DECLARATION

This certify that

a. The work contained in this report is original and has been done under the guidance of my supervisor(s).
b. The work has not been submitted to any other Institute for any degree or diploma.
c. I have followed the guidelines provided by the Institute in preparing the report.
d. I have conformed to the norms and guidelines given in the Ethical Code of Conduct of the Institute.
e. Whenever I have used materials (data, theoretical analysis, figures, and text) from other sources, We have given due credit to them by giving their details in the references. Further, We have taken permission from the copyright owners of the sources, whenever necessary.

Signature of students

Md. Zobayer Karim
2013-2-53-018

………………………

Md Naimul Hasan
2013-3-55-012

………………………

APPROVAL

This project report titled **Rectangular Microstrip Antenna For WIFI Communications Around 2.4 GHz** was prepared and submitted by **MD ZOBAYER KARIM(2013-2-53-018)** and **MD NAIMUL HASAN(2013-3-55-012)-** has been found satisfactory in term of scope, quality and presentation as partial fulfillment of the requirement for the Bachelor of Electronics & Communications Engineering, East West University

Checked and Approved by

…………………………….

DR. M.MOFAZZAL HOSSAIN

Professor & Chairperson

Department of Electronics & Communications

Engineering, East West University

Project Supervisor

MOHAMMAD ARIF IFTEKHAR

Lecturer

Department of Electronics & Communications Engineering

East West University

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ABSTRACT

An integrated directional patch antenna uses multiple patch radiating elements to control the direction of a beam of radio frequency energy (RF) over a large scan volume. The antenna includes a ground plane element and a first dielectric planar member placed on a major surface of the ground plane element. A plurality of first patch radiator elements is arranged on a surface of the first dielectric member remote from the ground plane element. A second dielectric planar member is placed on first patch radiator elements, and a plurality of second patch radiator elements arranged on a surface of the second dielectric member remote from the first patch radiator elements. First regions are formed in the dielectric planar member that have a first dielectric constant and are separated from each other by second regions that have a dielectric constant different from the first dielectric constant to effectively prevent surface wave energy from propagating in the first dielectric planar member, thereby increasing the scan volume of the antenna.

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Chapter 1

1.1 INTRODUCTION

In now day’s the wireless system has become a part of human life. Most of the electrical and electronics equipment around are using the wireless system. An antenna is an essential element of the wireless system. Antenna is an electrical device which transmits the electromagnetic waves into the space by converting the electric power given at the input into the radio waves and at the receiver side the antenna intercepts these radio waves and converts them back into the electrical power. There are so many systems that uses antenna such as remote controlled television, cellular phones, satellite communications, spacecraft, radars, wireless phones and wireless computer networks. Day by day new wireless devices are introducing which increasing1 demands of compact antennas. Increase in the satellite communication and use of antennas in the aircraft and spacecraft has also increased the demands a low profile antenna that can provide a reliable communication. A microstrip antenna is one who offers low profile and light weight. It is a wide beam narrow band antenna can be manufactured easily by the printed circuit technology such as a metallic layers in a particular shape is bonded on a dielectric substrate which forms a radiating element and another continuous metallic layer on the other side of substrate as ground plane. Not only the basic shapes any continuous shape can be used as the radiating patch. Instead of using dielectric substrate, some of the microstrip antennas use dielectric spacers which results in wider bandwidth but in the cost of less ruggedness. Microstrip antennas are low profile antenna and mechanical rugged and can be easily mounted on any planar and non planar surfaces. The applications of microstrip antennas are above the microwave frequency because below these frequencies the use of microstrip antenna doesn’t make a sense because of the size of antenna. At frequencies lower than microwave, microstrip patches don't make sense because of the sizes required. Now a day’s microstrip antenna is used in commercial sectors due to its inexpensiveness and easy to manufacture benefit by advanced printed circuit technology. Due to the development and ongoing research in the area of microstrip antenna it is expected that in future after some time most of the conventional antenna will be replaced by microstrip antenna.

1.2 HISTORY

Earlier in the 19th century in microwave circuitry we have started using coaxial cable and twin parallel wire line as the transmission lines. In the mid-20th century the invention of printed circuit board technology allow us to make the printed circuit versions of these transmission lines which were very inexpensive and simple. The two wire transmission line in printed circuit version is known as microstrip line, has a metallic ground plane providing the virtual 2nd conductor and the coaxial line cable is adapted in printed circuit version as Stripline.The attention on the fact that these microstrip structures can be used as radiator for electromagnetics wave got in 1950s. First in year the 1953 Deschamps introduces the concept of microstrip radiators. In 1955 a patent on the name of Gutton and Baissinot was issued in France . After getting the concept of microstrip radiator about 20 year a practical microstrip antenna was fabricated. Earlier these microstrip radiators were limited in the laboratories no commercial antennas are available at that time due to high loss and poor radiation. One of the reasons was unavailability of good dielectric material with minimum loss tangent which can use as substrate and can radiate efficiently. At that time stripline got more attention due to easy to design, analysis and suitable to microwave planar structure and it also allows transverse electromagnetic wave (TEM) . In 1955 R. M. Barret commented that “advantages of stripline and microstrip line are essentially the advantage of coaxial and twin wire transmission line”. May be these were some reasons microstrip radiators didn’t get the instant attention in that period.The research on microstrip radiator got attention when some good dielectric material were found with better thermal and mechanical properties has a low loss tangent. In 1969 Denlinger found the microstrip radiators with rectangular and circular shape could be able to radiate efficiently .Researchers had found previously that the half of the input power would escape in microstrip radiator as a radiation. Denlinger found the mechanism behind the radiation that if microstrip line is left open ended at the end this discontinuity will cause the electromagnetic waves to arise from the each open end. It was realized that the radiations will be more from the discontinuity when these are separated by half of wavelength distance or a multiple of that long to each other. It was also realized that the amount of power radiated from the open ends will increase if the height of the dielectric substrate increases. Denlinger noted that by increasing the height of substrate microstrip radiators was able to radiate the 70% of power available. He also carried his research on circular microstrip radiators and found that it was possible to attain up to 75% of radiation from a circular microstrip radiators. Microstrip radiators were now termed as microstrip antenna. One of the major benefit of microstrip antenna is that they are very comfy to planar and nonplanar surfaces can be easily mounted on that. This was the main reason that the microstrip antenna acquired the serious attention to the researchers in early 1970s when high performance application such as aircraft, spacecraft, missile, satellite communication put the motivation for researchers to investigate on usefulness of conformal microstrip antennas. After about 2 years Howell introduced a basic rectangular shape microstrip antenna that was fed using the microstrip transmission line. In that days microstrip antenna was a major focus for investigators. Researchers introduced many various designs. But it was difficult to get the better radiation efficiency that was limited upto 90%. Narrow bandwidth was also a severe problem for microstrip antenna. By 1981 research and study of microstrip antenna got a drift when IEEE made the microstrip antenna a special issue in the IEEE Transaction on Antenna and propagation.

1.3 ULTRA-WIDE BAND TECHNOLOGY

UWB technology has been used in the areas of radar, sensing and military communications during the past 20 years. A substantial surge of research interest has occurred since February 2002, when the FCC issued a ruling that UWB could be used for data communications as well as for radar and safety applications. Since then, UWB technology has been rapidly advancing as a promising high data rate wireless communication technology for various applications .This chapter presents a brief overview of UWB technology and explores its fundamentals, including UWB definition, advantages, current regulation state and standard activities. The UWB band covers a frequency spectrum of 7.5GHz. Such a wide band can be utilized with two different approaches: single-band scheme and multiband scheme.

1.4 SIGNAL MODULATION SCHEME

Information can be encoded in a UWB signal in various methods. The most popular signal modulation schemes for UWB systems include pulse-amplitude modulation (PAM) , pulse-position modulation (PPM) , binary phase-shift keying (BPSK) , and so on.

1.4.1 PAM

The principle of classic PAM scheme is to encode information based on the amplitude of the pulses, as illustrated in

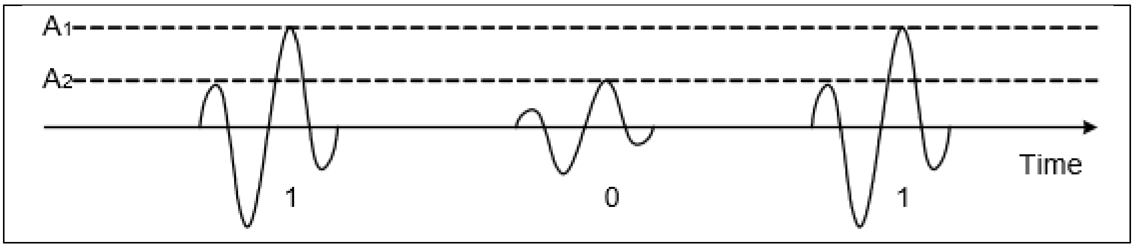


Figure 1.1: PAM MODULATION

The transmitted pulse amplitude modulated information signal x(t) can be represented as: x(t) = di ·w.r.t.(t) ,where w.r.t(t) denotes the UWB pulse waveform, i is the bit transmitted (i.e. ‘1’ or ‘0’), and

$$d_i = \begin{cases} A_1, & i = 1 \\ A_2, & i = 0 \end{cases}$$

Figure 1.1 illustrates a two-level (A1 and A2) PAM scheme where one bit is encoded in one pulse. More amplitude levels can be used to encode more bits per symbol

1.4.2 PPM

In PPM, the bit to be transmitted determines the position of the UWB pulse. As shown in Figure, the bit ‘0’ is represented by a pulse which is transmitted at nominal position, while the bit ‘1’ is delayed by a time of a from nominal position. The time delay a is normally much shorter than the time distance between nominal positions so as to avoid interference between pulses.

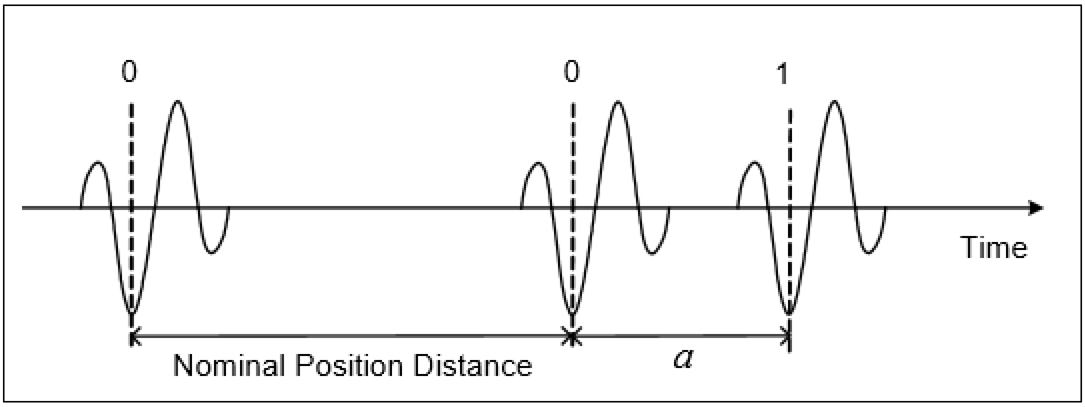


Figure 1.2: PPM MODULATION

The pulse position modulated signal x(t) can be represented as:

$$x(t) = w_{tr}(t - a \cdot d_i)$$

where wtr(t) and i have been defined previously, and

$$d_i = \begin{cases} 1, & i = 1 \\ 0, & i = 0 \end{cases}$$

Above figure illustrates a two-position (0 and a) PPM scheme and additional positions can be used to achieve more bits per symbol.

1.4.3 BPSK

In BPSK modulation, the bit to be transmitted determines the phase of the UWB pulse. As shown in Figure 1.3, a pulse represents the bit‘0’; when it is out of phase, it represents the bit ‘1’. In this case, only one bit is encoded per pulse because there are only two phases available. More bits per symbol may be obtained by using more phases.

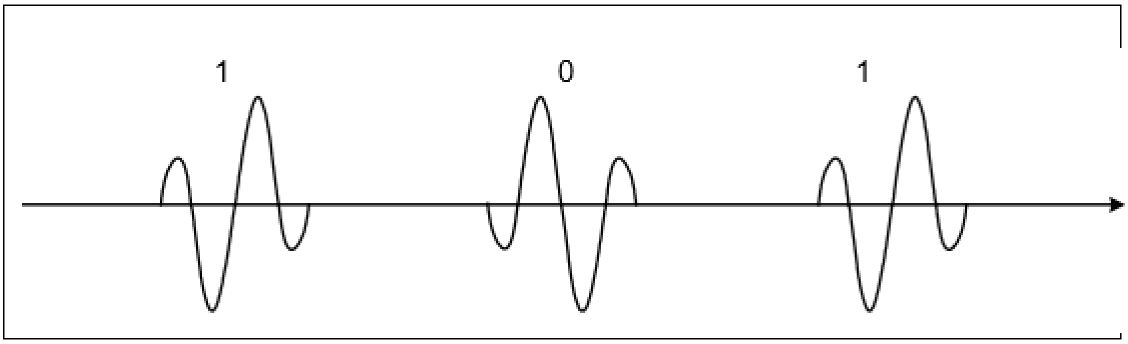


Figure 1.3: BPSK MODULATION

The BPSK modulated signal x(t) can be represented as:

$$x(t) = w_{tr}(t)e^{-j(d_i \cdot \pi)}$$

where wtr(t) and i have been defined previously, and

$$d_i = \begin{cases} 1, & i = 1 \\ 0, & i = 0 \end{cases}$$

1.5 FEATURES

There are five features we have discussed about Ultra Wide Banned Technology below. And these are also the benefits for using UWB technology

1.5.1 LARGE BANDWIDTH

The FCC allocated an absolute bandwidth more than 500 MHz up to 7.5 GHz which is about 20% up to 110% fractional bandwidth of the center frequency. This large bandwidth spectrum is available for high data rate communications as well as radar and safety applications to operate in. Figure.1.4 shows the comparison between conventional narrowband (NB) versus UWB communications in both time- and frequency-domains. The conventional NB radio systems use NB signals which are sinusoidal waveforms with a very narrow frequency spectrum in both transmission and reception. Unlike a NB system, an Ultra-wideband radio system can transmit and receive very short duration pulses. These pulses are considered UWB signals because they have very narrow time duration with very large instantaneous bandwidth .The nature of the short-duration pulses used in UWB technology offers several advantages over narrowband communications systems. In this section, we discuss some of the key benefits that UWB brings to wireless communications.

1.5.2 VERY SHORT DURATION PULSES

A typical received UWB pulse shape which is known as a Gaussian doublet is shown in Figure. 1.5 (a). This pulse is often used in UWB systems because its shape is easily generated. Ultra-wideband pulses are typically of nanoseconds or picoseconds order. This is the origin of the name Gaussian pulse, monocycle or doublet .Transmitting the pulses directly to the antennas results in the pulses being filtered due to the properties of the antennas. This filtering operation can be modeled as a derivative operation. The same effect occurs at the receive antenna. The spectrum of the Gaussian doublet is shown in Figure. 1.5(b). Due to using UWB systems those very short duration pulses, they are often characterized as multipath immune or multipath resistant.

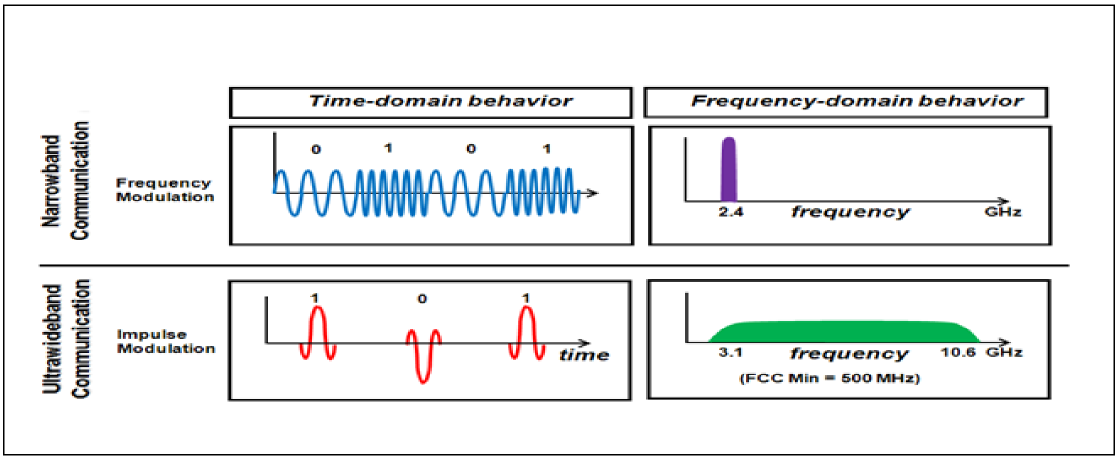
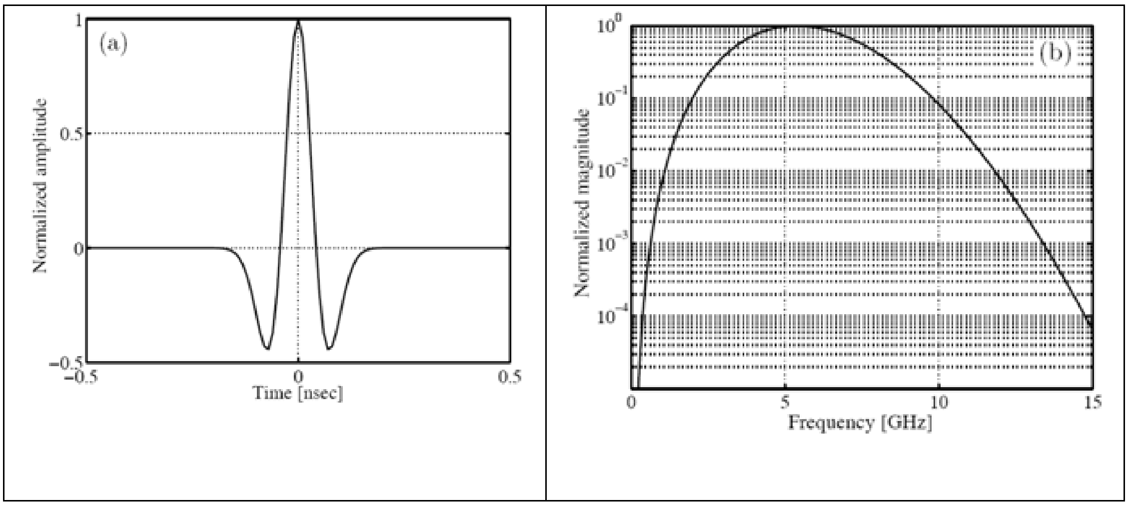


Figure 1.4:Time and frequency-domain behaviors for narrowband versus UWB communications



(a) (b)

Figure 1.5: (a) Idealized received UWB pulse shape and (b) Idealized spectrum of a single received UWB pulse

1.5.3 ABILITY TO SHARE THE FREQUENCY SPECTRUM

The FCC’s power requirement of –41.3 dBm/MHz, equal to 75 nano-watts/MHz for UWB systems, puts them in the category of unintentional radiators, such as TVs and computer monitors. Such power restriction allows UWB systems to reside below the noise floor of a typical narrow-band receiver and enables UWB signals to coexist with current radio services with minimal or no interference.

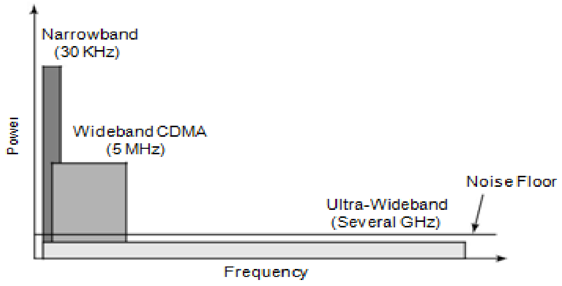


Figure 1.6: Coexistence of UWB signals with narrowband and wideband signals in the RF spectrum

1.5.4 LARGE CHANNEL CAPACITY

One of the major advantages of the large bandwidth for UWB pulses is improved channel capacity. *Channel capacity*, or data rate, is defined as the maximum amount of data that can be transmitted per second over a communications channel. The large channel capacity of UWB communications systems is evident from Hartley-Shannon’s capacity formula:

$$C = B\log_2(1+SNR)$$

Where C represents the maximum channel capacity, B is the bandwidth, and SNR is the signal-to-noise power ratio.

1.5.5 ABILITY TO WORK WITH LOW SIGNAL-TO-NOISE RATIOS

The Hartley-Shannon formula for maximum capacity also indicates that the channel capacity is only logarithmically dependent on signal-to-noise ratio (SNR). Therefore, UWB communications systems are capable of working in harsh communication channels with low SNRs and still offer a large channel capacity as a result of their large bandwidth.

1.5.6 LOW PROBABILITY OF INTERCEPT AND DETECTION

Because of their low average transmission power, as discussed in previous sections, UWB communications systems have an inherent immunity to detection and intercept. With such low transmission power, the eaves-dropper has to be very close to the transmitter (about 1 meter) to be able to detect the transmitted information. In addition, UWB pulses are time modulated with codes unique to each transmitter/receiver pair. The time modulation of extremely narrow pulses adds more security to UWB transmission, because detecting picoseconds pulses without knowing when they will arrive is next to impossible. Therefore UWB systems hold significant promise of achieving highly secure, low probability of intercept and detection (LPI/D) communications that is a critical need for military operations. The abbreviation *dBm* stands for decibels per milli watt. Hence, –41.3 dBm/MHz is equal to 75 nW/MHz.

1.6 **DRAWBACKS:**

UWB technology for communications is not all about advantages. In fact, there are many challenges involved in using nanosecond-duration pulses for communications. Some of the main difficulties of UWB communications are discussed in the following subsections.

1.6.1 DISTORTED PULSE SHAPE

The transmission characteristics of UWB pulses are more complicated than those of continuous narrowband sinusoids. A narrowband signal remains sinusoidal throughout the transmission channel. However, the weak and low-powered UWB pulses can be distorted significantly by the transmission link. We can show this distortion mathematically with the widely used Friis transmission formula:

Equation :

$$P_r = P_t\, G_t\, G_r \left(\frac{c}{4\pi d f}\right)^2$$

where P_r and P_t are the received and transmitted signal power, respectively; G_t and G_r are the transmitter and receiver antenna gains, respectively; c is the speed of light; d is the distance between the transmitter and the receiver; and f is the signal frequency.

This formula shows that the received signal power will decrease quadratically with the increase in frequency. In narrowband signals with a very narrow frequency band, the change in frequency only minimally changes the received power and hence can be overlooked. However, due to the wide range of frequencies that is covered by the UWB spectrum, the received power drastically changes and thus distorts the pulse shape. This will limit the performance of UWB receivers that correlate the received pulses with a predefined template such as classical matched filters.

1.6.2 ESTIMATED CHANNEL

Channel estimation is a core issue for receiver design in wireless communications systems. Because it is not possible to measure every wireless channel in the field, it is important to use training sequences to estimate channel parameters, such as attenuations and delays of the propagation path. Given that most UWB receivers correlate the received signal with a predefined template signal, prior knowledge of the wireless channel parameters is necessary to predict the shape of the template signal that matches the received signal. However, as a result of the wide bandwidth and reduced signal energy, UWB pulses undergo severe pulse distortion; thus, channel estimation in UWB communications systems becomes very complicated.

1.6.3 High-Frequency Synchronization

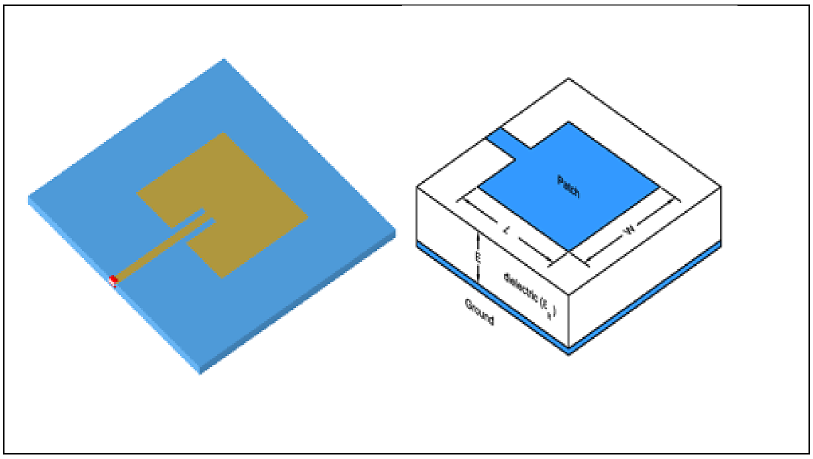
Time synchronization is a major challenge and a rich area of study in UWB communications systems. As with any other wireless communications system, time synchronization between the receiver and the transmitter is a must for UWB transmitter/receiver pairs. However, sampling and synchronizing nanosecond pulses place a major limitation on the design of UWB systems. In order to sample these narrow pulses, very fast (on the order of gigahertz) analog-to-digital converters (ADCs) are needed. Moreover, the strict power limitations and short pulse duration make the performance of UWB systems highly sensitive to timing errors such as jitter and drift. This can become a major issue in the success of pulse-position modulation (PPM) receivers, which rely on detecting the exact position of the received signal.

CHAPTER 2

2.1 PATCH ANTENNA

2.1.1 PATCH ANTENNA INTRODUCTION

A patch antenna is a wafer-like directional antenna suitable for covering single-floor small offices, small stores and other indoor locations where access points cannot be placed centrally. Patch antennas produce hemispherical coverage, spreading away from the mount point at a width of 30 to 180 degrees. Patch antennas are also known as panel, flat panel or microstrip antennas. They are formed by overlaying two metallic plates, one larger than the other, with a dielectric sheet in the middle. This type of antenna is usually encased in white or black plastic, not only to protect the antenna, but also to make it easy to mount. Because they are flat, thin and lightweight, patch antennas are often hung on walls or ceilings where they remain visually unobtrusive and blend easily into the background.



(a) (b)

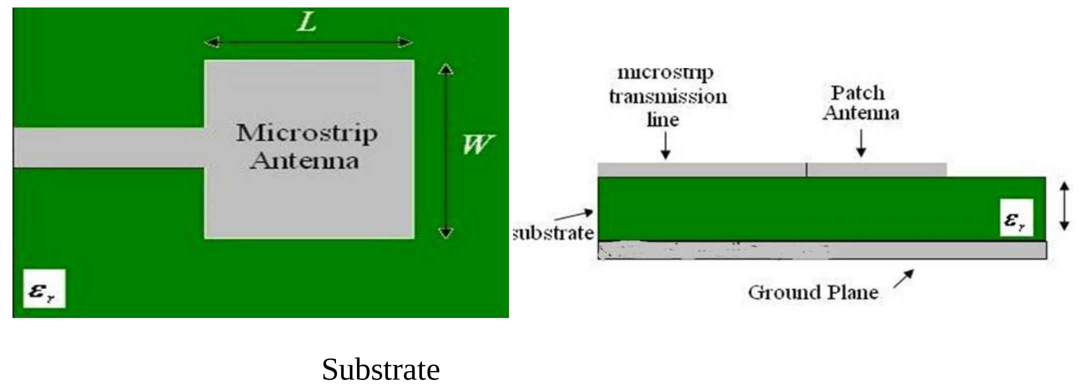
Figure 2.1: (a) A simple Patch antenna (b) A geometrical figure of patch antenna

A **patch antenna** (also known as a rectangular microstrip antenna) is a type of radio antenna with a low profile, which can be mounted on a flat surface. It consists of a flat rectangular sheet or "patch" of metal, mounted over a larger sheet of metal called a ground plane. They are the original type of microstrip antenna described by Howell in 1972; the two metal sheets together form a resonant piece of microstrip transmission line with a length of approximately one-half wavelength of the radio waves. The radiation mechanism arises from discontinuities at each truncated edge of the microstrip transmission line. The radiation at the edges causes the antenna to act slightly larger electrically than its physical dimensions, so in order for the antenna to be resonant, a length of microstrip transmission line slightly shorter than one-half a wavelength at the frequency is used.

A variant of the patch antenna commonly used in mobile phones is the shorted patch antenna, or planar inverted-F antenna (PIFA). In this antenna, one corner of the patch (or sometimes one edge) is grounded with a ground pin. This variant has better matching than the standard patch.

2.1.2 GEOMETRICAL ANALYSIS

Consider the microstrip antenna shown in Figure 1, fed by a microstrip transmission line. The patch antenna, microstrip transmission line and ground plane are made of high conductivity metal (typically copper). The patch is of length L, width W, and sitting on top of a substrate (some dielectric circuit board) of thickness h with permittivity permittivity or dielectric constant. The thickness of the ground plane or of the microstrip is not critically important. Typically the height h is much smaller than the wavelength of operation, but should not be much smaller than 0.025 of a wavelength (1/40th of a wavelength) or the antenna efficiency will be degraded.



(a) (b)

Figure 2.2: (a) top view patch antenna (b) Side view patch antenna

The frequency of operation of the patch antenna of Figure 2.2 (a) is determined by the length L. The center frequency will be approximately given by:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}}$$

The above equation says that the microstrip antenna should have a length equal to one half of a wavelength within the dielectric (substrate) medium.

The width W of the microstrip antenna controls the input impedance. Larger widths also can increase the bandwidth. For a square patch antenna fed in the manner above, the input impedance will be on the order of 300 Ohms. By increasing the width, the impedance can be reduced. However, to decrease the input impedance to 50 Ohms often requires a very wide patch antenna, which takes up a lot of valuable space. The width further controls the radiation pattern. The normalized radiation pattern is approximately given by:

$$E_\theta = \frac{\sin\left(\dfrac{kW \sin\theta \sin\phi}{2}\right)}{\dfrac{kW \sin\theta \sin\phi}{2}} \cos\left(\frac{kL}{2}\sin\theta\cos\phi\right)\cos\phi$$

$$E_\varphi = -\frac{\sin\left(\dfrac{kW \sin\theta \sin\phi}{2}\right)}{\dfrac{kW \sin\theta \sin\phi}{2}} \cos\left(\frac{kL}{2}\sin\theta\cos\phi\right)\cos\theta\sin\phi$$

In the above, k is the free-space wave number, given by $2\pi / \lambda$ the magnitude of the field is given by

$$f(\theta,\phi) = \sqrt{E_\theta^2 + E_\phi^2}$$

The fields of the microstrip antenna are plotted in Figure 2 for W=L=0.5lambda

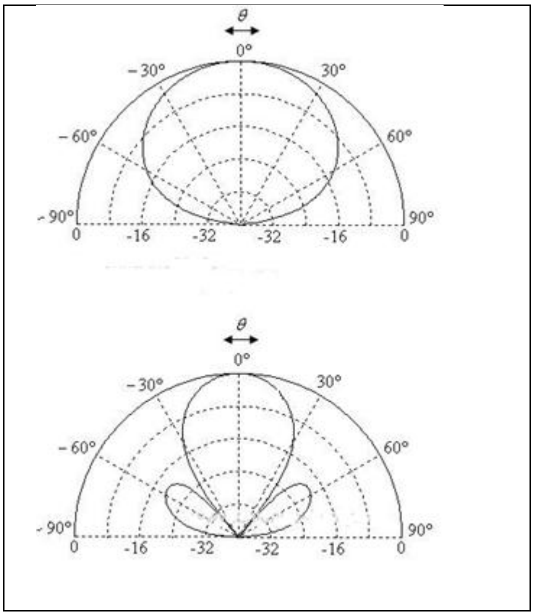


Figure 2.3 : Normalized radiation pattern for patch antenna

The directivity of patch antennas is approximately 5-7 dB. The fields are linearly polarized, and in the horizontal direction when viewing the microstrip antenna as in Figure 2.3(we'll see why in the next section). Next we'll consider more aspects involved in Patch (Microstrip) antennas.Consider a square patch antenna fed at the end as before in Figure 1a. Assume the substrate is air (or styrofoam, with a permittivity equal to 1), and that L=W=1.5 meters, so that the patch is to resonate at 100 MHz. The height h is taken to be 3 cm. Note that microstrips are usually made for higher frequencies, so that they are much smaller in practice. When matched to a 200 Ohm load, the magnitude of S11 is shown in Figure 2.4.

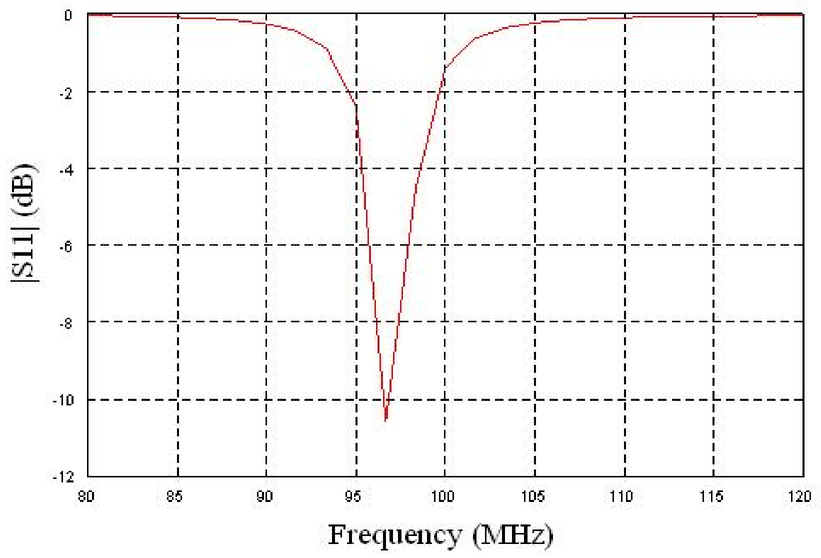


Figure 2.4: Magnitude of S11 versus Frequency for Square Patch Antenna.

Some noteworthy observations are apparent from Figure 2.4. First, the bandwidth of the patch antenna is very small. Rectangular patch antennas are notoriously narrowband; the bandwidth of rectangular microstrip antennas are typically 3%. Secondly, the microstrip antenna was designed to operate at 100 MHz, but it is resonant at approximately 96 MHz. This shift is due to fringing fields around the antenna, which makes the patch seem longer. Hence, when designing a patch antenna it is typically trimmed by 2-4% to achieve resonance at the desired frequency.

2.1.3 ADVANTAGES

1.low fabrication cost,hence can be manufactured in large quantities

2.Easily integrated with microwave integrated circuits(MICs)

3.Capable of dual and triple frequency operations

4.Supports both linear as well as circuler polarization

5.Low cost,less size, low mass

6.Mechanically robust when mounted on rigid surfaces

7.High perfomance

8.Light weight and low volume

2.1.4 DISADVANTAGES

1.Narrow bandwidth associated with tolerence prolem

2.Lower gain(nearly 6db)

3.Excitation of surface waves

4.Most microstrip antennas radiate into half space

5.Relatively high level of cross polarization radiation

6.Inherently low impedence bandwidth

7.Iow efficiency

8.Low power handling capacity

2.2 DESIGNING AND APPLICATION

2.2.1 ANALYSIS TECHNIQUE

Analysis Techniques The main reason for developing an analytic model for the microstrip antenna is to provide a means of designing the antenna without costly and tedious experimental iteration. Also, it may allow the designer to discover the physical mechanisms of how the microstrip antenna operates.With an analysis technique, the engineer should be able to predict the antenna performancequalities, such as the input impedance, resonant frequency, bandwidth, radiation patterns, and efficiency.There are many different analysis techniques that have been developed for analyzing the microstrip antennas.However, the most popular ones can be separated into five groups: transmission-line circuit model, multimode cavity model, moment method, finite-difference time-domain (FDTD) method, and finite-element method.

2.2.2Design Methodology

The previous section presented different techniques to analyze the microstrip antenna. To ease the design process, these different analysis techniques have been developed into several user-friendly computer-aided design (CAD) tools by several institutions. However, an analysis technique or a CAD tool, by itself, cannot generate an antenna design. It can only analyze a design and provide calculated performance results for a design. The basic and initial antenna design has to originate from human experience, knowledge, and innovation, even though an optimum and accurate design often cannot be achieved without an analysis tool. Figure 4.7 depicts a typical microstrip antenna development process. The block labeled "Computer Analysis Software" represents the central processing unit into which a human must enter the proper design data to initiate the design process. The block labeled "Antenna Design Techniques" represents the knowledge for generating a set of preliminary input design data, which is the main subject of this section.It includes techniques to design patch elements, array configurations, and power division transmission lines, which areseparately discussed next. The first step in designing a microstrip array should be the element design.

There are few designing techniques:

1.Patch Element Design

2.Array Configuration Design

3.Power Division Transmission-Line Design

2.2.3 Applications

The microstrip patch antennas are famous for their performance and robust design. Microstrip patch antennas have applications in various fields such as in the medical field, satellites and even in the military systems just like in the rockets, aircrafts missiles and many more. Now they are booming in the commercial aspects due to their low cost of the substrate material and the fabrication. Microstrip patch antenna has a number of applications. Some of these applications are discussed as

- **Mobile and satellite communication application:** Mobile communication requires small, low profile, low cost antennas. Microstrip patch antenna meets all the necessities and a number of microstrip antennas have been designed for use in mobile communication systems.
- **Global positioning system applications:**Microstrip patch antennas having high permittivity sintered substrate material for global positioning system (GPS). These antennas are circularly polarized, very compact
- **Radio frequency identification (RFID**): RFID is used in different areas like mobile communication, logistics, manufacturing, transportation and health

care. RFID system generally uses frequencies between 30 Hz and 5.8 GHz depending on its applications. Basically RFID system is a tag or transponder and a transceiver or reader.

- **Reduced size microstrip patch antenna for Bluetooth applications:** In this, the microstrip antenna operates in the 2400 to 2484 MHz ISM Band. Although an air substrate is introduced, microstrip antenna occupies a small volume of 33.3×6.6×0.8 .
- **Interoperability for microwave access (WiMax):** The IEEE 802.16 standard is known as WiMax. It can reach upto 30 mile radius theoretically and data rate 70 Mbps. Microstrip patch antenna generates three resonant modes at 2.7, 3.3 and 5.3 GHz and can, therefore, be used in WiMax compliant communication equipment. In the wireless communication, networking, aerospace & defense industries. For WiMAX, LTE, multi-gigabit per second data links, radar, & satellite applications, ADS provides full, standards-based design and verification with Wireless Libraries and circuit-system-EM co-simulation in an integrated platform.
- **Broadband microstrip S-shaped patch antenna for wireless communication**: This is a single-patch broadband microstrip S-shaped patch antenna. MicrostripSshaped patch antenna is fed by a coaxial feeding. The antenna is designed by inserting two slots into rotated square patch then it look like English
  letter ‘S’. Because of the slots and thick substrate, bandwidth of antenna is increased.
- **Radar application:** Radar can be used for detecting moving targets such as people and vehicles. The microstrip antennas are an ideal choice. The fabrication technology based on photolithography enables the bulk production of microstrip antenna with repeatable performance at a lower cost in a lesser time frame as compared to the conventional antennas.

2.3 FEED/EXCITATION METHODS

2.3.1 TECHNIQUE:

A microstrip patch radiator can be fed or excited to radiate by many techniques; several common ones are listed and briefly discussed next.

2.3.2 Coax Probe Feed:

A microstrip patchas shown in Figure 4.1 can be fed by a 50-ohm coax probe from behind the ground plane, where the flange of the coax probe (outer conductor) is soldered to the ground plane. The center conductor pin penetrates through the substrate and the patch and is then soldered to the top of the patch. The location of the probe should be at a 50-ohm point of the patch to achieve impedance matching. There are various types of coax probes for different frequency ranges. Type N, TNC, or

BNC can be used for VHF, UHF, or low microwave frequencies. OSM or OSSM can be used throughout microwave frequencies. OSSM, OS-50, or K-connector should be used for the millimeter-wave frequency range.

2.3.3 Coax Probe with Capacitive Feed:

For wider bandwidth (5–15%) applications, thicker substrate is generally used. If a regular coax probe were used, a larger inductance would be introduced, which results in impedance mismatch. In other words, the electrical field confined in the small cylindrical space of the coax cannot suddenly transition into the large spacing of the patch. To cancel the inductance occurring at the feed, capacitive reactance must be introduced. One method is to use a capacitive disk as shown in Figure 2.5,where the patch is not physically connected to the probe. Another method is to use a “tear-drop” shaped or a cylindrical shaped probe as illustrated in Figure 2.6. With this method the probe is soldered to the patch, where mechanical rigidity may be offered for some applications.

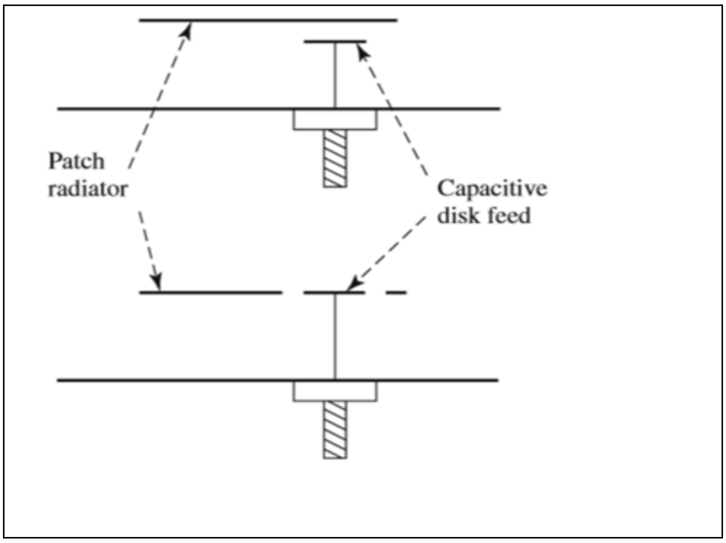


Figure 2.5 : Two different capacitive feed methods for relatively thick substrates

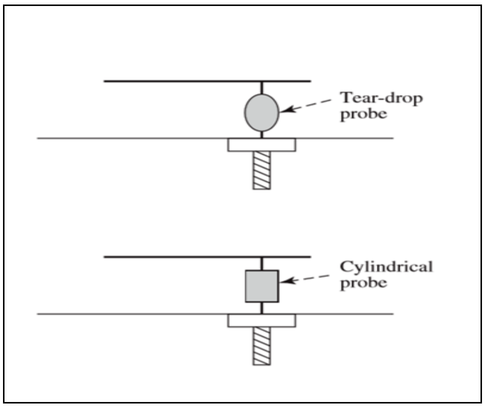


Figure 2.6: Tear drop and cylindrical shaped feed probes for relatively thick substrates

Chapter 3

3.1 CST STUDIO INTRODUCTION

CST is a market leader in providing 3D electromagnetic (EM) field simulation tools through a global network of sales and support staff and representatives. CST develops CST STUDIO SUITE, a package of high-performance software for the simulation of EM fields in all frequency bands. Its growing success is based on a combination of leading edge technology, a user-friendly interface and knowledgeable support staff. CST solutions are used by market leaders in a diverse range of industries, including aerospace, automotive, defense, electronics, healthcare and telecommunications. CST is part of SIMULIA, a Dassault Systems brand.

Release Version 2016.00 - Jan 22 2016

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- The Qt GUI Toolkit is Copyright © 1994-2015 The Qt Company Ltd.

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Figure 3.1: CST studio starting layout

3.2 SOLVING TECHNIQUES

1. **High frequency:**
   - Transient solver – general purpose
   - Frequency domain solver – general purpose
   - Integral equation solver – electrically large structures, RCS
   - Asymptotic solver – installed performance, RCS
   - Eigen mode solver – resonant cavities
   - Multilayer solver – planar structures
   - Filter Designer 2D – RF filter analysis and synthesis
   - Filter Designer 3D – cross-coupled cavity filter synthesis

2. **Low frequency:**
   - Electrostatic / Magneto static – fast static simulation
   - Stationary current solver – DC applications
   - Time domain solver – non-linear materials, transient effects
   - Frequency domain solver – eddy currents, displacement current

3. **EDA:**
   - PEEC solver – boards without reference planes
   - Transmission line solver – signal integrity
   - 3D FEFD solver – power integrity
   - Rule Check – EMC and SI on PCB

4. **Particle dynamics:**
   - Particle tracking solver – low energy particles, electron guns
   - PIC solver – high energy particles, RF devices
   - Wake field solver – accelerator components

5. **Multiphysics:**
   - Thermal solvers – electromagnetic heating, bio heat
   - Structural mechanics solver – thermal expansion, deformation

6. **EMC:**
   - Transmission line matrix (TLM) solver – general purpose, EMC
   - Cable solver – cable harness simulation
   - Rule Check – EMC and SI on PCBs.

3.3 MICROSTRIP ANTENNA DESIGN PARAMETERS

All of the parameters in a rectangular patch antenna design (L, W, h, permittivity) control the properties of the antenna. As such, this page gives a general idea of how the parameters affect performance, in order to understand the design process. First, the length of the patch L controls the resonant frequency as seen here. This is true in general, even for more complicated microstrip antennas that weave around - the length of the longest path on the microstrip controls the lowest frequency of operation. Equation (1) below gives the relationship between the resonant frequency and the patch length:

$$f_c \approx \frac{c}{2L\sqrt{\varepsilon_r}} = \frac{1}{2L\sqrt{\varepsilon_0 \varepsilon_r \mu_0}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Second, the width W controls the input impedance and the radiation pattern (see the radiation equations here). The wider the patch becomes the lower the input impedance is. The permittivity epsilon r permittivity (dielectric constant) of the substrate controls the fringing fields - lower permittivities have widerfringes and therefore better radiation. Decreasing the permittivity also increases the antenna's bandwidth. The efficiency is also increased with a lower value for the permittivity. The impedance of the antenna increases with higher permittivities.

Higher values of permittivity allow a "shrinking" of the patch antenna. Particularly in cell phones, the designers are given very littlespace and want the antenna to be a half-wavelength long. One technique is to use a substrate with a very high permittivity. Equation (1) above can be solved for L to illustrate this:

$$L \approx \frac{1}{2 f_c \sqrt{\varepsilon_0 \varepsilon_r \mu_0}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots..(2)$$

Hence, if the permittivity is increased by a factor of 4, the length required decreases by a factor of 2. Using higher values for permittivity is frequently exploited in antenna miniaturization.

The height of the substrate h also controls the bandwidth - increasing the height increases the bandwidth. The fact that increasing the height of a patch antenna increases its bandwidth can be understood by recalling the general rule that "an antenna occupying more space in a spherical volume will have a wider bandwidth". This is the same principle that applies when noting that increasing the thickness of a dipole antenna increases its bandwidth. Increasing the height also increases the efficiency of the antenna. Increasing the height does induce surface waves that travel within the substrate (which is undesired radiation and may couple to other components).The following equation roughly describes how the bandwidth scales with these parameters:

$$B \propto \frac{\varepsilon_r - 1}{\varepsilon_r^2} \frac{W}{L} h \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots..(3)$$

3.4 THE TRANSMISSION LINE EQUATIONS:

1) To find Width (W) :

$$W = \frac{c}{2 f_o \sqrt{\frac{(\varepsilon r+1)}{2}}} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

2) TO FIND THE EFFECTIVE DIELECTRIC CONSTANT:

$$\varepsilon_{reff} = \frac{\varepsilon r+1}{2} + \frac{\varepsilon r-1}{2} \left(1 + 12\,\frac{h}{W}\right)^{-1/2} \qquad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (2)$$

3) <u>TO FIND THE EFFECTIVE LENGTH:</u>

$$L_{eff} = \frac{c}{2f_{\circ}\sqrt{\varepsilon reff}}$$

....................................(3)

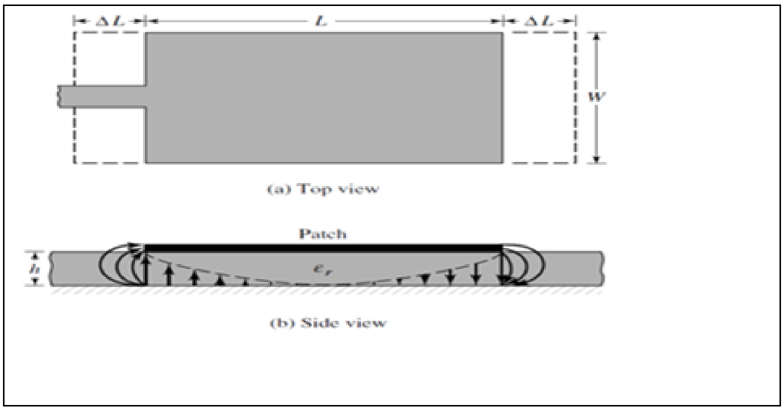


Figure 3.2: Physical and effective lengths of microstrip patch antenna

<u>4) TO FIND THE FRINGING LENGTH (ΔL) :</u>

$$\Delta L = 0.412\,h\,\frac{(\varepsilon reff+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon reff-0.258)\left(\frac{W}{h}-0.8\right)}$$

…………………………….(4)

5) <u>To find the actual length L and the width and length of the Ground</u> :

$$L = L_{eff} - 2\Delta L$$

……………………………………………………….(5)

1) Lg=2∗L 2)Wg=2*W

6) <u>The length of inset (Fi)</u> :

Fi= 10^4*.001699∗εr7+0.13761∗εr6−6.1783∗εr5+93.187∗εr4−682.69 ∗εr3..... (6)

7) <u>The feed line width of (Wf)</u> :

$$w = \frac{7.48 \times h}{e^{\left(Z_0\frac{\sqrt{\varepsilon_r+1.41}}{87}\right)}} - 1.25 \times t$$

`**…………………………………..**(7)

3.5 PARAMETERS:

We took different inset feed value for the square microstrip antenna.And we have got 3 different sparameters. We mainly used FR-lossy material for the antenna using cst.

The box shown below is all the parameters we used for the design of the microstrip antenna

Parameter Name	FR-lossy ε_r (4.3)
Width (w)	28.45
Length (l)	28.45
feed line width (wf)	1.137
gap-patch an feed (gpf)	1
Ground length (lg)	2*l
Ground width(wg)	2*w
Height-conductor(ht)	0.035
Substrate (hs)	1.6

3.6 PART DESIGNING OF AN ANTENNA: This are the process we have gone through while designing the desire antenna

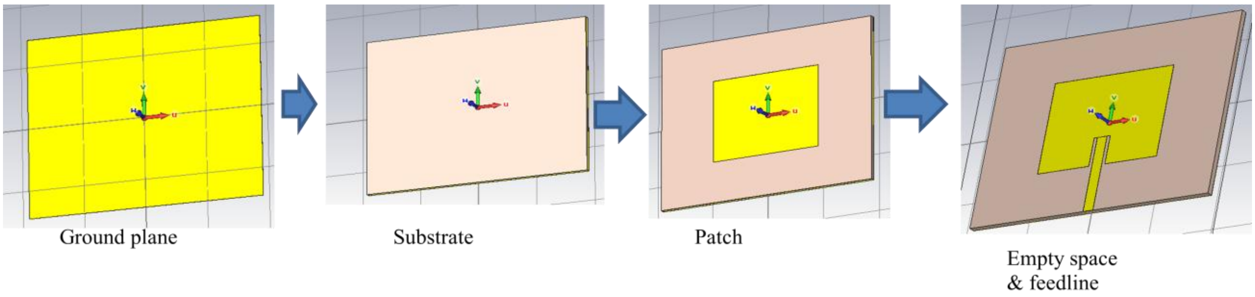


Figure 3.3: Different parts of an antenna

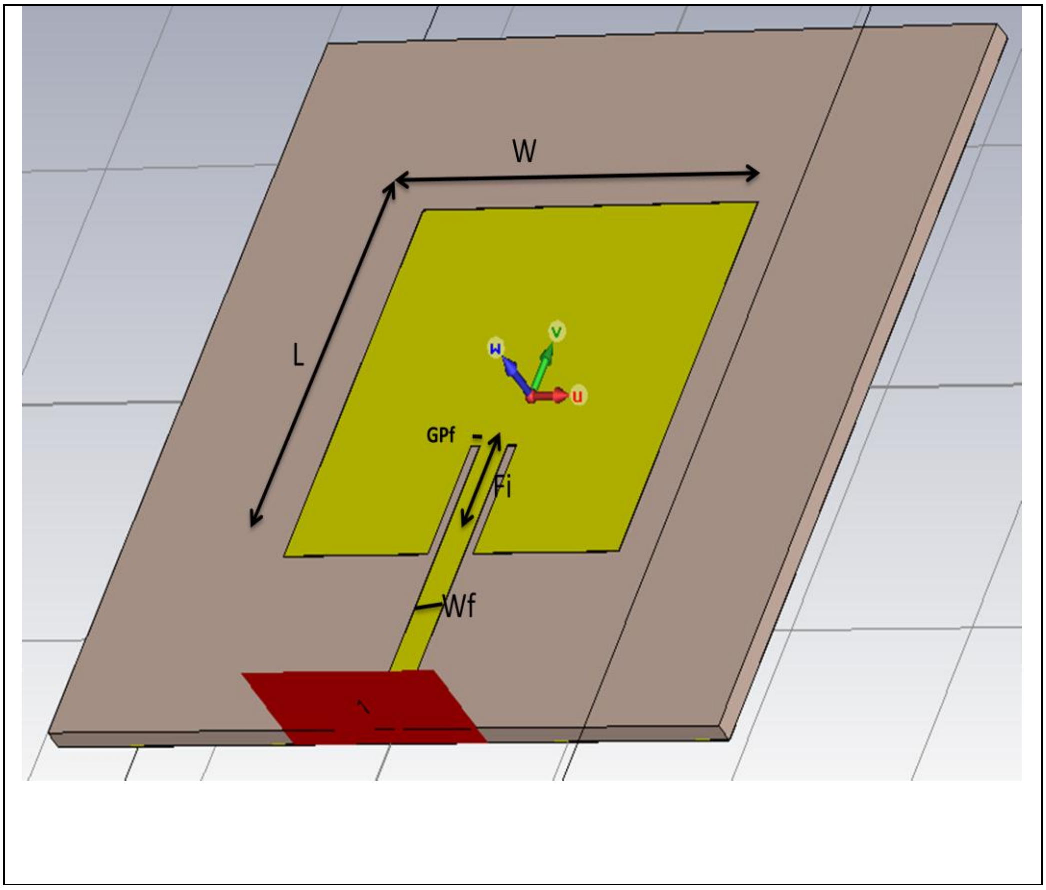


Figure 3.4 :Complete patch antenna

So In Figure 3.4 this the complete patch antenna with labeling in 3D view where Gpf means (gap between patch and inset feed) and Wf (width of the feed line) and Fi means (length of the inset feed)

Chapter 4

4.1 SIMULATION:

After successfully design the antenna in CST studio suite , Now it's time for the simulation part where we can check the bandwidth through "S-parameter" , can also check the Gain, Realized Gain , Far-field, H-field, Balance, Efficiency, VSWR (voltage Standing Wave Ratio). So we were simulated our antenna through Time Domain Solver Parameter , in figure 4.1 the solver setting is given for our antenna and in figure 4.2 successfully simulated message for our antenna

4.2 S PARAMETERS:

S parameter(fi=8)

where fi=inset feeding

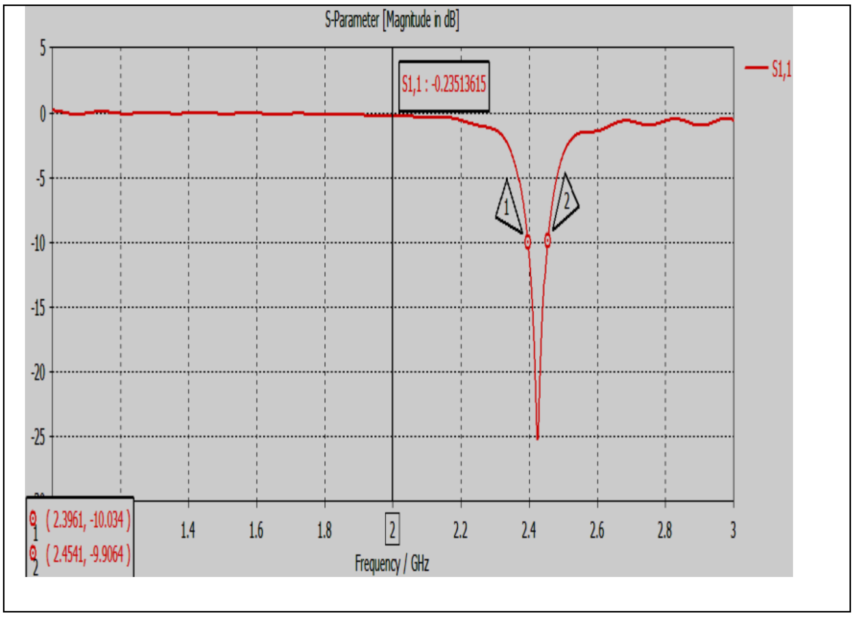


Figure 4.1: sparameter where fi=8

Here we change the inset feed to 8 ,width and length 28.45, feed line width 1.137, gap patch an feed 1.height conductor .035,substrate 1.6

S parameter(fi=9)

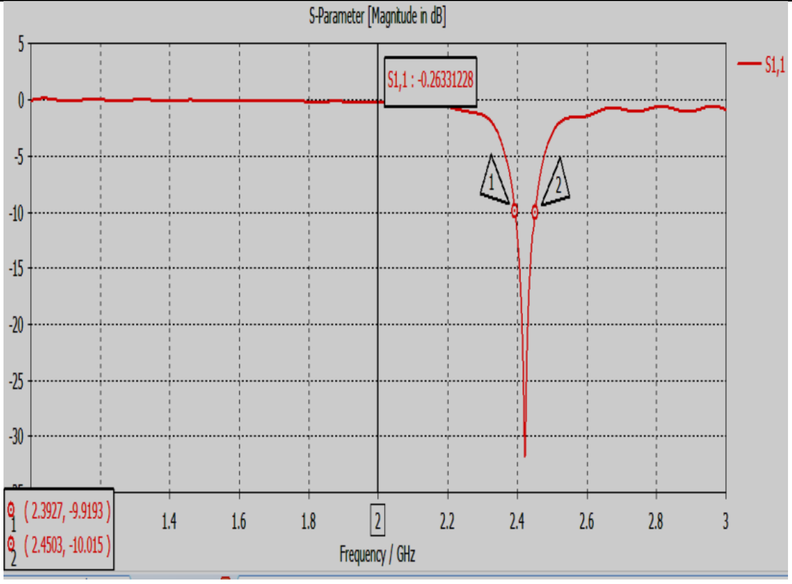


Figure 4.2 : sparameter where fi=9

Here we change the inset feed to 9 ,width and length 28.45, feed line width 1.137,gap patch an feed 1.height conductor .035,substrate 1.6

OUR PROPOSED ANTENNA:

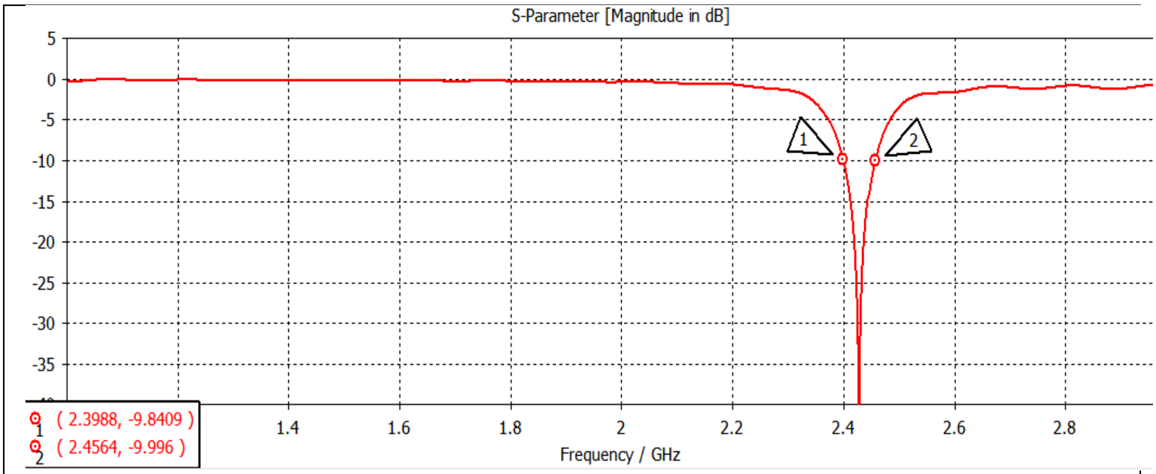
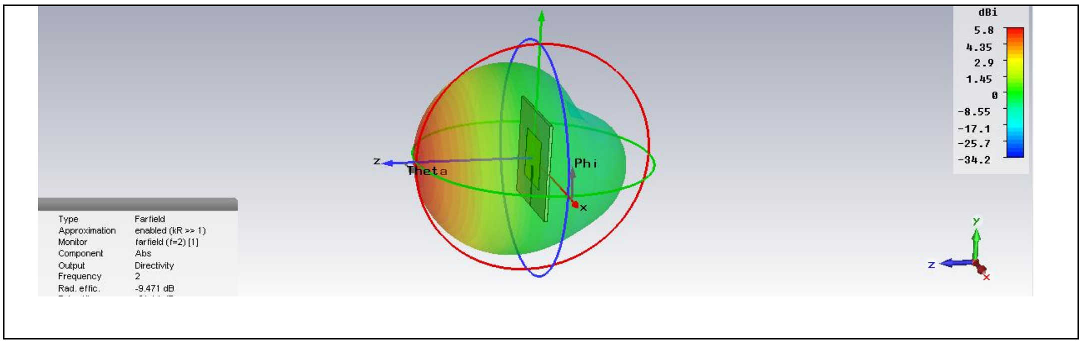


Figure 4.3: sparaeter where fi=10

Here we change the inset feed to 10 ,width and length 28.45, feed line width1.137,gap patch an feed 1.height conductor .035,substrate 1.6

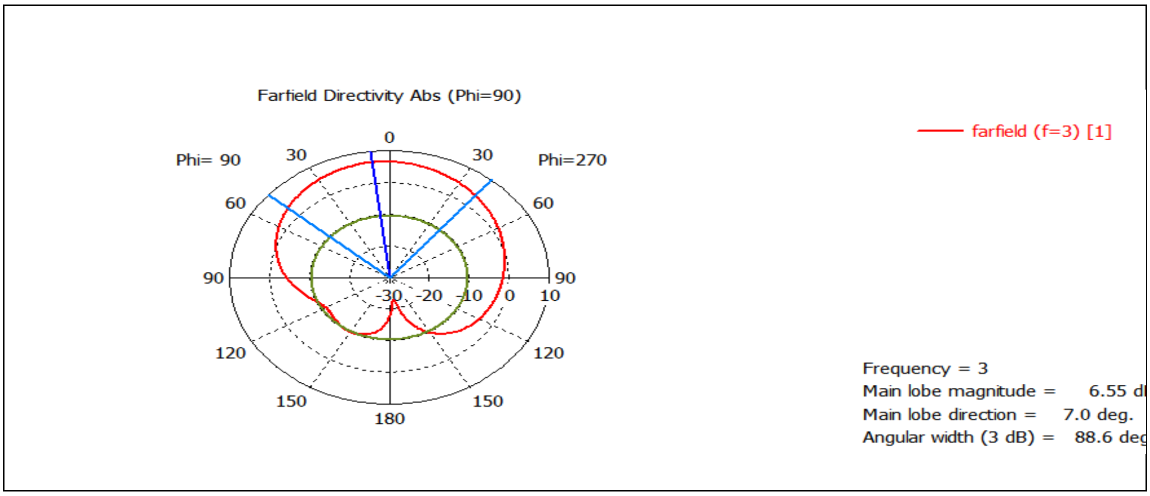
4.3 RADIATION PATTERN

The far field is the region far from the antenna, as you might suspect. In this region, the radiation pattern does not change shape with distance (although the fields still die off as 1/R, the power density dies off as 1/R^2). Also, this region is dominated by radiated fields, with the E- and H-fields orthogonal to each other and the direction of propagation as with plane waves



```
Type            Farfield
Approximation   enabled (kR >> 1)
Monitor         farfield (f=2) [1]
Component       Abs
Output          Directivity
Frequency       2
Rad. effic.     -9.471 dB
```

Figure 4.4: Far Field Radiation pattern in 3D form



```
Frequency = 3
Main lobe magnitude =     6.55 d
Main lobe direction =    7.0 deg.
Angular width (3 dB) =   88.6 deg
```

Figure 4.5: Polar form

Chapter 5

5.1 CONCLUSION:

In this paper we have discussed a rectangular microstrip antenna for wifi communication which is around 2.4 Ghz. We have operate it at frequency band 1 GHz to 3 GHz. The return loss at 2.4 GHz frequency is below -10db. For a better result we have changed inset feeding many times to come up with best result. We search and studied several things until we get the best possible result for our desired antenna. And this paper will help to have a better WIFI communication with the patch antenna.

5.2 DISCUSSION:

For the rectangular microstrip antenna we mainly focused on better WIFI communications. We have gathered some papers to compare and to have a better result of our project work . Comparison with some literature is shown below:

Width (mm)	**Length (mm)**	**Height (mm)**	**Volume (mm3)**	**BW(MHz) (-10dB)**	**Return loss(dB)**
38 [8]	**28.36** [8]	**4** [8]	**4310** [8]	**155.1** [8]	**-21.76** [8]
38.03 [9]	**28.30** [9]	**1.6** [9]	**1722** [9]	**78.84** [9]	**-26.01** [9]
38 [10]	**38** [10]	**3** [10]	**4332** [10]	**95** [10]	**-21.29** [10]
28.45	**28.45**	**1.6**	**1295**	**56.6**	**-40**

REFERENCE:

1. Faranak Nekoogar,*Ultra-Wideband Communications: Fundamentals and Applications*,prentice hall,new jersey,2005
2. Constantine A.balanis, *Antenna theory analysis and design,* john wiley & sons,Canada,2005
3. B. D. Patel,Tanisha Narang and Shubhangi Jain*, Microstrip Patch Antenna- A Historical Perspective of the Development,*2013,445-449
4. Constantine A. Balanis,*Modern antenna handbook*,john wiley & sons,Canada,2008
5. Sumaiya Wasiq, Shubhi Gupta, Varun Kumar Chandra and Vivek Varshney, *A REVIEW ON DIFFERENT SHAPES OF PATCH ANTENNAS,*vol **2**,issue 1,59-65
6. C. L. Bennett and G. F. Ross, "Time-Domain Electromagnetics and Its Applications," in *Proceedings of the IEEE* **66**, 1978, pp. 229–318.
7. Jianxin Liang,*Antenna Study and Design for Ultra Wideband Communication Applications*,2006, 10-13
8. Ali A. Dheyab Al-Sajee and Karim A. Hamad ,*IMPROVING BANDWIDTH RECTANGULAR PATCH ANTENNA USING DIFFERENT THICKNESS OF DIELECTRIC SUBSTRATE* Ali , APRIL 2011, VOL**. 6**, NO. 4,
9. P.A. Nawale, *Rectangular Microstrip Patch Antenna For 2.4 GHz Communication Using Defected Ground Structure, Volume 2, Issue 1, January 2015.*
10. Muhammad Aamir Afridi, *Microstrip Patch Antenna − Designing at 2.4 GHz Frequency*, Volume 2015, 128-132