Chapter 1

INTRODUCTION

An antenna is a vital element of a wireless system because it acts as the input and the output interface for wireless tools. In modern wireless systems, characteristics like bandwidth, channel capacity rate, the speed of data transfer, the reliability of data, interference between two signals, cost as well as the size of device etc. plays a significant role. An antenna is used as a conducting element while transmitting and receiving electromagnetic waves in wireless applications. Since the antenna is a resonating structure, its tuning according to applications plays an important role. Enrichment in multimedia applications can be done to offer higher data rates. Shanon's channel capacity theorem is used to enhance channel capacity by increasing either signal to noise ratio or by a wide range of bandwidth. Due to various regulatory laws and cost involved in buying bandwidth in the crowded spectrum, it is difficult to achieve above metrics. The data rate of the system at the transmitter as well as at the receiver can be enhanced by using multiple radiating elements. In Multiple Input Multiple Output (MIMO) technology, multiple antennas operate in different modes based on characteristics of the different channel. The concept of using multiple antennas for wireless transmission was introduced by Foschini. Issues like isolation enhancement, low-cost maintenance, compact size are of prime importance for the designer in a single band as well as for multi band applications which makes MIMO antenna as a challenging area for the researcher.

This research work presents a comprehensive review of the investigation of performance parameters of antenna design using MIMO technology. In recent years, planar antennas have been received greater attention in wireless applications. The wireless

system suffers from problems like multipath fading, signal interference, low bandwidth etc. Nowadays, the MIMO technique in wireless system design provides higher data throughput, reliability, and wider bandwidth without consumption of excessive radio frequency. In this report, high gain and low correlation coefficient MIMO antenna are analyzed using different techniques.

1.1 Motivation

The rapid growth in radio communication industries and applications has clustered the electromagnetic spectrum. As most of the current wireless systems operate at HF (3 MHz to 30 MHz), VHF (30 MHz to 300 MHz) and UHF (300 MHz to 3 GHz) bands, the electromagnetic spectrum at these bands is crowded. In addition, the relative bandwidth of communication channels at these bands is in the range of few megahertz. Shannon-Hartley theorem for channel capacity (C) is directly dependent on the bandwidth (BW) of a communication channel and the signal to noise ratio. Therefore, applications which require higher data speed cannot operate satisfactorily at these low bandwidth channels. The most logical solution for this problem is shifting wireless applications towards higher frequencies. In the present scenario, most of the Wi-Fi routers have an inbuilt antenna with omnidirectional radiation features. That possesses the limitation in terms of directivity of the antenna. Hence it is the need of an hour to design highly directional antennas. Highly directional antenna helps in radiating the signal in a particular direction to achieve maximum directivity to obtain a signal in the desired area. This enables the user to achieve maximum signal strength for access of the internet for a longer distance from the router. The directional antenna helps to achieve signals with maximum strength in densely populated areas as well as rural areas. The purpose of this research is designing different antenna prototype by adopting different techniques such as Defected Ground Structure (DGS), slot, parasitic elements, monopole and various configurations of MIMO antenna suitable for high gain, compact size, low profile wireless applications.

Another motivation for designing MIMO antenna is to sort the issues of interference between the wide band and narrow band devices in wireless system networks. The receiver gets overloaded due to the mixing of the signal from strong narrow-band signals

within the wideband. Rejection characteristics can be achieved by using filters. Filters used in the system increases complexity, size and weight of the system . Hence antenna with band-notched characteristics can be designed for the particular application. As antenna size reduces there is degradation in impedance bandwidth. Hence designing antenna having compact size with wide bandwidth and high gain is a challenging task. The design prototype developed in this report can be utilized for wireless applications such as internet communications as well as satellite downlink operations.

1.2 Problem statement

- To improve data rate of wireless communication systems single antenna is not sufficient.
- Problem of mutual coupling is a challenging task in designing MIMO antenna.
- Mutual coupling can be improved by changing distance between two antenna elements. This increases size of the antenna structure.
- Also designing MIMO antenna with high gain, large bandwidth, low correlation coefficient and compact size is a challenging task.

This research project aims to design, simulate, fabricate and validates measurements of MIMO antenna for wireless applications. The designs exhibiting optimum return loss, high gain is to be fabricated and tested in comparison with simulated results. In this work commercially available Mentor graphics IE3D electromagnetic simulation tool is used.

1.3 Objective of the research

The objectives of this research are as follows:

- To develop MIMO antenna possessing high gain, compact size and low mutual coupling for wireless applications.
- To obtain a wide impedance bandwidth to support high data rate channels.

- To study polarization characteristics in the MIMO antenna by orienting each antenna element in the different direction so that maximum front to back ratio is desired.
- To study band-notch characteristic of the MIMO antenna is also one of the objectives of this research work.
- To characterize theoretical and experimental parameters such as return loss, insertion loss, bandwidth, gain.
- The overall objective is to design, fabricate and demonstrate the characteristics of MIMO antennas for wireless applications.

1.4 Methodology

This research work incorporates design of different types of MIMO antennas for multi-band applications. The various steps includes:

- Identification of application in wireless communication systems
- To decide frequency band of operation
- To design parameters of an antenna
- To study various parameters of an antenna like return loss, VSWR, bandwidth, gain etc
- To design multiple antenna element structure
- To study MIMO antenna characteristics such as isolation characteristics , diversity characteristics, gain etc.
- To fabricate antenna prototype and test hardware results for all characteristics

1.5 Organization of the thesis

This thesis comprises of following eight chapters:

Chapter 2: An introduction to the MIMO antenna is presented in this chapter. Various performance parameters are described in brief. Current challenges in the field of

designing MIMO antenna are discussed.

A review for the reported work related to the design of multiple antennas is presented. The proposed solution for overcoming disadvantages of available work is also discussed. This chapter explains the methodology of design, simulation, fabrication and testing methods carried out on different configurations proposed in thesis.

Chapter 3 to chapter 7: These chapters gives the systematic investigation and study of various MIMO antennas for wireless system applications. These antennas include MIMO antenna for high gain applications, ultra wideband MIMO antenna design, MIMO antenna with dual notched performance, MIMO antenna for satellite applications and dual polarized, multiband MIMO antenna. The comparison between the theoretical and experimental results on various configurations is also presented.

Chapter 8:This chapter is about summary of research contribution made by researcher while designing different configurations of MIMO antenna.

Chapter 9: The conclusions derived from the theoretical and experimental studies are discussed in this chapter. The scope of future work is also outlined.