

CHARACTERIZATION OF WIRELESS MIMO CHANNEL BY USING ANGLE
DIVERSITY

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UNIVERSITI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : CHARACTERIZATION OF WIRELESS MIMO CHANNEL
BY USING ANGLE DIVERSITY

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*To my dear beautiful mother,
my dear beloved father,
and my lovely friends:*

*Thank you for your continuous Encouragement
and deepest Support.*

You are always my Inspiration to do Better.

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ABSTRACT

Due to continuous development of wireless technology, wireless channel modeling has always been research in order to enhance the performance. The development of communication system begins with Single Input and Single Output (SISO), Single Input and Multiple Output (SIMO), and then followed by Multiple Input and Single Output (MISO) and the recent communication system technique is Multiple Input and Multiple Output (MIMO). Basically, MIMO system uses multiple antennas at both transmitter and receiver. The main objective this project is to characterize the wireless MIMO communication channel by using angle diversity scheme. This project will investigate the best configuration that provides the highest channel capacity for indoor environment. MIMO system is one of the methods that can increase capacity within the same bandwidth and power received. But, there are some researches mentioned about whenever the number of antenna increase, mutual coupling and local correlation between them occurred. One of the solutions of this problem is angle diversity which is one of the diversity techniques to reduce the correlation effect and increase the channel capacity. There are four scopes in this project which cover the characterizing wireless MIMO channel by varying angle diversity, the front-end system, the measurement campaign and the channel analysis based on the measurement result.

ABSTRAK

Disebabkan oleh perkembangan pesat teknologi tanpa wayar, model siaran tanpa wayar selalu dikaji untuk meningkatkan prestasi. Pembangunan sistem komunikasi bermula dengan Masukkan Tunggal dan Keluaran Tunggal (SISO), Masukkan Tunggal dan Beberapa Keluaran (SIMO), dan kemudian diikuti dengan Beberapa Masukkan dan Keluaran Tunggal (MISO) dan teknik komunikasi terkini ialah Sistem Beberapa Masukkan dan Beberapa Keluaran (MIMO). Pada dasarnya, sistem MIMO menggunakan beberapa antena pada kedua-dua pemancar dan penerima. Tujuan utama projek ini adalah untuk mengkarakterisasi saluran komunikasi tanpa wayar MIMO dengan menggunakan skim kepelbagaian sudut. Projek ini akan menyiasat tatarajah terbaik yang menghasilkan kapasiti saluran yang tertinggi untuk persekitaran dalam bilik. Sistem MIMO adalah salah satu kaedah yang dapat meningkatkan kapasiti dalam lebar jalur dan kuasa yang diterima yang sama. Namun, ada beberapa kajian disebutkan tentang apabila jumlah antena ditambah, *mutual coupling* dan korelasi tempatan antara mereka berlaku. Salah satu penyelesaian dari masalah ini adalah kepelbagaian sudut yang merupakan salah satu teknik kepelbagaian untuk mengurangkan kesan korelasi dan meningkatkan kapasiti saluran. Ada empat skop dalam projek ini. Ia merangkumi mengkarakterisasi saluran tanpa wayar MIMO dengan memvariasikan kepelbagaian sudut, sistem *front-end* kempen pengukuran dan yang terakhir, analisis siaran berdasarkan hasil pengukuran.

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LIST OF SYMBOLS

SYMBOL	DESCRIPTION
H	Channel Matrix
x	input
y	output
n	receiver noise
N	transmitter
M	receiver
SNR	Signal-to-Noise Ratio
SINR	Signal-to-Noise Plus Interference Ratio
ϵ_r	dielectric constant
f_r	resonance frequency
v_0	speed of light
L	length of patch
L_{eff}	effective length of patch
h	height of substrate
W	width of patch
μ_0	Permeability Constant

LIST OF ABBREVIATIONS

SYMBOL	DESCRIPTION
CST	Computer Simulation Technique
SISO	Single Input Single Output
SIMO	Single Input Multiple Output
MISO	Multiple Input Single Output
MIMO	Multiple Input Multiple Output
DOA	Direction of Arrival
AOA	Angle of Arrival
LOS	Line-of-Sight
NLOS	non Line-of-Sight
PAS	Power Angle Spectrum
V-Pol	Vertical Polarized
H-Pol	Horizontal Polarized
DC	Direct Current
RF	Radio Frequency
UV	Ultra-Violet

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CHAPTER 1

INTRODUCTION

1.1. Project Background

Due to continuous development of wireless technology, wireless channel modeling has always been research in order to enhance the performance. Many of future wireless service application to be provided by the future generation mobile communication system are likely to be used in low-mobility environment with limited temporal or multipath diversity [1]. The development of communication system begins with Single Input and Single Output (SISO), Single Input and Multiple Output (SIMO), and then followed by Multiple Input and Single Output (MISO) and the recent communication system technique is Multiple Input and Multiple Output (MIMO). Basically, SISO system uses one antenna at both transmitter and receiver. For SIMO, it uses one antenna at transmitter but multiple antennas at receiver. For MISO, this system uses multiple antennas at transmitter and one antenna at the

receiver. For MIMO system, it uses multiple antennas at both transmitter and receiver. The concept of MIMO was first introduced by Jack Winters in 1987 for two basic communications [2]. The first was for communication between multiple mobiles and a base station with multiples antenna and the second for communication between two mobile each with multiple antennas [3]. Figure 1.1 shows the development of communication system.

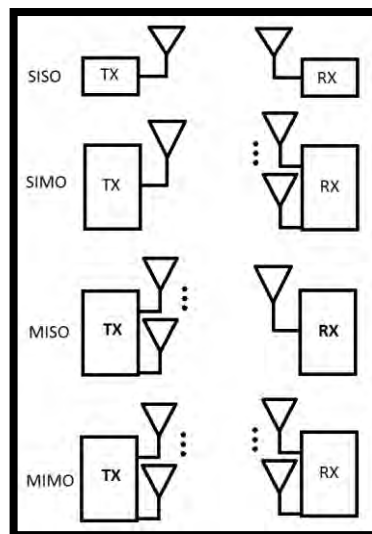


Figure 1. 1: Development of Communication System

1.2. Project Objective

The objective of the project is to characterize the wireless MIMO communication channel by using angle diversity scheme. This project investigated the best configuration that provides the highest channel capacity for indoor environment. The RF front-end MIMO developed in order to investigate the angle diversity effect in MIMO channel capacity.

1.3. Problem Statement

High capacity is very crucial in wireless as it is required for future application. It is important in order to increase data transferred in one time. Today's channel suffers from attenuation due to multipath in the channel [4]. The increasing demand for capacity in wireless systems has motivated considerable research aimed at achieving higher throughput on a given bandwidth. From [2], [4], [5], and [6] it is mentioned that antenna diversity and multiple antennas at both transmitter and receiver can improve the wireless channel capacity within the same bandwidth and power received. Also, it is mentioned that multiple antennas are proven to introduce robustness against channel fading and interference. In [6] and [7], these papers are mentioned about increasing the number of antennas and patches are also increasing the mutual coupling and local correlation between them. In multi-element antennas, mutual coupling depends on the antenna element separation, geometry of array and antenna elements, location of antenna elements in the array, frequency, substrate thickness and constant, near-field scatterers, and direction of arrival (DOA) of the incoming wave [6]. So, by using multiple antennas at both transmitter and receiver also can reduce channel performance. Angle diversity is one of the diversity techniques to reduce the correlation effect and increase the channel capacity. Angle diversity technique using multiple antenna beams to receive multipath signals arriving at different angles.

1.4. Scope of Project

There are four scopes in this project. The first scope is characterizing wireless MIMO channel by varying angle diversity for indoor environment.

The second scope is the front-end system. A basic 2×2 array rectangular patch antenna is designed to be used as the front end system. The frequency

resonance of the design is 2.4 GHz and the return loss of the design is less than -10dB to make sure the antennas' efficiency is 90 percent. Then, it simulated using CST STUDIO SUITE 2010 software, after that, eight pieces of antennas fabricated and measured. The parameters measured are return loss, gain, and the radiation pattern.

The third scope is the measurement campaign. The measurement is done in a labortary room which is indoor environment. The **4x4** MIMO are setup in several configurations which is typical and angle diversity. For typical, the spacing between antennas are varied. For angle diversity configuration, there are several arrangements is done. For each arrangements, there are several angle between antennas varied. In order to analysis the configurations, the data collected from Direction of Arrival (DOA) and Angle of Arrival (AOA) environment recorded. The data collected are in terms of power received in decibel (dB) and S-Parameter for each configuration. The distance between the transmitter and receiver is 1.2meters.

The last scope is the channel analysis based on the measurement result. The channel capacity that obtained from the measurement data for each configuration are calculated and compared.

1.5. Methodology Flow Chart

The first process in this project is literature review. In this process all information related to the project are studied such as MIMO channel, channel capacity, channel correlation, mutual coupling, micro-strip antenna, angle diversity, and so much more. The review should using IEEE journal, books, and magazine that consider relevant.

The second process is developing the Front-End System. It is started by designing antenna. Antenna that designed is a **2x2** array rectangular micro-strip patch antenna. The designing and calculation process are referring to the literature review

that have been done in previous process. Next, simulation process is done using CST STUDIO SUITE 2010 software and after the simulations succeed, fabrication process is done. Fabrication process is using chemical etching equipment with using micro-strip technology. The measurement of the antennas fabricated is done. The parameter measured is the return loss, gain, and the radiation pattern. The result then compared to the simulation result.

The next process is the measurement campaign. The measurement is done indoor which is in the laboratory room. Equipments used are Spectrum Analyzer for transmitted-received power measurement and Network Analyzer for S-parameter measurement. There are several configurations for each AOA and DOA that setup to define which configuration that produce highest channel capacity.

After the measurement process is done, the analysis processes are done. The channel capacity of MIMO channel can be calculated from S-parameter and power transmitted-received measured. The data obtained from all the configurations calculated and compared.

After that, report writing process can be done and this project is complete. Figure 1.2 shows flow chart of methodology of this project.