

# DUAL-BAND MICROSTRIP LOOP ANTENNA FOR WIRELESS APPLICATION

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## ABSTRACT

In recent years, microstrip and printed antennas are widely used in order to fulfill the commercial needs. The emergence of wireless applications requires compact antenna easy manufacture. The purpose of this project is to design of dual band microstrip loop antenna for wireless applications with a reduction in size. The aim of this antenna was to operate from 2 GHz to 4 GHz. A square microstrip patch antenna has been chosen as antenna design pattern due to its low-profile structure. The development of this project comprised two main stages where the first level is a software simulation (CST Microwave studio2012) and secondly is a hardware development. CST Microwave studio2012 has been used to simulate the antenna design for a purpose of preliminary design which the inherent of the advantages of the antenna can be identified, then the second stage is the development of the microstrip patch antenna which have been fabricated on FR4 substrate and tested using the network analyzer which has range between to 1GHz to 14GHz. Based on this project, the antenna parameters such as return loss, radiation pattern, voltage standing wave ratio (VSWR) and bandwidth have been investigated. For further investigation, a substrate material with higher dielectric constant can be used to reduce a microstrip antenna size. The dual band antenna performance shows agreement between both simulation and measurement results.

## ABSTRAK

Dalam tahun-tahun kebelakangan ini, microstrip dan antenna dicetak digunakan secara meluas bagi memenuhi keperluan komersial. Kemunculan aplikasi tanpa wayar memerlukan padat antenna pembuatan mudah. Tujuan projek ini adalah untuk mereka bentuk band antenna gelung dua microstrip untuk aplikasi tanpa wayar dengan pengurangan dalam saiz. Tujuan antenna ini adalah untuk beroperasi dari 2 GHz 4 GHz. Sebuah antenna patch microstrip persegi telah dipilih sebagai corak reka bentuk antenna kerana struktur rendah profil. Pembangunan projek ini terdiri daripada dua peringkat utama di mana tahap pertama adalah simulasi perisian (CST Microwave Studio) dan kedua adalah pembangunan perkakasan. CST Microwave Studio telah digunakan untuk meniru reka bentuk antenna untuk tujuan reka bentuk awal yang sedia ada kelebihan antenna boleh dikenal pasti, maka peringkat kedua ialah pembangunan antena patch microstrip yang telah direka pada FR4 substrat dan diuji dengan menggunakan penganalisis rangkaian yang mempunyai pelbagai antara untuk 1GHz untuk 14GHz. Berdasarkan projek ini, parameter antenna seperti kehilangan kembali, corak sinaran, nisbah gelombang pegun voltan (VSWR) dan jalur lebar telah diasas. Untuk siasatan lanjut, bahan substrat dengan pemalar dielektrik yang lebih tinggi boleh digunakan untuk mengurangkan saiz antenna mikrostrip. Prestasi antena dual band menunjukkan perjanjian antara kedua-dua simulasi dan keputusan ukuran.

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## LIST OF SYMBOLS AND ABBREVIATIONS

$c$	Speed of light
$D$	Directivity
$E$	Efficiency
$f$	Operating frequency
$f_c$	Center frequency
$f_H$	Upper frequency
$f_L$	Lower frequency
$G$	Gain
$h$	Substrate thickness
$L$	Length
$L_{eff}$	Effective length
$R_{in}$	Antenna resistance
$S_{11}$	Return loss or Reflection Coefficient (dB)
$X_{in}$	Antenna reactance
$W$	Width
$Z_{in}$	Input impedance
$Z_o$	Characteristic impedance
$\lambda$	Free space wavelength
$\epsilon_r$	Dielectric constant
$\Delta L$	Extended length due to fringing field effect
$\Gamma$	Reflection coefficient
dB	Decibel
HPBW	Half power beamwidth
PCB	Printed circuit board
RL	Return loss
SWR	Standing wave ratio
VSWR	Voltage standing wave ratio

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## CHAPTER I

### INTRODUCTION

#### 1.1 Project Background

Wireless communication devices have been playing a very important part in our daily life, especially for the past ten years. Due to this reason, antennas designed for wireless applications have attracted much attention from researchers all over the world. Multiband antennas are able to provide multiple reception and transmission functionalities. It is therefore much desirable to have a single antenna using a single feed point that covers multiple frequency bands. The designed antennas are expected to be compact and simple and such as to be integrated well with other communication devices. The printed antenna is well-known for its compactness, low cost, ease of manufacturing and ease of integration with other circuits.

Today we have a number of land and satellite based systems for wireless communications using a wide range of frequency bands. Not only do we see an increase in the number of subscribers in the different systems but also a demand for dual or multi band equipment capable of handling two or more frequency bands

Antenna is an important device in WLAN communication system because its performance will directly impact on the quality of wireless communications. Moreover, one antenna that can operate at all these frequencies is more efficient than several antennas for each frequency band. Therefore dual-band antenna which can work at IEEE

standards for WLAN is needed. In recent years, some dual-band antennas for WLAN application have proposed. However, these researches cannot cover all of the WLAN frequencies.

Many microstrip printed antennas have been reported for wireless communication applications. The antennas are somewhat complicated with many design dimensions. This results in a somewhat complicated fabrication procedure, with the consequence that even small changes in the dimensions could affect the antenna operating frequency. Double-sided antennas are proposed to cope the need for fabrication precision, as both sides of the antenna have to be properly aligned. The antenna proposed by Li [1] requires careful fabrication as the balun on the other side of the antenna is not symmetrical.

Nowadays, microstrip-fed printed monopole antennas play a key role in WLAN applications because of their attractive features, such as low profile, low cost, light weight, and are suitable for integration with MMICs and active devices.

The worldwide growth of personal wireless communication devices has been tremendous. One of the trends in wireless mobile technology in the last decade has been to dramatically decrease the size and the weight of the handset. With this progress in mobile terminal size reduction, the design of antennas is acquiring even greater importance. Antennas must be small, and yet achieve specified electrical performance, such as wide bandwidth, operation in dual or triple frequency bands, diversity, and so forth. Accordingly, antenna designers have encountered difficulty in designing antennas that can maintain electrical performance characteristics while being reduced in size because, in general, efficiency and bandwidth degrade with size decrease.

## **1.2 Problem statement**

Due to the capacity problems today encountered in the AMPS 800 MHz and GSM 900 MHz wireless communication systems; many operators have acquired licenses in the 1800 or 1900 MHz bands. Since a major problem during the deployment of a cellular

radio network is to find suitable sites for the base stations, one can expect these operators to use their existing sites for the new 1800 or 1900 MHz base station wherever possible. Then, one possibility is to replace an existing GSM or AMPS antenna with a dual band GSM/DCS or AMPSPCS antenna. In this will present an antenna element suited for the GSM/DCS bands, i.e. 880-960 MHz and 1710-1880MHz. A dual band base station antenna would have a linear array of such elements positioned along the vertical axis.

### 1.3 Project Objectives

The objective of this proposed research is as follow:

- To design a dual band microstrip antenna this will be operating in the wireless LAN band, IEEE 802.11 a/b/g. The dimensions of the single elements of the operating frequencies were calculated using transmission line model.
- To achieve a techniques for dual band or multiband antenna using 2 element of square patch microstrip antenna using inset feed for each frequency band at 2.4 GHz band and 3.8 GHz band.

### 1.4 Project Scopes

For the overview of the project, the project scopes focusing on four major components which represent as follows:

- i) The antenna is intended to be operated at 2 GHz and 3.8 GHz for wireless application such as, PCS, UMTS , IMT-2000 and WiMax.
- ii) The antenna will be simulated by using CST microwave studio. This software is chosen because it is a specialist tool for the 3D EM simulation of high frequency components.

- iii) Some of antenna parameters will be studied in this project such as radiation pattern, gain, reflection coefficients, return loss ( $S_{11}$ ), VSWR, bandwidth and so on.
- iv) The square microstrip patch antenna will be tested by using Network Analyzer. The device has good performance and it is available in the university.

## 1.5 Thesis Outline

The thesis outline has been arranged as follows. Chapter II describes about the theory of the dual band patch antenna, antenna properties and also explains about the researches that have been done associated to this project.

Chapter III of this thesis explains about the methodology that has been used in order to complete this project. Details about the software and equipment's that has been used also were described.

Chapter IV of this thesis describes about the simulation and measurement that has been obtained. Analyses for both of the results were also explained.

Lastly, Chapter V explains several recommendations to upgrade this project. Overall conclusion for this project also has been stated.

## 1.6 Chapter summary

This first chapter contains all the important parts needed in order to complete this project. It consists of background of study for this project, the problem statement, the objective and scopes. The background study explains briefly about the application of the dual band antenna that will be used in this project. As for the problem statement, it explains about the advantages of using the microstrip patch antenna compared to other

conventional antennas. The objective explains the project objective and the scope explains about software that will be used in the project.



## **CHAPTER II**

### **LITERATURE REVIEW**

#### **2.1 Overview**

This chapter reviews some similar previous work, related journals and researches that include dual frequency antenna designs that can contribute in ideas for completing this project.

#### **2.2 Background of Microstrip Antenna**

Microstrip antenna because it is very popular primarily for space borne up application today they are used for the government and commercial applications. These antennas consist of metallic patch on grounded substrate. The metallic patch can take any different configurations, as shown in figure 2.1 (a) however the rectangular and circular patch, shown in figure 2.1 (b) are the most popular because of easy of analysis and fabrication, and their attractive radiation characteristic, especially low cross polarization.

The microstrip antennas are low profile, conformable to planar and non-planar surfaces, simple and inexpensive to fabricate using modern-printed circuit technology,

mechanically robust when mounted on rigid surfaces, compatible with MMIC design, are very versatile in terms of resonant frequency, polarization and impedance.

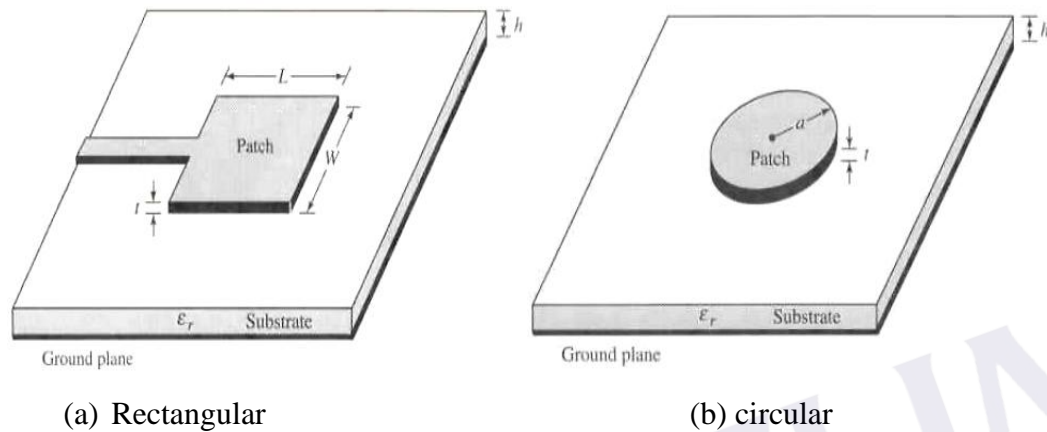


Figure 2.1 Rectangular and circular (patch) microstrip antenna.

Microstrip is a planar transmission line, similar to stripline and coplanar waveguide. Microstrip was developed by ITT Telecommunications Laboratories in Nutley New Jersey, as a competitor to stripline. According to Pozar [2] early microstrip work used fat substrates, which allowed non-TEM waves to propagate which makes results unpredictable. In the 1960s, the thin version of microstrip became popular.

By 1955, ITT had published a number of papers on microstrip in the IEEE transactions on microwave theory and technique. A paper by M. Arditi titled “characteristics and applications of microstrip for microwave wiring” is a good one [2].

In its simplest configuration, microstrip antenna consists of radiating patch on one side of a dielectric substrate which has a ground plane on the other side. The patch conductors, normally is copper or gold. The radiating patch and feeding lines is usually photo etched at the dielectric substrate [3].

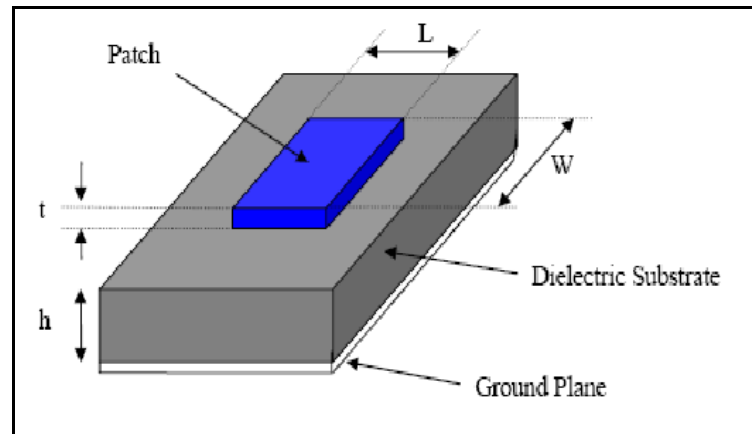


Figure 2.2 Microstrip Patch Antenna Structure.

Based on the Figure 2.2, it shows the common microstrip patch antenna structure.  $L$  is the length of the patch,  $W$  is the width of the patch,  $h$  is the height of the patch and  $t$  is the patch thickness.

To achieve great antenna performance, thick dielectric substrate having low dielectric constant is needed. This will provide higher efficiency, larger bandwidth and greater radiation. But, in order to achieve this, larger antenna size will be needed. So, in order to produce a compact design, higher dielectric constant which are less efficient and will contribute to narrower bandwidth will be used [3].

Microstrip antenna has several advantages compared to conventional microwave antenna. These types of antennas are light weight, low volume and thin profile configurations, which can be made conformal. The cost of fabrication is also low. So, it can be manufactured in large quantities [3]. For the polarization types, it can support both linear and circular polarization depending on the radiation pattern. Microstrip patch antennas also are capable of dual and even triple frequency operations [3].

On the other hand, microstrip patch antennas also have some disadvantages. These types of antenna have narrow bandwidth, low efficiency and also have low gain [3].



### 2.2.1 Literature study

This section provides an overview of various microstrip antenna design and applications. The purpose of this overview is to summarize the main development in the area of Dual-Band Microstrip Loop Antenna in the past several decades and reveal the motivation of this research.

Nowadays most preferred type of antenna for communication are microstrip antennas because of their lucrative features such as small size, light weight, low cost, conformability to planar and non-planar surfaces, rigid, and easy installation. They have a wide range of application in wireless communication especially in mobile communications devices and are becoming more general due to low cost and versatile designs. Recently, dual-band cellular phones capable of operating in two different cellular systems are increasing [3].

### 2.2.2 Advantages and Disadvantages

Microstrip antennas are used as embedded antennas in handheld wireless devices such as cellular phones, and also employed in satellite communications. Some of their principal advantages are given below:

- Light weight and low fabrication cost.
- Supports both, linear as well as circular polarization.
- Can be easily integrated with microwave integrated circuits.
- Capable of dual and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from more drawbacks as compared to conventional antennas. Some of their major disadvantages are given below:

- Narrow bandwidth.
- Low efficiency and Gain.
- Extraneous radiation from feeds and junctions.
- Low power handling capacity.
- Surface wave excitation.

### 2.2.3 Feed Techniques

Microstrip antenna feed techniques can be categorized in two categories which are contacting and non-contacting. In the contacting method, the RF Power is fed directly to the radiating patch using a connecting element such as a microstrip line. The microstrip line and the coaxial probe are examples of contacting method. In the non-contacting, electromagnetic field coupling will be done to transfer the power between the microstrip line and the radiating patch. Techniques that are in these non-contacting methods are aperture coupling and proximity coupling [3].

The feed technique that was used in this project is the coaxial feed. This feed method is easy to fabricate. The feed can be placed at any location to match with its input impedance. However, it provides narrow bandwidth and it is difficult to model. Figure 2.3 below shows the coaxial feed [3].

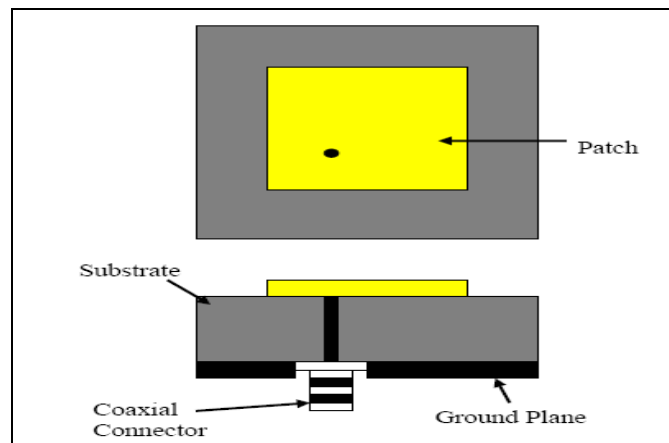


Figure 2.3: Coaxial Feed

## **2.3 Antenna Properties**

The performance of the antenna can be determined by these important parameters.

### **2.3.1 Radiation pattern**

It is defined as a mathematical function or a graphical representation of the radiation properties of the antenna as a function of space coordinates. The radiation property of most concern is the two or three-dimensional spatial distribution of radiated energy as the function of the observer's position along a path of surface of constant radius [4].

#### **2.3.1.1 Principal Patterns**

For a linearly polarized antenna, the performance is usually described in terms of its principal E- and H-plane patterns. The E-plane is defined as the plane containing the electric-field vector and the direction of maximum radiation.

The H-plane is defined as the plane containing the magnetic-field vector and the direction of maximum radiation [4].

#### **2.3.1.2 Radiation pattern lobes**

A radiation lobe is a portion of the radiation pattern bounded by regions of relatively weak radiation intensity. A major lobe also called as the main beam is defined as the radiation lobe containing the direction of maximum radiation. A minor lobe is any lobe except a major lobe. A side lobe is a radiation lobe in any direction other than the intended lobe. Usually a side lobe is adjacent to the main lobe and occupies the hemisphere in the direction of the main beam. A back lobe is a radiation lobe which the axis makes an angle of approximately 180 degrees with respect to the beam of an antenna [4].

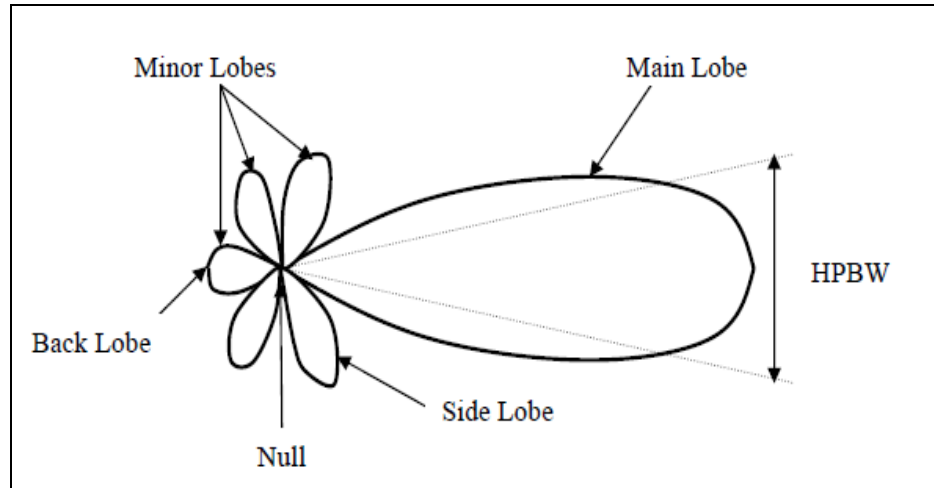


Figure 2.4: Radiation pattern of a generic directional antenna.

### 2.3.2 Directivity

It can be defined as the ratio of the radiation intensity in a given direction from the antenna to the radiation intensity averaged of all directions. The average radiation intensity is equal to the total power radiated by the antenna divided by  $4\pi$ . If the direction is not specified, the direction of maximum radiation intensity is implied [4].

If the direction is not specified, the direction of maximum radiation intensity can be expressed as:

$$D_{\max} = D_o = \frac{U_{\max}}{U_o} = \frac{4\pi U_{\max}}{P_{\text{rad}}} \quad (2.1)$$

Where:

$D$  = directivity (dimensionless)

$D_o$  = maximum directivity (dimensionless)

$U$  = radiation intensity (W/unit solid angle)

$U_{\max}$  = maximum radiation intensity (W/unit solid angle)

$U_o$  = radiation intensity of isotropic source (W/unit solid angle)

$P_{\text{rad}}$  = total radiated power (W)

Reference antennas usually are isotropic radiator where the radiated energy is the same in all direction and have directivity of 1. It can be defined as:

$$D = \frac{F_{\max}}{F_o} \quad (2.2)$$

Where:

$F_{\max}$  = maximum radiated energy

$F_o$  = isotropic radiator radiated energy

### 2.3.3 Gain

Gain is closely related to directivity but it is a measure that takes into account the efficiency of the antenna and also the directional capabilities. Absolute gain of an antenna in a given direction is defined as the ratio of the intensity, in a given direction, to the radiation intensity that would be obtained if the power accepted by the antenna were radiated isotropically. The radiation intensity corresponding to the isotropically radiated power is equal to the power accepted by the antenna divided by  $4\pi$  [4].

It also can be expressed as:

$$\text{Gain} = 4\pi \frac{\text{radiation intensity}}{\text{total input (accepted) power}} = 4\pi \frac{U(\theta, \phi)}{P_{in}} \quad (2.3)$$

For a lossless isotropic source,

$$G = \frac{4\pi U(\theta, \phi)}{P_{in}(\text{lossless isotropic source})} \text{ (dimensionless)} \quad (2.4)$$

### 2.3.4 Half-power beamwidth

It can be defined as in a plane containing the direction of the maximum of a beam, the angle between the two directions in which the radiation intensity is one-half of the maximum value of the beam. It is used to describe the 3dB beamwidth. As the beamwidth decreases, the sidelobe increases and vice versa [4]. Antenna gain is inversely proportional to the beamwidth ; the higher the gain, the narrower the antenna beamwidth [4].

### 2.3.5 Bandwidth

The term bandwidth is defined as the range of frequencies within which the performance of the antenna, with respect to some characteristic, conforms to a specified standard. For narrowband antenna, the bandwidth is expressed as a percentage of the frequency difference over the center frequency of bandwidth. The characteristics such as input impedance, gain and polarization of antenna do not necessarily affect the frequency.

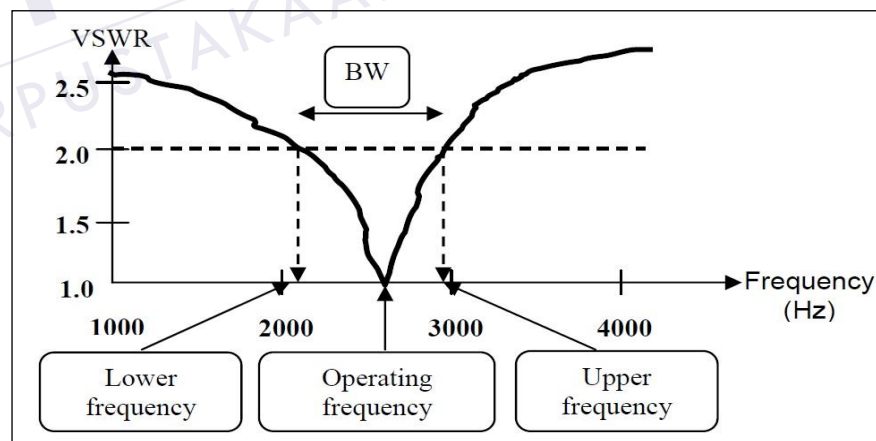


Figure 2.5 Antenna bandwidth

So, there is no unique characterization of the bandwidth. There are distinctions made between pattern and input impedance variations. Pattern bandwidth and impedance

bandwidth are used to emphasize this distinction. Gain, side lobe level, beamwidth, polarization and beam direction are associated with pattern bandwidth while input impedance and radiation efficiency are associated with impedance bandwidth [4].

Narrowband by percentage can be expressed by:

$$BW = \frac{\text{Higher cut - off frequency} - \text{Lower cut - off frequency}}{\text{operating frequency}} \times 100\% \quad (2.5)$$

### 2.3.6 Input impedance

It is defined as the impedance presented by an antenna at its terminals or ratio of the voltage to current at a pair of terminals or the ratio of the appropriate components of the electric to magnetic fields at a point. The input impedance can be determined by the maximum power transfer between transmission line and the antenna. When the input impedance, antenna and transmission line are matched, maximum power transfer will be achieved. Reflected wave will be generated at the antenna terminal and travel back towards the energy source if it is not matched. It will cause reduction on the overall system efficiency [4].

The input impedance can be described as:

$$Z_1 = Z_o \left| \frac{1 + S_{11}}{1 - S_{11}} \right| \quad (2.6)$$

Where:

$Z_1$  = n input impedance

$Z_o$  = characteristic impedance

$S_{11}$  = return loss

### 2.3.7 Polarization

Polarization of an antenna in a given direction is defined as the polarization of the wave transmitted (radiated) by the antenna. The polarization of a wave can be defined in terms of a wave radiated or received by an antenna in a given direction. The polarization of a wave radiated by an antenna in a specified direction at a point in the far field is defined as the polarization of the plane wave whose electric field strength is the same as that of the wave and whose direction of propagation is in the radial direction from the antenna [4].

Polarization can be classified as linear, circular and elliptical. The field is said to be linearly polarized if the vector that describes the electric field at a point in space as a function of time is always directed along a line. If the electric field traces an ellipse, the field is elliptically polarized. For circular polarization, a time-harmonic wave is circularly polarized at a given point in space if the electric field or magnetic field vector at that point traces a circle as a function of time [4].

Polarization characteristics of an antenna can be represented by its polarization pattern which is defined as the spatial distribution of the polarizations of a field vector excited by an antenna taken over its radiation sphere [4].

### 2.3.8 Reflection coefficient

Determining the value of the input reflection coefficient of the antenna is necessary to determine the location of the resonant bands. The input reflection coefficient,  $\Gamma_{in}$ , is obtained from expression below [4]:

$$\Gamma_{in} = \frac{Z_{in} - Z_0}{Z_{in} + Z_0} \quad (2.7)$$

Where

$Z_{in}$  = input impedance of the antenna

$Z_0$  = characteristic impedance used in the transmission line, as a reference.



The absolute value of the reflection coefficient can be also expressed as the ratio of the reflected power from the antenna input,  $P_{in}$  and the power delivered to the antenna,  $P_{in}$  as in expression below [4]:

$$|\Gamma_{in}| = \frac{P_{ref}}{P_{in}} \quad (2.8)$$

### 2.3.9 Voltage Standing Wave Ratio (VSWR) and Return Loss

When a load is mismatched to a transmission line, not all power from the generator will be delivered to the load. The loss is called return loss and expressed as:

$$RL = -20 \log |\Gamma| \text{ dB} \quad (2.9)$$

A matched load, where the reflection coefficient,  $\Gamma=0$ , has return loss of  $\infty$  dB, whereas a total reflection of all power, where  $\Gamma=1$ , has a return loss of 0 dB. In a mismatched line, the presence of reflected wave leads to standing wave, where the magnitude of the voltage oscillates along the line.

As the value of reflection coefficient increases, the ratio of the minimum and maximum voltage values ( $v_{max}$  and  $v_{min}$ ) also increases. So, the Voltage Standing Wave Ratio (VSWR) measures the ratio of these voltages on a transmission line. It can be expressed as:

$$SWR = \frac{V_{max}}{V_{min}} = \frac{1+|\Gamma|}{1-|\Gamma|} = \frac{1+S_{11}}{1-S_{11}} \quad (2.10)$$

For an antenna to be reasonably functional, a minimum  $SWR \geq 1.5$  is required.

## 2.4 Analysis for Transmission Line Model

The patch and ground-plane are separated by a dielectric. The patch conductor is normally copper. The patches are usually photo-etched on the dielectric substrate. The substrate is usually non-magnetic. The relative permittivity of the substrate is normally in the region between 1 and 4, which enhances the fringing fields [5]. The rectangular patch is characterized by its length  $L$ , width  $w$  and thickness  $h$ , as shown in Figure 2.6 below.

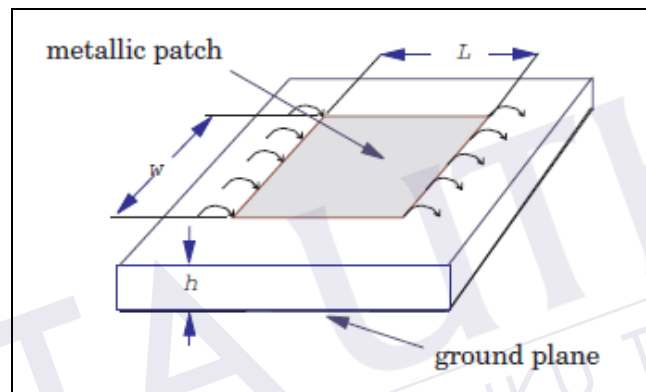


Figure 2.6A rectangular microstrip patch antenna showing fringing fields that account for radiation.

The inner conductor of the coaxial-line is connected to the radiating patch, while the outer conductor is connected to the ground-plane, as shown in Figure 2.7 below.

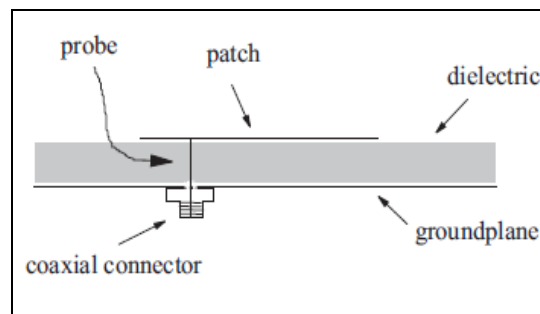


Figure 2.7: A patch excited using coaxial probe.

An effective dielectric constant ( $\epsilon_{eff}$ ) must be obtained in order to account for the fringing and the wave propagation in the line. The value of  $\epsilon_{eff}$  is slightly less than  $\epsilon_r$  because the fringing fields around the periphery of the patch are not confined in the dielectric substrate but are also spread in the air. It can be expressed by [6]:

$$\epsilon_{eff} = \frac{\epsilon_r + 1}{2} + \frac{\epsilon_r - 1}{2} \left( 1 + 12 \frac{h}{w} \right)^{-\frac{1}{2}} \quad (2.11)$$

Where

$\epsilon_{eff}$  = Effective dielectric constant

$\epsilon_r$  = Dielectric constant of substrate

$h$  = Height of dielectric substrate

$W$  = Width of patch

For a given resonance frequency  $f_0$ , the effective length is given by [6]:

$$L_{eff} = \frac{c}{2 f_0 \sqrt{\epsilon_{eff}}} \quad (2.12)$$

The fringing fields along the width can be modeled as radiating slots and electrically the patch of the microstrip antenna looks greater than its physical dimensions. The dimensions of the patch along its length have now been extended on each end by a distance,  $\Delta L$ .

The  $\Delta L$  can be expressed as [6]:

$$\Delta L = 0.412h \left( \frac{(\epsilon_{eff} + 0.3)}{(\epsilon_{eff} - 0.258)} \left[ \frac{\frac{W}{h} + 0.264}{\frac{W}{h} + 0.8} \right] \right) \quad (2.13)$$

The effective length of the patch  $L_{eff}$  now becomes:

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

Where

$\Delta L$  = Length due to fringing effects

$L$  = Length of patch

$L_{eff}$  = Effective length of the patch

$h$  = Height of dielectric substrate

$W$  = Width of patch

$\epsilon_{reff}$  = Effective dielectric constant

For efficient radiation the width,  $W$  is given by [6]:

$$W = \frac{c}{2fo\sqrt{\frac{\epsilon_r + 1}{2}}} \quad (2.14)$$

#### 2.4.1 Coaxial Probe Feed

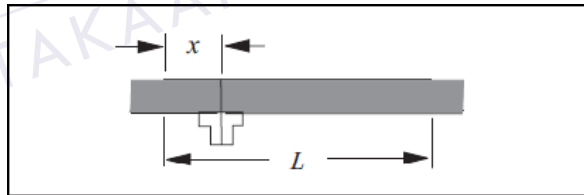


Figure 2.8: Choice of feed point for a probe fed-patch.

An advantage of this technique is that it can be placed at any location, and the impedance match will depend on its location on the patch. An improved impedance match will ideally increase the bandwidth, the return loss and improve performance by reducing the excitation of unwanted modes of radiation. The feed co-ordinates were calculated using the following equation [7]:

$$Y \text{ (along the width)} = \frac{W}{2} \quad (2.15)$$

$$X \text{ (along the length)} = \frac{L}{2\sqrt{\epsilon_{\text{eff}}(l)}} \quad (2.16)$$

## 2.5 Technology Development

### 2.5.1 Application: PCS

Personal Communications Service or PCS describes a set of wireless communications capabilities that allows some combination of terminal mobility, personal, and service profile management [8]. More specifically, PCS refers to any of several types of wireless voice and wireless data communications systems, typically incorporating digital technology, providing services similar to advanced cellular mobile or paging services. In addition, PCS can also be used to provide other wireless communications services, including services that allow people to place and receive communications while away from their home or office, as well as wireless communications to homes, office buildings and other fixed locations. Described in more commercial terms, PCS is a generation of wireless-phone technology that combines a range of features and services surpassing those available in analog and digital-cellular phone systems, providing a user with an all-in-one wireless phone, paging, messaging, and data service [8].

### 2.5.2 Application: UMTS

Universal Mobile Telecommunications System (UMTS) is a third generation mobile cellular system for networks based on the GSM standard. Developed and maintained by the 3GPP (3rd Generation Partnership Project), UMTS is a component of the International Telecommunications Union IMT-2000 standard set and compares with the CDMA2000 standard set for networks based on the competing cdma One technology. UMTS uses wideband code division multiple access (W-CDMA) radio

access technology to offer greater spectral efficiency and bandwidth to mobile network operators. UMTS specifies a complete network system which uses, covering the radio access network (UMTS Terrestrial Radio Access Network, or UTRAN), the core network (Mobile Application Part, or MAP) and the authentication of users via SIM (subscriber identity module cards). The technology described in UMTS is sometimes also referred to as Freedom of Mobile Multimedia Access (FOMA) [8] or 3GSM. Unlike EDGE (IMT Single-Carrier, based on GSM) and CDMA2000 (IMT Multi-Carrier), UMTS requires new base stations and new frequency allocations.

### **2.5.3 Application: IMT-2000**

IMT-2000 is simply a term used by the International Telecommunications Union (ITU) to refer to many third generation (3G) wireless technology, that provide higher data speed between mobile phones and base antennas [8].

### **2.5.4 Application: WiMax**

Worldwide Interoperability for Microwave Access (WiMAX) is a "wireless" communications standard designed to provide 30 to 40 Mbps data rates [8], with the 2011 update providing up to 1 Gbps for fixed stations. The name "WiMAX" was created by the "WiMAX" forum, which was formed in June 2001 to promote conformity and interoperability of the standard. The forum describes WiMAX as a standards-based technology enabling the delivery of last mile wireless broadband access as an alternative to cable and DSL.

## **2.6 Wireless Local Area Network (WLAN)**

A WLAN is a flexible data communication network used as an extension to, or an alternative for, a wired LAN in a building. Increasingly more and more wireless LANs

are being setup in home and home office situations as the technology is becoming more affordable [9].

The increasing popularity of indoor wireless LAN capable of high-speed transfer rate is prompting the development of efficient broadband antennas. Due to increased usage in residential and office areas, these systems are required to be low profile, low cost as well as highly effective and efficient [9].

Microstrip patch antennas are well suited for wireless LAN application systems due to their versatility, conformability, low cost and low sensitivity to manufacturing tolerances. Conventionally, patch antennas have showed a narrowband response, implicating low bit rate transfer.

The most commonly used WLAN system is the IEEE 802.11b system, with maximum throughput of 11 Mbps using a narrowband system. Broadband refers to transmission of information using a system that uses a comparatively larger frequency band, resulting in increases data transfer rate or throughput. The broadband 802.11a system requires them to have a good coverage without failing signal strength. The range of coverage is dependent directly on the antenna performance hence the significance of the broadband antenna. A key requirement of a WLAN system is that it should be low profile, where it is almost invisible to the user. For this reason the microstrip patch antennas are the antennas of choice for WLAN use [9].

## **2.7 Research Paper Literature Review**

The papers related to this title are chosen and studied. With the help from this literature review, it gives more clear understanding to perform this project.

## **2.8 Related Works**

Several researches have presented dual-band microstrip loop antenna with application on wireless communication. Ooi and Selvan [10] proposed a simple square loop dual-band CPW-fed printed antenna for Personal Communication System (PCS 1.85-1.99 GHz),

Universal Mobile Telecommunication System (UMTS 1.92-2.17 GHz), International Mobile Telecommunications-2000 (IMT 1.9-2.2 GHz), Industrial Scientific Medical (ISM 2.4-2.484 GHz) and Worldwide Interoperability for Microwave Access (WiMAX 3.49-3.79 GHz) wireless applications.

The achieved bandwidth was 36.4% at the lower frequency band and 11.8% at the higher frequency band. The antenna offers acceptable reflection coefficient and radiation pattern characteristics, as evidenced through measurement and simulation. This simple low-profile dual-band printed monopole antenna could be useful for PCS, UMTS, IMT, ISM and WiMAX wireless applications.

Mun et al [11] proposed and elaborated a novel dual band antenna for usage in WLAN compatible devices. This compact antenna was designed to form two different resonant paths in order to excite dual band resonance at 2.4 GHz and 5.2 GHz. The design was able to support the IEEE 802.11a/b/g bands completely at return loss less than -10 dB. Microstrip feeding technique was opted to accomplish planar structure. This antenna was capable to support wideband operation. At lower band and higher resonance band, the impedance bandwidth was 31.6% and 30.3%. The compactness and wideband characteristic associated with the proposed dual band antenna promotes employment in WLAN devices at ISM bands. A relatively high and constant gain was obtained at lower resonance band. Gain of 6.15 dB and 2.12 dB was obtained at 2.44 GHz and 5.21 GHz, respectively.

A dual-band monopole antenna fed by a 50  $\Omega$  microstrip transmission line was proposed by Hazeri and Azizkhani [12] for Wireless Local Area Network. The proposed microstrip-fed monopole antenna consists of a rectangular patch with four notches at the four corners of the rectangular patch and a small rectangular patch slot. For the microstrip-fed antenna, two resonant bands are seen. The first band was about 7% for the center frequency of 2.41 GHz and the second band extends from 4.876 to 6.2 GHz with a fractional bandwidth of 24%.

A novel multiband printed monopole antenna for WLAN communication has been introduced. By using a simple configuration, the prototype of the antenna has achieved satisfactory multiband performances, which obtains impedance bandwidths



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