4 = 1 µF at V_{CC} = 5 V ± 0.5 V.