Design and Analysis 4*4 MIMO antenna for UWB Application

BY

MD Shaman Rahman Shanto , ID: 181-33-653 &

Mohammad Fazuan Al Mahmud , ID:181-33-645

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Supervised By

MD Asraful Haque

Assistant Professor

Department of EEE

Daffodil International University

DAFFODIL INTERNATIONAL UNIVERSITY

DHAKA, BANGLADESH

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CERTIFICATE OF APPROVAL

Design and Analysis 4*4 MIMO antenna for UWB Application.

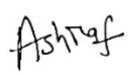
MD Shaman Rahman, Mohammad Fazun Al Mahmud bearing Student ID 181-33-653 and 181-33-645 of Academic Year 2018-2021 has been found satisfactory and accepted as partial fulfillment of the requirement for the degree of Bachelor of Science in Electrical and Electronic Engineering in 31 December 2021.

Signature of the candidates

MD Shaman Rahman
ID : 181-33-653

Mohammad Fazuan Al Mahmud
ID : 181-33-645

Countersigned



Md Asraful haque

Assistant professor

Declaration of Candidate

It is hereby declared that this thesis or any part of it has not been submitted elsewhere for the award of any Degree or Diploma.

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List Of Symbols And Abbreviations

ADC	Analog-to-digital converter
AGC	Automatic gain control
BLAST	Bell Laboratories layered space-time architecture
CDF	Cumulative distribution function
CEPT	Conference of Postal and Telecommunications Administration
CW	Continuous-waveform
DAA	Detect and Avoid
DSSS	Direct-Sequence Spread-Spectrum
DSP	Digital signal processing
EBG	Electromagnetic band gap
EC	European Commission
ECC	Electronic Communications Committee (under CEPT)
E.I.R.P	Equivalent Isotropic Radiated Power
FBW	Fractional bandwidth
FCC	Federal communications commission
FDTD	Finite-Difference Time Domain
FEM	Finite Element Method
FH	Frequency hopping
Gbps	Gigabits per seconds
HFSS	High frequency structure simulator
IEEE	Institute of Electrical and Electronics Engineers
IoT	Internet of Things
IR-UWB	Impulse Radio Ultra-Wideband
ISI	Inter Symbol Interference
ISM	Industrial, scientific, and medical radio band
LDC	Low Duty Cycle
MB-OFDM	Multi-Band Orthogonal Frequency Division Multiplexing
MC	Mutual coupling

MIMO	Multiple-input-multiple-output
MISO	Multiple-input-single-output
MoM	Method of Moments
NB	Narrowband
NLOS	Non-line-of-sight propagation
PHY	Physical layer
PSD	Power spectral density
RF	Radio Frequency
SIMO	Single-input-single-output
SNR	Signal-to-noise ratio
STC	Space–time coding
S-V	Saleh-Valenzuela
SVD	Singular Value Decomposition
TG3	Task Group 3
TH-PPM	Time hopping pulse position modulation
TPC	Transmit Power Control
UHF	Ultra high frequency
UWB	Ultra-wide band
VNA	Vector network analyzer
VSWR	Voltage standing wave ratio
WBAN	Wireless Body Area Network
WiMAX	Worldwide Interoperability for Microwave Access
WiMedia	WiMedia Alliance
WLAN	Wireless local area network
WLP	WiMedia Link layer Protocol
WPAN	Wireless Personal Area Network

Abstract

Ultra-wide band (UWB) communication technology has received much publicity over the years as the most efficient solution for short distance wireless data communication. This is due to the large unlicensed bandwidth provided by the Federal Communications Commission (FCC) for UWB communications. Also, UWB technology is well suited to high-level data communications such as multimedia video streaming.

Moreover, as the world welcomes the beginning of the Internet of Things (IoT) era, the UWB Communication recovers some attention in home-based, home-based systems network systems and internal communication of health care systems. In these application areas, device manufacturers are interested in making their devices more portable as well as equipped with a high-level data connection. UWB technology meets these requirements.

This thesis introduces the design and analysis of a new two-hole band Ultra-wide multiple-input-multiple-output (UWB-MIMO) antenna for multi-band wireless application.

The proposed MIMO antenna achieves maximum variation on a single monopole note and so on thus suitable for high-speed wireless applications. To build a MIMO antenna, first, a UWB monopole antenna is carefully designed by cutting the beveling slot on the sides of a rectangular monopole antenna. This process improves the impedance bandwidth of an antenna and also helps to achieve multiband resonance features. The antenna reaches a 5.5 GHz bandwidth with 5 GHz, 6 GHz, 7 GHz and 9 GHz audio modes respectively. This makes the stick suitable for wireless multi-band communication.

These two the port MIMO antenna is then designed by removing the monopole antenna from the planar FR4 dielectric substrate size 34 *72 mm^2. Each MIMO feature is a feed separated by a feed line of 50Ω microstrip.

Also, this thesis presents a detailed analysis of effects of bevel spaces, antenna size, and spacing distance between features of the MIMO antenna in the performance of the proposed UWB monopole antenna and the MIMO antenna as well. The results are simulated with the help of a three-dimensional (3D) high frequency structure simulator (HFSS) simulation software.

Imitation effects indicate that the antenna is suitable for the multiband wireless system UWB-MIMO.

CHAPTER 1

OVERVIEW

1.1 Introduction

With the rapid development of wireless communication technology and the growing need for multimedia service, it is very urgent to see the data connection at high speed and high power. As a context wireless communication technology, MIMO technology has not only experienced a significant increase in power communication, but also significantly improved communication quality. In literature, the power of MIMO systems can be upgraded by MIMO systems if the channels are independent and uniformly distributed. Number and space of the antenna parameters are important MIMO notes. Theoretically, if the number of horns is present, the performance is improved. However, on cell phones and other small mobile terminals, with multiple antennas, space between the horns is not enough to ensure access.

High separation between horns. In fact, there are technical challenges in using mobile horns with

both low connection properties and sufficient antenna advantage for mobile devices. If the separation between multiple antenna systems is insufficient, system performance decreases in profitability and affiliation merging between the horns .

In recent years, multi-input communication systems (2 × 2 MIMO) use multiple antennas installed on receivers and transmission terminals to improve not only available data quality but capacity in multiple locations. To improve the separation between the two MIMO antenna ports,

Many designs have adopted a low-density structure to meet the requirements for high separation in MIMO antenna designing an ultra wideband stick (UWB). The seam gap and direct polarization are combined to improve the separation between the two horns in the 3 - 4.5 GHZ band. [4] shows what the MIMO system is made of two identical printed monopoly sticks. The upper distinction between antenna elements can be obtained by L-twisted branches and rectangular spaces embedded in the ground. The book [5] investigates how to apply DGS to dual-band antennas with high port-isolation. Study [6] provides the design of the UWB MIMO two-horn system with a high partition using a fork-shaped structure. Ultra Wideband (UWB)

The MIMO antenna is designed to [7], which uses a ground gap and a straight polarization mode to effectively prove the two-horn separation in the 3 - 4.5 GHZ band.

EBG structure. In order to reduce the overlap between the antenna elements, the four antenna elements are separated vertically to achieve the vertical effect; in the construction of [9], the UWB antenna is a printed dipole the antenna, as well as the antenna element are also adjusted vertically to achieve maximum separation between the horns. Based on these, in this paper, I am designing a dual antenna model 4 × 4 MIMO.

1.2 Background

The world is already happy with the promises of a multi-gigabit wireless connection. This is now considered the basic requirement for all future levels of wireless communication. In 2009, the IEEE announced the big deal validation of IEEE 802.15.3 standard for Wireless Local Networks (WPANs). This validation has emphasized the launch of the first IEEE 802 radio system that will deliver multi-gigabit output to consumer electronics . And, in the same year, the regular IEEE board made a major amendment to IEEE 802.11n by outlining a new approach that would allow significant visual output of wireless LANs (WLANs). This emphasizes high short-term data measurement WPAN and WLAN have made UWB technology a promising alternative in standard radio technology.

The latest emphasis on UWB technology is primarily due to the broad spectrum band assigned to UWB communications technology by the Federal Communications Commission (FCC). In the United States, UWB technology is given a bandwidth of 3.1 to 10.6 GHz.

Therefore, UWB technology allowed for multi-gigabit wireless communication [2]. However, in order to minimize legacy technology interference within the UWB spectrum (such as WLAN, WiMAX), FCC limits spectral density (PSD) UWB output to -41.3 dBm / MHz [3] - [4]. This limitation on PSD severely limits UWB technology data transfer rates.

To solve this problem, researchers are considering the possibility of merging UWB together with MIMO antenna technology. This is because MIMO antenna technology can greatly improve channel capacity (bits / Hertz) and wireless network speed without the need to increase channel bandwidth or transmission capacity. MIMO technology uses multiple sticks in both transmitter and receiver, and this has the advantage of improving channel capacity and signal quality without the need for add-ons, new spectrum or power . MIMO technology achieves maximum channel capacity to improve spectrum efficiency. In addition, a combination of MIMO antenna technology upgrades UWB device capabilities to minimize errors due to blurring of the signal path distributed by the NLOS environment. It is well known that UWB technology is abundant in indoor areas, where the problem of multi-way distribution is exacerbated and this leads to Inter Symbol Interference (ISI) error. Therefore, as MIMO antenna technology exploits distributing multiple ways to improve the capacity of a wireless channel, it only makes sense to combine UWB technology with MIMO [6]. Other advantages of MIMO antenna technology include high gain, low affinity, improved link quality, extended, reduced installation requirements for analog computer hardware, and local simultaneous performance.

In addition, MIMO-time space code (STC) strengthens the power of a particular signal transmitted without increasing the power For general transmission power, MIMO beamforming can increase signal coverage and provide multi-user communication support in a cost-effective way, the UWB-MIMO relay improves NLOS communication, and time conversion (TR) transmission explores multiple pathways distribution to improve the reliability or targeted availability of MIMO radars . These benefits will have a collective impact on the UWB communication system. Therefore, the design of the UWB MIMO antenna has gained popularity and is expected to dominate the future WPAN and WBAN.

However, there are two key issues encountered in the construction of the UWB-MIMO antenna. First, there is the need to make the antenna rod more compact. Second, the need to reduce the interaction between antenna components. Motivated by the desire for this to overcome these design problems, this thesis proposes a highly integrated multi-band object UWB-MIMO antenna with minimal connection between objects.

Also, the proposed antenna gains a high degree of versatility, good radiation material and very high resistance bandwidth. In addition, the proposed antenna has multi-resonance modes and can be used in various applications within the UWB spectrum. Thesis includes a complete description of the design process, simulation of performance features, and parameter analysis of outcomes of geometric size in antenna operation.

1.3 Objectives

The main objectives of this thesis are outlined below:

- To design an efficient multi-band UWB monopole antenna and analyze its performance.
- To describe the benefits of using MIMO antenna technology for UWB communication.
- Design a 4*4 MIMO antenna with improved bandwidth.
- To reduce antenna, return loss

1.4 Thesis contribution

- The thesis describes the benefit of using a MIMO over the UWB spectrum by simulating the diversity gain of the proposed UWB-MIMO antenna.

- The thesis presents a detailed description of the design procedure and performance analysis of a compact UWB-MIMO.
- To analyze the performance of all designed antennas individually in terms of antenna characteristics especially antenna gain, antenna return loss and antenna bandwidth.
- Thesis describes how to determine the balance between cohesion and alignment between UWB-MIMO antenna materials by performing the parameter of the envelope coefficient of connection and cohesion as a function of differentiation between antenna materials.

CHAPTER 2

Literature Studies

2.1 The UWB Antenna

“UWB communication systems" include communications that serve a variety of purposes. In the extreme case, the ultra wideband communication system is a system that requires a bandwidth of 500 MHz. Therefore, applications can be found in a few segments of the electromagnetic spectrum, from the UHF band up to mm wavelengths and wavelengths below mm. This section focuses on UWB antennas for communications within the UWB designated FCC frequency range, 3.1–10.6 GHz. When the UWB network began to draw the attention of researchers, (UWB-ICUWB First International Conference, 2001, considered a milestone), in the early 2000's, the horns used were large in size. Some of the previous versions of the UWB antenna include self-propelled antenna (spiral antenna) or wideband dipoles [22]. With the use of UWB technology on mobile devices, the large size of the antenna was becoming a constraint. As a result, size reduction was one of the main goals of UWB antenna designers.

2.1.1 History of UWB Antennas

The antenna is an integral part of all wireless systems. Russia's greatest physicist, Aleksandr Stepanovich Popov is revered as the founder of the antenna. In 1895, during experimenting with coherers, a device developed by Oliver Lodge, in Popov found that he could find "Hertzian waves" by attaching a stick to the coherer. As a result of this discovery, Popov is now widely regarded close to Marconi and Lodge as the founder of radio. Later, in 1898, Oliver Lodge filed a patent for a radio operator the raw horns are called the “capacity area”. In his patent, Lodge introduced the concept of "syntony," which means that the transmitter and receiver must be connected to the same frequency for obtaining a clear signal [45]. The Lodge went on to design several tuning circuits using horns similar to a modern antenna.

Lodge patent application too including images of his two horns. Therefore, the history of UWB antennas can be traced back to the era of spark-gap radios. Oliver Lodge was also praised for introducing the concept of monopole horns that used the earth as a ground plane. Lodge horns are described in.

By the beginning of the 20th century, interest in the mass media had waned immediately due to the introduction of narrowband communication technology. However, for decades after the pioneer work of Lodge and Popov, Carter revived the science and art of the broad band antenna construction in the 1940s. This renewed interest in wideband connections was due to the advent of television and the need for a wider bandwidth of video signal transmission. Carter antenna gained wide bandwidth by introducing a feed attached to the original Lode antenna .Carter it also improved on the Lodge biconical antenna and made an improved monopole antenna.

Also, in 1940 Schelkunoff proposed a circular waveguide in conjunction with a circular dipole. He says. These projects were patented in 1941. The Schelkunoff antenna is similar to a coaxial horn antenna when assembled. Schelkunoff's antenna was later developed by Linenbald in 1941 In 1962, Marie approved an improved slot antenna that worked with Schelkunoff. He says. In 2000, Barnes made further progress on the Marié antenna. Schelkunoff's coaxial horn antenna, Lindenblad antenna and Marie antenna are described in .

From a brief historical study of the above, it is clear that the broad band horns go back to the era of spark plug and therefore long ago preceded the recent thunder of UWB radio. However, in recent times too many UWB antennas have been established due to the development of UWB radio. In addition, UWB's latest antennas are smaller and work better than before with broad bands. In the next section, we will briefly describe the artistic status of the latest UWB horns.

2.1.2 Advantages and Disadvantages of UWB Technology

The UWB network has gained popularity as a future standard for the WPAN shortlist communication. This is due to its large bandwidth. According to Hartley-Shannon's law, the maximum bandwidth translates to a larger channel volume. This allows for much faster data values in the range of a few gigabits per second (Gbps) per channel up to 10m.

Also, UWB has some exciting benefits that have made it so popular. Table 2 introduces a summary of the benefits and benefits of UWB communication.

Following are the advantages of UWB:

Low Power
Good noise immunity
Signals can penetrate variety of materials
easily high immunity to multipath fading
potentially very high data rates

Following are the disadvantages of UWB:

Higher cost
Slower adoption rate
Long signal acquisition times
FCC has limited emission requirements which is less than 0.5 watt max power over 7.5 GHz band
The UWB technology has issues of co-existence and interference with other radio based technologies.

2.1.3 Application of UWB technology

The UWB has found application in various areas. These areas include: Wireless personal area communications (WPAN and sensor networks), radar, positioning systems, and imaging systems. The impact of the UWB technology in these areas is briefly described in Table

Applications		
	Military and Government	**Commercial**
Data communications	-Secure LPI/D communications -Covert wireless sensor networks (battlefield operations)	-Secured WPAN - Local and personal area networks - Wireless streaming video distribution (home networking) - Wireless sensor networks (health and habitat monitoring, home automation)

Radar	-Through-wall imaging (for law enforcement, firefighters) -Ground-penetrating radar (for rescue operations) -Surveillance and monitoring	- Medical imaging (remote heart monitoring) - Ground-penetrating radar (detection of electrical wiring, studs, etc. on construction sites) - Automotive industry (collision avoidance, roadside assistance) - Home security (proximity detectors)
Localization	-Personnel identification -Lost children -Prisoner tracking	-Inventory tracking -Tagging and identification -Asset management

2.2 Antenna Parameters

An antenna can be defined as a transducer that converts electrical energy into magnets and vice versa. In order to determine if a machine design is good or bad, there must be some measurable features of that device that can be measured by standard values. Antennas also have different types of parameters to help one understand power once and for all weaknesses of design. The antenna parameters are different and depend on each other. Therefore, whenever an antenna is built, one has to make sure everything is in order with advanced parameters. For example, if the design of an omnidirectional antenna is made with reflection efficiency greater than - 6dB, and that omnidirectional pattern has no value, as he says it will not emit rays. The key parameters associated with this thesis will be discussed briefly in this section.

2.2.1 Antenna Field Regions

Although not the antenna parameter itself, the knowledge of the antenna field regions is such It is important to understand how far the antenna takes from the antenna shine. The fields around the antenna are divided into 3 regions:

• Nearby Active Stadium
• It emits radiation near the Camp or Fresnel District
• Remote Area or Fraunhofer District

The distance to the remote field is very important, as this determines the radiation pattern of the pole and many other parameters. Also, horns are used for wireless communication from a long distance, so this is a working place for many horns.

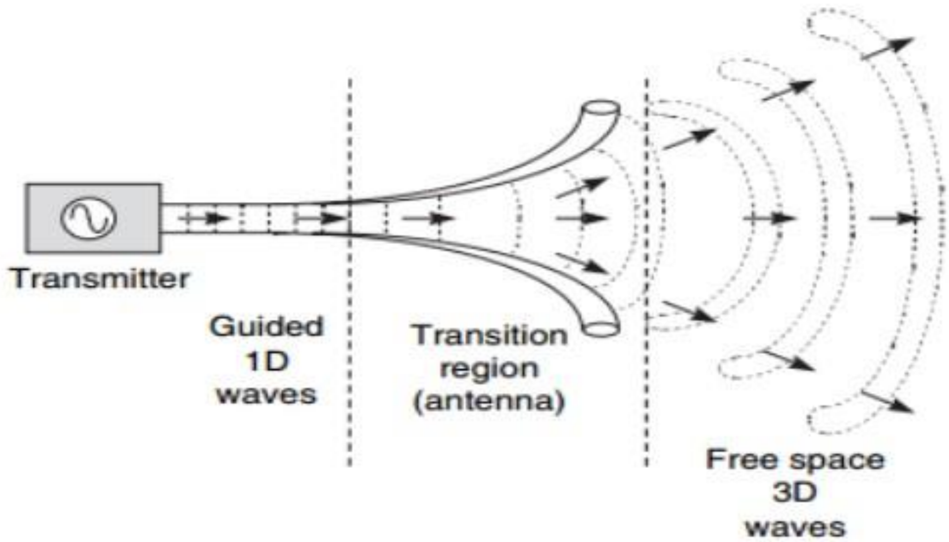


Figure : 2.2.1

Antennas have two field components in electric field measurements and Magnetic. These are called radiation fields and active fields. In parts of the active field, usually there the distance ‘r’ is a numerical denominator that is two or more systems two. There is a distance to the radiant part and with an ‘r’ of the first system.

As a result, as the distance increases, the active part of the field dies but becomes radiant the remaining part, which dies at a greater distance than the active areas. As the field is large in the vicinity, there is not much radiation available. But this distance is too small to hear, of the R $<\lambda$ (Wavelength Length of Active Waves), mm and cm in microwave frequencies. As a result, anytime any parameter is said to be discussed, in fact far away, as only radiation is present there, unless it is specified that it is done in the vicinity of the field.

2.2.2 Radiation Pattern

The pattern of the antenna radiation pattern is a symbolic representation of the intensity of the antenna about space links, usually in a circular link system. Based on the radiation pattern, horns appear as directional or omnidirectional. When the antenna shines equally at azimuthal angle but varies with height sinusoidally, the antenna is called omnidirectional. On the other hand, if the antenna pole is lit. with high direction at any particular angle relative to other angles, it is said to be precise. The direction of the antenna is expressed by a term called directional. The radiation pattern can be displayed as a 3D architecture, a 2D architecture or a Polar architecture. 2D and Polar sites are important for analytical purposes. We can see in the picture the pattern when you say glory in different ways from these figures.

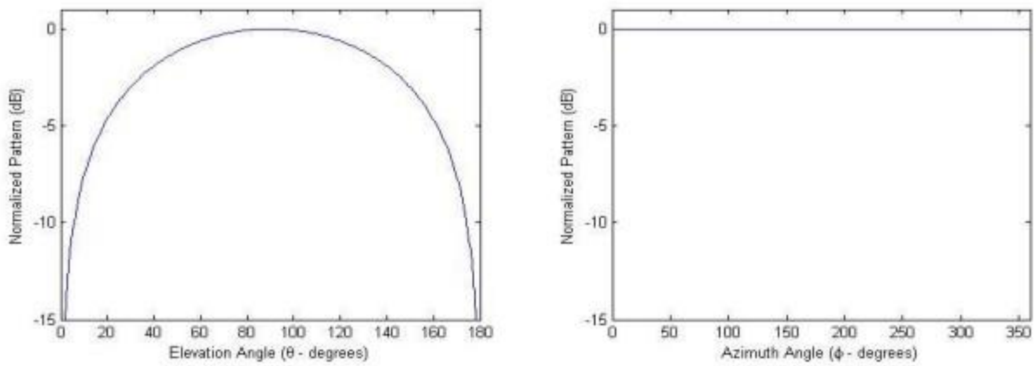


Fig : 2.2.2

2.2.3 Directive Gain

The directional antenna shines differently at different angles. The degree of intensity of radiation at a certain angle in relation to the degree of radiation in all directions is of direct benefit to that angle. It is often displayed in 'dBI'.

$$Directive\ Gain\ at\ an\ angle = \frac{Radiation\ intensity\ at\ that\ particular\ angle}{Average\ radiation\ intensity}$$

2.2.4 Directivity

A directional antenna always has an angle of radiation where radiation intensity is higher than all other directions. The directive gain of a directional antenna at the direction of its maximum radiation is called directivity of the antenna.

2.2.5 Antenna Efficiency

The antenna is always associated with at least two types of losses. One is due to the difference in collision between the feed line and the antenna and due to the blocking difference between the antenna and the free space. Another is due to the loss associated with the antenna due to its conductor. As a result, all input power will not be distributed. The ratio between the output power and the input power of the antenna is called its efficiency.

$$Antenna\ Efficiency = \frac{Output\ power}{Input\ Power} \times 100\%$$

2.2.6 Antenna Gain

The gain of the antenna direction of the antenna is considered for the efficiency of the antenna. It can be said that the direction of the antenna is a valid case and the gain is a real offense. Therefore, if it is not guaranteed that all the rainbow powers will be distributed, then the profit and direction will be the same. As in real situations, there will always be losses associated with sticks; profit is always less than direct.

$$Antenna\ Gain = Antenna\ Efficiency \times Directivity$$

2.2.7 Voltage Standing Wave Ratio

Since it is not possible to fully match the tangible line between the antenna and the generator, there will always be some conflict. This misalignment of impedance will force another signal to be displayed backwards from the antenna to the generator. The forward wave to the antenna and this wave from the antenna are all inside the waveguide. These two voltages together form a 'Standing Wave' within the waveguide. This wave has its limitations and limitations. The ratio between the maximum and minimum voltage within a waveguide is called the Voltage Standing Wave Ratio (VSWR).

$$VSWR = \frac{Maximum\ voltage\ of\ standing\ wave}{Minimum\ Voltage\ of\ standing\ wave}$$

The minimum VSWR value is 1 where there is no difference between generator and note. Represents a wavelength of 100% radiation and a reflected wave of 0%. Generally, VSWR 2 is accepted as a good match as it represents about 10% of the power shown.

2.2.8 Return Loss / S11 Parameter

Recovery loss is another parameter for transmitting impedance variance information. Although it gives you the same details as the VSWR, it is a very popular parameter to explain the differences in impedance and resonance in antenna books. Reflection is a coefficient measure of the strength shown and the effect of the event. It is calculated as follow

$$Reflection\ Co-efficient, \tau = \frac{z_A - z_o}{z_A + z_o}$$ s:

There, zA = Antenna impedance z_0 = Transmission inefficiency If there is a perfect match between line obstruction and line rotation, signal efficiency is zero which should not be displayed. The loss of return is the amount of reflection coefficient in decibel. The relationship between Reflection Coefficient and VSWR is as follows:

$$VSWR = \frac{1-\tau}{1+\tau}$$

Comparative information can be obtained about VSWR and recovery losses. The loss of return is given in the following figure in dB. The minus sign confirms that the refund loss rate remains at the positive value to comply with the IEEE definition. The minimum value of the return loss is called the s11 parameter.

$$Return\ Loss = -20\log\frac{VSWR-1}{VSWR+1}\ dB$$

2.2.9 Input impedance

Input impedance is the impedance presented by a ticket to its terminals or the voltage rating to current in two terminals. If the input impedance of the transmission line and antenna are matched, the maximum power transmission will be achieved. Failure to adjust it will result in a decrease in the efficiency of the system as a whole. This is because the reflected wave is generated at the antenna terminal and will revert back to the power source. In this parameter, the input impedance should be the same as the blocking of the signal transmission line in order to achieve a maximum power transfer between the transmission line and the pool. If the input impedance is different, the reflected wave will be generated at the antenna terminal and returned to the power source. Demonstration of power causes a decrease in the efficiency of the whole system. If the antenna is used to transfer or gain power, and only then will this efficiency of losses occur.

2.2.10 Antenna Bandwidth

An antenna has different types of bandwidth depending on the different types of parameters. There is a range of frequencies where the recovery loss is less than -10dB which will be called the s11 bandwidth parameter. If there is a list of frequencies where the radiation pattern stays as expected, that will be the radiation pattern bandwidth. But when there is a range of frequencies, where all the parameters of the poles are within the acceptable range, it is called antenna bandwidth.

2.3 Feeding Technique

MPA has a variety of feeds As these horns have a dielectric substrate on the one hand and radioactive material on the other. These feed methods are classified as dual different contact and non-contact categories. The connection mode is right there power is delivered directly to the radiation pool by the connecting object i.e. through microstrip line The unaffected method is where a magnetic field is formed to transmit energy between the microstrip line and the radiation pool. Although there are many new ways, feed strategies are the most popular or widely used microstrip line, coaxial probe, aperture coupling and proximity coupling.

2.4 Feed Point Location

After selecting the L size and W size of the given substrate, the feed point should be determined to determine the positive impedance similarity between the impedance of generator and piercing element input. Changes in diet cause a change in input impedance and thus provides an easy way to match impedance. The feed point is selected in such a way that the resistance of the input of Rin is equal to the impedance of the feed line, usually considered to be 50 ohm.

2.4.1 Polarization

The polarization of the rectangular pool antenna is linear and oriented on the resonating side, when operating in prominent mode. . Heavy-duty antennas can work in High order mode too. The radiation pattern and polarization of these pathways may vary from the control mode. Another source of cross-polarization is the fringing field near no glittering edges. These fields are oriented 90 degrees relative to the field at the output edge radiation Their contribution to radiation in planes E and H is zero. . However, in flights between intercardinal, even final, patch single mode will output different fields. The level of cross-polarization increases with the strength of the substrate The polarization of the antenna can be replaced mechanically or electronically. Electronic tuning, PIN diodes or varactor diodes can be used. Varieties of polarization used in mobile communications to reduce signal strength due to blurring.

Comparison between Different Feeding Techniques

Characteristics	**Microstrip Line feed**	**Coaxial Feed**	**Aperture coupled Feed**	**Proximity coupled Feed**
Spurious feed radiation	More	More	Less	Minimum
Reliability	Better	Poor due to soldering	Good	Good
Ease of fabrication	Easy	Soldering and drilling needed	Alignment required	Alignment required
Impedance Matching	Easy	Easy	Easy	Easy
Bandwidth	2-5%	2-5%	2-5%	13%

Table: 2.4.1 (Comparison between Different Feeding Techniques)

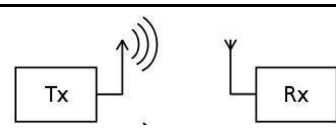
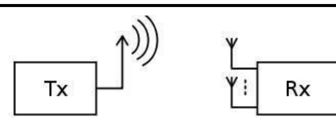
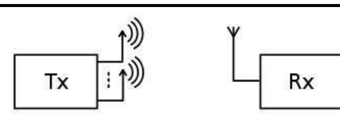
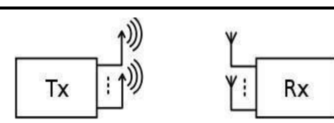
CHAPTER 3

UWB-MIMO antenna system

3.1 Multi Antenna Systems

Multi-horn communication system has received a lot of attention in wireless communication because it promises to increase the output and reliability of communication links . Multiantenna technology represents a major technological breakthrough from the standard Single input-single-output (SISO) technology. There are several types of multi-antenna systems used for wireless communication. These are SIMO, MISO and MIMO. Table 6 provides a brief description of the various antenna systems. Although all three multi-horned systems can increase the variability of the communication interface, the MIMO antenna system offers the greatest advantage. The MIMO method referring to the use of antenna series in both transmission and reception can significantly improve channel capacity, durability in multi-channel blurring and overall wireless connection performance.

Table 3.1: Multi-antenna system

Multi-antenna types		
SISO	Single-input-single-output means that the transmitter and receiver of the radio system have only one antenna.	
SIMO	Single-input-multiple-output means that the receiver has multiple antennas while the transmitter has one antenna.	
MISO	Multiple-input-single-output means that the transmitter has multiple antennas while the receiver has one antenna.	
MIMO	Multiple-input-multiple-output means that both the transmitter and receiver have multiple antennas.	

Normal radio systems are very limited. The connectivity capacity of the SISO radio system can only be increased by increasing channel bandwidth. Also, noise and blur on the channel can only be overcome by increasing the transmission capacity. These solutions comply with the Shannon-Nyquist terms. However, an important Bell Laboratories study with Gerard J.

Foschini's space-time architecture (BLAST) layer changed the field of wireless communication. Foschini has proven that by using multiple horns on both the transmitter and receiver, the wireless channel capacity can be greatly increased without increasing the channel bandwidth and transmission capacity. Foschini realized that by carefully supplying the data packets to be transmitted to the transmitting antennas, he could not simultaneously transmit multiple data streams through the same channel. Therefore, BLAST has improved the channel capacity by enabling local duplication over wireless communication systems with multiple antennas.
The BLAST system has proven that multi antennas can be used to increase channel capacity. Also, researchers have investigated some of the benefits of using multiple horns on the receiver. The researchers showed that by using the appropriate processing properties to integrate the different types of transmitted data packets received by multiple antennas into the receiver, the multipath scatter in the channel could be used more efficiently to increase channel capacity and make the communication link more powerful. against the problems of blurring of the multidisciplinary approach seen in the receiver. This is in stark contrast to SISO radio programs where multi-channel congestion caused by station constraints is considered a major problem for the receiver. These findings have made the use of many antenna systems popular in modern wireless communications.
In this chapter, we will briefly discuss the variations of MIMO and the benefits of using the MIMO strategy in UWB communications. This chapter includes a brief discussion of MIMO channel modeling, a brief review of the UWB-MIMO State-of-Art antenna program and the challenges of designing UWB-MIMO antenna systems.

3.2 MIMO Diversity

Diversity is a method used to increase the reliability and spectral efficiency of a blurring channel by introducing some unwanted features. The main purpose of the variation is to increase the performance of the blurred channel by transmitting the desired signal through different M channels. Therefore, while some copies of signal received may be extremely detailed, other copies may not be. So by introducing redundancy (transferring several copies of the same signal) we can overcome the problems of deep depression.
There are three main types of variation: time variation, frequency variation and spatial variability. Over time, the signal carrying information is transmitted to different time zones. That is, each sign is transmitted several times. In order to ensure that each transmission has an independent blur, successive transmissions should be separated by a time interval that should be at least equal to the compliance time. Consistent with the appropriate error code, time variables can be used to combat selective (instantaneous) blur on the channel. With a variety of frequencies, the same information signal is adjusted by the different M carriers. 15
In order to ensure that the different copies of the received signal are blurred independently, each network company must be allocated at least the corresponding bandwidth (Δf) c . Sound variation is used to overcome the blurring selection frequency in the channel.
Depending on the location, the same information signal is transmitted or received by different Ms for maximum gain. To ensure that the different copies of the received signal are dimmed independently, the sticks must be properly separated. Alamouti 2×1 space code is considered

an important study in the transmission of diversity. The MIMO antenna method uses location variation on both the transmitter and the receiver side. Therefore, each receiving antenna provides an independent signal path from the sender to the receiver. This makes the connection link stronger against channel blurring and allows local duplication which can greatly increase channel capacity without increasing channel bandwidth or transmission capacity. Popular local duplication schemes include BLAST, Vertical-BLAST, Turbo-BLAST and Diagonal-BLAST.

3.3 MIMO Channel Model

The standard MIMO system has antennas that transmit and receive horns. The transmitter simultaneously sends copies of the same information signal via antennas. For the recipient, each state receives not only the signals for which they are made but also the intended components receive the sticks [83]. The receiver determines the actual information by combining all the received signals. Therefore, the MIMO channel can be modeled as a matrix channel that combines m n methods. The direct route from the first transmission line to the receiving receiver is defined as h11 and the direct route from the second receiving signal to the second receiving receiver is specified as h22 etc. Channel matrix, H will be modeled as n × m. matrix given as:

$$H = \begin{bmatrix} h_{11} & h_{12} & h_{..} & h_{1m} \\ h_{21} & h_{22} & h_{..} & h_{2m} \\ h_{..} & h_{..} & h_{..} & h_{.m} \\ h_{n1} & h_{n2} & h_{n.} & h_{nm} \end{bmatrix}$$

The MIMO system is modeled by the transmission formula:

$$Y = Hx + n$$

Where y is the receive vector, x is the transmit vector and n is the noise. Figure 3.3.1 shows a general MIMO system.

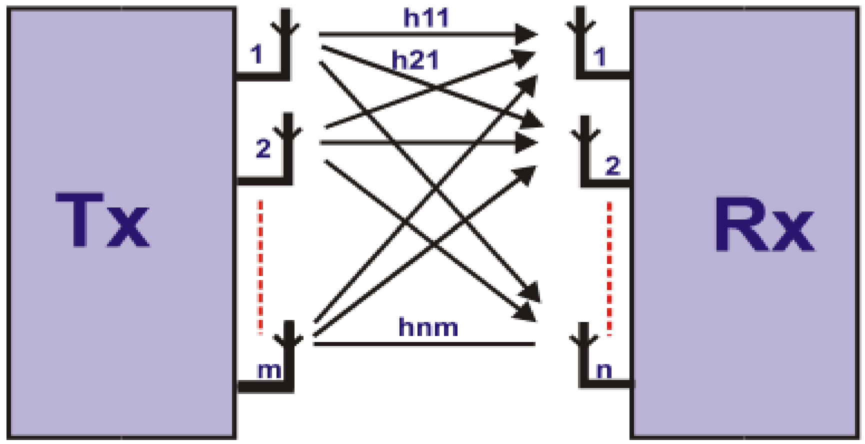


Figure 3.3.1: General MIMO system

The channel model for a 2×2 MIMO system is shown in figure 3.3.2. The figure shows that the data is divided into four independent streams. At the receiver end, the received signal $y_1(t)$and $y_2(t)$ are processed by a DSP to extract the transmitted data (original data). The purple arrows in the figure-

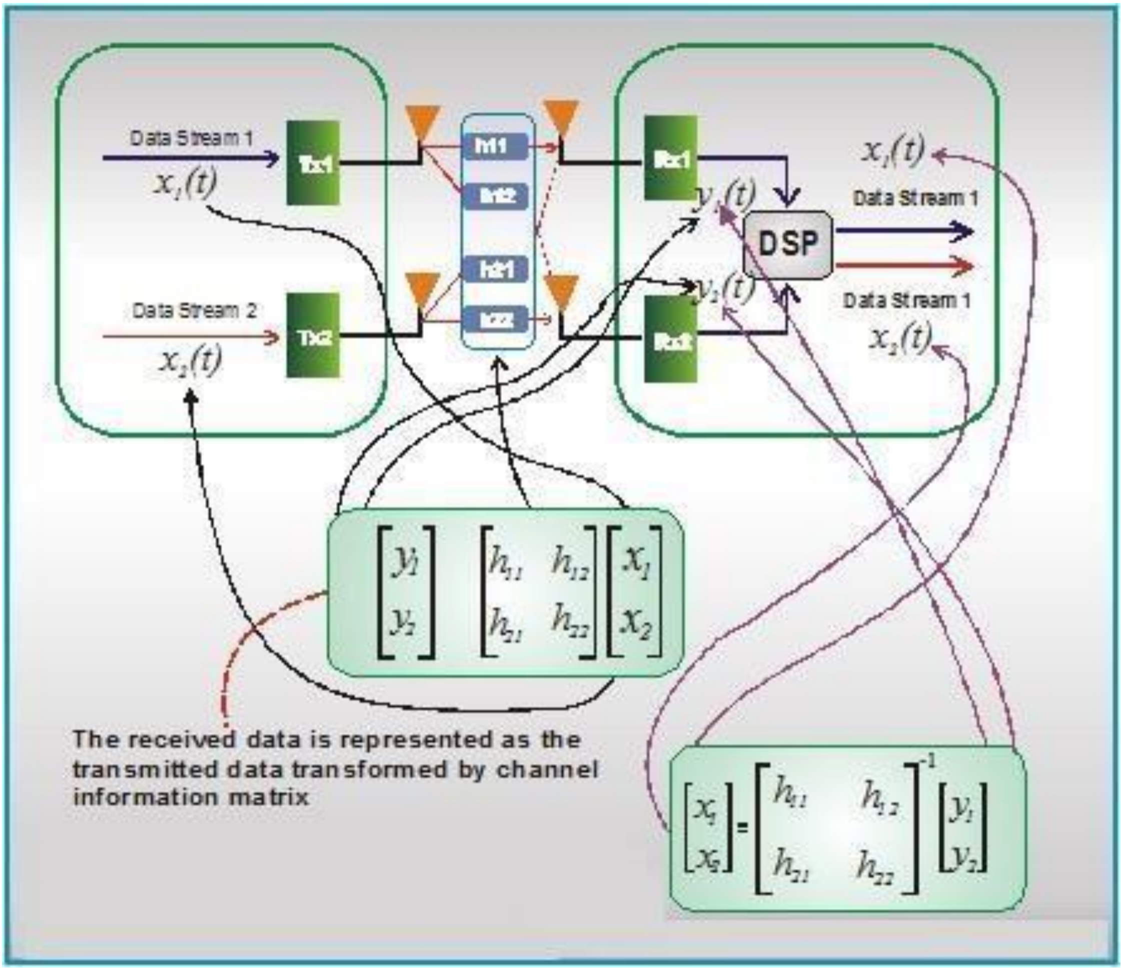


Figure 3.3.2: 2×2 MIMO channel model

show the process (matrix conversion) used to restore the original data received. The recipient can retrieve the transferred data by duplicating the channel information matrix and the received data. However, since not all channel matrices are flexible, this method will not always work. Fortunately, there are other strategies that can be used to circumvent this problem. They include SVD (Singular Value Decomposition). In SVD, the channel matrix is divided into three more matrics

The channel capacity of the MIMO channel will depend on the number of independent streams displayed by M. In the standard MIMO antenna line (m = n), M is less than the number of horns; while in asymmetric constellation (m, M remains smaller than the low number of horns. In any case, the capacity of the MIMO channel is given to ShannonHartley theorem such as: $C = MB \log_2(1+S/N)$

When B is the channel bandwidth and is the signal level in the sound. Therefore, it is clear that the capacity of the MIMO channel will grow in line with the number of independent streams. Therefore, as we increase the number of transmissions and embrace diversity in the MIMO system, the channel capacity grows linearly. Therefore, by adding more antenna components, we can increase spectral efficiency without increasing bandwidth or signal strength. This MIMO attribute can be used in UWB programs where signal output capabilities are severely delayed and therefore limit UWB systems to very short-term applications. In addition, there are other benefits to using MIMO antenna techniques in UWB communications.

3.4 Benefits of MIMO for UWB communication

Over the past two decades, the spectral efficiency and efficiency of wireless communication technology have greatly improved without increasing bandwidth or transmission capacity by integrating MIMO techniques into the PHY layer. As a result, in recent times, the design of a multiantenna system consisting of a few UWB high-speed data communications has been very promising. There are five important benefits of merging UWB with MIMO. These are: channel capacity, space time code (STC), beamforming, UWB-MIMO transmission and time reversal transmission (TR).

It has been proven by experiments that MIMO systems can significantly increase the capacity of a wireless channel by improving the utilization of transmission and power spectrum [86]. This process benefits from the use of space variability on both sides of the radio interface and the use of the appropriate STC to improve the output and reliability of the wireless connector [86]. The STC improves the reliability of the communication link in terminals by relying on the use of multiple transmission channels to transmit inactive copies of the same information signal . Thus, while Shannon-Hartley's (MIMO channel) theory explains the high benefits of merging UWB with MIMO (i.e., using multiple horns in the UWB system), STC enables the achievement of greater profits .

UWB beamforming provides a cost-effective way to maximize coverage of UWB communications, providing high data connectivity where needed and useful for internal implementation. TR is a non-traditional method that uses spatial variability to achieve spatial and temporal focus that helps to reduce intersymbol (ISI) disturbances caused by time-varying variables of the dispersed pathways and compensates for the diversity of channels in a highly obscure area. Also, since UWB releases have a limited PSD, their installation is limited. Multihop transmission has emerged as a solution that enhances the coverage of UWB programs by separating the link between the data source and destination. This reduces the loss of the end point between the source and the destination, especially in non-linear (NLOS) indoor areas . In addition to reducing route losses, by enabling co-operation between the source, destination and relays, the UWB-MIMO transmission can also enhance the benefits of location variability. Results show operational benefits of using the UWB-MIMO relay.

3.5 State-of-Art of UWB-MIMO antenna Design

In view of the aforementioned benefits of using MIMO horns in UWB systems, a variety of design techniques for UWB MIMO sticks have been proposed. In [99], the authors investigated the effects of inserting a Y-shaped stub into a UWB-MIMO sub-plane with two identical monopoles. The stub acts as a filter that enhances the separation between the holes for the glittering material and reduces the cohesive bonding. This also helped to slow down the proposed UWB-MIMO antenna. However, the introduction of the inverted-Y shape made the design very difficult to implement. In , the authors investigated the effects of antenna position on impedance simulations and similar combinations of two UWB-MIMO antenna components. From their analysis, the horizontal antenna positioning system gained lower affiliation than the vertical antenna positioning system. However, the antenna configuration achieves more cohesion in MIMO list configuration than the previous antenna configuration. M. Ju-soh et al. investigates the impact of spatial design on the radiation pattern of the dual band UWB-MIMO with similar characteristics . The authors conclude that their proposed MIMO antenna has a higher efficiency than a single antenna due to the equal influence of radiation intensity. However, the design of the antenna is complex and not very complex. In , the novel suspension of the quasi rhomboid shaped bowtie antenna for UWB-MIMO applications was introduced. The antenna that is connected and has a good connection. However, the formation is very complex as it requires attaching a radioactive reservoir to both sides of the substrate. This is a time-consuming process and will require great care to ensure balance in understanding the radiation leaflets on both sides of the substrate. Recently, it was reported that some of these UWB-MIMO horns are getting applications on portable wireless devices such as handheld [103] and emerging wireless systems such as underground sensor networks used in mines [104] and UWB radar. imaging systems.

3.6 Challenges in designing UWB-MIMO antenna systems

Although significant benefits can be gained through the use of MIMO sticks in wireless communication systems, there are three major challenges encountered in the construction of UWBMIMO horns. These are: cohesion, integration and relation. These challenges are related; thus increasing cohesion will increase the cohesiveness and the merging effect. Therefore, several authors have focused on a variety of strategies to minimize the effects of compounding and compilation. The natural way is to use the spatial division between the elements of the UWB-MIMO system. Recently, researchers have attempted to adopt a different designation for each item in the MIMO antenna list in order to minimize compounding and integration effects. Also, some researchers have suggested the use of well-constructed stubs to provide differentiation between antenna materials. In, the use of parasitic elements to reduce coupling by creating the opposite coupling was proposed. In and the authors propose the use of electromagnetic band-gap (EBG) and sequential dividing strip structures to reduce cohesive bonding. In each case, they have seized it, despite obstacles we can scarcely imagine. " Therefore, it is important for designers to use techniques that best fit their needs without compromising the purpose of the design.

CHAPTER 4

Design 4*4 MIMO antenna

In the literature review it has been noted that sticks, operating in the UWB band, bandwidth and gain remain poor on the same antenna. Therefore, the main focus of this idea is to design a microstrip MIMO antenna with an improved bandwidth and advantage over the UWB band. In this chapter the antenna designs are shown in chronological order where the gradual improvement of the antenna performance bandwidth is seen from the rectangular MIMOantenna to the multi antenna proposed.

Designing the desired antennas of CST simulation software has been used. All antennas are unique and capable of operating the UWB band system.

4.1. Basic Parameters

Three general parameters are given below for designing all the antennas accordingly.

· The frequency of operation: UWB band frequency domain has been selected for MPAs operation.

· Dielectric constant: RT/duroid substrate with dielectric constant of 2.3 has been selected as dielectric material for MPAs.

· Height of substrate: Generally, MPAs are very compact devices so for basic configuration of MPA standard thickness has been selected as 5 mm.

4.2 Substrate Selection

Substrate clearance and tangent loss are two of the most important parameters to consider when designing mimo antennas. The worst obstacles for the mimo antenna are its low bandwidth and low gain. Therefore, proper selection of substrate clearance reduces the amount of overhead losses and consequently improves the performance of the antenna in particular, impedance bandwidth and radiation efficiency. A thick substrate, in addition to being effective, will increase radiation power, reduce operator losses and improve impedance bandwidth. However, it will also increase weight, dielectric shrinkage, excessive wave loss and external radiation from the probe server. The lower dielectric constant of the substrate will increase the fringing field in the mimo periphery. As a result, the glowing power of the antenna will also increase. Therefore, a dielectric constant of less than 6.6 is preferred unless a small peach size is required. The tangent loss of the upper substrate increases the dielectric loss of the antenna and reduces the efficiency of the antenna.

The most widely used dielectric substrate materials are to print horns with permits ranging from 2 to 10 depending on the application. The lower the permit, the more the sticks benefit. This is because in order to get high clearance the lower moving wave decreases as it travels on the pole. In addition, increased substrate permeability causes light energy to leap more frequently and increase energy dissipation in dielectric material.

4.3. MIMO Antenna Dimension

The proposed UWB -MIMO antenna system is shown in Figure 4.3.1. The antenna has a total size of 2073.6 mm3 and is built on a FR4 substrate with a relative clearance and a loss tangent. The antenna is designed by carefully cutting the bevel spaces from the four edges of the rectangular monopole antenna. These bevel spaces help to improve the impedance bandwidth of the resulting antenna. Also, they help create more meaningful ways in the UWB operating bandwidth. Each area of the rod acts as a resonator. And a circular area is placed in the center of the stem. Along with the bevel spaces, the circular motion helps to control the flow of excess energy to determine the radiation pattern of the distant beam. In addition, the lower the antenna plane is reduced and this helps to improve the bandwidth restriction bandwidth.
The proposed antenna is designed with the help of a high-resolution three-dimensional (3D) architecture. Figure 4.3.2 shows a stick designed in CST. The antenna is happy using the 50 Ω feedline. Based on this design, a prepared set of design parameters is given in Table . This set of advanced parameters is obtained by carefully performing the simulation model parameters for each design parameter.

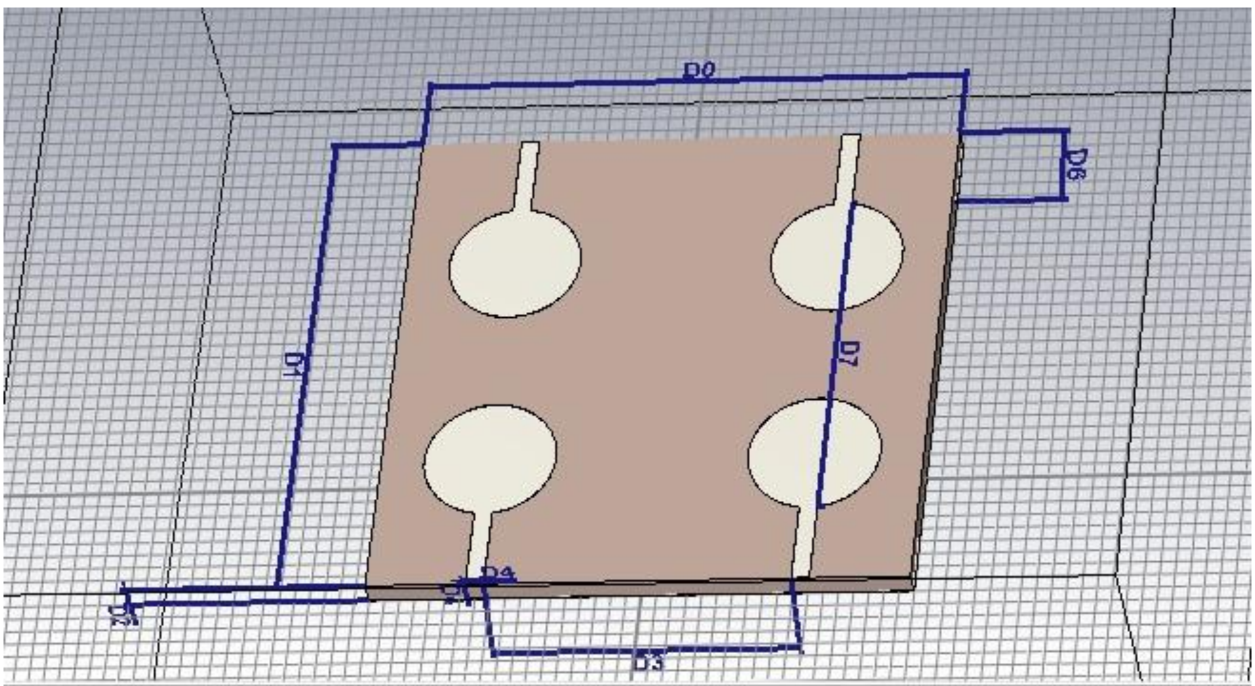


Figure : 4.3.1 The geometry of the proposed MIMO antenna

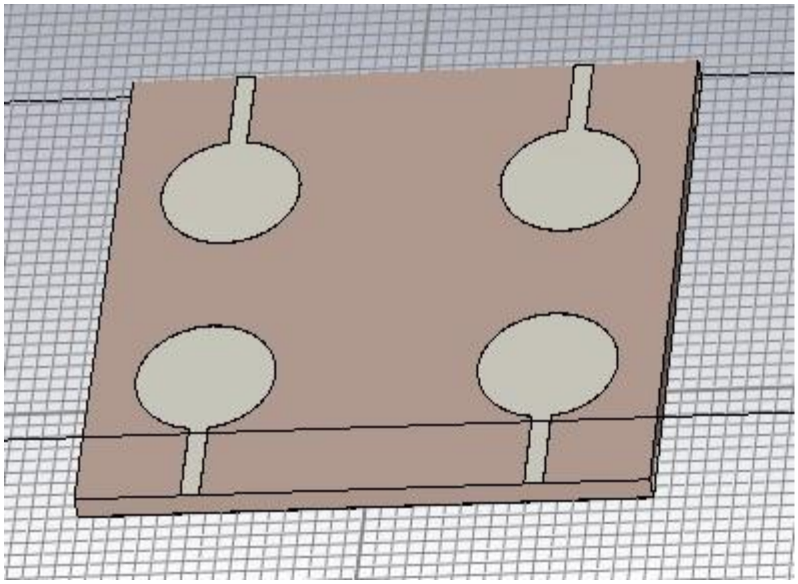


Figure : 4.3.2 The antenna modeler designed in CST

Antenna Parameters	Optimized value
D0	**36.00mm**
D1	**36.00mm**
D2	**1.60mm**
D3	**20.30mm**
D4	**1.20mm**
D5	**0.04mm**
D6	**4.78mm**
D7	**24.64mm**

CHAPTER 5
RESULTS AND ANALYSIS

5.1 Simulated Results of the Proposed Antenna using CST Software

To achieve the basic purpose of the thesis an in-depth simulation was performed to obtain the desired antenna designed for uwb operation. Four specific horns and layout systems have been designed where gradual bandwidth improvements have been observed. In the proposed cutting method the antenna slot is reserved for better antenna features. Bandwidth is greatly increased due to space structures. The proposed antenna has a 3.65 GHz bandwidth and can cover 100% uwb frequency range, meaning the antenna is capable of supporting uplink and broadcast satellite service as well as satellite broadcasting, fixed microwave, cable TV relay, fixed-satellite (Earth-to Space), satellite exploration, aeronautical radio and space exploration, regular and time-satellite (earth-to-space) satellite, earth-to-space satellite), and radio astronomy.
Antenna performance metrics such as bandwidth, retrieval loss, current distribution rate, current velocity distribution, 2D, profitable 3D radiation and directional patterns are simulated using the IE3D template. Similar performance metrics are also simulated using the CST simulation tool for comparison purposes to be discussed in the section.
The current distribution shows the shape of the antenna and helps to understand the density and direction of the current movement within the pool at any frequency. It also shows how different parts of the system behave in different operating waves. The 2D and 3D radiation patterns represent the image of the energy emitted by the rod as a function of the remote control. The 2D radiation option provides information primarily about antenna benefit and directional gain of EH fields in axial, azimuth and altitude formations in both polar and cartesian form while the 3D radiation pattern provides a rotating 3D view of antenna direction and gain in output style. Simulations are performed on the proposed antennas in various frequencies that provide a better understanding of the antenna parameters.

5.1.1 Antenna Bandwidth

Bandwidth is another fundamental antenna parameter. Bandwidth describes the range of frequencies over which the antenna can properly radiate or receive energy. Often, the desired bandwidth is one of the determining parameters used to decide upon an antenna. For instance, many antenna types have very narrow bandwidths and cannot be used for wideband operation. One of the requirements for the design of UWB systems is a very wide impedance bandwidth and therefore the FCC has made available 7.5 GHz for this purpose within the unlicensed band from 3.1 to 10.6 GHz. The impedance bandwidth of the UWB antenna is best expressed in terms of its FBW. According to , the definition of FBW is given as a measure of signal bandwidth to the average frequency. An antenna with a 25% FBW or a full bandwidth of 500 MHz is considered UWB.
The impedance and FBW bandwidth can be easily measured by the image from the reflection coefficient structure (also called the S11 structure or return loss).

The structure of the bright coefficient of the proposed antenna is simulated with the help of cst and shown in Figure 5.1.1

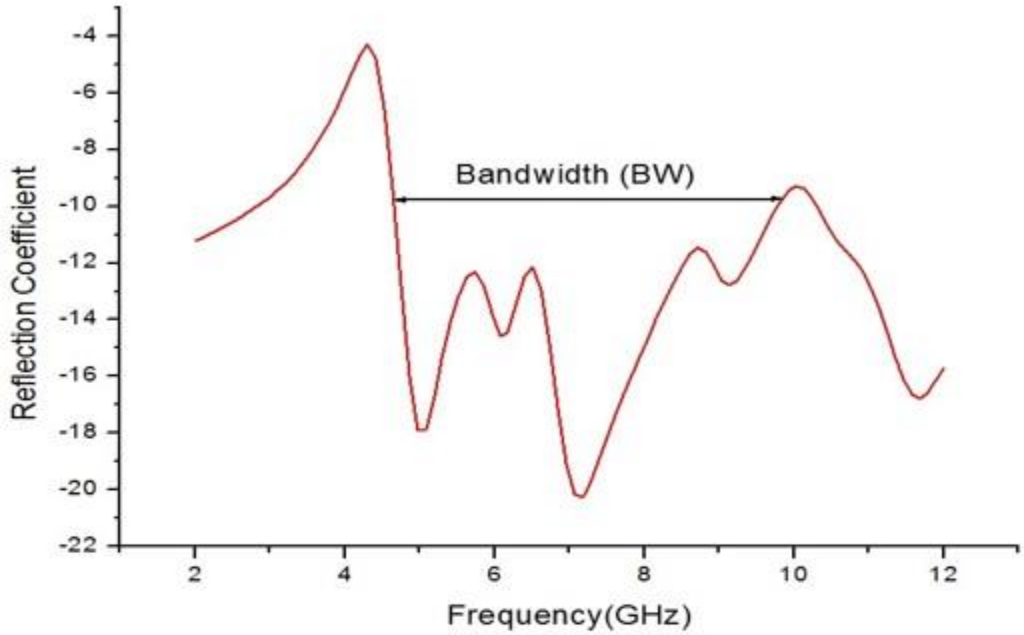


Figure : 5.1.1

5.1.2 Radiation Pattern

It is important that UWB monopoles have a good radiation property. Theoretically, perfect omnidirectional radiation pattern is ideal but not releasable in practice. The far field 3D radiation pattern for each of the resonant frequencies of the proposed antenna is shown in figures 5.1.2. From these figures, it is obvious that the antenna has a good radiation property (closely omnidirectional).

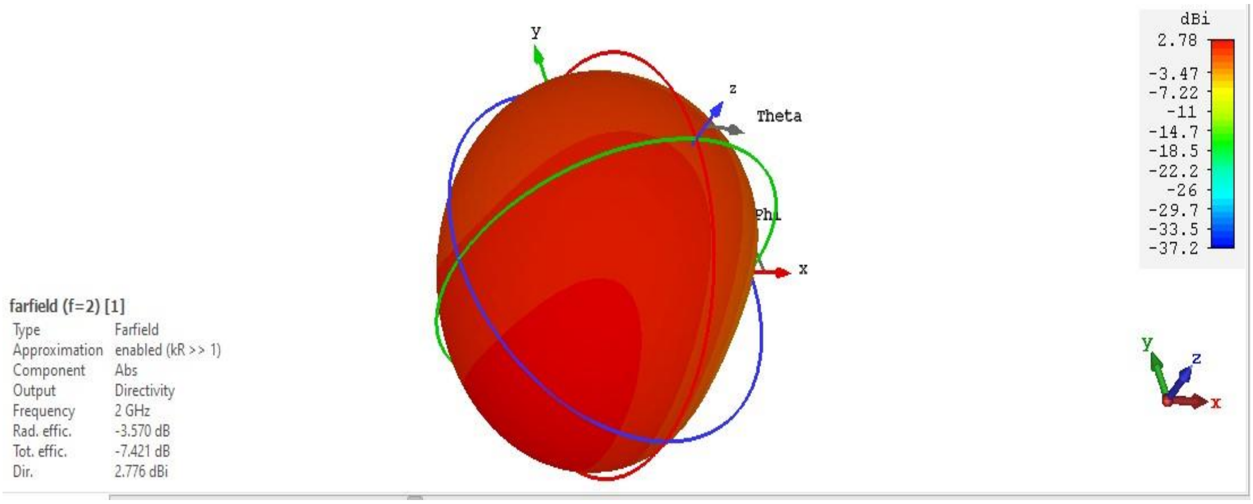


Figure : 5.1.2 a (frequency 2 GHz)

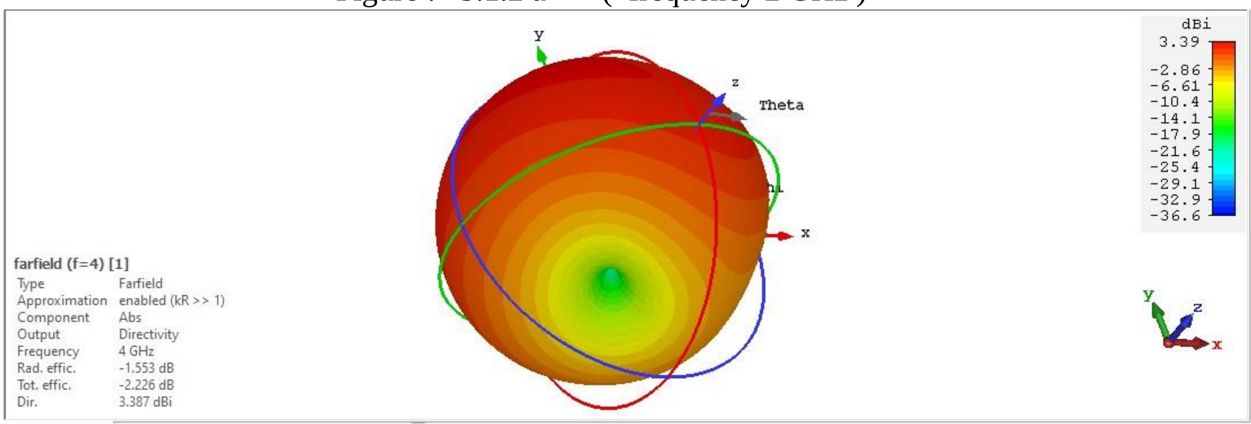


Figure : 5.1.2 b (frequency 4 GHz)

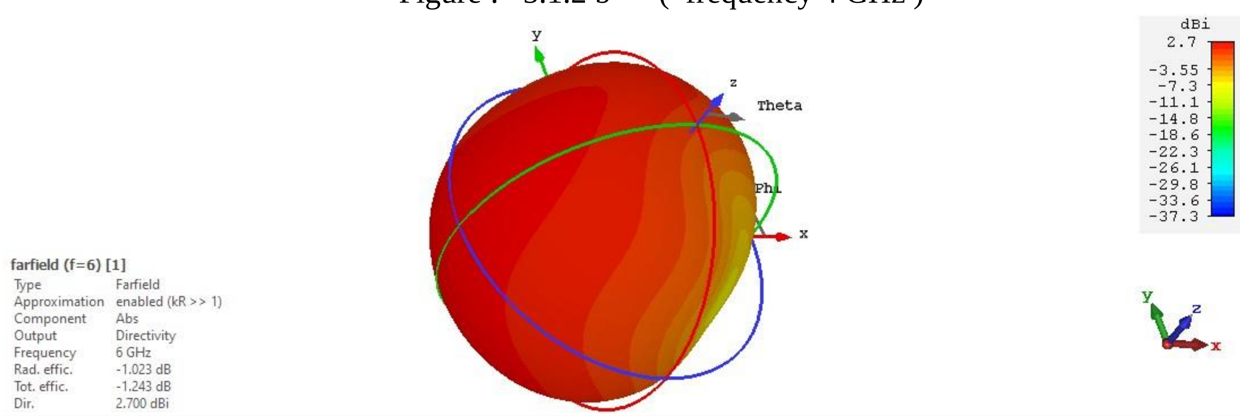


Figure : 5.1.2 c (frequency 6 GHz)

5.1.3 Mutual coupling in the proposed UWB-MIMO

Mutual coupling (MC) is a well-known feature that affects the performance of any antenna. Theoretically, merging is a current approach to an antenna feature created as a result of voltage flow across the neighboring part of the antenna. It is similar to the interaction between the primary and secondary coils in a power transformer. The presence of MC may have a negative impact on the capacity of the MIMO channel as described in . Also, MC can have a negative impact on the radiation pattern of the same members, the greater range, and similar features of the antenna material . However, in some MIMO programs, the MC can have positive effects on the channel. This is because MC can actually have an associated effect on channel coefficients and consequently increase channel capacity .
For the same MIMO components consisting of two elements, the MC (S12) coefficient is the measure of the port-to port separation between the two antenna components. Figure 30 shows the variance of MC under different D values. From this structure, we can clearly see that the MC decreases as the magnitude of the D increases. And the statistics show that the antenna list has the lowest MC most desirable in the UWB-MIMO system.

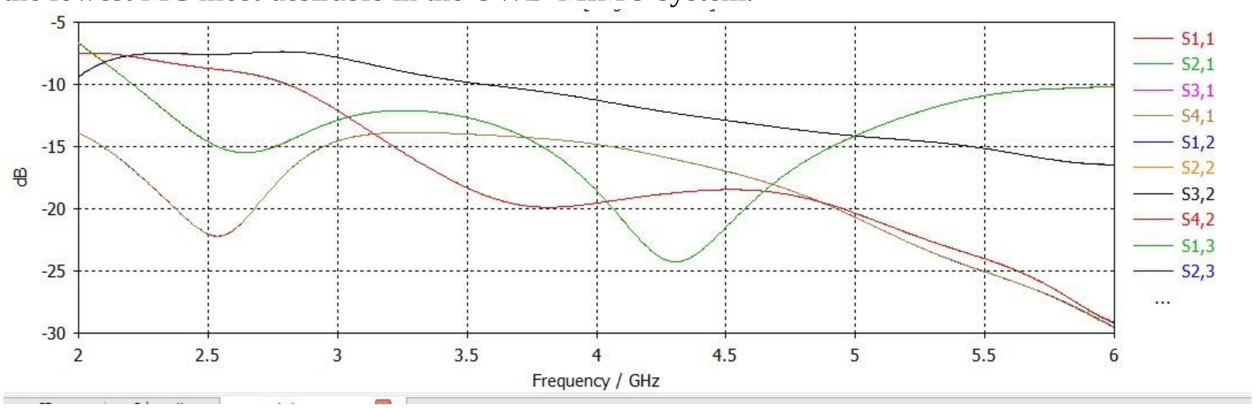


Figure : 5.1.3

5.1.4 Result and Discussion

The 3D, 2D pattern and polar radiation of the proposed antenna are shown in this section. Figure 5.1.4.a. shows a 3 D radiation pattern while Figure 5.1.4.b shows a 2 D radiation pattern at resonance frequencies 2 GHz, 4 GHz and 6 GHz respectively.

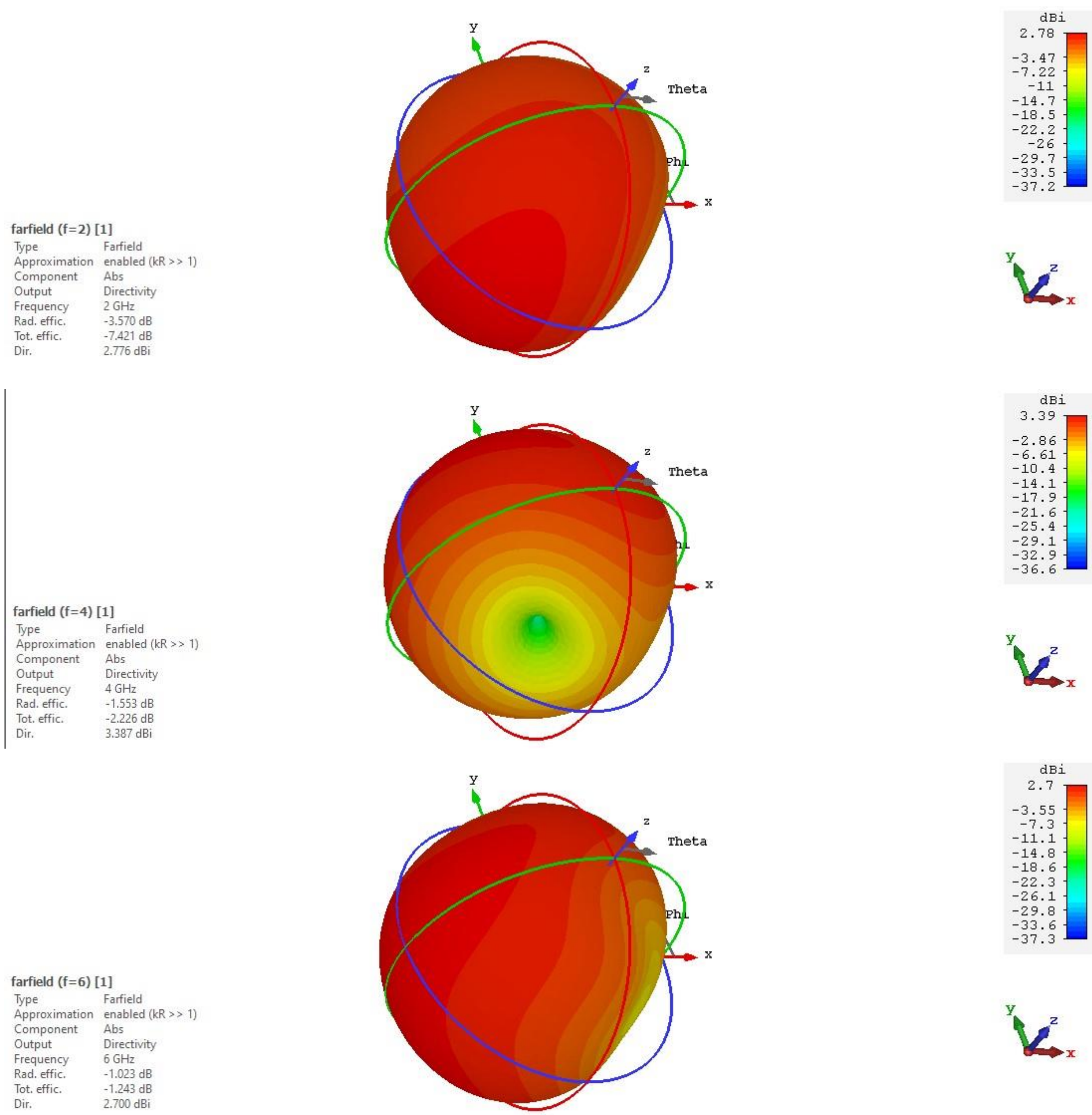

farfield (f=2) [1]
Type Farfield
Approximation enabled (kR >> 1)
Component Abs
Output Directivity
Frequency 2 GHz
Rad. effic. -3.570 dB
Tot. effic. -7.421 dB
Dir. 2.776 dBi
dBi
2.78
-3.47
-7.22
-11
-14.7
-18.5
-22.2
-26
-29.7
-33.5
-37.2
farfield (f=4) [1]
Type Farfield
Approximation enabled (kR >> 1)
Component Abs
Output Directivity
Frequency 4 GHz
Rad. effic. -1.553 dB
Tot. effic. -2.226 dB
Dir. 3.387 dBi
dBi
3.39
-2.86
-6.61
-10.4
-14.1
-17.9
-21.6
-25.4
-29.1
-32.9
-36.6
farfield (f=6) [1]
Type Farfield
Approximation enabled (kR >> 1)
Component Abs
Output Directivity
Frequency 6 GHz
Rad. effic. -1.023 dB
Tot. effic. -1.243 dB
Dir. 2.700 dBi
dBi
2.7
-3.55
-7.3
-11.1
-14.8
-18.6
-22.3
-26.1
-29.8
-33.6
-37.3
y
z
x
Theta
Phi

Figure : 5.1.4.a.

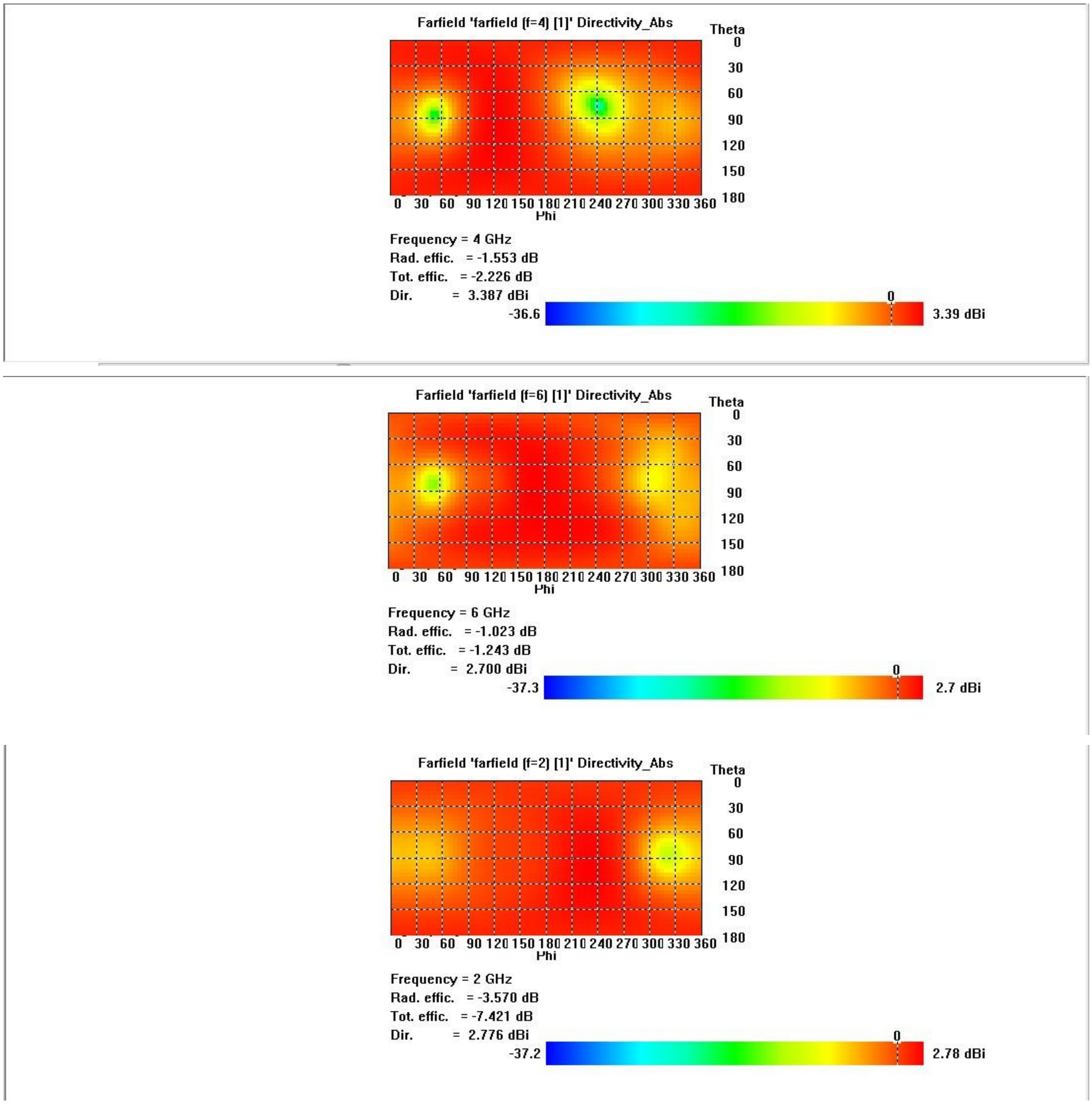


Figure : 5.1.4.b

From 3D and 2D radiation patterns that are shown in Figure 5 and Figure 6 the Dir at resonance frequency 2 GHz is 2.776 dBi, at resonance frequency 4 GHz is 3.387 dBi and at resonance frequency 6 GHz is 2.700 dB. The simulated directivity at the three different resonance frequencies are 2.776 dBi, 3.387 dBi and 2.700 dBi respectively.

The simulated polar plot of the radiation pattern of the designed antenna is shown in Figure 5.1.4.c The Figure shows the 3 dB beam width, side lobe level (SLL) main lobe direction and main lobe magnitude.

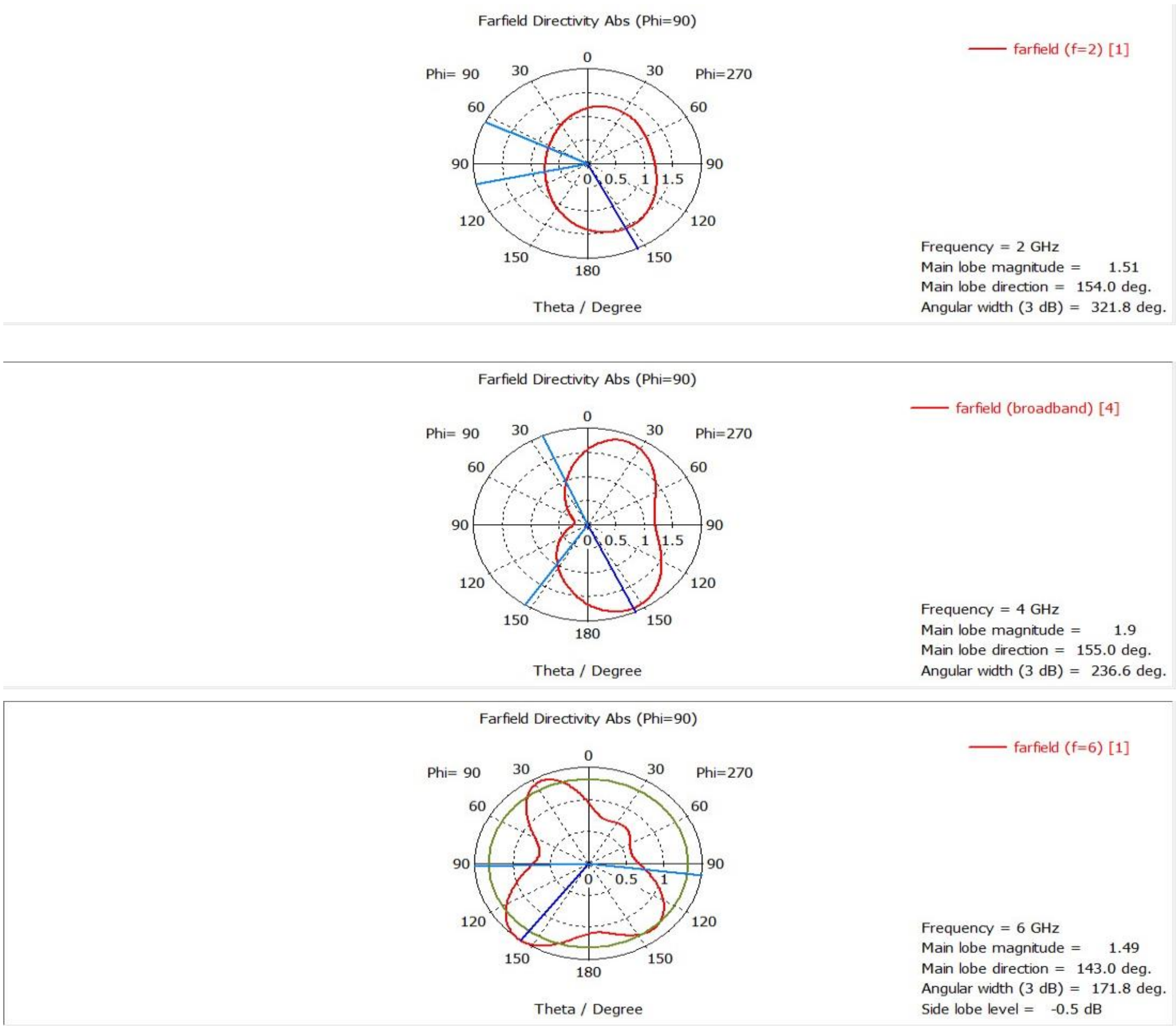


Figure : 5.1.4.c

CHAPTER 6

CONCLUSION & FUTURE WORK

6.1. Major Contributions of the Thesis

Ultra-wide band technology has received a lot of attention in recent times to be used in the short range of WPAN, local performance and faster radar systems. In order to improve the coverage, capacity and speed of the UWB system, many researchers have decided to test the feasibility of integrating the MIMO antenna method into UWB systems.

The purpose of this thesis is twofold: First, the thesis is an attempt to provide a general survey of past trends and the future of UWB technology. This is in line with the proper understanding of technology and the motivation behind the current trend. Second, the thesis suggested the design of a wide-range antenna for UWB-MIMO novel for multi-wireless applications. The proposed UWB-MIMO antenna consists of two integrated UWB monopole components separated by a small distance in the feed of each element by a separate microstrip feed line. The proposed UWB-MIMO highly compact is 36 in size and can fit on several WPAN portable devices. Each section of the proposed UWB-MIMO antenna has a wide operating bandwidth of 3.6 GHz and excellent radio equipment. Also, the impact of mutual coupling (MC) and communication is reduced in construction by using active spatial separation between MIMO objects. The UWB-MIMO has a MC that goes very low -20 dB with a separation distance of 16 mm or more. This is a good result and ensures the reliability of the antenna system. Also, the antenna system has a very low correlation envelope coefficient (value that is less than 0.5 even in the closet space between antenna objects. Also, the antenna system gains a maximum gain of 8.5 out of 0.5 variants. This ultimately explains advantages of using UWB multi-channel antenna system.In addition, multiband resonating features make the antenna stick suitable for many applications. design parameters to meet design specifications.

The main limitation of the thesis is the lack of a real anechoic chamber to compare simulation results. Although the design software, HFSS, is considered the most reliable RF engineers, it does not underestimate the need to perform actual testing in the anechoic chamber.

6.2 Future Scope of Work

In this thesis, we examined the mimo antenna and the impact of the slot and rectangular spaces to improve bandwidth. Future work may involve changing the type of antenna (which includes the antenna structure and the dielectric substrate) and further research with other slot structures. The impedance simulation network may be used to improve impedance bandwidth.

Various techniques can also be used in the future to design advanced horns such as the following:

- Formation of Split-Ring Resonator (SRRS).
- Electromagnetic Band Gap Structure (EBG)
- Metamatadium

Other mimo antenna feeding techniques such as line feeds can be used in the future to design mimo patch horns for better features. For future work, the construction of these horns can be done to monitor the real-time performance of the horns. The proposed antenna project can be produced to market Ku band applications worldwide. Further enhancement of the antenna feature can be made by using other common methods on the proposed antenna.

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