DESIGN OF PLANAR ANTENNA FOR OFF GRID WIRELESS COMMUNICATION SYSTEM

MUHAMMAD KHAIRUL AZRI BIN ZAKARIA

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DR. ZAHRILADHA BIN ZAKARIA
Profesor Madya
Fakulti Kejuruteraan Elektronik Dan Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh: 5/6/2017

"I hereby declare that this report is the results of my own except for quotes as cited in the reference"

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Author : Muhammad Khairul Azri Bin Zakaria

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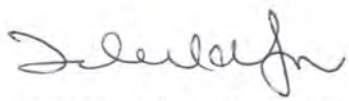
Signature : 

Supervisor's Name : PM Dr Zahriladha Bin Zakaria

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Special dedication to,

My beloved and supportive parents,

My Supervisor,

My family,

And to all my friends

For their encouragements, and best wishes.

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ABSTRACT

Currently, the wireless coverage for outdoor communication system depends to the tower antenna to function well. However, most of the remote area such as hills, jungle or isolated area are not fully covered by any telecommunications coverage. Hence, it is difficult to interact with outside people. The same thing happen during natural disaster. Communications cannot be created if the antenna tower break down during flood or earthquake. Therefore, to solve this problem, Malaysia Communication And Multimedia Commission have introduced specific frequency spectrum for Short Range Device. Further to this, a prototype of a planar antenna which supports wide range of spectrum especially for outdoor application is the main purpose of this project. So, an antenna with frequency of 915MHz is designed using Computer Simulation Technology (CST) software. This study also will propose a planar antenna, comes with compact size but have great performance. As the end product, the antenna has successfully being used as SRD antenna application, with gain of 5.704dB and return loss of -14.345dB in the range of 500m. This study is important for off grid wireless communication system to reconnect the isolated area and during emergency.

ABSTRAK

Pada masa kini, liputan tanpa wayar untuk sistem komunikasi bagi kegunaan luar bergantung kepada menara stesen untuk berfungis dengan baik. Walaubagaimanapun, kebanyakan kawasan terpencil seperti kawasan berbukit, hutan dan kawasan pedalaman tidak diliputi rangkaian telekomunikasi. Ini menyebabkan berlakunya kesulitan untuk berinteraksi dengan orang luar. Hal yang sama berlaku semasa bencana alam melanda. Komunikasi tidak dapat dicipta jika menara stesen rosak disebabakan banjir atau gempa bumi. Oleh hal yang demikian, untuk menyelesaikan masalah ini, Suruhanjaya Komunkasi Dan Multimedia Malaysia (MCMC) telah memperkenalkan spektrum frekuensi yang khusus untuk Alat Jarak Pendek (SRD). Oleh itu, prototaip mengenai antenna yang menyokong spektum lebar terutama untuk kegunaan luar telah menjadi tujuan projek ini. Antenna itu akan dibina menggunakan perisian Computer Simulation Technology (CST). Projek ini juga akan mengusulkan sebuah antenna planar yang bersaiz kompak tetapi mempunyai kesan yang baik. Sebagai hasil akhirnya, antenna itu telah berjaya dibina untuk aplikasi antenna SRD dengan ‘gain’ 5.704dB dan ‘return loss’ -14.345dB dalam lingkungan 500m. Projek ini penting untuk kegunaan sistem komunikasi tapa wayar tanpa kuasa untuk menyambung semula orang di kawasan terpencil dan semasa kecemasan.

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ABBREVIATION

SRD	Short Range Device
CST	Computer Simulation Technology
dB	Decibles
MPA	Microstrip Patch Antena
RL	Return Loss
VSWR	Voltage Standing Wave Ratio
MCMC	Malaysia Communications And Multimedia Commisions
m	Meter
km	Kilometer
BW	Bandwidth
VNA	Vector Network Analyzer
MHz	Kilohertz
GHz	Gigahertz

CHAPTER 1

INTRODUCTION

This chapter discussion about general overview and briefly explain the project by stating the objectives, problem statement and the scope of projects.

1.1 Project Briefing

Planar antenna is a directional antenna in where all the elements are in one plane. This project is focusing on the development of planar antenna for off-grid communication system applications. Currently, the wireless coverage for outdoor communication system depends to the tower antenna to function well. Hence, Malaysia Communications and Multimedia Commission (MCMC) have introduced frequency spectrum for Short Range Device (SRD).

The design of the high gain planar antenna using the technique microstrip patch which is a planar antenna is expected to compensate the narrow bandwidth characteristic possessed by the conventional monopole or dipole antenna. It is also supposed to be an alternative way to communicate, if natural disaster occur that cause the tower to break down. Further to this, a prototype of a high-gain planar antenna which supports wide range of spectrum especially for outdoor application is the main purpose of this project. Shortly, this project will use the technique of microstrip patch antenna. The design of stacked patch antenna will be completed by using Computer Simulation Technology (CST) software. Then, the antenna will be

connected to Short Range Devices (SRD) in frequency of 915MHz to create the off-grid wireless communication system in the range of 500m. This devices also is supposed to reconnect the rural area with the urban area.

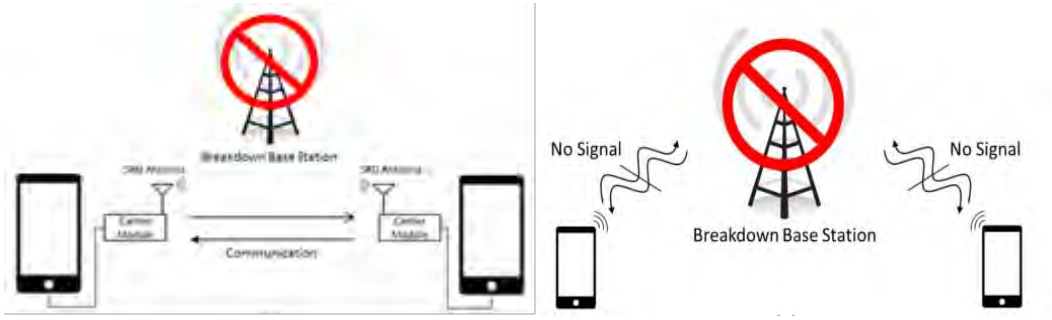
1.2 Problem Statement

As we know, isolated and rural area, such as remote areas, jungle, hills and others are basically not covered with any telecommunication, hence the communication between the area and outside that area cannot be achieved. Therefore, make it difficult to communicate, even with basic text, call or GPS location to that off-grid areas.[1] A phone without network coverage is useless, as service operators of the telecommunication company mainly serve to urban areas and have non-existent coverage to the remote areas.[2] [5] Telecommunication company in our country, such as Celcom, Maxis and DiGi are unable to reach the areas.[3] When a natural disaster occur, such as flood or earthquake, the current telecommunication towers have the possibility to be unusable due to the weather conditions. [1],[2],[4]. Hence, the smartphone will lost its function to communicate due to break-down tower antenna that cause the communication to be paralyzed.

To help human during the disaster and help people at the remote areas, a new technology has been proposed by developing a wireless off-grid communication system, that can be alternative way to communicate in the absence of normal communication. Malaysia Communications And Multimedia Commission (MCMC) have introduced specific frequency spectrum for Short range Device (SRD) [3]. SRD can be used to create off-grid communication to replace the normal communication in the absence of base station or tower antenna as shown in Figure 3b. SRD that can operate in the frequency of 915MHz, are able to cover until 500m. [3] therefore, my study will propose and improve the SRD range, so that I can produce antenna with higher gain in small size and can cover until 500m.

Figure 1.1 : Sky view of the incident flood happen in Kuala Krai, Kelantan [1]

Figure 1.2 : Earthquake disaster, that happen in India [4]



(a) (b)

Figure 1.3 : (a) Normal communication with breakdown base station , (b) Proposed communication using SRD antenna. [3]

1.3 Objective

The objectives of this project are to develop a planar antenna for off-grid wireless communication system. In order to complete this project, some objectives has been listed down :

a. To design a planar antenna for off-grid communication system application (915MHz).[3]
b. To design the antenna for short range device and SRD module based on microwave circuit-theory approach in order to model an ideal circuit.
c. To analyze the proposed design through the simulation of planar antenna using the designated circuit and electromagnetic (EM) simulator such as Computer Simulation Technology (CST).
d. To evaluate and validate the design in laboratory and field test environments.

1.4 Scope of Project

The scope of this project involves Computer Simulation Technology software (CST) and Short Range Device (SRD). The main objective of this project is to design a planar antenna for off-grid wireless communication system. The first thing to do is making some research, either by using journals or from internet. The research is focused on the planar antenna to study the performance of antenna in term of bandwidth, gain and frequency. The parameter of antenna also being calculated by using the formulae. Then, the process of designing the antenna will be working in Computer Simulation Technology (CST) software. In this step, the substrate, thickness of material used, material used and others will be deeply investigated, to find the best result. When the expected result is obtained, the design will be fabricated, followed by laboratory test using Vector Network Analyzer (VNA). Lastly, field test will be held to validate the functioning of the new technology between carrier module with SRD antenna. Two laptops, each is connected to carrier module is used in separate distance to prove that it can achieve the expected range of communication.

1.5 Organisation of Thesis

In chapter 1, a brief overview has been done. It covers the problem statement that becomes the motivation to do the project, and set some target or objectives to be achieved at the end of the project. Scope of work also has been state to know what is the software and process of the study.

In chapter 2, 26 references from journals and websites has been a source to get the information. Information from websites are more focused to how to solve the problem whereas the information from journal take pressure to the antenna design. Then, the antenna are study in term of frequencies, bandwidth, gain, return loss and its size to get the best antenna design.

For chapter 3, a flow chart shows the process of the project, divided to 6 phases, which is starting from literature review until report writing. The project uses hardware device such as Vector Network Analyzer (VNA) and software devices such as CST. Design and simulation of antenna also be explained here especially in designing the substrate and patch and the slot of antenna. After that simulation of antenna take place and both simulation and measurement results has been recorded and being compared.

In chapter 4, explain about the design of antenna. The results of the simulation from CST and result from lab measurement has been compared in term of return loss, gain, frequency, bandwidth and radiation pattern. From there, the difference between these two results has been compared and the reasons has been identified. Also, the tuning process which is includes changing the patch dimensions and varying the u-slot dimensions. Based on the results, the patch act to shift to lower frequency but u-slot change the return loss of antenna.

For chapter 5, it is about the end product of the project, make a conclusions about it. Hence, for the future work, the antenna design can be improved in some ways to get better results and better performance.

CHAPTER 2

LITERATURE REVIEW

This chapter review on some of the sources such as paper, previous journals and websites as references in this project. All references has been cited.

2.1 Theory

Telecommunication technology is changing rapidly, and hence, new communication methods and sophisticated devices are created [5]. The rising of telecommunication technology give a lot of advantage to human, especially by creating a foster community and allow exchange of information. Unfortunately, the rural, remote or isolated areas such as jungle, hills are not fully covered by the communication. Therefore, make it difficult to communicate, even with basic text, call or GPS location to that off-grid areas. A phone without network coverage is useless, as service operators of the telecommunication company mainly serve to urban areas and have non-existent coverage to the remote areas. [5] Telecommunication companies in our country, such as Celcom, Maxis and DiGi are unable to reach the areas. When natural disasters occur, such as flood or earthquake, the current telecommunication towers have the possibility to be unusable due to the weather conditions. [1],[2],[4]. Also, the cellular tower can be easily destroyed by these natural phenomena [7].

Hence, the smartphone will lose its function to communicate due to break-down tower antenna that caused the communication to be paralyzed. To solve this problem, Malaysia Communications And Multimedia Commission (MCMC) have introduced specific frequency spectrum for Short Range Device (SRD) [3]. SRD is used in this project to produce bidirectional and unidirectional communication, as it has low capability to cause interference with other radio equipment.[3] SRD can be used to create off-grid communication to replace the normal communication in the absence of base station or tower antenna. SRD that can operate in the frequency of 915MHz, are able to cover until 500m. [3] Therefore, my study will propose and improve the SRD range, so that I can produce antenna with higher gain in small size and can cover until 2km. The new design of my antenna is small in size, but provide higher gain with wider range. The SRD then will be connected with smartphones as a solution to the off-grid communication system.

2.2 Critical literature review.

In this project, 19 references are reviewed critically as shown in table 2.1.

Table 2.1 : The review of 19 references used in this project.

Ref.	Title	Remarks
[6]	High Gain Filtering Antenna For WCDMA Application	• The antenna was built with a driven patch and a stacked patch. • Exhibits a narrower bandwidth, that is 1.92-2.17GHz with gain of 9.7dBi. • The permittivity of substrate is 2.65 for both patch. • The bandpass filtering response of the antenna is obtained by the three radiation nulls. • Good and stable boresight radiation characteristics are

		achieved across the entire passband.
[8]	High gain planar antenna using optimised partially reflective surfaces	• 13.8-14.8GHz frequency with 22.5dBi gain are used with 14.275-14.45GHz bandwidth. • This antenna is complex, need high cost and has low efficiency. • This antenna introduces a leaky wave and beamforming effect when placed in front of a grounded waveguide aperture. • Gain and bandwidth depend on the reflection from partially reflective surface. • Several elements of geometries such as dipoles, crossed dipoles, patches, rings and square loops have been used. • Dipoles were the best element as other element did not show variation even they were packed closely together.
[9]	Planar Ultrawideband Antennas With Improved Realized Gain Performance	• The shape is arc-shaped slot. • Multimode-resonator filter is combined with slot modified UWB antenna. • The frequency is 3.1-10.6GHz, 10GHz bandwidth with 0.22-2.13dBi gain. • Passband does not completely cover the 10-dB return loss band.
[10]	The Design of High Gain Substrate Integrated Waveguide Antennas	• Design of circularly polarized substrate integrated waveguide antenna. • Stable gain is obtained, that is 4dBi, by using 10.70 - 12.16GHz frequency. • The result shown is in E-field pattern, and from the pattern, no slots the gain is comparatively less. Without slots, the gains increased by 4.0025.
[11]	High Gain Patch Antenna for	• The antenna suited for inter-satellite. • Consists of four patch antenna array. • The CubeSat is 96mm square antenna substrate, have good impedance matching at 2.46GHz.

	CubeSat	• Rely on high frequency, to provide high bit rate and use S-Band. • Provide gain of 9.6dB to avoid communication discrepancy during transmission of signals with bore site direction of 10.06dBi and beam width of 54.8^{o}.
[12]	Design And Fabrication Of A Microstrip Printed T Monopole Antenna For ISM Application	• T-shaped printed monopole antenna, fed by 50Ω inset feed techniques, with FR4 substrate. • The frequency is 2.4GHz, but 0.2GHz shift occur in the measurement resonant frequency. • Conventional cylindrical monopole suffers from low gain, not compatible for Monolithic MIC's design.
[13]	A Wideband Planar Inverted F Antenna For Wireless Communication Devices	• Shows a wide range of frequency, 1.35-2.51GHz with VSWR<2 and it is achieved with the help of two open ended slots on the ground. • The radiation pattern for the proposed antenna is Omni-directional. • Average gain is 2.72dBi and is shows that there is perfect matching between antenna structure and co-axial feed.
[14]	A Compact Multiband Partially Reflective Surface Antenna For XBAND And WLAN Applications	• The substrate used is RT-Duroid 4003, thickness of 20mm and permittivity of 2.2. • Operate at 1.8GHz and 5.375GHz for WLAN and GSM application, and 5.498GHz – 7.535GHz for X-band application. • Radiation pattern is Omni-directional radiation pattern. • Reconfigurable defected microstrip based phase shifters are use in the feed network.
[15]	Design And Simulation Of Patch Antenna For 3.51GHz S-Band	• Works on 3.51GHz, minimum return loss at this frequency is -19.6 dB and gain is 9.13 dB with 1.2 VSWR. • Substrate used is FR-4, permittivity is 4.4. • The patch is in circular shape and gives higher gain,