DESIGN OF MICROSTRIP PATCH ANTENNA FOR IEEE 802.16-2004 APPLICATIONS

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ABSTRACT

This thesis presents microstrip patch antenna IEEE 802.16-2004 standards for microwave applications and WiMax. Narrow bandwidth (BW) is the main defect of microstrip patch antenna in wireless communication. The bandwidth can be improved by increasing the substrate thickness, and using air as substrate with low dielectric constant. The antennas were fabricated using FR4 board. Two types of microstrip antenna were used, the first was a single microstrip patch antenna and the second was using an air-gap technique as the dielectric between two antenna boards. The spacer of the air-gap has thickness of 2mm. It was made of wood to separate between the two boards. The transmission line model was used to get the approximate dimension for the design. Different parameters were obtained depending on the simulation and measurement. The Computer Simulations Technology (CST) software was used to simulate the design and the measurement was executed by Vector Network Analyzer (VNA). The two designs were compared to each other and found that some improvements were obtained on the air-gap technique. The bandwidth was improved by 4.51 % with air-gap technique and only 1.02 % with the single patch antenna.

Abstrak

Tesis ini mempersebahka *microstrip patches antenna* untuk standard IEEE 802.16-2004 bagi kegunaan mikrogelombang dan WiMax. *Microstrip patches antenna* menghadapi masalah lebar jalur yang sempit dalam komunikasi wayarles. Lebar jalur tersebut boleh ditambah baik dengan menambah ketebalan *substrate* dan menggunakan udara (pemalar dielektrik, 1) sebagai *substrate*. Kedua-dua antenna ini dibuat menggunakan papan litar tercetak FR4. Dua jenis *microstrip patch antenna* telah digunakan, pertama *microstrip patch antenna* tunggal, dan yang kedua menggunakan teknik sela-udara sebagai dielektrik yang memisahkan antara dua papan. Sela udara mempunyai ketebalan sebanyak 2 mm yang dibuat menggunakan kayu sebagai pemisah antara dua papan. Model *line* penghantaran digunakan untuk mendapatkan dimensi anggaran untuk merekabentuk parameter yang berbeza bergantung pada simulasi dan pengukuran. Perisian Simulasi Komputer Teknologi (CST) digunakan untuk mensimulasi rekabentuk sementara pengukuran dilaksanakan dengan rangkaian Vector Network Analyzer (VNA). Daripada simulasi lebar jalur mencapai peningkatan sebanyak 4,51% dengan teknik sela udara berbanding dengan antena *patch* tunggal yang hanya mempunyai 1,02% sahaja.

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LIST OF SYMBOLS AND ACRONYMS

IEEE	-	Institute of Electrical and Electronics Engineers
WIMAX	-	Worldwide Interoperability for Microwave Access
WLAN	-	Wireless LAN
GHz	-	Giga Hertz
KHz	-	Kilo Hertz
FR4	-	Flame Retardant woven glass reinforced epoxy resin
BW	-	Bandwidth
Q-factor	-	Quality factor
CST	-	Computer Simulation Technology
1G	-	first Generation
2G	-	Second Generation
3G	-	Third Generation
4G	-	Fourth Generation
Mbit/s	-	Megabit/Second
A-D	-	Analogue-Digital
FM	-	Frequency Modulation
AMPS	-	Advanced Mobile Phone Service
TACS	-	Total Access Communication System
TDMA	-	Time Division Multiple Access
CDMA	-	Code Division Multiple Access
GSM	-	Global System for Mobil
IS	-	Interim Standard
PDC	-	Personal Digital Cellular
IMT	-	International Mobile Telecommunication
ITU	-	International Telecommunication Union
IP	-	Internet Protocol
TD-SCDMA	-	Time Division Synchronous Code Division Multiple Access

WLL	-	Wireless local loop
WiFi	-	Wireless Fidelity
ISM	-	industrial, scientific and medical band
DSS	-	Direct Sequence Spread
CCK	-	Complimentary Code Keying
PBCC	-	Packet Binary Convolution Coding
OFDM	-	Orthogonal Frequency Division Multiplexing
OFDMA	-	Orthogonal Frequency Division multiple access
MIMO	-	Multiple Input Multiple Output
FDD	-	Frequency Division Duplex
TDD	-	Time Division Duplex
VSWR	-	Voltage Standing Wave Ratio
CW	-	ClockWise
CCW	-	Counter Clock Wise
MPA	-	Microstrip patch Antenna
W	-	Patch Width
ε_{reff}	-	Effective Dielectric Constant
ΔL	-	Frings factor
L_{eff}	-	Effective length
VNA	-	Vector Network Analyzer
CST	-	Computer Simulation Technology
TST	-	Thin Sheet Technique
S-parameters	-	Scattering parameters
SMA	-	Sub Miniature type A
TEM	-	Transverse Electromagnetic Mode
AutoCAD	-	Aided Design or Computer Aided Drafting

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CHAPTER 1

INTRODUCTION

1.1 Overview

Radio or wireless communication means to transfer information over long or short distance without using any wires. Peoples exchange information every day using pager, cellular, telephones, laptops, various types of personal digital assistants and other wireless communication product. Telecommunication is assisted transmission of signals over a distance for the purpose of communication. In early time this may involve the use of smoke signals, drums, semaphore (an apparatus for conveying information by means of visual signals, as a light whose position may be changed), flags or heliograph (a device for signalling by means of a movable mirror that reflects beam of light. In modern times, telecommunication typically involves the use of electronic transmitters such as the telephone, television, radio or computer.

1.2 Antenna

Antenna is basic component of any electronic system which depends on free space as a propagation medium. An antenna is a device used for radiating or receiving radio waves. It is a transducer between a guided electromagnetic wave and electromagnetic wave propagating in free space (Smith, 1988). The guiding device or transmission line may take the form of a coaxial line or a hollow pipe (waveguide), and it is used to transport electromagnetic energy from the transmitting source to the antenna or from the antenna to the receiver. This antenna can be mounted on the surface of high performance aircraft, spacecraft, and satellites (Balanis, 1997). The antenna can be in a form of Microstrip.

Microstrip is a type of electrical transmission line which can be fabricated using printed circuit board (PCB) technology, and is used to convey microwave frequency signals. It consists of a conducting strip separated from a ground plane by a dielectric layer known as the substrate. Microwave components such as antennas, couplers, filters, power dividers etc. can be formed from microstrip, the entire device existing as the pattern of metallization on the substrate. Microstrip is much less expensive than traditional waveguide technology, as well as being far lighter and more compact.

According to Balanis (1997), microstrip antennas became very popular primarily for space borne applications. Today they are used for government and commercial applications. These antennas comprise a plurality of generally planar layers including a radiating element, an intermediate dielectric layer, and a ground plane layer. The radiating element is an electrically conductive material imbedded or photo etched on the intermediate layer and is generally exposed to free space. Depending on the characteristics of the transmitted electromagnetic energy desired, the radiating element may be square, rectangular, triangular, or circular and is separated from the ground plane layer as shown in Figure 1.1. The metallic patch can take many different configurations, as shown in Figure 1.2, the rectangular and circular patches are the most popular because of ease of analysis and fabrication, as well as their attractive radiation characteristics, especially low cross-polarization radiation.

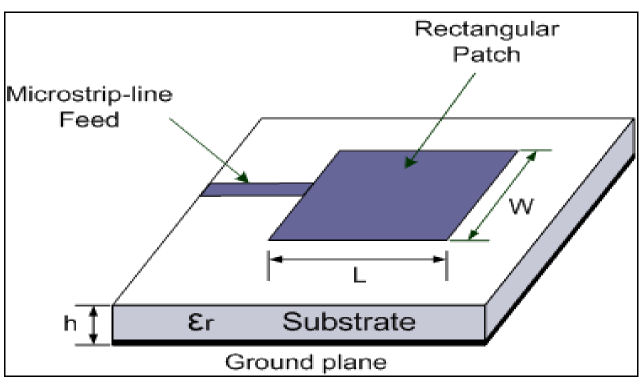

Figure 1.1: Microstrip patch antenna (MPA) (Balanis, 1997).

A microstrip patch antenna is a type of antenna that offers a low profile, i.e. thin and easy manufacturability, which provides a great advantage over traditional antennas. Patch antennas are planar antennas used in wireless links and other microwave applications.

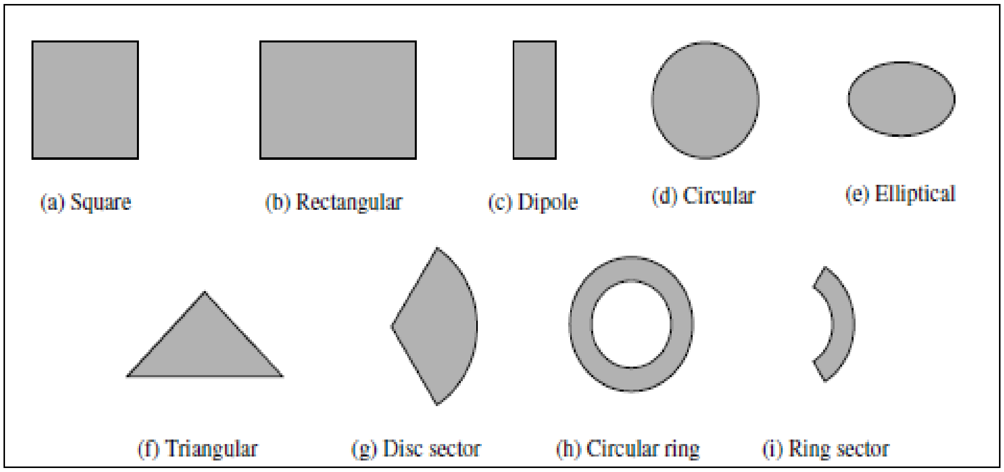

Figure 1.2: Different types of patches (Balanis, 1997).

1.3 Microstrip Antenna Advantage and Limitation:

Microstrip patch antennas have numerous advantages compared to conventional microwave antennas, and for that many applications cover the broad frequency range from 100 MHz to 100 GHz. Some of principle advantage of microstrip antenna is presented by (Garge *et al*., 2001).

i. Light weight, low volume, and thin profile configurations, which can be conform.
ii. Low fabrication cost, eagerly amenable to mass production.
iii. Linear and circular polarizations are possible with simple feed.
iv. Dual frequency and dual polarization antennas can be easily made.
v. Can be easily integrated with microwave integrated circuit.
vi. Feed lines and matching networks can be fabricated concurrently with the antenna structure.

And the limitation of microstrip antenna compared with conventional microwave antennas:

i. Narrow Bandwidth (BW) and associated tolerance problems.
ii. Complex feed structure required for high performance arrays.
iii. Unrelated radiation from feeds and junction.
iv. Excitation of surface waves.
v. Lower power handling capability (100 Watt).

1.4 Problem Statements

The main drawback of microstrip patch antenna that will be used in wireless communication is suffered from narrow bandwidth. Antenna bandwidth can be improved by increasing the substrate height (with using transmission line model). The height of substrate increases surface waves, which pass through the substrate and scattered at bends of the radiating patch which take up apart of energy of the signal thus decreasing the desired signal amplitude caused degradation the antenna performance. To overcome this problem, the technique of air-gap is used in which surface waves is not excited easily. The resonant frequency can be tuned by compromise between two factors the height of the substrate and the length of the patch without need for new design.

1.5 Project Objectives

The main objective of this project is to design and simulate microstrip patch antenna for using IEEE 802.16 for WiMax applications using 3.5 GHz.

i. To increase the efficiency of the microstrip patch antenna by decrease the loss of the reflection, it's executed by using air-gap technique as a substrate in microstrip patch antenna.

ii. To improve the bandwidth by increasing the thickness of dielectric substrate and dielectric constant with lower value. By increasing the Bandwidth more data can be carried out, on the other side high Q-factor gives better directivity hence more gain for that here a trade off is required between Bandwidth and Q-factor (quality factor). Reduce the microsrip bandwidth limitation due to the narrow band of microstrip patches in order to increase the bandwidth.

iii. To reduce the cost used in the fabrication of the antenna by using the cheap and popular FR4 material that used as a substrate material. The resonant frequency of the fabricated microstrip patch antenna can easily adjust without require additional design by just varying the height of the air-gap also as well as the FR4 material this will be made the fabrications very cost effective.

iv. To reduce the energy loss that happening from surface wave, the surface waves consume apart of energy of the signal thus decreasing the desired signal amplitude and contributing to deterioration in the antenna efficiency that weaken the microstrip antenna's performance.

1.6 Project Scopes

The scopes of this project have various strategies can be used for this purpose such as:

i. Use the resonant frequency 3.5 GHz for WiMax application, the resonant frequency is chosen from IEEE 802.16-2004 span of 2-11GHz.

ii. Choose the air as dielectric substrates that have the value of dielectric constant 1 in order to reduce the surface wave excisions.

iii. Utilize the transmission Line model for calculation of patch dimension. It's simplest of all and gives good physical insight.

iv. Simulate and Verify antenna design performance by apply Computer Simulation Technology Software (CST) to design patch antenna.

v. Employ AutoCAD software to open the DXF file that exported from CST software simulation. DXF file is printed and converted to the dry film that contain the design and dimensions that's simulated by CST software.

CHAPTER 2

LITERATURE REVIEW

2.1 History

Guglielmo Marconi opened the way for modern wireless communications in1895, by transmitting the three-dot Morse code for the letter 'S' over a distance of three kilometers using electromagnetic waves. From this beginning, wireless communications has developed into a key element of modern society. From satellite transmission, radio and television broadcasting to the now ubiquitous mobile telephone, wireless communications has revolutionized the way societies function (Schiller, 2000). In 1901 Guglielmo Marconi sent telegraphic signals across the Atlantic Ocean from Cornwall to St. Johan's Newfoundland, it covers a distance of 1800 miles. His invention allowed two parties to communicate by sending each other alphanumeric characters encoded in an analog signal by (Stalling, 2004). Wireless communications is enjoying its fast growth period in history, over the last century, wireless technologies have led towards the radio, television, Paging system, Cordless phone, Mobile telephone, Satellite and wireless networks. This advancement in wireless communication is widely deployed and used throughout the world in last four decades (Rappaport, 2002). Due to Lightman & Rojas (2002) said the first practical standard of cellular communication named First Generation (1G) was deployed and used in 1980. 1G uses the analog signal for communication of voice calls only. In the beginning of nineteen's century this standard changed to digital Second Generation (2G) and to the end of nineteen's century it was still digital but better bandwidth and good quality of signal in Third Generation (3G), now a day's industries are working on Fourth Generation (4G). The early1990s marked the beginning the fully of digital system, the IEEE standard looks like the winner for local area networks, it works at 2.4GHz and infrared offering 2 Mbit/s up to10 Mbit/s with special solution, (Schiller, 2000). The sequence time of wireless technology development is shown in Table 2.1 by (Dubendorf, 2003).

Table 2.1: Simple timeline in wireless technologies evolution

Year	Wireless technologies evolution
1896	Guglielmo Marconi develops the first wireless telegraph system
1927	First commercial radiotelephone service operated between Britain and the US
1946	First car-based mobile telephone set up in St. Louis, using 'push-to-talk' technology
1948	Claude Shannon publishes two benchmark papers on Information Theory, containing the basis for data compression (source encoding) and error detection and correction (channel encoding)
1950	TD-2, the first terrestrial microwave telecommunication system, installed to support 2400 telephone circuits
1950s	Late in the decade, several 'push-to-talk' mobile systems established in big cities for CB-radio, taxis, police, etc.
1950s	Late in the decade, the first paging access control equipment (PACE) paging systems established
1960s	Early in the decade, the Improved Mobile Telephone System (IMTS) developed with simultaneous transmit and receive, more channels, and greater power
1962	The first communication satellite, Telstar, launched into orbit
1964	The International Telecommunications Satellite Consortium (INTELSAT) established, and in 1965 launches the Early Bird geostationary satellite
1968	Defense Advanced Research Projects Agency – US (DARPA) selected BBN to develop the Advanced Research Projects Agency Network (ARPANET), the father of the modern Internet
1970s	Packet switching emerges as an efficient means of data communications, with the X.25 standard emerging late in the decade
1977	The Advanced Mobile Phone System (AMPS),invented by Bell Labs, first installed in the US with geographic regions divided into 'cells' (i.e. cellular telephone)
1983	January 1, TCP/IP selected as the official protocol for the ARPANET, leading to rapid growth
1990	Motorola files FCC application for permission to launch 77 (revised down to 66) low earth orbit communication satellites, known as the Iridium System (element 77 is Iridium)
1992	One-millionth host connected to the Internet, with the size now approximately doubling every year
1993	Internet Protocol version 4 (IPv4) established for reliable transmission over the Internet in conjunction with the Transport Control Protocol (TCP)
1994	FCC licenses the Personal Communication Services (PCS) spectrum (1.7 to 2.3 GHz) for $7.7 billion
1998	Ericsson, IBM, Intel, Nokia, and Toshiba announce they will join to develop Bluetooth for wireless data exchange between handheld computers or cellular phones and stationary computers

Table 2.1 (Continued)

1999	Late in the decade, Virtual Private Networks (VPNs) based on the Layer 2 Tunneling Protocol (L2TP) and IPSEC security techniques become available
2000	802.11(b)-based networks are in popular demand
2001	Wired Equivalent Privacy (WEP) Security is broken. The search for greater security for 802.11(x)-based networks increases

2.2 Basic Communication System

Shows the illustrate of communication system block diagram in Figure 2.1

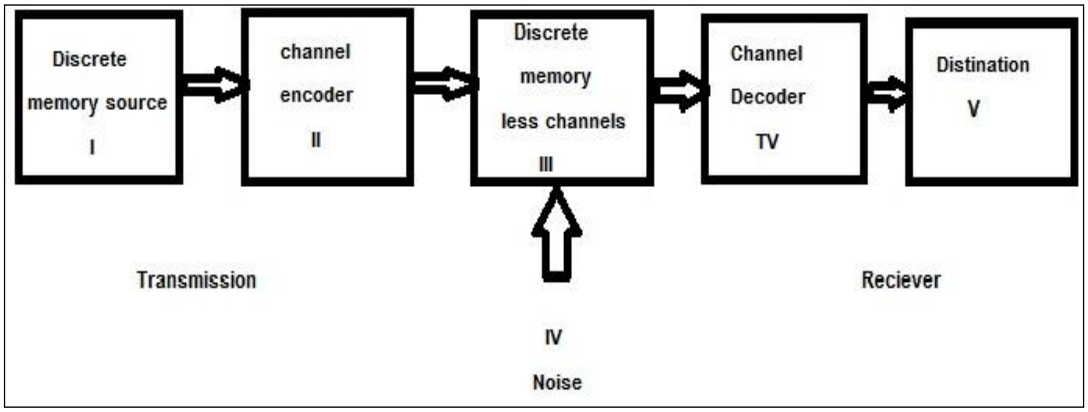

Figure 2.1: Block diagram of digital communication system (Haykin, 1998).

The input data which can be take any shape as voice, video, images and applied to the channel encoder, this portion changing the data into very suitable manners like A-D converter after that transmit the data. Channel is actually a medium (wired or wireless) between transmitter and receiver as well as in channel part there are two inputs one is coming from transmitter and other is channel noise (unwanted signal or information is called noise). Thus the resultant data at the output of channel is altered, the altered data at the output of channel is received by the receiver and the received data is decoded to reconstruct an original data transmitted by transmitter, at the last the reconstructed data is forward to the destination.

2.3 The Cellular Concept

The cellular concept was a major breakthrough in solving the problem of spectral congestion and user capacity. It offered high capacity with a limited spectrum allocation without any major technological changes. The cellular concept is a system level idea in which a single, high power transmitter (large cell) is replaced with many low power transmitters (small cells). The area serviced by a transmitter is called a cell. Each small powered transmitter, also called a base station provides coverage to only a small portion of the service area. Base stations close to one another are assigned different groups of channels so that all the available channels are assigned to a relatively small number of neighboring base stations. Neighboring base stations are assigned different groups of channels so that the interference between base stations is minimized. By symmetrically spacing base stations and their channel groups throughout a service area, the available channels are distributed throughout the geographic region and may be reused as many times as necessary, so long as the interference between co-channel stations is kept below acceptable levels (Manoj & MS, 1999*)*. In 1968 Bell Labs proposed the cellular telephone concept to the Federal Communications Commission (FCC). Then it was approved, it used the spectrum frequency of 845MHz to 870-890MHz band (Clint & Collins, 2007). In 1960 to 1970's Bell working on mobile system give the concept of dividing the coverage area into small cells, each of reused portions of spectrum. This leads to greater system infrastructure. It is the hexagon geometry cell shape (Rappaport, 2002).

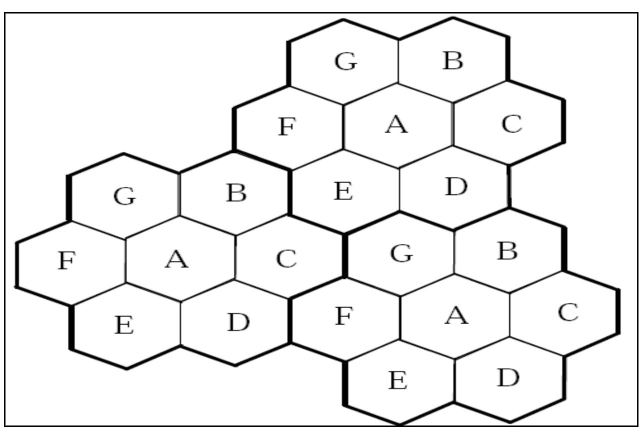

Figure 2.2: Frequency reuse in cellular networks (Rappaport, 2002).

In Figure 2.2, the cells labeled with the same letter use the same group of channels. The frequency reuse plan is overlaid upon a map to indicate where different frequency channels are used. The hexagonal cell shape shown is conceptual and is a simplistic model of the coverage for each base station. The hexagon has been universally adopted since the hexagon permits easy and manageable analysis of a cellular system, also considering geometric shapes which cover an entire region without overlap and with equal area; hexagon has the largest area considering the distance between the center of a polygon and its farthest perimeter points. The actual footprint is determined by the contour in which a given transmitter serves the mobiles successfully (Manoj *et al.*, 1999).

2.4 Different Mobiles Generation

Mobile telephony dates back to the 1920s, the progress was made in 1930s with the development of frequency modulation (FM). The limited mobile telephony service became available in 1940s. But systems were limited capacity. However, and it took many years for mobile telephone to become a viable commercial product (Clint & Collins, 2007).

2.4.1 First Generation System

Mobile communication as we know it today really started in the late 1970s with the implementation of trail system in Chicago in 1978. The system used a technology known as Advanced Mobile Phone Service (AMPS), operating in 800 MHz band for numerous reasons. However, including the breakup of AT&T, it took a few years before commercial system was launched in the United States. Lunching occurred in Chicago in 1983. The European also was active in mobile communications technology. The European system used a technology known as Nordic Mobile Telephony (NMT), operating in 450 MHz band. NMT was developed to operate in the 900 MHz band and known as Total Access Communication System (TACS) (Clint Smith & Collins, 2007).

2.4.2 Second Generation System

Unlike first generation system, which are analogue, second generation systems are digital. The use of digital technology has a number of advantages, including increased the capacity, greater security against fraud, and more advanced service, various type of second generation technology have been developed like Time Division Multiple Access (TDMA), Code Division Multiple Access(CDMA),Global System for Mobile communications (GSM) (Clint & Collins, 2007).

2.4.2.1 GSM

Global System for Mobile Communications, or GSM (originally from Group Special Mobile), is the world's most popular standard for mobile telephone systems. The GSM Association estimates that 80% of the global mobile market uses the standard and used by over 1.5 billion people across more than 212 countries, which enable the subscribers can use their phones throughout the world, enabled by international roaming arrangements between mobile network operators. It supports 8 time slotted users for each 200 KHz radio channels. It uses the 890-915MHz for uplink and 935-960 MHz for downlink.

2.4.2.2 Interim Standard (IS-136)

It is also known as North American Digital Cellular or US Digital Cellular. It supports three time slotted users for each 30 KHz radio channel and it is a popular choice for carrier in North America. It uses the frequency band of 824-894 MHz and also using the channels scheme of TDMA (Rappaport, 2002).

2.4.2.3 Personal Digital Cellular (PDC)

The Personal Digital Cellular or Pacific Digital Cellular (PDC) system is a second-generation mobile phone technology introduced in 1991. Although it is only found in Japan, its use there is very widespread and there are a considerable number of users. This technology is the move from analogue to digital technology. It uses TDMA technology and it is very similar to the US "TDMA" or IS54 / IS136 system but operates in the 800 and 1500 MHz bands. The modulation scheme, voice frame size, TDMA frame duration, and interleaving remain the same. The major difference is that it uses a 25 KHz channel spacing instead of 30 KHz.

2.4.2.4 Interim Standard 95 (IS-95)

It relates to second generation technique which is known as Code Division Multiple Access (CDMA). It is based on Direct Sequence CDMA multiple access. Thus multiple users simultaneously share the same channel (Channel Spacing is 1.25 MHz (Rappaport, 2002).CDMA is widely used in all over the world.

2.4.3 Third generation system

System such as IS-95, GSM, and IS-136 are much more secure, and they also offer higher capacity and more calling features compared with first generation system. However, still optimized for voice service and they are not well suited to data communications. In the environment of the Internet, electronic commerce and multimedia communications, limited support of data communications is a serious drawback. Although subscribers want to talk as much as ever, they now want to communicate in myriad of new ways, such as e-mail, instant messaging, and the World Wide Web and so on, not only do subscribers want these services, but they also want mobility, to provide all these capabilities means that new advanced technology is required which called third generation technology.

The International Mobile Telecommunication-2000 (IMT-2000) effort within International Telecommunication Union (ITU) has led a number of recommendations. These recommendations address areas such as user bandwidth (144 kbps for mobile service and up to 2Mbps for fixed service). In 1998, numerous air interface technical proposal were submitted. These were reviewed by the ITU, which in 1999 selected five technologies for terrestrial service (non satellite based). The five technologies are:

1. Wideband CDMA (WCDMA)
2. CDMA2000 (an evolution of IS-95 CDMA)
3. TDD-CDMA (Time Division-CDMA [TD-CDMA] and Time Division-Synchronous CDMA [TD-SCDMA])
4. UWC-136(an evolution of IS-136)
5. DECT

These technologies represent the foundation for a suit of advanced mobile multimedia communications services and are starting to be deployed across the globe (Clint & Collins, 2007).

2.4.4 Forth generation system and beyond

Forth generations will be an Internet Protocol (IP) based solution and allow seamless mobility between 3G wireless networks and fixed wireless, allowing users to take advantage of technology access method that best suits the environment in which they are located. The prevalence of IP ensures that this type of protocol will be in existence for many years to come with no other technology access that exceeds adoption and usefulness. 4G and the vision beyond will use CDMA regardless of whether it is WCDMA, CDMA-2000, TD-CDMA, or TD-SCDMA and seamlessly interface with WIFI, WIMAX, and WIMAN system (Clint & Collins, 2007).

2.5 Wireless local loop (WLL)

The rapid growth of the Internet has created an equivalent demand for broadband internet and computer access from businesses and homes throughout the world. There are numerous of wireless data systems that can and do complement a mobile wireless network.

2.5.1 WiFi (802.11)

Wireless Fidelity (WiFi) is a wireless local area network based on 802.11 standards. The prevalence of WiFi is now standard feature for laptops, computers, and personal digital assistance (PDAS). WiFi enable various computers or separates local area network (LAN) to be connected together into a LAN or a wide area network (WAN). 802.11 are important for wireless mobility because it provides direct mobile data interoperability between the LAN of a corporation and the wireless operator's system.

2.5.1.1 IEEE 802.11b

The 802.11b standard was published in 1999 and has been adapted widely by manufacture of infrastructure, such as access points, routers, and bridges. It also adapted widely by vendors of interface devices for laptops, desktops, and PDAS. 802.11b operates in industrial, scientific and medical (ISM) band at 2.4 GHz and specify data rates of up to 11 Mbps. The standard Direct Sequence Spread Spectrum (DSS) Complimentary Code Keying (CCK) and Packet Binary Convolution Coding (PBCC) (Clint & Collins, 2007).

2.5.1.2 IEEE 802.11g

WiFi specification 802.11g provides higher data rates (up to 54 Mbps) than 802.11 b. The 802.11g standard employs (DSS)/Frequency Hopping Spread Spectrum (FSSS) and

Orthogonal Frequency Division Multiplexing (OFDM) and also is abackward compatble with 802.11b. This mean that any 802.11g device must be able to coexist with 802.11b devices.

2.5.1.3 IEEE 802.11a

WiFi system using 802.11a specification operates in Unlicensed National Information Infrastructure (UN11) band, which enables systems using this exacting network to operate not only at higher speeds but also at higher power. The 802.11a operate the UNII band at 5GHz and uses OFDM as its modulation design. 802.11a is designed to provide data rate of up to54 Mbps. The 802.11a are not compatible with 802.11b/802.11g, its not abnormal to use them both in enterprise network. Most users may be employing 802.11b/802.11g, while power users may be assigned to 802.11a.

2.5.1.4 IEEE 802.11n

802.11n protocol is designed to poorly replace 802.11a, b, and g for local area networking. 802.11n enables speeds of 540 Mbps through improved modulations schemes and increased channel bandwidth that achieved by joining two channels therfor rising the bandwidth from 20MHz to 40MHz. 802.11n uses multiple antennas to both send and receive information, the multiple antenna system is normally referred to as Multiple Input Multiple Output (MIMO), this applications incraease the range of the 802.11n network as well as the throughput is well.

2.6 Bluetooth

Bluetooth is basically an IEEE standard of 802.15. It is used for small distance transmission of data. Bluetooth is founded by special interest group (Ericsson, Nokia, and Intel IBM Toshiba) responsible for its standard. It uses the Industrial, scientific and Medical (ISM) frequency band of 2.4GHz. Frequency jumps is 1600 hops/s and switching time for transmission and reception is 220 micro second. Bluetooth is designed for low power consumption, with short range depending on the power class. Bluetooth can effectively operate as an extension of a LAN or a peer to peer LAN to provide connectivity between a mobile device and the other device type as printers, PDAs, mobile phones, LCD projectors, wireless LAN device, notebooks and desktops PCs (Clint & Collins, 2007).

2.7 IEEE 802.16

802.16 is referred to as Wireless Metropolation Area Network (wireless MAN) and subcomponent of the standard is called Worldwide Interoperability for Microwave Access (WiMAX) and falls under 802.16 d/e, 802.16 is a set of evolving IEEE standards that are related to a huge array of spectrum ranging from 2 to 66 GHz, currently that include both licensed and un licensed bands the following table gives a brief overview of some of the various 802.16 specifications.

Table 2.2: Define some of the various 802.16 specifications.

Standard	Comments
802.16	Wireless WAN, Hiper Access
802.16d	WiMAX, HiperMAN (fixed)
802.16e	WiMAX, (fixed and mobile)

Basically, 802.16 is the enabling technology or standard that is planned to supply wireless access to locations. 802.16 is a point to multipoint protocol used as a connection oriented system that can take on a star or mesh configuration using Frequency Division Duplex (FDD) and Time Division Duplex (TDD). 802.16 is different from 802.11 and wireless mobility systems such as the GSM communications, CDMA, and UMTS. 802.16 is a unique wireless access system whose purpose is to provide broadband to multiple subscribers or locations within the same geographic area. It uses microwave radio as a essential transport medium and it is not essentially a new technology but rather an adaption and standardization of existing technology for broadband service implementation (Clint & Collins, 2007). The 802.16 standard has many fundamental properties

1- It supports multiple services simultaneously.
2- Bandwidth on demand.
3- Link adaption (4QAM/16 QAM /64 QAM).
4- Point to point topology integrated with mesh topology (Clint & Myer, 2004).

Table 2.3: The different 802.16 specification occupy inside different bands.

Standard	Band	Comments
802.16	10-66 GHZ	Wireless WAN, Hiper Access
802.16a	2-11 GHZ	WiMAX, Hiper MAN Licensed bands
802.16a (formerly b)	5-6 GHZ	un Licensed band (Mesh)

2.7.1 IEEE 802.16d

The specification 802.16d is also referred to as 802.16-2004, the 802.16d focuses on spectrum that is between 2-11GHz. 802.16d use both Orthogonal Frequency Division multiple (OFDM) as well as Frequency Division multiple Access (OFDMA) techniques. Worldwide, 802.16d is meant for 3.5 and 10.5 GHz bands because they are seen as good prospects for residential and small business service.

2.7.2 IEEE 802.16e

IEEE 802.16e was introduced first in 2005. In this version for mobile users provide high bandwidth, handover and network architecture and also the cell reselection. This feature of Wi-Max compete all the standard of cellular. OFDM Modulation technique is used for this standard.

Table 2.4: Comparison of different 802.16 standards.

	802.16	**802.16d**	**802.16e**
Spectrum	10-66 GHz	2-11 GHz	2-6 GHz
Channel bandwidth	20,25 and 28 MHz	1.75/3/3.5/5.5/7 (OFDM) 1.25/3.5/7/14/28 (FDMA)	1.25/2.5/5/10/20
Modulation	QPSk/16QAM, 64QAM	OFDM 256 subcarriers 2048 OFDMA	SOFDM 128/256/412/1024/2048
Bit rate	32-134 Mbps (28 MHz channel)	15 Mbps (5 MHz channel)	15 Mbps (5 MHz channel)
Channel condition	LOS	Non LOS	Non LOS
Typical cell radius	2-5 KM	2-5 KM	2-5 KM
Access	FDD	FDD/TDD	TDD

Wi-Max technology appears to be on great economic and practical success for two reasons, first, ability to support mobile applications (802.16e) is very promising and also it can provide greater transmission range as compare to WLAN.

2.8 Importance of Antenna in Wireless System

An antenna is a metallic structure, which converts electromagnetic waves into electrical currents and vice versa. In wireless communication system same antennas used for both transmission and reception. Antenna is one of the most important elements in wireless communication system. A general method to express the performance of an antenna is radiation pattern which is graphical representation of radiation properties of an antenna as a function of space coordinates.

2.9 Antennas Types

Antennas are key components of any wireless communication system. They are the devices that allow for the transfer of a signal to waves that, in rank, propagate through space and can be received by another antenna. The receiving antenna is responsible for the reciprocal process, that of turning an electromagnetic wave into a signal or voltage at its terminals that can subsequently be processed by the receiver (Volakis, 2007).

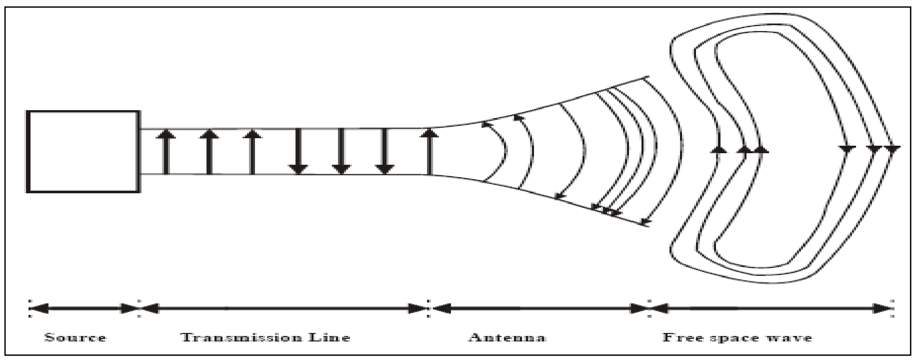

Figure 2.3: Antenna is transition device (Balanis, 1997).

When a sinusoidal voltage source is applied across a transmission line the electric field is created between two conductors which in turn provides magnetic field due to time varying electric and magnetic fields electromagnetic waves are created and travel through the transmission line to the antenna and radiate in free space. Some forms of the various antennas types.

2.9.1 Wire Antennas

Wire antennas are familiar to the layman because they are seen virtually every where on automobiles, buildings, ships, and aircraft and almost immediately (Balanis, 1997). These are various shapes of wire antennas such as straight (dipole), loop, and helix as shown in Figure 2.4. Loop antennas need not only be circular, they may take the form of a rectangle, square, ellipse, or any other configuration. The circular loop is the most common because of its simplicity in construction.

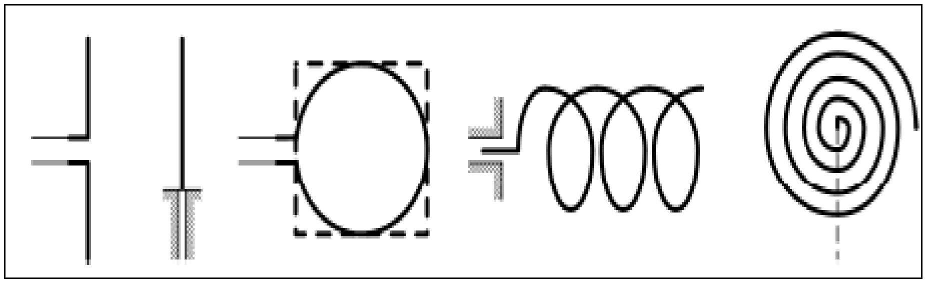

Figure 2.4: Wire antenna configurations. From left to right, dipole, monopole, circular/rectangular loops, helix, and spiral. (Balanis, 1997).

2.9.2 Aperture Antennas

The increasing demand for more complicated forms of antenna and utilization of higher frequencies made aperture antenna is more familiar than wire antenna, some forms of aperture antennas are shown in Figure 2.5. Aperture antennas are very useful for aircraft and spacecraft applications, because they can be very suitably flush-mounted on the skin of the aircraft or spacecraft

Figure 2.5: Aperture Antenna Configurations. From left to right, pyramidal horn, conical horn, and rectangular waveguide. (Balanis, 1997).

2.9.3 Microstrip antenna

Microstrip antennas became very popular in the 1970 for space born applications. It consist of a metallic patch on a ground substrate. The metallic patch can take many different configurations like rectangular, circular, dipole etc as shown in Figure 2.6.

However, these antennas can be mounted on the surface of high performance aircraft, spacecraft, satellite, missile, cars, and even handheld mobile telephones (Balanis, 1997).

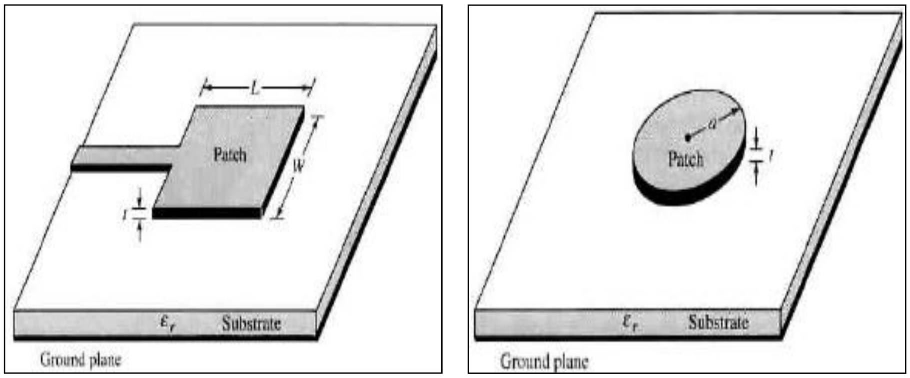

Figure 2.6: Microstrip patch antenna. From left to right, rectangular patch, square patch (Balanis, 1997).

2.9.4 Array antenna

Many applications require radiation characteristics that may not be achievable by a single element. The total of radiating elements in an electrical and geometrical arrangement (on array) will result in desired radiation characteristics. The arrangement of the array may be such that the radiation from the elements adds up to give a radiations maximum in particular direction or directions, minimum in others, or otherwise is desired. They are the different types that shown in Figure 2.7 such microstrip patch array (Balanis, 1997).

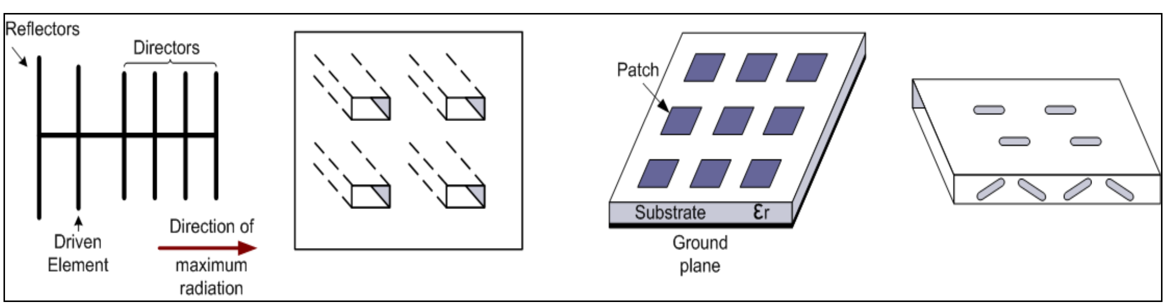

Figure 2.7: Typical array antennas. From left to right, yagi-uda array, aperture array, microstrip patches array, and slotted waveguide array (Balanis, 1997).

2.9.5 Reflector Antennas

Because of the need to communication over great distance, sophisticated forms of antennas had to be used in order to transmit and receive signals that had to travel millions of miles. A common antenna form for such application is a parabolic reflector shown in Figure 2.8. The diameter of this antenna is as large as 305 m. Such large dimensions are needed to achieve the high gain required to transmit or receive signals after millions of miles of travel (Balanis, 1997).

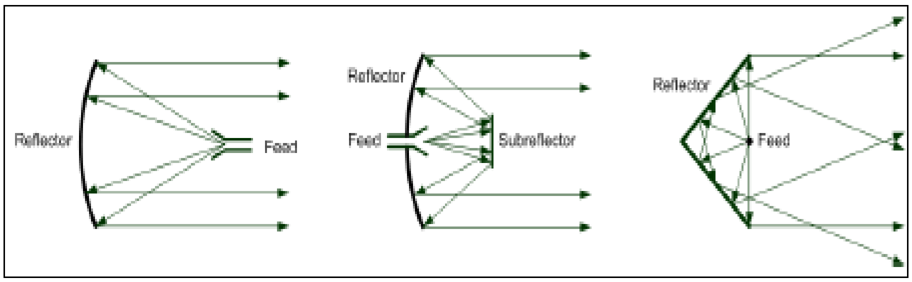

Figure 2.8: Typical reflector antennas. From left to right, parabolic reflector with front feed, parabolic reflector, and corner reflector (Balanis, 1997).

2.9.6 Lens Antennas

Lenses are primarily used to collimate incident divergent energy to prevent it from spreading in undesired directions as shown in Figure 2.9**.** After choosing the proper geometrical shape configration and select the suitable material of the lenses, they can transform various forms of divergent energy into plane waves. They can be used in most of the same applications as are the parabolic reflector, especially at higher frequencies (Balanis, 1997).

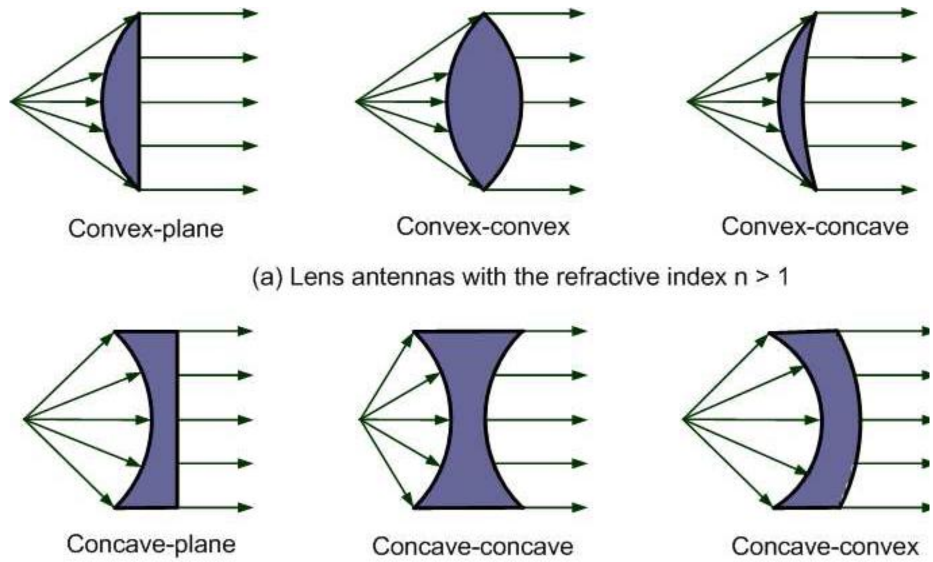

Figure 2.9: Typical lens antennas (Balanis, 1997).

2.10 Antenna characteristics

It is necessary to describe the characteristics of antenna, especially concentrate on characterizing a transmit antenna.

2.10.1 The transmitting antenna

The transmitting antenna is a device that converts the energy of a guided wave into the energy of a free space wave, with the radiation power distributed in a certain pattern in space. The thevenin equivalent circuit in Figure 2.10 can be used to analyze the performance of electrically small transmitting antennas, where (Monser, 1996)
R_{rad} is the radiation resistance, which is related to the radiated power as

$$p_{rad} = I_A^2 * R_{rad} \tag{2.1}$$

R_L is the loss resistance, which is related to conduction and dielectric losses.

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