DESIGN OF SLOT X-POLARIZED MICROSTRIP PATCH ANTENNA AT ISM BAND

MUHAMMAD SAUFI BIN ISMAIL

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BORANG PENGESAHAN STATUS LAPORAN
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ABSTRACT

This project is about design of slot X-polarized microstrip patch antenna at ISM band. Microstrip patch antenna is widely used in wireless communication system due to its advantages such as low electromagnetic coupling to human head and low cost. Due to the rapid development in various wireless communication systems, several methods have proposed to develop antenna with reduced size and enhanced frequency bandwidth to achieve the efficiency requirement of mobile systems. One of the methods proposed to increase the bandwidth is insert slot on the microstrip patch. This project will analyze the effects of slot when placed on the microstrip patch antenna. The parameter will be analyzed such as bandwidth, gain, directivity and radiation pattern. These parameters will show the performance of microstrip patch antenna when slot has inserted.

ABSTRAK

Projek ini adalah tentang merekabentuk antena slot X-polarized microstrip patch. Antena microstrip patch digunakan secara meluas dalam sistem telekomunikasi masakini disebabkan kelebihannya seperti kesan elektmagnetik rendah dan murah. Disebabkan pengembangannya semakin pesat dalam pelbagai sistem telekomunikasi, banyak kaedah dan teknik dicadangkan untuk mencipta antena dengan saiz yang kecil dan jalur lebar yang besar untuk mencapai kecekapan sistem telekomunikasi. Salah satu cara yang dicadangkan adalah meletakkan slot ke atas antena microstrip patch. Projek ini akan mengkaji kesan slot yang diletakkan ke atas microstrip patch. Parameter antena yang akan dikaji untuk melihat prestasi dan pencapaian antenna X-polarized microstrip patch apabila diletakkan slot di atas microstrip patch adalah penggandaan, jalur lebar, directiviti dan corak radiasi.

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LIST OF ABBREVIATIONS / SYMBOLS

DPS	-	Direct Broadcast Satellites
PCS	-	Personal Communication System
UMTS	-	Universal Mobile Telecommunication System
WLAN	-	Wireless Local Area Network
GPS	-	Global Positioning Satellites
PEC	-	Perfect Electric Conductor
ISM	-	Industrial, Scientific and Medical
FR4	-	Flame Resistant 4
dB	-	Decibel
ε_r	-	Dielectric Constant Of Material
ε_{eff}	-	Effective Dielectric Constant
λ_g	-	Waveguide Wavelength
λ	-	Wavelength In Free Space
μ_o	-	Permeability of vacuum
ε_o	-	Permittivity of vacuum
RF	-	Radio Frequency
PCB	-	Printed Circuit Board
CST	-	Computer Simulation Technology
f_r	-	Resonance frequency

LIST OF APPENDICES

CHAPTER 1

INTRODUCTION

1.1 Background

Currently electronic devices are becoming very significant in people life and popular in computer systems, communication systems and wireless application. Due to the rapid development in various wireless communication systems, a lot of method have suggested to develop antenna with reduced size and enhanced frequency bandwidth to achieve the efficiency requirements of mobile systems such as mobile cellular, mobile cordless, direct broadcast satellites (DPS), personal communication system (PCS), universal mobile telecommunication system (UMTS), wireless local area network (WLAN), global positioning satellites (GPS) and other next generation wireless system [1].

Microstrip patch antennas are widely used in wireless communication system. This is due to its advantages such as low electromagnetic coupling to the human head, increased mechanical reliability, low cost and capability to maintain high performance over wideband of frequencies. In communication system, wide bandwidth is a main element requirement to make the patch antenna can be used in multipurpose application and operate more efficiency. Narrow bandwidth is a major disadvantage for microstrip patch antenna [2]-[4].

Several techniques have been proposed by researchers previously to increase the bandwidth. The conventional method is by using parasitic patches either in another layer (stacked geometry) or same layer (coplanar geometry). Both methods will increase the antenna size. Air gap will also increase the bandwidth but this method requires adjusting the air gap width mechanically, which is not an easy task in practice. Another method which is can be used to increase the bandwidth is increasing patch height over ground plane, using a lower substrate permittivity and cut the slot on the patch [5][6]..

1.2 Problem Statement

Microstrip patch antenna has a lot of disadvantages such as narrow bandwidth, low gain and low power handling capabilities. Besides, it is also has narrow transmission signal. The polarization of wave radiated in conventional microstrip antenna is linear polarized. This type polarization will introduce losses because mismatch signal will occur during transmission signal. A narrow bandwidth is a main disadvantage of microstrip patch antenna in practical application normally a few per cent around 2% - 3%. Therefore, many methods have proposed to enhance the performance of microstrip patch antenna especially bandwidth. The narrow bandwidth will limits the function of microstrip antenna in the present modern communication system.

1.3 Objectives

The main objective for this project is to design, simulate and fabricate of slot X-polarized microstrip patch antenna at ISM band frequency. The operating frequency for this device operates in ISM band is 2.4 GHz. Another goal in this project is to enhance the bandwidth than conventional microstrip patch antenna and high gain and investigate the effects of slot on bandwidth when placed into the microstrip patch antenna.

1.4 Scope of work

This project will focus to the X-polarized microstrip patch antenna by inserting slot on the patch. This project has designed and simulated by using CST 2009 software to obtain the return loss, radiation pattern, gain and bandwidth. The operating frequency for this microsrip patch antenna used in ISM band application is 2.4GHz. The material applied for the substrate of the patch antenna is FR4 which is the dielectric constant is 4.4, thickness is 1.6mm and tangent loss is 0.019. Etching method has used to fabricate this antenna. For measurement return loss, radiation pattern, gain and bandwidth of patch antenna will be measured.

1.5 Project Methodology

All information about the microstrip patch antenna and slot types patch antenna are gathering from several sources such as journal, reference book and paper which is can obtain any website. But the most popular to obtain the information about the microstrip patch antenna and slot microstrip patch antenna are from IEEE explore. In this procedure, the information how to improve the characteristic of microstrip patch antenna such as bandwidth and gain has been investigated and proposed. From the literature review, the method to design slot was shown by using parametric study.

The design for this project is according to the design and characteristic of conventional microstrip patch antenna, X-polarized microstrip patch antenna and slot microstrip patch antenna. All information is obtained from literature review. Several methods can be used to design antenna such as calculation, parametric study and empirical approach. In this project, calculation and parametric study will be used to design the microstrip patch antenna. Dimension patch, inset feed and microstrip line can be calculated and designed using approximate equation from literature review. Slot shape can be designed any shape such as horizontal slot, X slot, double vertical slot and T slot. There has not approximate equation to determine dimension of slot. Therefore parametric study method used to determine dimension of slot. Slot is designed in single microstrip patch and X-polarized microstrip patch antenna to analyze the effects of slot on bandwidth and gain by varying Ws (width) and Ls (length) slot.

This project has been simulated in the microwave application software, CST 2009. In this software, the parameter of antenna can be observed. This parameter is important to ensure that the antenna is operating well, efficient and in good condition before continue to fabricating process. The parameter antenna such as radiation pattern, return loss, gain, directivity and bandwidth is commonly analyzed.

In fabricating process, design from simulation is converted to *dxf* file and print out on the transparency paper. This transparency paper is patched on the substrate before fabricate. Several type substrate materials can be used to fabricate. In this project, FR4 substrate has selected. This substrate has dielectric constant is 4.4, thickness substrate is 1.6mm and tangent loss is 0.019. This substrate will be etching using chemical in the laboratory.

For measurement, it has been done in the laboratory. Network Analyzer, Spectrum Analyzer and Antenna Trainer are used for measurement. By using Network Analyzer, bandwidth, return loss and resonance frequency of antenna will be measured. To measure radiation pattern, gain and directivity Antenna Trainer is used.

This is the final step in this project. All information about literature review, design, simulation, fabricate and measurement has been collected and saved in this final report writing. The result for simulation and measurement is analyzed and compared. The suggestion for the future work to improve the efficiency and performance this project also included in this final report writing. Figure 1 is illustrated the flow of methodology during doing this project.

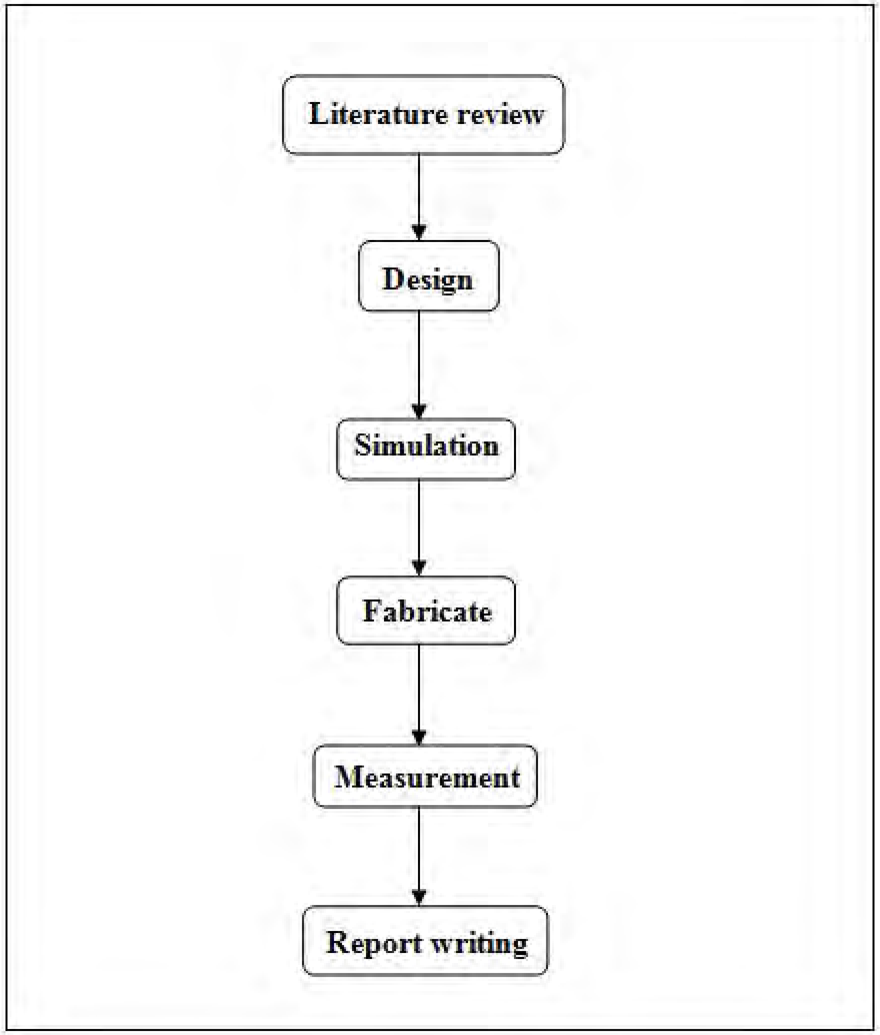

Figure 1: Flow of methodology

CHAPTER 2

LITERATURE REVIEW

2.1 Parameters of the antenna

Parameter of the antenna is used to describe the performance and operation of the antenna. This parameter can be used to ensure that the antenna is operating well. The parameters of the antenna such as radiation pattern, radiation power density, radiation intensity, beamwidth, directivity, numerical techniques, antenna efficiency, gain, beam efficiency, bandwidth, polarization, input impedance, antenna radiation efficiency and antenna temperature. The parameter commonly used is radiation pattern, gain, bandwidth and polarization [7].

2.1.1 Radiation pattern

Radiation pattern can be defined as a graphical representation of the radiation properties of the antenna as a function of space coordinates. The radiation pattern can determine the far field region. The properties of radiation pattern such as power flux density, radiation intensity, field strength, directivity and polarization. A trace of the received electric or magnetic field at a constant radius is called the amplitude field pattern and a graph of the spatial variation of the power density along a constant radius is called an amplitude power pattern. Usually, the field and power patterns are normalized with respect to their maximum value. The power pattern is usually plotted in decibels (dB) [7].

Field pattern in linear scale indicated in Figure 2.1.1 (a) normally represents a plot of the magnitude of the electric or magnetic field as a function of the angular space. Power pattern in linear scale illustrated in Figure 2.1.1 (b) normally represents a plot of the square of the magnitude of the electric or magnetic field as a function the angular space. Power pattern in dB scale indicated in Figure 2.1.1 (c) represents the magnitude of the electric or magnetic field as a function of the angular space [7].

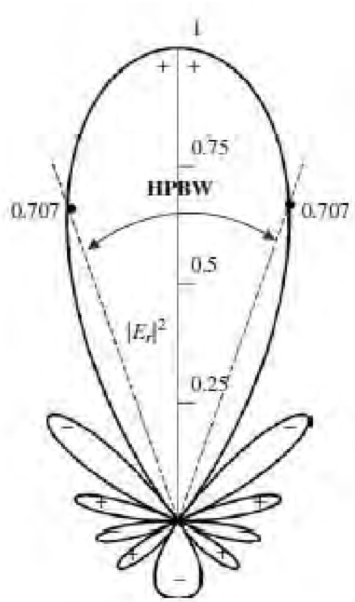

Figure 2.1.1 (a): Field pattern in linear scale

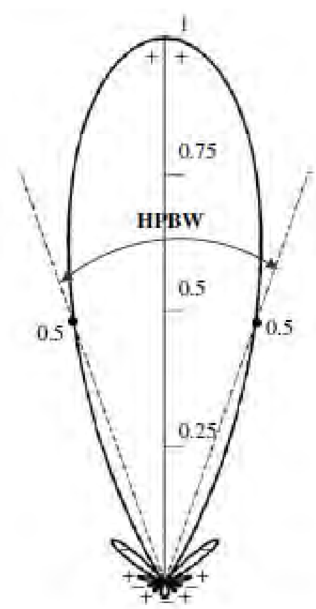

Figure 2.1.1 (b): Power pattern in linear scale