WIRELESS DATA COMMUNICATION BETWEEN TWO COMPUTERS

Submitted in partial fulfillment of the requirement for

the degree of

Bachelor of Technology

In

Electronics and Communication Engineering

By

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May-15

CERTIFICATE

This is to certify that project report entitled "**Wireless Data Communication between Two Computers**", submitted by **Rafsan Ali(111038), Sudhanshu Shekhar (111129), Bhavuk Lalwani (111133)** in partial fulfillment for the award of degree of Bachelor of Technology in Electronics and Communication Engineering to Jaypee University of Information Technology, Waknaghat, Solan has been carried out under my supervision. This work has not been submitted partially or fully to any other University or Institute for the award of this or any other degree or diploma.

Date:

Supervisor's Name: Dr. S. V. Bhooshan
Designation: Professor
Signature:

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We owe a great many thanks to a great many people who have helped and supported us during this project. Our deepest thanks to **Prof.S.V.Bhooshan**, our project guide for his exemplary guidance, monitoring and constant encouragement throughout the course of this project work. He has taken great pains to go through the project and make necessary corrections as and whenever needed. We are also grateful to all the lab in charge of ECE department for their practical help and guidance. We would also like to thank all the faculty members of ECE department without whom the progress of this project would have been a distant reality. We also extend our heartfelt thanks to our family and well-wishers.

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S No.	Symbol	Meaning
1	k	Kilo
2	MHz	Mega Hertz
3	V	Volt
4	μF	Micro Farad
5	m	Metres
6	mA	Milli Ampere
7	cm	Centi meter
8	mm	Milli Metre
9	µH	Micro henry
10	Hz	Hertz
11	nH	Nano henry
12	dB	Decibel
13	Ω	ohm
14	°	degree

Abstract

In this project the main task is to establish a connection between two computer using RS 232 protocol and the connection should be wireless. Purpose of doing this project is in a rural area where there is absence of any kind of network or there is natural calamity where there is no network present and people still want to communicate within a particular area so they can use it.

So we have used our best knowledge and experience to design this project. In this project we mainly used discrete electronics components and because this is wireless so there should be an antenna so we designed helical antenna which is best for this project and we want to make it simple and cost effective so we hardly used any kind of chip.

The project has implemented step by step in several modules and stages. In first stage we designed wired data communication system using RS 232 and Matlab after that we designed modulator and demodulator and this worked. Since connection should be wireless so we designed antenna which is helical in nature and its radiation pattern has been plotted and observed after that we added these antennas at the transmitter and receiver.

Chapter-1: Introduction

1.1Objective:

The motivation behind taking this project is that is in a rural area where there is absence of any kind of network or there is natural calamity where there is no network present and people still want to communicate within a particular area so they can use it.

Project should be cost effective, simple, reliable, ease of use, easy maintenance.
So we used discrete component (diode, transistor, capacitor, resistor, copper wire) and basic of communication engineering.

This project is completed in two sub parts:
1. Wired data communication
2. Wireless data communication

Before starting the project let's discuss about wireless and wired communication and their application and advantages.

1.2Wireless communication:

It is the transfer of information between two or more points that are not connected by any physical medium.
Wireless communication generally works through the electromagnetic waves that are transmitted by an enabled device within the air, physical environment or atmosphere.
The sending device can be a sender or an intermediate device having ability to transmit radio signals. The communication between two devices occurs when the destination device senses these signals, creating a wireless communication link between the sender and receiver device.

1.2.1 Examples of wireless communication:-

Codeless telephones:-use radio to connect a portable handset to a dedicated base station over a distance of a few tens of meters.

Paging systems:-Communication systems that broadcast a page from every base station in the network and send brief messages to a subscriber.

Cellular telephone systems:-provide a wireless connection to the PSTN (Public Switched Telephone Network) for any user location within the radio range of a system.

Garage car opener, Remote controllers for home entertainment equipment,

Hand-held walkie-talkies, Wireless keyboard and mouse

Wireless LAN router and adapter

1.2.2 Advantages of wireless communication:

Convenience:

In case of wired communication you must physically connect the devices with wires, so you will need to install large number of wires which is not convenient, but in case of wireless communication devices have no cables to connect, if the signal has sufficient strength, the device will work. This is also working for mobile devices, if you have the password for the local wireless network, your smartphone or laptop connects automatically. When you leave a location, your mobile device automatically leaves the connection and picks up the next strong network signal it senses.

Flexibility:

For a traditional analog system such as AM radio broadcasting, a wireless transmitter accommodates any number of receivers. It doesn't matter if 10 people or 10,000 tune in to the local radio station. Although, a wired communications system is limited to the number of physical connections on the equipment; if these run out, you must replace the equipment to support more users. A typical Ethernet router for home use, for example, offers only eight sockets, even though its network software can handle 254 users.

Lower cost:

Wireless communications networks are less expensive to install and maintain than equivalent wired systems. Not only do you have to pay the per-foot costs of the cable itself, but to install wire in place you will need to invest time and labor. If anyone wants to change the wiring plan it will be expensive. Although even wireless systems need some cabling, the amount involved is a small fraction of that needed for wired system.

1.3 Wired communication:

It is transfer of data or any kind of information between two or more points that are connected by wires or any physical medium.

The wired network has been in existence for a long time. Many users consider a wired network as the more secure of the two choices. Wired networks offer powerful barriers for keeping computer users far away from the grasps of dangerous hackers. The single manner by which an impostor may get inside of the individual network is via the outside internet connection. However, these interruptions could usually be prevented through the use of firewalls as well as routers that utilize substantial security.

But, wired network is more complex to implement due to installation of wire and so it is more expensive. Maintenance work is also expensive and hard.

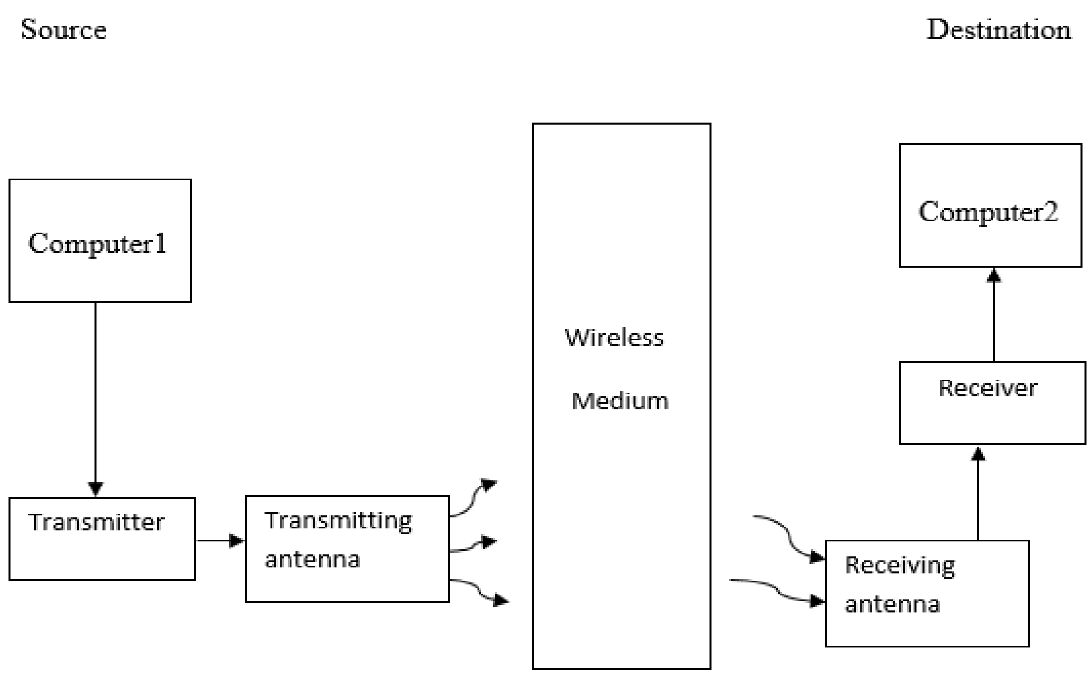


Figure 1.1: Block diagram of wireless data communication

Chapter 2: Implementation of wired communication

To implement wired communication, RS 232 protocol and Matlab software has been used.

2.1 RS 232 protocol:

RS-232 is a recommended standard protocol for linking computers and its peripheral devices to allow asynchronous serial data communication. It is asynchronous serial communication because it does not use any separate clock signal for synchronizing purpose. In simple terms RS232 defines the voltage for the path used for data exchange between the devices. It specifies common voltage and signal level, common pin wire configuration and minimum, amount of control signals.

As the technology was growing many electronic devices were being developed during this time like computers, printers, test instrument etc. There came a time where manufacturers felt the need to exchange information between these electronic devices. For example data exchange between a computer and a printer or two computers. But there was no standard or method to accomplish this task. RS232 was the only available standard at the time which was used for data exchange.

RS232 inserts Start/Stop bits into each byte of data to synchronize the communication. As it uses less wires for communication (no clock signals), It is simpler and more cost-effective.

2.1.1 Pin diagram of RS232:

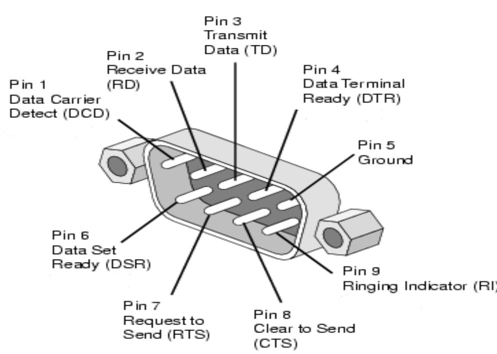


Figure 2.1-1: Pin diagram of RS232 [8]

Table 2.1-1: Input-output description of RS232 pin [8]

Pin	**SIG.**	**Signal Name**	**DTE (PC)**
1	DCD	Data Carrier Detect	in
2	RD	Receive Data	in
3	TD	Transmit Data	out
4	DTR	Data Terminal Ready	out
5	GND	Signal Ground	-
6	DSR	Data Set Ready	in
7	RTS	Request to Send	out
8	CTS	Clear to Send	in
9	RI	Ring Indicator	in

2.1.2 Pin description of RS232:-

RTS/CTS:-These pins are used by PCs to start and stop communication

The PC1 sets RTS to high and another PC2 respond with CTS high.

If PC2 wants to stop or interrupt communication, it drops CTS to low. PC1 uses RTS to control data flow.

DTR/DSR:-These pins are used to establish a connection at very beginning i.e both PCs “shake hand”

First to ensure both are present and active.one PC set DTR to high and another answer with DSR high

DCD:-This pin used by modem to indicate that it has detected the carrier of modem on other side

RI:-It is used in telephone.

RD-This pin is used to receive the data.

TD-This pin is used to transmit the data.

2.1.3 Transmission Diagram:-

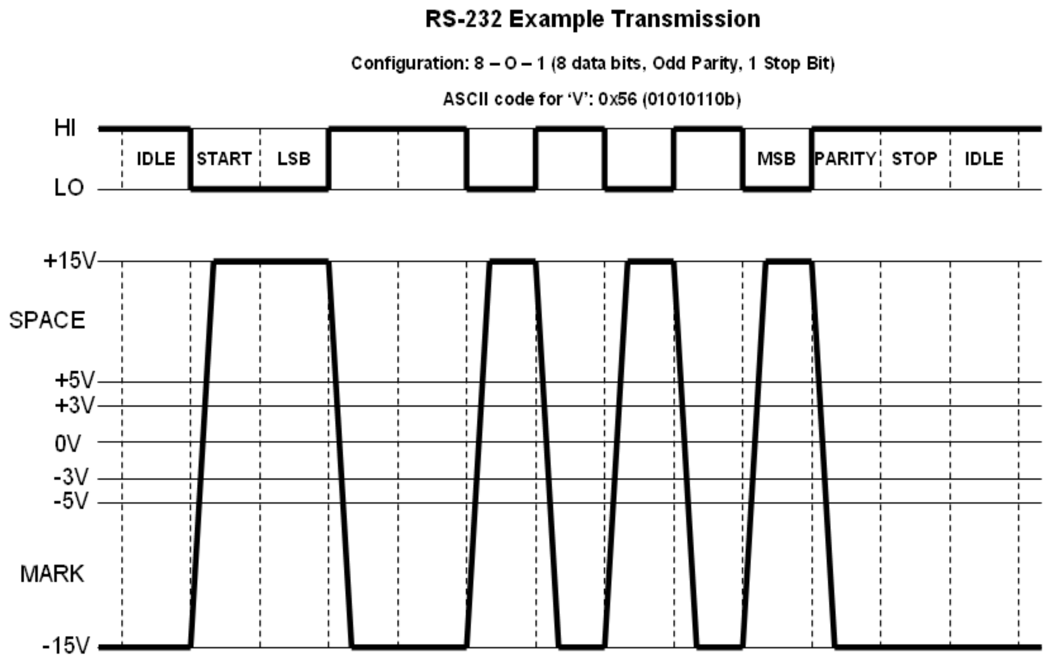


Figure 2.1-2: transmission diagram of RS232 [9]

2.2 Connection between two computers:

Cross connection is made between two computers using their RS232 port that means TD pin of one computer is connected to RD pin of other computer and vice-versa. Ground pin is common for both computers.

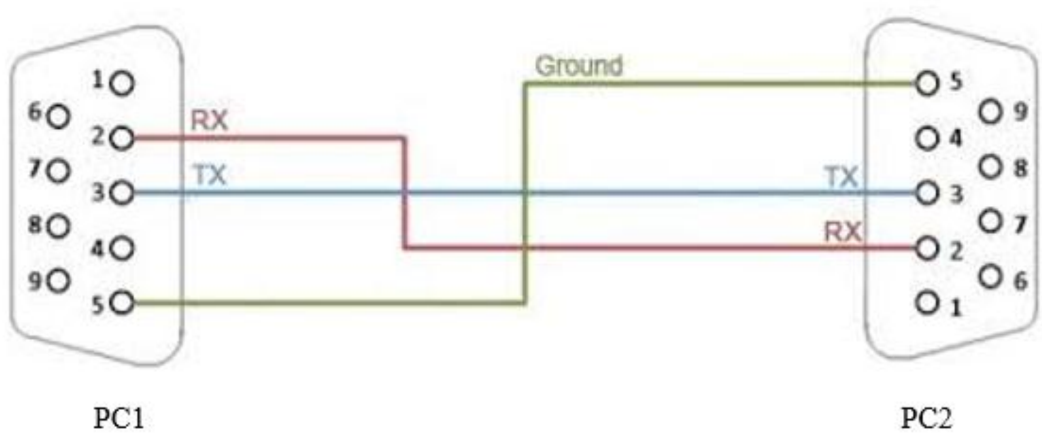


Figure 2.2-1: cross connection between two RS232 port

Connection between two computers is made in project lab of Jaypee University as shown in figure 2.2-2.

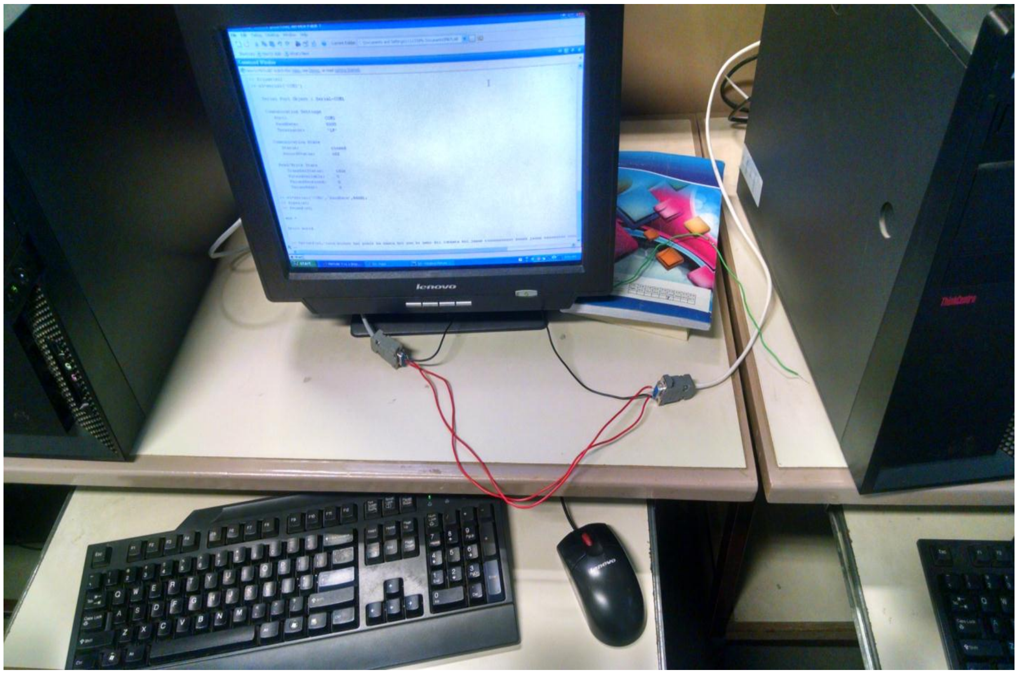


Figure 2.2-2: Connection between two computers

2.3 Transmission and Reception of data over cross connection:

Data can't be send and receive directly over cross connection, so, there is need of programming the serial port using any software. So here, Matlab has been used for programming purpose. There are some simple commands in Matlab that can be used for this purpose.

2.3.1 Matlab (Matrix Laboratory):

MATLAB is the high-level language and interactive environment used by millions of engineers and scientists worldwide. It lets you explore and visualize ideas and collaborate across disciplines including signal and image processing, communications, control systems, and computational finance.

2.3.2 Command used in Matlab:

1. Instrhwinfo ('serial'): It provides a list of available serial ports.

2.Syntax: obj = serial ('port');

Description: It will create a serial port object associated with the serial port specified by port. If port does not exist, or if it is in use, you will not be able to connect the serial port object to the device.

3. Syntax: obj=serial (‘COM1’,’Baudrate’, 9600);

Description: It will set Baud Rate to 9600 of Com1 port.

4. Syntax: fopen(obj)

Description: fopen(obj) connects the serial port object, obj to the device.

5. Syntax: fclose(obj)

Description: fclose(obj) disconnects obj from the device, where obj is a serial port object or an array of serial port objects.

6. Syntax: fprintf(obj,'cmd')

Description: fprintf(obj,'cmd') writes the string cmd to the device connected to the serial port object, obj. The default format is %s\n. The write operation is synchronous and blocks the command-line until execution completes.

7. Syntax: A = fscanf(obj)

Description: A = fscanf(obj) reads data from the device connected to the serial port object, obj, and returns it to A. The data is converted to text using the %c format.

Screen shot of Matlab code which is executed in both the computers during wired communication is shown in figure: 2.3-1 and figure: 2.3-2.

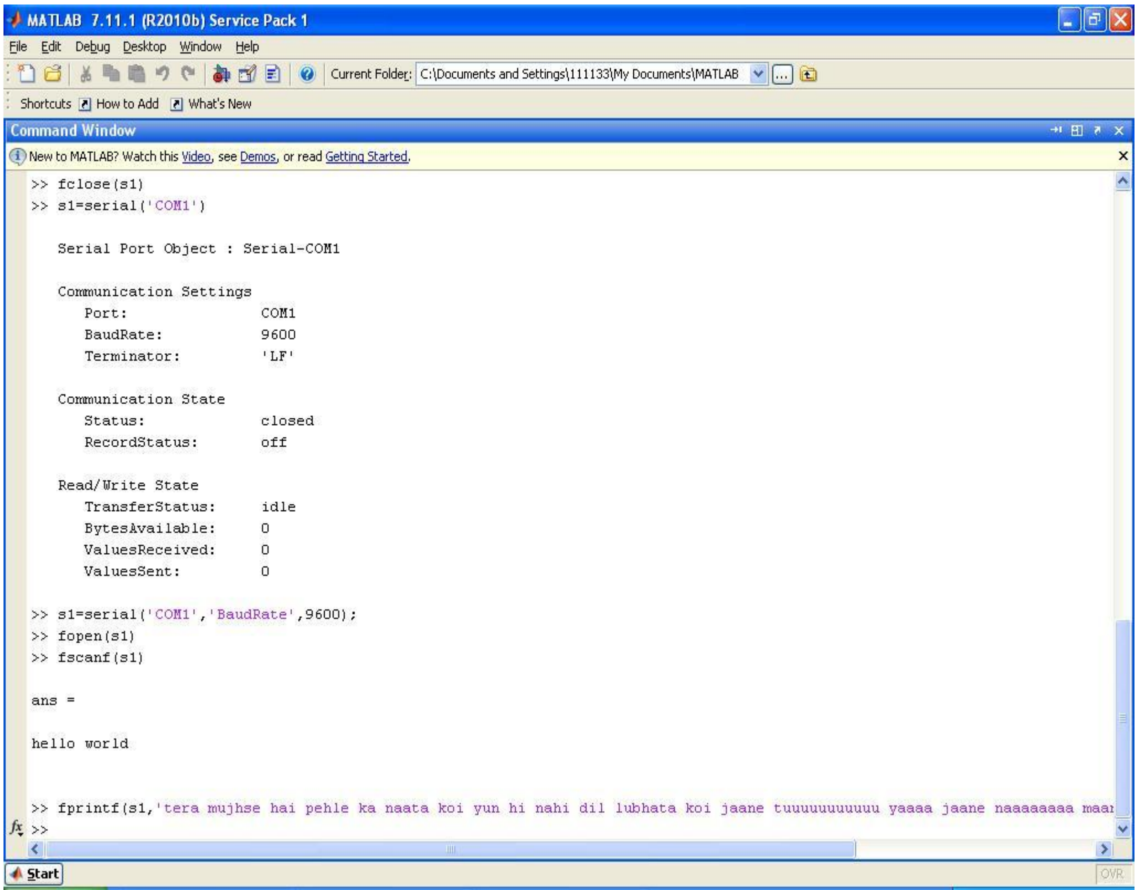


Figure 2.3-1: screen shot of matlab code on PC1

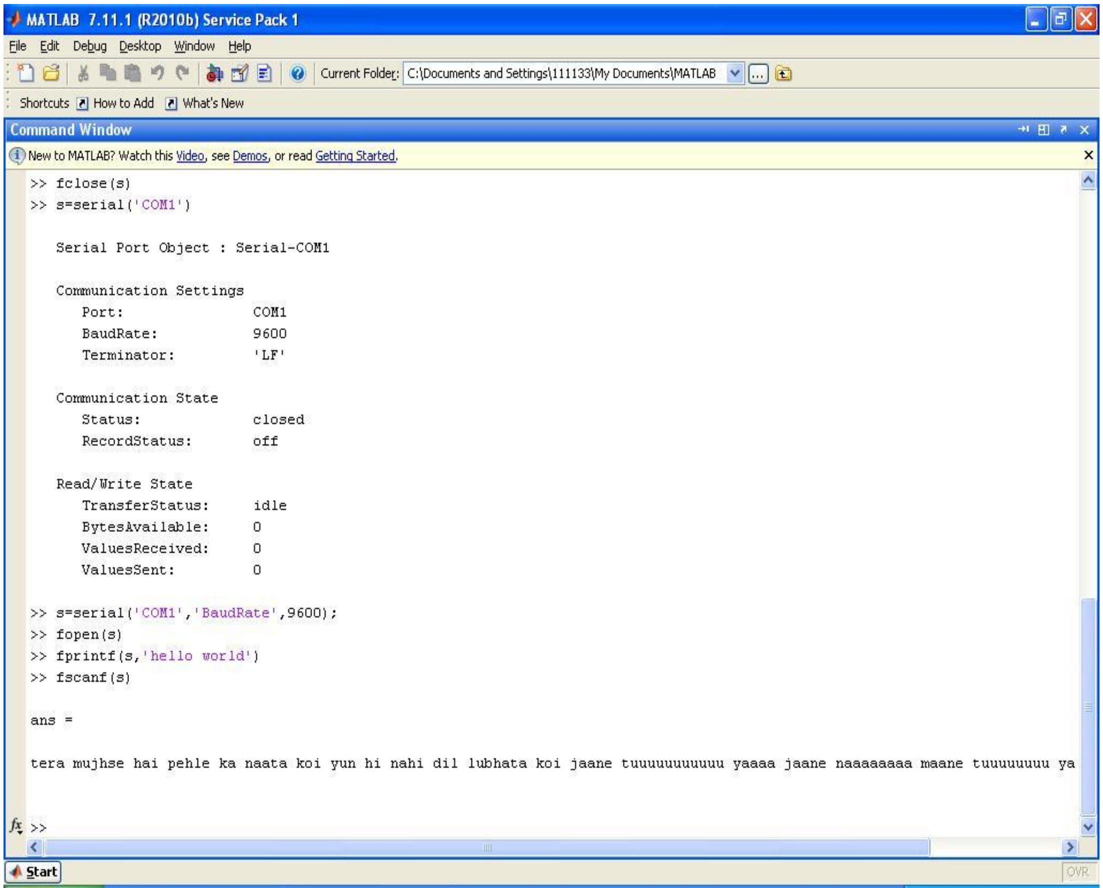


Figure 2.3-1: screen shot of matlab code on PC2

Chapter 3: Modulation and Demodulation

3.1 Modulation:

Modulation is the process of varying one or more properties of a periodic waveform, called the carrier signal, with a modulating signal that typically contains information to be transmitted. Modulation is used for the purpose of minimizing loss of strength of signal, error and distortion and also to increase the range of transmission.

In this case Amplitude shift keying (ASK) have been used.

3.1.1 Amplitude shift keying (ASK):

Amplitude shift keying (ASK) is a simple and elementary form of digital modulation in which the amplitude of a carrier sinusoid is modified in a discrete manner depending on the value of a modulating signal.

Strength of carrier signal is varied to represent binary 1 or 0.

Both frequency & phase remain constant while amplitude changes.

3.1.2 Advantage of ASK:

Hardware is simple and cost effective. Detection of signal at receiver is easy.

3.1.3 Disadvantage of ASK:

ASK is very susceptible to noise interference, noise usually (only) affects the amplitude. Therefore, ASK is the modulation technique most affected by noise.

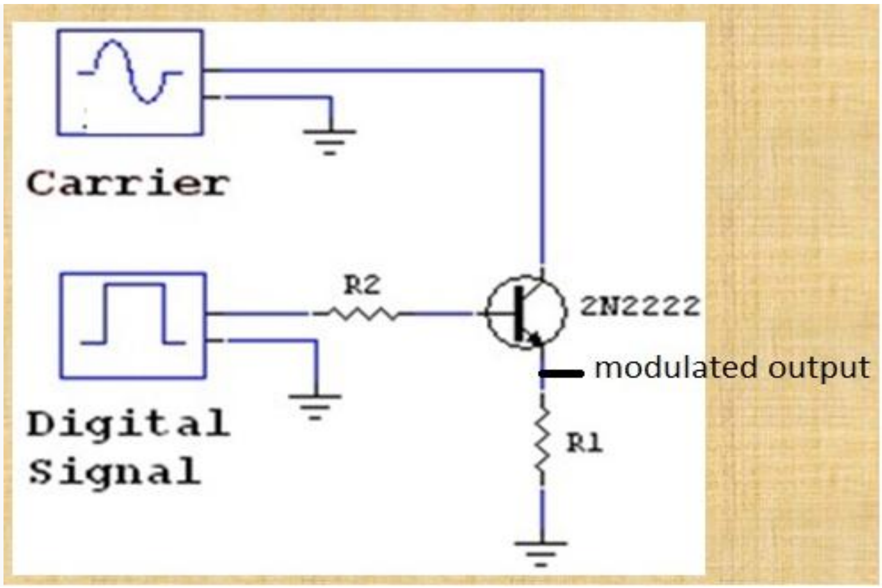


Figure 3.1.1: circuit diagram of ASK [6]

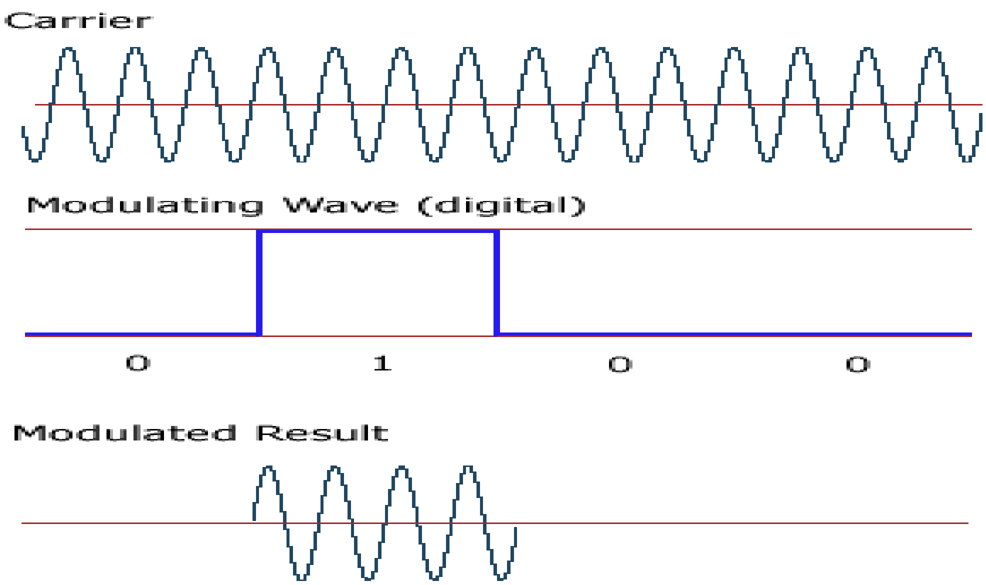


Figure 3.1-2: waveforms related to ASK

Figure 3.1-3: Practical waveform observed in laboratory of Jaypee University

3.2 Demodulation:

Demodulation is the process of extracting the original information bearing signal from a modulated carrier wave. Only the presence or absence of a sinusoid in a given time interval needs to be determined.

In this case demodulation of ASK has been performed.

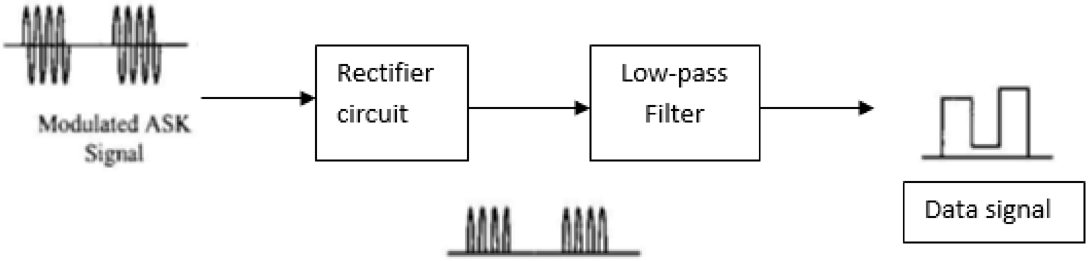


Figure 3.1-4: Block diagram of ASK demodulation

This structure is a typical asynchronous ASK detector. When the ASK signal pass through the rectifier, we can obtain the positive half wave signal. After that the signal will pass through a low-pass filter and data signal will be obtained on receiver.

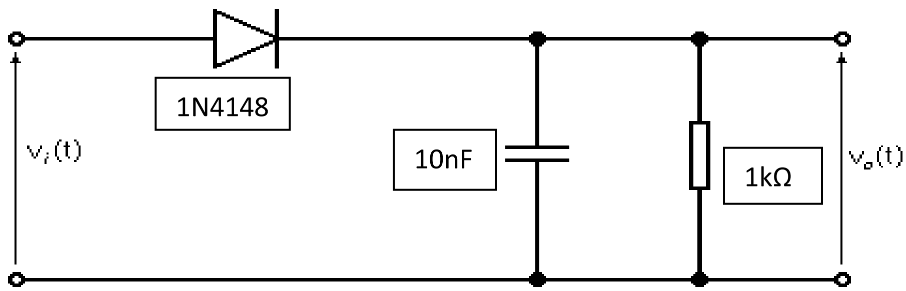


Figure 3.1-5: Circuit diagram of ASK demodulation [5]

In above circuit 1N4148 Diode has been used for rectification which is a fast switching diode and can operate on 13Mhz frequency which is required, since carrier signal used in modulation having frequency 13Mhz.

A 10nF capacitor and 1kΩ resistor has been used for the purpose of low pass filtering to pass only message signal to the destination. This combination of resistor and capacitor will pass the signal having frequency equal to or less than 15khz. Cut of frequency of low pass filter (f_C) is calculated by following formula:

$$f_C = \frac{1}{2\pi RC}$$

Where R is resistor and C is capacitor.

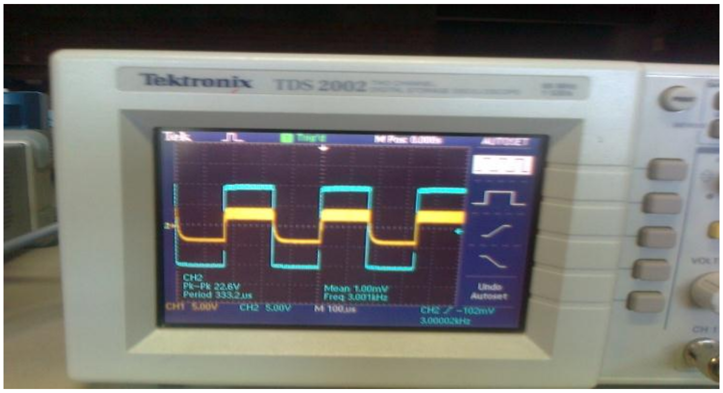


Figure 3.1-6: waveform observed after demodulation on oscilloscope

Chapter 4: Antenna designing

4.1 Antenna:

An antenna is an electrical device which converts electrical signals into radio signals, and vice versa. It is usually used with a transmitter or receiver. In transmission, a transmitter supplies an electric current oscillating at radio frequency (i.e. a high frequency alternating current) to the antenna, and the antenna radiates the energy from the current as electromagnetic waves (radio waves). At receiver, an antenna intercepts some of the power of an electromagnetic wave in order to produce a tiny voltage at its terminal, which is applied to a receiver for detecting message signal.

The first antennas were built in 1888 by German physicist Heinrich Hertz in his pioneering experiments to prove the existence of electromagnetic waves predicted by the theory of James Clerk Maxwell.

Basically an antenna is an arrangement of conductors which is connected (often through a transmission line) to the receiver or transmitter. A time varying current creates an oscillating magnetic field around the antenna elements and accelerated charge also creates an oscillating electric field along the elements. These time-varying fields radiate away from the antenna into space as a moving electromagnetic plane wave. Conversely, during reception the oscillating electric and magnetic fields of an incoming radio wave exert force on the charges in the antenna elements and cause them to move back and forth to create oscillating current and voltage in the antenna.

Antennas can be designed to transmit and receive radio waves in all directions equally (omnidirectional antennas), or it can be directional. In the latter case, an antenna may also consist of dielectric elements to get desired radiation pattern.

4.1.1 Application of Antennas:

Antennas are essential components of all equipment that uses radio waves. They are used in systems such as radio transmitter and receiver, television transmitter and receiver, radar, cell phones, and satellite, as well as other devices such as garage door openers, wireless microphones, Bluetooth-enabled devices, wireless networks.

4.2 Different parameters of antenna:

4.2.1 Directivity: It is a fundamental component of antenna. It is a measure of ratio of peak value of radiated power to the average power radiated over all directions. It is a measure of how directional an antenna's radiation pattern is.

4.2.2 Antenna Efficiency: The efficiency of an antenna relates the power delivered to the antenna and the power radiated or dissipated within the antenna. If an antenna radiates most of the fed power by transmitter then it is called as high efficiency antenna. A low efficiency antenna has most of the power absorbed as losses within the antenna, or reflected away due to impedance mismatch.

The losses associated within an antenna are typically the conduction losses (due to finite conductivity of the antenna) and dielectric losses (due to conduction within a dielectric which may be present within an antenna).

Radiation efficiency of the antenna can be written as the ratio of the radiated power to the input power of the antenna:

$$k = \frac{P_{radiated}}{P_{input}}$$

4.2.3 Antenna Gain: It describes how much power is transmitted in the direction of peak radiation to that of a source. Antenna gain (G) can be related to Directivity (D) as:

$$G = kD$$

4.2.4 Beam widths and Side lobe Levels:

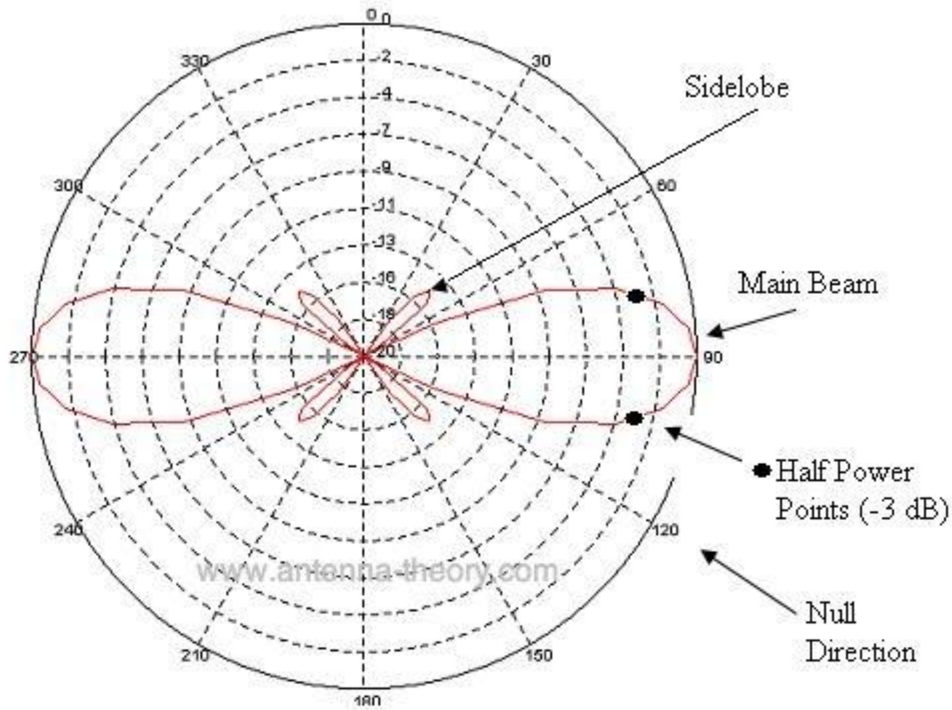


Figure 4.2-1: Polar radiation pattern [3]

The main beam is the region around the direction of maximum radiation (usually the region that is within 3 dB of the peak of the main beam). The main beam in Figure 4.2-1 is centered at 90°.

The side lobes are smaller beams that are away from the main beam. These side lobes are usually radiation in undesired directions which can never be completely eliminated. The side lobes in Figure 4.2-1 occur at roughly 45° and 135°.

The Half Power Beam width (HPBW) is the difference of two angles at which the magnitude of the radiation pattern decreases by half (or -3 dB) from the peak of the main beam.

Null Beam width is the angular difference from which the magnitude of the radiation pattern decreases to zero away from the main beam.

4.2.5 Bandwidth: Bandwidth is another fundamental antenna parameter. It describes the range of frequencies over which the antenna can properly radiate or receive signals.

4.2.6 Polarization of Antennas: An antenna radiates electromagnetic plane wave which is a polarized wave. So, polarization of an antenna is same as that of polarization of plane wave which is evaluated in the far field.

The concept for antenna to antenna communication is based on reciprocity theorem which states that antennas transmit and receive in exactly the same manner. That means horizontally polarized antenna will not communicate with a vertically polarized antenna and a vertically polarized will communicate with vertically polarized antenna.

In general, for two linearly polarized antennas that are rotated from each other by an angle, the power loss due to this polarization mismatch will be described by the Polarization Loss Factor (PLF):

$$\text{PLF}=(\cos\varphi)^2 \quad [3]$$

Hence, if both antennas have the same polarization, the angle between their radiated E-fields is zero and there is no power loss due to polarization mismatch. If one antenna is vertically polarized and the other is horizontally polarized, the angle is 90 degrees and no power will be transferred.

4.2.7 Antenna aperture:

It is a parameter which helps in calculating the receive power of an antenna. Assume that a plane wave with the same polarization as the receive antenna is incident upon the antenna and the wave is travelling towards the antenna in the direction of maximum radiation of antenna.

Let p be the power density of the plane wave (in W/m^2). If P_t represents the power (in Watts) at the antennas terminals available to the antenna's receiver, then power received from a given plane wave is given by:

$$P_t = pA_e$$

Hence, the effective aperture simply represents how much power is captured from the plane wave and delivered by the antenna.

Relation between the effective aperture and the peak antenna gain (G) of any antenna is given by:

$$A_e = \frac{\lambda^2}{4\pi} G$$

4.2.8 The Friis Equation:

The Friis Transmission Equation is used to calculate the power received by an antenna having gain G_R, when transmitted by another antenna having gain G_T, separated by a distance R, and operating at frequency f.

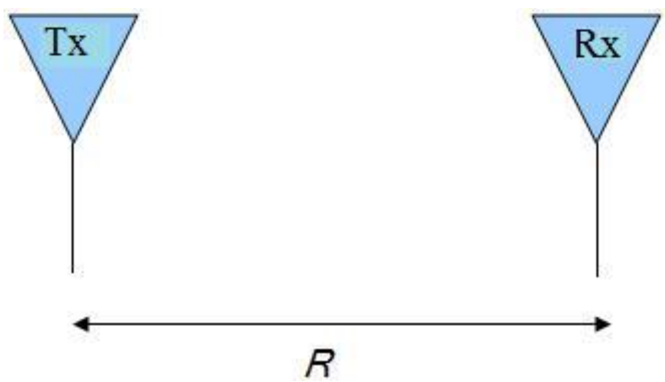


Figure 4.2-2: Transmitting (Tx) and Receiving (Rx) Antennas separated by R distance

Assume that P_T Watts of total power are delivered to the transmitting antenna and the transmit antenna is omnidirectional, lossless, and the receiving antenna is in the far field of the transmit antenna. Then the power density P (in Watts per square meter) of the plane wave incident on the receive antenna a distance R from the transmit antenna is given by:

$$P = \frac{P_T}{4\pi R^2}$$

If the transmit antenna has an antenna gain (G_T in the direction of the receive antenna given by, then the power density equation above becomes:

$$P = \frac{P_T}{4\pi R^2} G_T$$

Assume now that the receive antenna has an effective aperture A_{ER} , Then the power received by this antenna (S_R) is given by:

$$S_R = \frac{P_T}{4\pi R^2} G_T A_{ER}$$

The resulting received power can be written as:

$$S_R = \frac{P_T G_T G_R \lambda^2}{(4\pi R)^2} \quad \text{(since } A_e = \frac{\lambda^2}{4\pi} G \text{)} \quad [1]$$

This is known as the Friis Transmission Formula. It relates the free space path loss, antenna gains and wavelength to the received and transmitted powers.

4.3 Helical Antenna:

In this case helical antenna have been designed because it was fulfilled our requirement like operation frequencies, size, cost.

Helical antenna is an antenna consisting of a conducting wire wound in the form of a helix. The helical antenna is a hybrid of two simple radiating elements, the dipole and loop antennas. A helix becomes a linear antenna when its diameter approaches zero or pitch angle goes to 90. On the other hand, a helix of fixed diameter can be seen as a loop antenna when the spacing between the turns vanishes ($\alpha = 0$).

Helical antennas have been widely used as simple and practical radiators over the last five decades due to their remarkable and unique properties. The rigorous analysis of a helix is extremely complicated. Therefore, radiation properties of the helix, such as gain, far-field pattern, axial ratio, and input impedance have been investigated using experimental methods, approximate analytical techniques, and numerical analyses. In most cases, helical antennas are mounted over a ground plane. The feed line is connected between the bottom of the helix and the ground plane.

The geometry of a conventional helix is shown in Figure 4.3-1-a. The parameters that describe a helix are summarized below.

D = diameter of helix

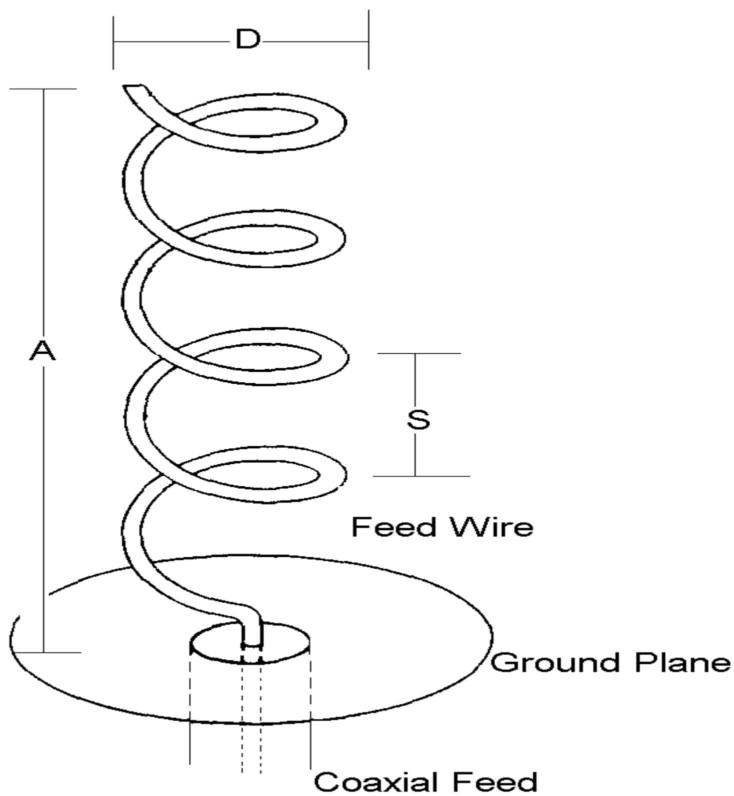
S = spacing between turns

N = number of turns

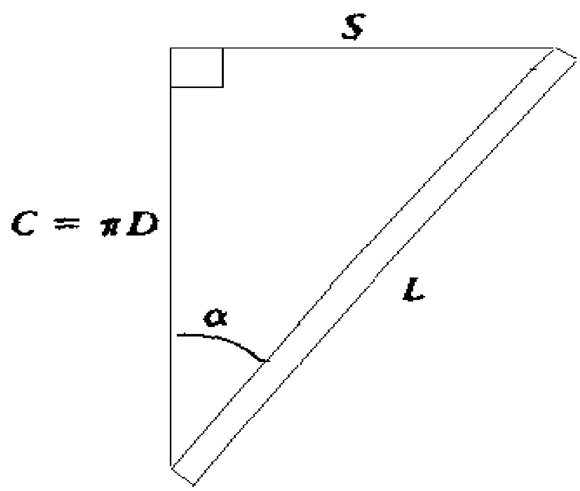
C = circumference of helix = πD

A = total axial length = NS

α = pitch angle



(a)



(b)

Figure 4.3-1: Geometry of helical antenna [7]

If one turn of the helix is unrolled, as shown in Figure 4.3-1(b), the relationships between S, C, α and the length of wire per turn, L , are obtained as:

S = L sinα = C tanα

$L = (S^2 + C^2)^{1/2} = (S^2 + (\pi D)^2)^{1/2}$

Helical antenna can operate in either normal mode or axial mode of radiation.

4.3.1 Normal Mode:

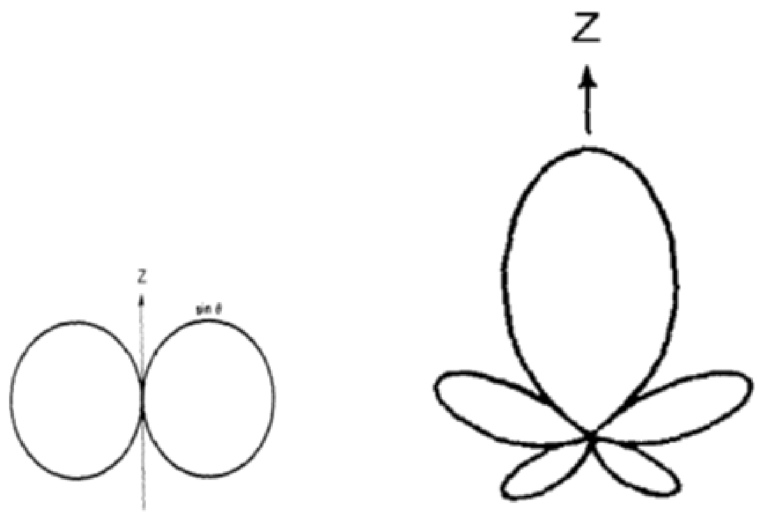
For a helical antenna with dimensions much smaller than wavelength (NL << λ),

The current may be assumed to be of uniform magnitude and with a constant phase along the helix. The maximum radiation occurs in the plane perpendicular to the helix axis, as shown in Figure 4.3-2(a). This mode of operation is referred to as the normal mode. In general, the radiation field of this mode is elliptically polarized in all directions. But, under particular conditions, the radiation field can be circularly polarized. Because of its small size compared to the wavelength, the normal-mode helix has low efficiency and narrow bandwidth.

4.3.2 Axial Mode:

When the circumference of a helix is of the order of one wavelength, it radiates with the maximum power density in the direction of its axis, as seen in Figure 4.3-2(b). This radiation mode is referred to as axial mode. The radiation field of this mode is nearly circularly polarized about the axis. The sense of polarization is related to the sense of the helix winding.

In addition to circular polarization, this mode is found to operate over a wide range of frequencies.



$C \ll \lambda$ (a) $C \approx \lambda$ (b)

Figure 4.3-2: Radiation patterns of helix: (a) Normal mode; (b) Axial mode [7]

4.3.3 Analysis of Helix:

Unlike the dipole and loop antennas, the helix has a complicated geometry. There are no exact solutions that describe the behavior of a helix. However, using experimental methods and approximate analytical or numerical techniques, it is possible to study the radiation properties of this antenna with sufficient accuracy.

4.3.3.1 Normal-Mode Helix:

The analysis of a normal-mode helix is based on a uniform current distribution over the length of the helix.

Generally, the polarization of this mode is elliptical with an axial ratio given by

$$AR=\frac{|E_\theta|}{|E_\varphi|}=\frac{2S\lambda}{(\pi D)^2}\ [1]$$

The normal-mode helix will be circularly polarized if the condition *AR* = 1 is satisfied. This condition will satisfy if the diameter of the helix and the spacing between the turns are related as

$$C=\sqrt{2S\lambda}\ [1]$$

It is noted that the polarization of this mode is the same in all directions except along the z-axis where the field is zero. It is also seen that maximum radiation occurs at $\theta = 90^\circ$; that is, in a plane normal to the helix axis.

4.3.3.2 Axial-Mode Helix:

Unlike the case of a normal-mode helix, simple analytical solutions for the axial mode helix do not exist. Thus, radiation properties and current distributions are obtained using experimental and approximate analytical or numerical methods.

Empirical Relations for Radiation Properties of Axial-Mode Helix:

Approximate expressions for radiation properties of an axial-mode helix have also been obtained empirically. A summary of the empirical formulas for radiation characteristics is presented below.

These formulas are valid when-

$$N > 3,\quad \frac{3}{4}<\frac{C}{\lambda}<\frac{4}{3}$$

and

$$12^\circ < \alpha < 15^\circ.\ [1]$$

An approximate directivity expression is given as

$$D=12.C_{\lambda}^{2}.N.S_{\lambda} \text{ [1]}$$

C_{λ} and S_{λ} are, respectively, the circumference and spacing between turns of the helix normalized to the free space wavelength (λ). Since the axial-mode helix is nearly lossless, the directivity and the gain expressions are approximately the same.

Half-Power Beam width:

The empirical formula for the half-power beam width is

$$HPBW = \frac{52^{\circ}}{C_{\lambda}\sqrt{NS_{\lambda}}} \text{ [1]}$$

Input Impedance:

Its terminal impedance is nearly purely resistive and is constant with frequency. The empirical formula for the input impedance is

$$R = 140C_{\lambda} \text{ (ohms). [1]}$$

Axial Ratio:

$$AR = \frac{2N+1}{2N} \text{ [1]}$$

Table 4.3-1: Parameter ranges for optimum performance of helix

Parameter	Optimum Range
Circumference	$\frac{3}{4} < \frac{C}{\lambda} < \frac{4}{3}$
Pitch angle	$12^{\circ} < \alpha < 15^{\circ}$
Number of turns	$3 < N < 15$
Wire diameter	Negligible effect
Ground plane diameter	At least $\frac{\lambda}{2}$

The peak gain smoothly drops as the diameter of the helix decreases.

If circumference and length of a helix is fixed, then gain increases smoothly as the pitch angle is reduced. However, the bandwidth becomes narrow as pitch angle is reduced. Due to this reason the optimal pitch angle for the axial-mode helix is about12.5°.

Number of turns affects gain, axial ratio, and beam width, of helix antenna.

As number of turns increase, the gain increases too. However, for very large number of turns, adding more turns has little effect. Also, the beam width becomes narrow as larger number of turns added. Adding more turns improves the gain of helix, but it makes the helix larger, heavier, and more costly. Practical helices have between 6 and 16 turns and if there is requirement of high gain, array of helices may be used.
Ground plane is used for the purpose of reflecting backward travelling wave which is weak.

4.4 Design of Helical antenna:

For designing an antenna it is needed to consider the frequency on which we want to work. According to frequency it is decided that what should be dimension of an antenna (like Length, diameter and other dimension parameters).

Frequency of 13Mhz is used in this case which is available in our Lab. So, according to this frequency, wavelength (λ) should be approximately equal to 23m.

From table 4.3-1 it will need to take $C \approx \lambda$, for optimum performance of a Helix antenna. But it is not practically possible to design a helix antenna having C=23m. So, two antennas have been designed by talking random value of dimension and then one of them has been used in this case according to their performance. So, antenna used in this case is designed by talking value of circumference(C) is approximately equal to 0.0164 times value of λ. By using these dimensions some conclusion is found practically which is listed in Table 4.3-2.

Table 4.4-1: Comparison of two antennas designed in this case

First antenna designed	Second antenna designed

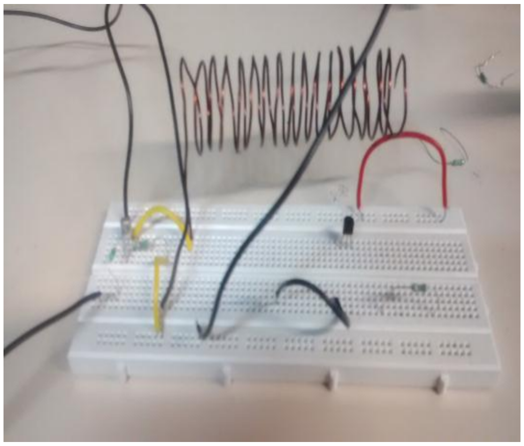
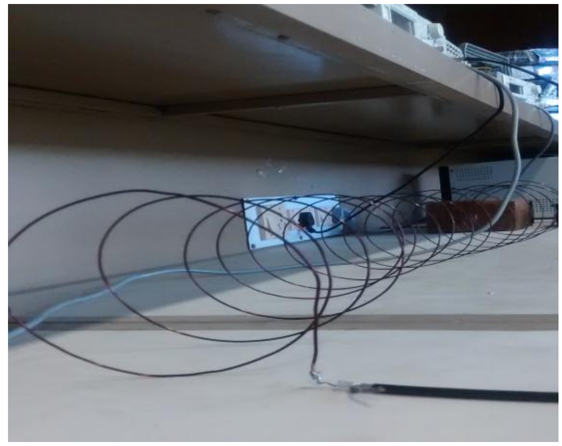

	

Figure 4.4-1: first helix antenna	Figure 4.4-2: second helix antenna
This is an antenna having very smaller dimension in comparison to wavelength. Parameters of this antenna is as follow:- Diameter of helix(D): D=2.5cm Spacing between two consecutive turns(S): S=8mm Circumference of helix(C): C=7.854cm Length of one turn(L): L=7.895cm Pitch angle(α°): $\alpha^{\circ} = 5.8^{\circ}$ Inductance of helix(l): l=1.3nH	This is an antenna having not very smaller dimension in comparison to wavelength. Parameters of this antenna is as follow:- Diameter of helix(D): D=12cm Spacing between two consecutive turns(S): S=7cm Circumference of helix(C): C=37.7cm Length of one turn(L): L=38.34cm Pitch angle(α°): $\alpha^{\circ} = 10.52^{\circ}$ Inductance of helix(l): l=5nH Resistance of helix(R): R=0.54Ω

Resistance of helix(R):

$$R=0.83\Omega$$

Impedance of helix(Z):

$$Z=0.83 + j0.08\ \Omega$$

This antenna is having very less gain as it is found very less voltage at receiver as shown in figure 4.4-3:

Figure 4.4-3: modulated wave fed by transmitter

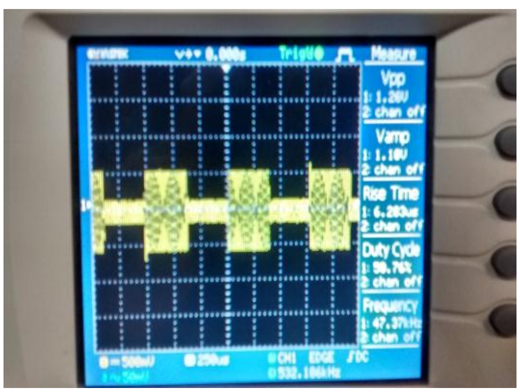


Figure 4.4-5: modulated wave received at receiver in 50cm range

Impedance of helix(Z):

$$Z=0.54 + j0.41\ \Omega$$

This antenna is having better gain than first antenna as it is found more voltage at receiver as shown in figure 4.4-4:

Figure 4.4-4: modulated wave fed by transmitter

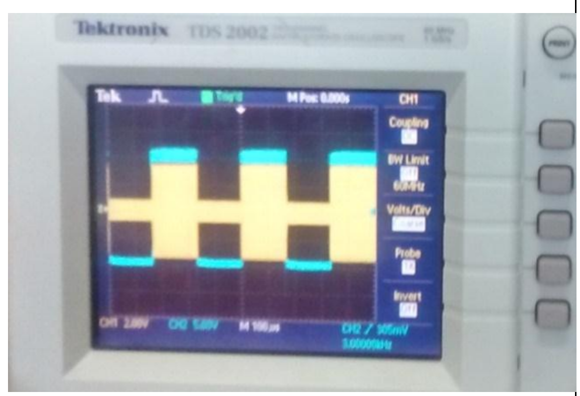


Figure 4.4.6: modulated wave received at receiver in 2-3m range

From above comparison it is found that second antenna designed is having better gain and better range so it is decided to use this antenna in this case.

Impedance matching of helix antenna:

To transfer maximum power from an antenna, impedance of antenna should be matched to transmitter circuit.

According to maximum power transfer theorem, impedance of generator circuit should be conjugate of load circuit that is

$$Z_G = Z_L{}^*$$

Calculation of Z_G from transmitting circuit:

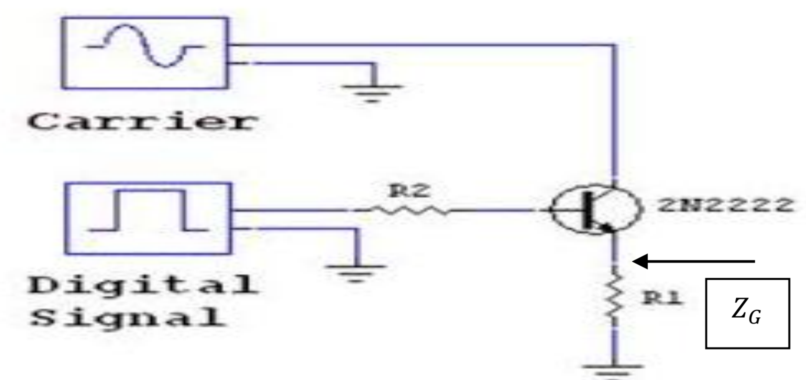


Figure 4.4-7: Transmitting circuit for calculation of Z_G.

R1 and R2 are 1.5kΩ and 2.2kΩ respectively. Forward current gain of transistor $(\beta) = 135$.

To calculate Z_G , first of all voltage across R1($V_{R1} = 0.561V$) is measure using digital multi-meter.

So, $I_E = {V_{R1}}/{R1}$ = 0.374mA and $r_e = {26mV}/{I_E} = 69.52\Omega$

Z_G=R1 parallel $(\frac{R2}{\beta+1} + r_e) = 81\Omega$.

So, to match transmitter to antenna there should be 81Ω resistance in series with Z_G since antenna has negligible impedance. Z_G can be loss resistance for antenna.

Now there are more observations about this helix antenna characteristics have observed. Characteristics like: antenna radiation pattern, radiation efficiency, half power beam width, directivity, gain, main lobe, side lobe.

4.4.1 Radiation efficiency (k):

$$k = \frac{R_r}{R_r + R_L} \text{ [1]}$$

$R_r \rightarrow$ Radiation resistance of an antenna.

$R_L \rightarrow$ Loss resistance of antenna.

4.4.2 Radiation resistance:

$$R_r = 395 * \left(\frac{2}{\pi}\right)^2 * h^2 \ \Omega \text{ [1]}$$

Where h=1.1m is the effective height of antenna.

So R_r is 193.7 Ω.

4.4.3 Loss resistance:

$$R_L = Z_G = 81\Omega$$

Now k = 0.705, so radiation efficiency is 70.5%.

4.4.4 Radiation pattern of designed antenna:

To draw radiation pattern of any transmitting antenna, current or power is measured by moving the receiving antenna from 0° *to* 360° around the transmitting antenna in the far field region.

Far field region is dominated by radiated fields, with the E- and H-fields orthogonal to each other and the direction of propagation as with plane waves.

If the maximum linear dimension of an antenna is D, then the following condition must all be satisfied to be in the far field region:

$$R > \frac{2D^2}{\lambda}$$

In this case R should be greater than 10.5cm and pattern is drawn in the range of 135cm. D is taken equal to total length of antenna which is 110cm.

Table 4.4-2 measured value of current in μA on the normalized scale of 100 at different angle.

Angle(θ in degree)	Peak to peak output voltage at receiver (in volt)	Current in μA on normalized scale of 100
0	6.4	22.63
10	5.0	17.67
20	5.0	17.67
30	5.0	17.67
40	5.8	20.51
50	4.4	15.56
60	4.4	15.56
70	4.0	14.14
80	4.6	16.26
90	4.6	16.26
100	4.8	16.97
110	4.0	14.14
120	1.0	3.54
130	0.9	3.18
140	0.9	3.18
150	1.0	3.54
160	1.2	4.24
170	1.0	3.53
180	0.8	2.82
190	0.6	2.12
200	0.7	2.48
210	0.7	2.48
220	1.6	5.68
230	2.0	7.08
240	1.9	6.76
250	4.4	15.56
260	3.8	13.54
270	3.2	11.31
280	3.9	14.04
290	4.2	14.68
300	4.5	16.11
310	4.1	14.39
320	3.5	12.64
330	3.4	12.37
340	5.0	17.67
350	5.0	17.67
360	6.0	21.21

4.4.5 Pattern drawn using polar plot:

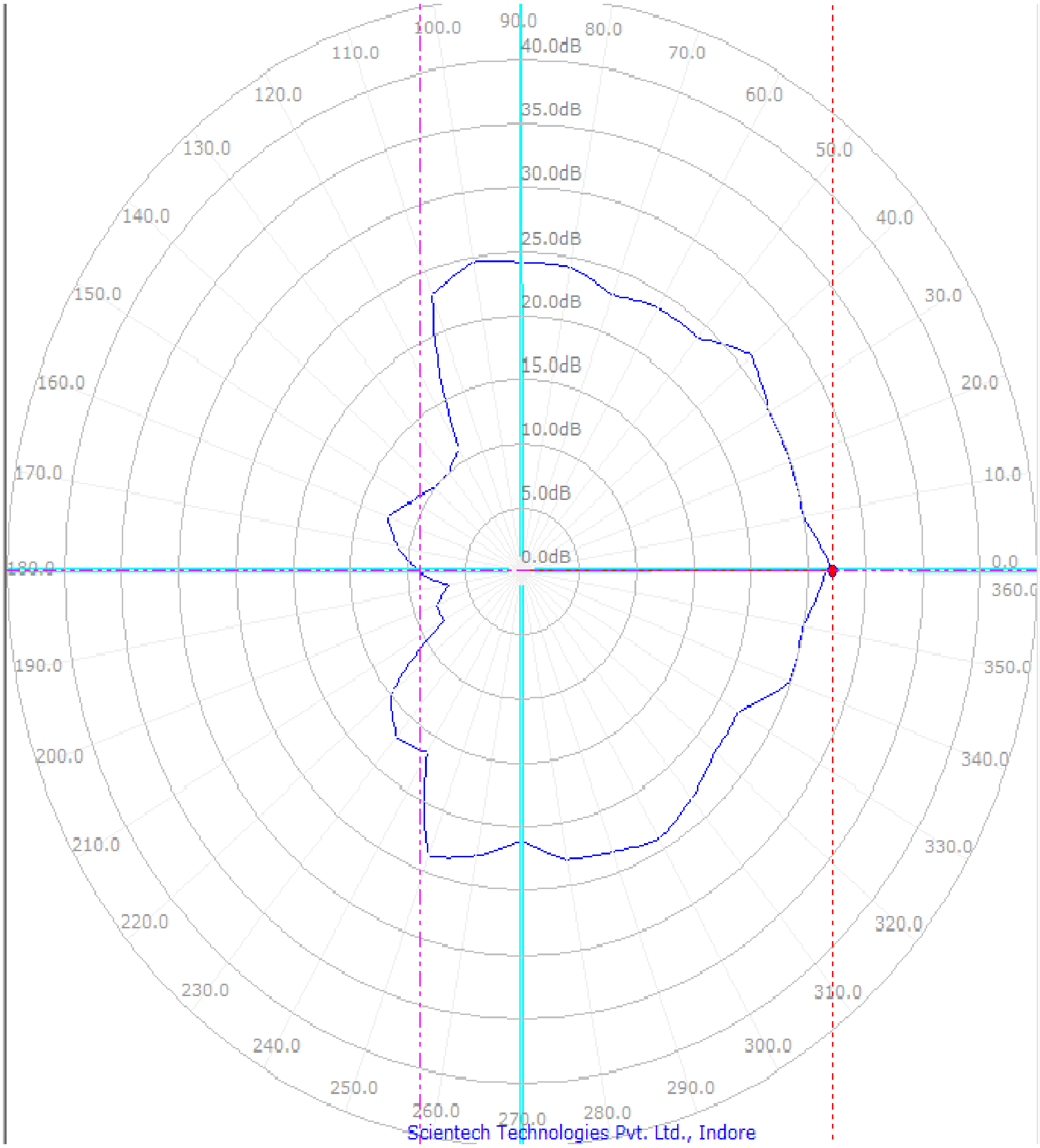


Figure 4.4-8: Radiation pattern of antenna using polar plot

4.4.6 Observation of directive gain:

From figure 4.4-8 it is found that maximum gain of antenna is 27.1dB at an angle of 0° which shows that antenna is radiating maximum along the helix axis that means this antenna is directive along helix.

4.4.7 Observation of half power beam width (HPBW):

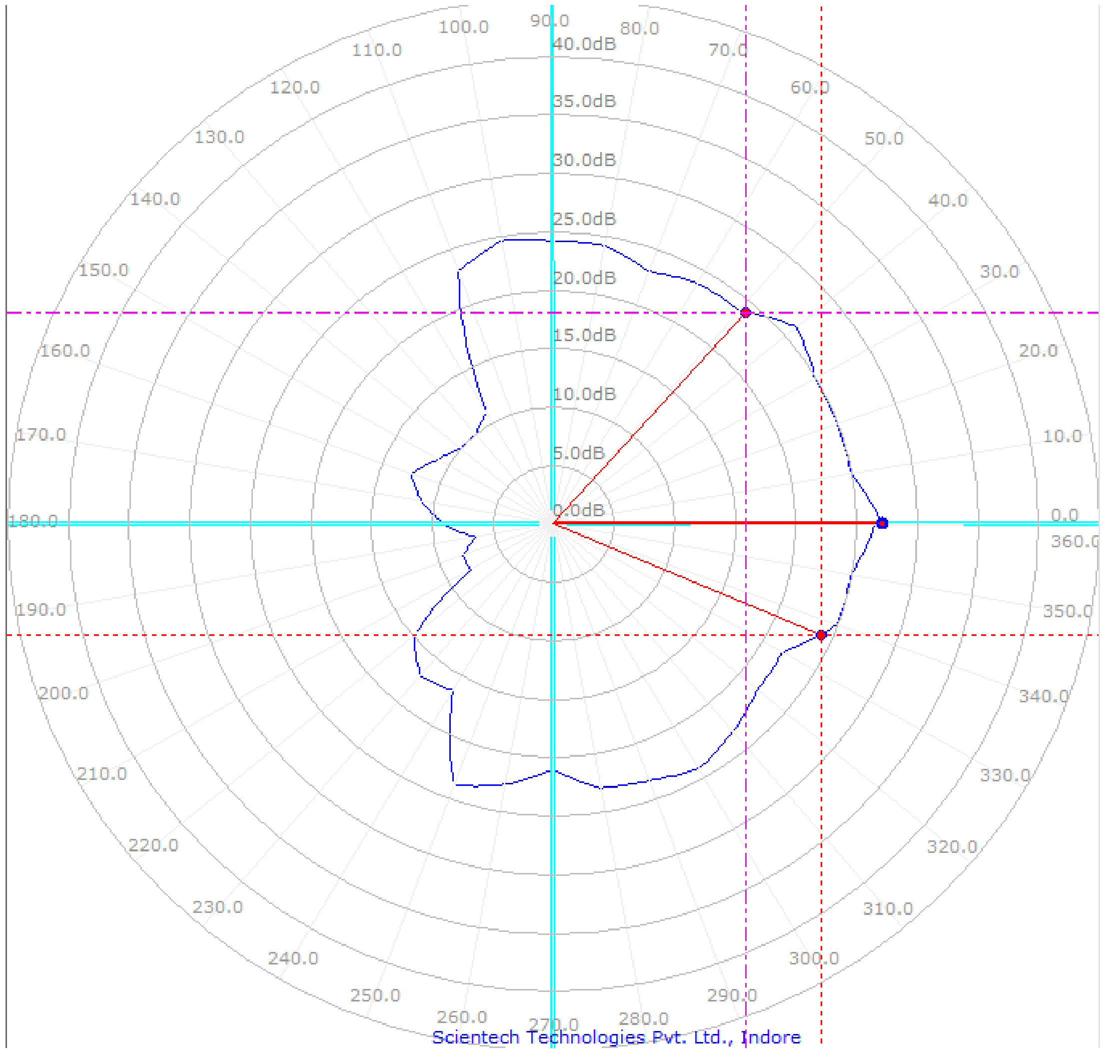


Figure 4.4-9: Radiation pattern showing HPBW of antenna

From figure 4.4-9 it is found that HPBW is equal to 72˚. Since -3dB gain or half power of maximum power is observed at 49˚ and 337˚ , so difference is 72˚ .

4.4.8 Observation of side lobe angle:

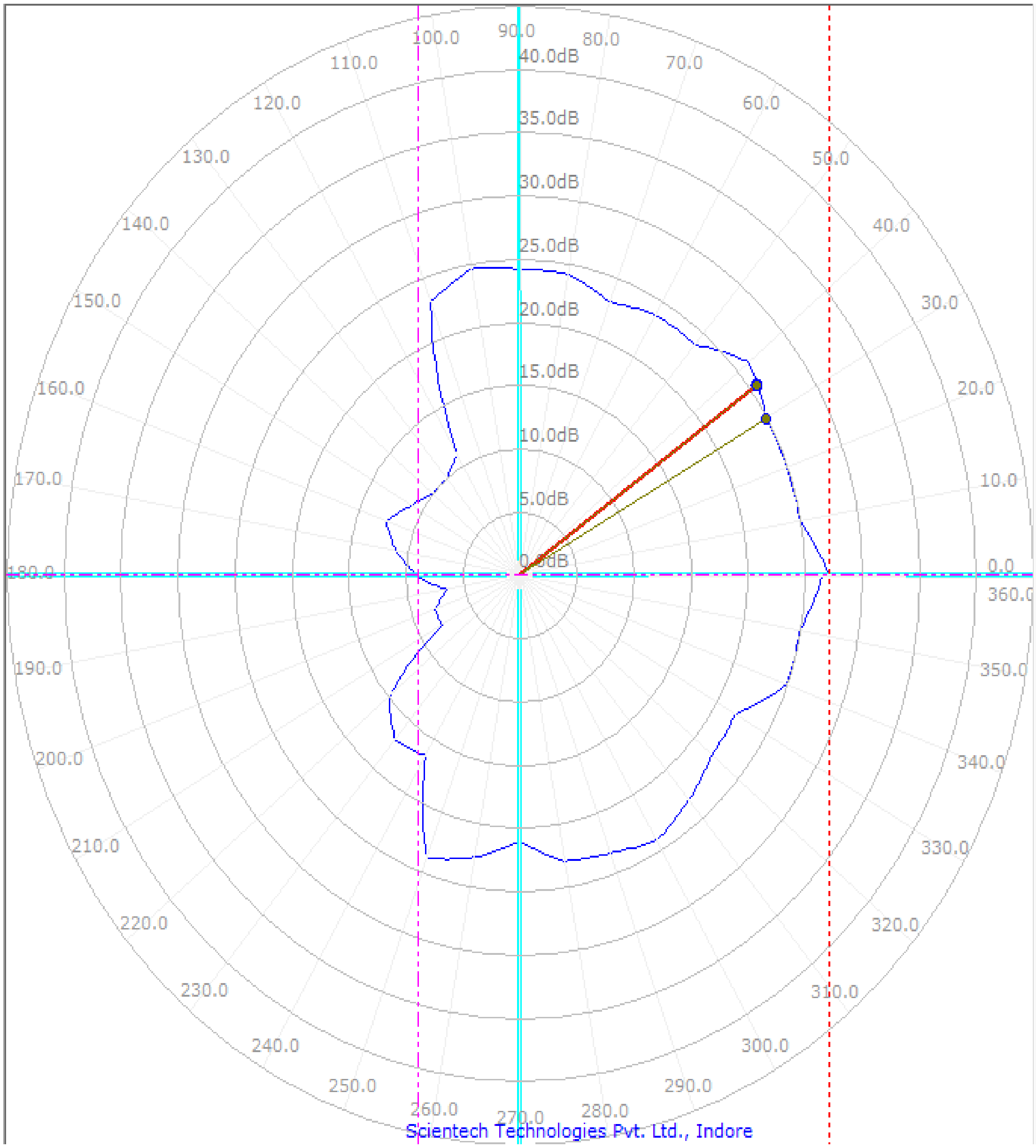


Figure 4.4-10: Radiation pattern showing side lobe angle of antenna

From figure 4.4-10 side lobe angle is found 6° and front to back ratio is 18.10 .

4.4.9 Radiation pattern of antenna using Cartesian plot:

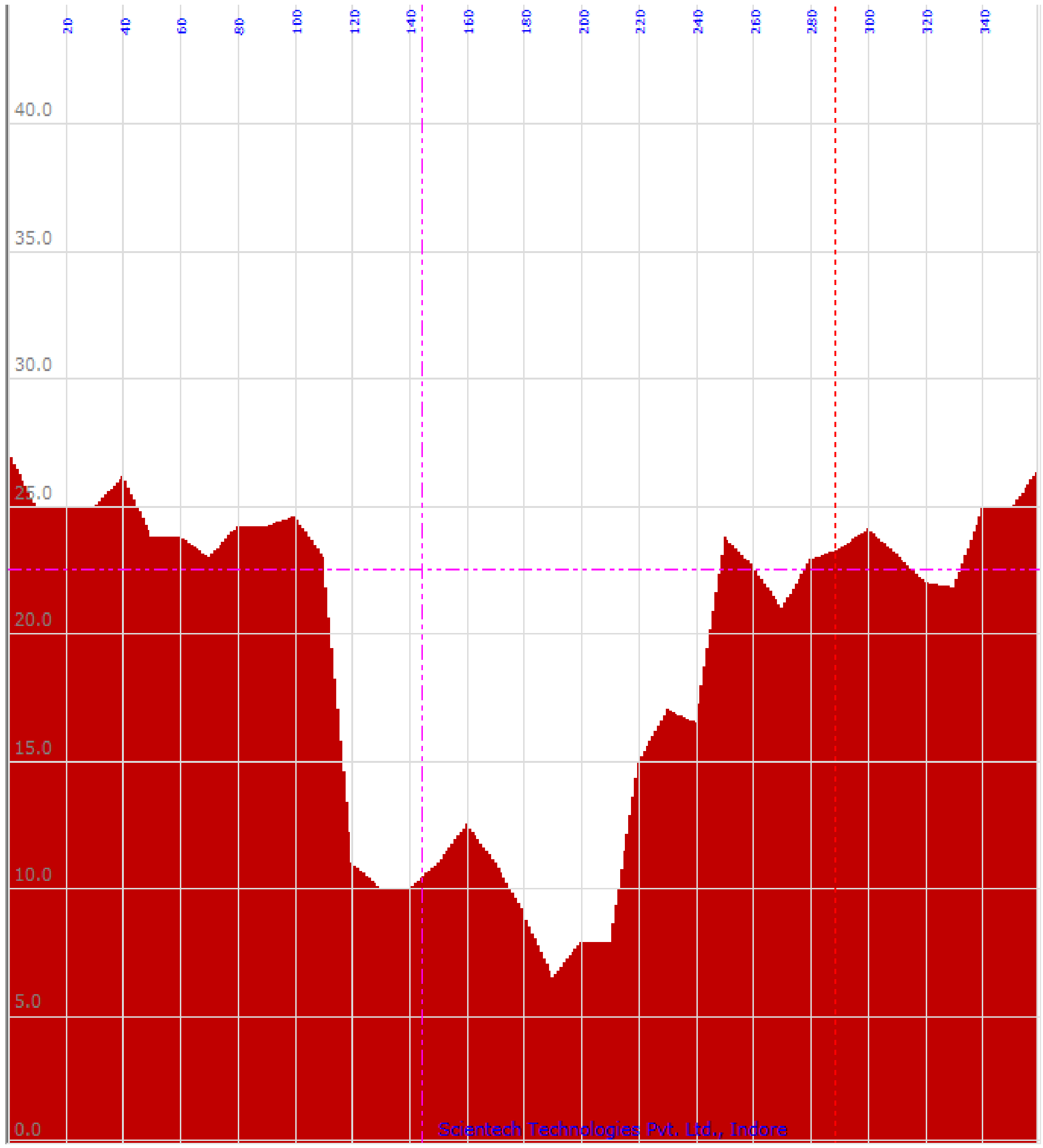


Figure 4.4-11: Radiation pattern of antenna using Cartesian plot

4.5 Receiving antenna:

To receive transmitted signal at receiver ferrite rod antenna has been used. Ferrite rod antenna is easy to design since only there is need of wound the wire over it and then there is need of capacitor for tuning purpose.

The ferrite rod antenna is a form of RF antenna design that is almost universally used in portable transistor receivers where the long, medium and possibly the short wave bands is required to receive.

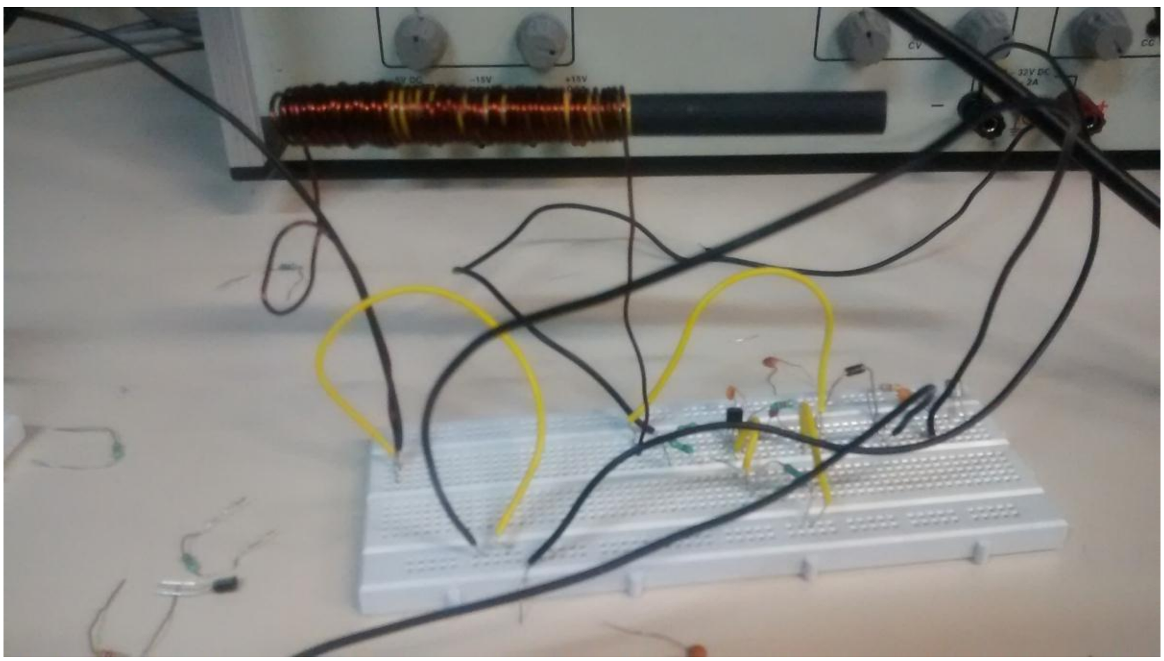


Figure 4.5-1: ferrite rod antenna used in this project

4.5.1 Ferrite rod antenna:

As the name suggests the antenna consists of a rod made of ferrite, an iron based magnetic material.

The antenna is designed using a ferrite rod of the high permeability which is basically used for the purpose of concentrating the magnetic component of the radio waves about the high permeability μ of the ferrite rod.

Antenna is directive since the way it concentrates the magnetic component of the radio signals towards it. It performs best only when it is at right angles to the direction of the transmitter so that the magnetic lines of force fall in line with the antenna. This means that the antenna receives minimum signals when the antenna is in line with the direction of the transmitter.

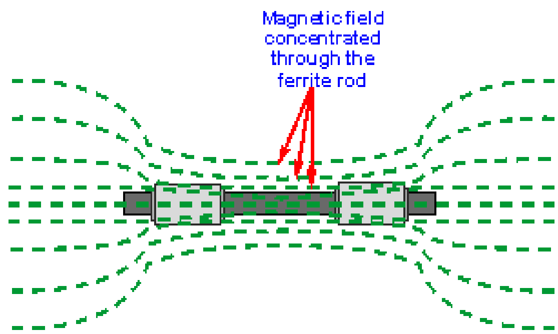


Figure 4.5-2: Operation of a ferrite rod antenna [2]

4.5.2 Performance of Ferrite rod antenna:

To design this antenna is very convenient for portable applications, but its efficiency is much less than that of a larger RF antenna. Ferrite material also limits the frequency response due to the losses in the ferrite. Normally this antenna is only effective on the long and medium wave bands, but it is sometimes used for lower frequencies in the short wave bands although the performance is significantly degraded.

Due to losses and poor efficiency, ferrite rod antennas are not used for transmitting anything but it is only used for receiving. If high levels of power were fed into them they would soon become very hot and there would be a chance that they would be destroyed. So, if power levels are very low and efficiency does not matter then it can be used as a transmitting antenna. As they are very much more compact than other forms of low or medium frequency RF antenna, this can be an advantage.

The two main parameters of ferrite rod antenna which are related to the efficiency are the Q of the tuned circuit, and the radiation resistance. These two parameters decide the application of this antenna.

4.5.3 Radiation resistance (R_r) of a ferrite rod antenna:

One of the advantages of using a ferrite in the antenna is that it increases the radiation resistance of the overall antenna so that it can work more efficiently and without the ferrite this small loop would have a very low radiation resistance. Accordingly the losses due to the resistance of the wire would be exceedingly high. By putting a Ferrite core in the coil it increases the radiation resistance by a factor of $\mu_{er}{}^2$, and thereby it brings the value into more acceptable limits.

While the ferrite rod increases the radiation resistance of the antenna, hence reduces the losses due to the resistance of the wire, it does introduce other losses. The ferrite itself absorbs power. This arises from the energy required to change the magnetic alignment of the magnetic domains inside the granular structure of the ferrite. The higher the frequency is greater the number of changes and hence the higher the loss [2].

R_r is given by following formula :

$$R_r = 197\ \mu_{er}{}^2\, n^2\, C^4\ \ \Omega\ [1]$$

Where,

μ_{er} is effective relative permeability of ferrite rod.

n is number of turns.

C is circumference of one turn of loop over rod.

4.5.4 Loss resistance of antenna (due to ferrite rod):

$$R_f = 2\pi f\, \frac{\mu_r{}''}{\mu_r{}'}\, \mu_\circ n^2 \frac{A}{l}\ \Omega\ [1]$$

The inductance of this antenna is

$$L_f = \mu_{er}\,\mu_\circ\, n^2 \frac{A}{l}\ H\ [1]$$

4.5.5 Ferrite rod antenna Q:

One of the requirements for an efficient ferrite rod antenna is that it should have a high Q at the frequencies over which it operates.

$$Q = \frac{2\pi f_\circ L_f}{R_f + R_r}\ [1]$$

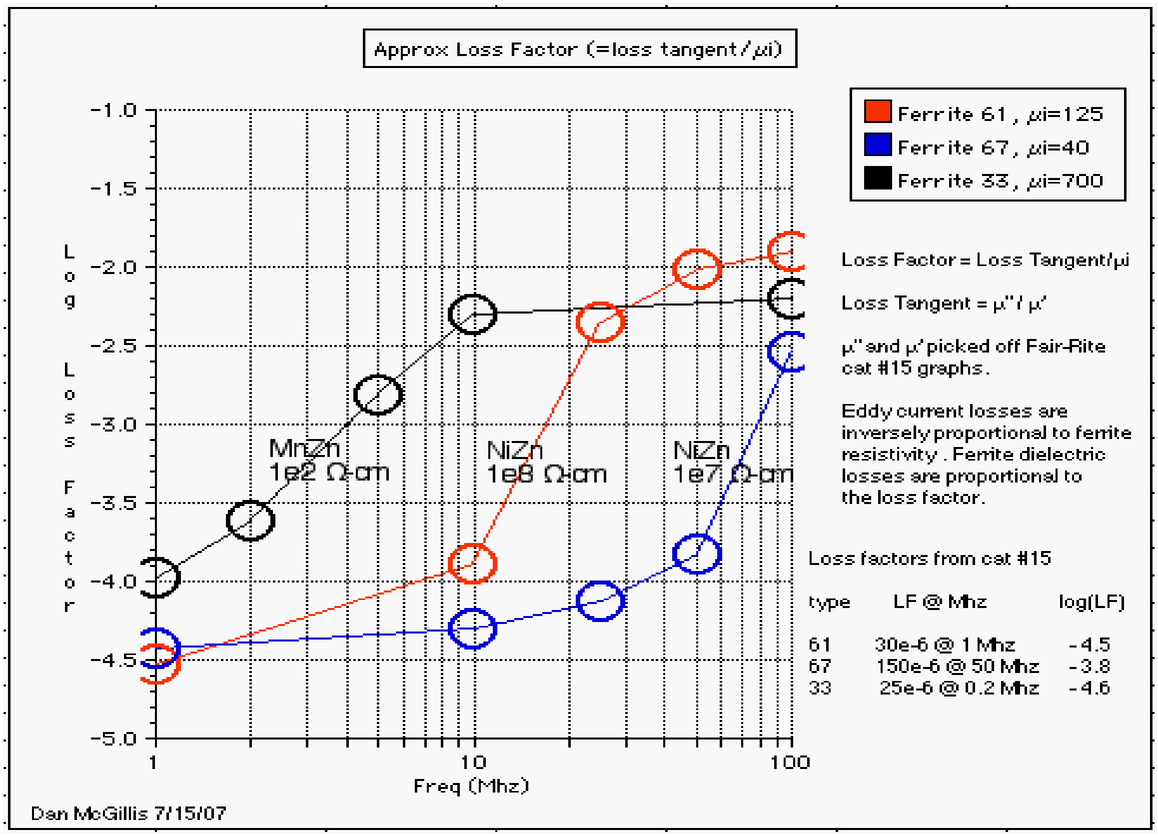


Figure 4.5-3: plot of loss factor of different ferrite rod [4]

4.5.6 Parameters of designed ferrite rod antenna:

Parameters of designed ferrite rod antenna (like loss resistance, loss tangent) are calculated using figure 4.5-3.

Table 4.5-1: calculated value of designed ferrite rod antenna

Parameter	**Value**
Number of turns(n)	56
Diameter of rod(D)	0.9cm
Length of rod(L)	14cm
Effective relative permeability of ferrite(μ_{er})	125
Loss tangent ($\frac{\mu_r''}{\mu_r'}$)	3.95×10^{-3}
Radiation resistance(R_r)	6.2kΩ
Loss resistance(R_f)	360Ω
Inductance of rod(L_f)	224μH
Quality factor(Q)	2.8

Conclusion and future work:

References:

[1] John D.Kraus, Antennas, 2nd ed. McGraw-Hill Inc, 1988.
[2] http://www.radio-electronics.com/info/antennas/ferrite_rod_antenna.
[3] http://www.antenna-theory.com/basics/main.html.
[4] http://theradioboard.com/rb/viewtopic.php?t=439.
[5] http://electronics.stackexchange.com/questions/100518/rc-time-constant-and-diode-detector.
[6] http://www.evalidate.in/lab3/pages/ASK/ASK_T.html.
[7] http://scholar.lib.vt.edu/theses/available/etd-02102000-19330046/unrestricted/07chapter2.PDF.
[8] http://www.db9-pinout.com/.
[9] http://www.dragonwins.com/domains/getteched/de248/rs232.htm.