DESIGN OF PARASITIC MEANDER LINE ANTENNA AT ISM BAND

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ABSTRACT

This report proposes the design of Parasitic Meander-line Antenna at ISM band which operates at frequency of 2.4 GHz. The ISM band used is 2.45 – 24.125 GHz. The meander line antenna is classified as microstrip antenna and it is designed using a single layer known as microstrip patch. The project is proposed to design a parasitic meander line antenna which emphasize the reduction in size and increasing the directivity of the antenna. Besides, the antenna is designed to attain the return loss as minimum as well. Initially, a basic meander line antenna is designed by using Parametric Study Method in order to obtain an optimum dimensions of basic design. Then, the project continues towards designing the parasitic meander line antenna by using the similar method. The parasitic element assist the antenna to change its directivity by itself. There are 3 different structures of parasitic meander line antenna are completed at the end of the project. The 3 structures are known as Skewed Up Parasitic Meander Line Antenna (Design I), Skewed Down Parasitic Meander Line Antenna (Design III) and the last is Diamond Shaped Parasitic Meander Line Antenna (Design II). The antenna is designed and simulated using Computer Simulation Technology (CST). It is fabricated on double-sided FR-4 printed circuit board using chemical etching technique. Then the fabricated antennas are measured using indoor measurement techniques with elevated ranges. The antennas are measured using network analyzer, spectrum analyzer and trainer. Similar parameters have been chosen for both simulation and measurement process. The parameters are the resonant frequency, return loss, radiation pattern, directivity, gain, bandwidth and polarization. The comparison between the simulation and measurement results of the designed antennas were presented in the form of report.

ABSTRAK

Laporan ini mencadangkan reka bentuk Antena Berlekuk Parasit yang berfungsi pada pita ISM iaitu pada frekuensi 2.4 GHz. Pita ISM digunakan adalah 2.45 – 24.125 GHz. Antena berlekuk dikelaskan sebagai mikrostrip antena dan direka menggunakan lapisan tunggal iaitu tampalan mikrostrip. Projek ini dicadangkan untuk mereka antena berlekuk parasit yang menekankan pengurangan saiz dan meningkatkan direktiviti antena selain dari mencapai pulangan kembali yang minimum yang baik. Pada awalnya, antena berlekuk yang asas direka dengan menggunakan Kaedah Kajian Parametrik untuk mendapatkan dimensi optimum. Kemudian, projek ini terus menuju merancang antena berlekuk parasit dengan menggunakan kaedah yang sama. Unsur parasit membantu untuk menukar direktivitinya dengan sendiri. Terdapat tiga struktur antena berlekuk parasit yang berbeza pada akhir projek tersebut. Setiap struktur ini dikenali sebagai "Skewed Up Parasitic Meander Line Antenna (Design I)", "Skewed Down Parasitic Meander Line Antenna (Design III)" dan akhirnya ialah "Diamond Shaped Parasitic Meander Line Antenna (Design II)". Antena ini direka dan disimulasikan menggunakan perisian Simulasi Komputer Teknologi. Antena ini dibuat pada dua sisi papan-4 litar dan dicetak menggunakan teknik etsa kimia. Kemudian diukur dengan menggunakan teknik pengukuran dalam bilik dengan rentangan yang tinggi dengan menggunakan penganalisis rangkaian, penganalisis spektrum dan pelatih antena. Parameter yang serupa telah dipilih untuk kedua-dua simulasi dan proses pengukuran. Parameternya adalah frekuensi resonansi, pulangan kembali, pola radiasi, direktiviti, kuasa penerimaan, lebar jalur frekuensi dan polarisasi. Perbandingan antara hasil kajian yang diperoleh daripada simulasi dan pengukuran direkod dan dipersembahkan dalam bentuk laporan.

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LIST OF ABBREVIATION AND SYMBOLS

RF	-	Radio Frequency
ISM	-	Industrial, Science and Medical (band)
FR-4	-	Flame Retardant (Type 4 – made of woven glass reinforced epoxy resin)
CST	-	Computer Simulation Technology
U	-	Radiation Intensity
G	-	Gain
G_θ	-	Gain in direction of x-y plane
G_φ	-	Gain in direction of y-z plane
U_θ	-	Radiation Intensity in direction of *x-y* plane
U_φ	-	Radiation Intensity in direction of *y-z* plane
P_{in}	-	Input power
E_x	-	Electric field in *x* direction
E_y	-	Electric field in *y* direction
U-MLA	-	Uniform meander line antenna
NU-MLA	-	Non Uniform Meander Line Antenna
MLA_N	-	Non Uniform Meander Line Antenna
GA	-	Genetic Algorithm
MoM	-	Method of Moment

$\boldsymbol{d}$	-	Vertical separation between meander line turns
$\boldsymbol{s}$	-	Horizontal length of meander line design
$\boldsymbol{L}$	-	Vertical length of meander line design
$\boldsymbol{w}$	-	Width of meander line design
λ	-	Wavelength
λg	-	Guided wavelength
$\in_r$	-	Relative dielectric constant
$\in_{reff}$	-	Effective dielectric constant
d	-	Height or thickness of substrate
RFID	-	Radio Frequency Identification
N	-	Number of turns
$wn1$	-	Horizontal length of Non Uniform Meander Line Antenna
$wn2$	-	Horizontal length of Non Uniform Meander Line Antenna
$hn1$	-	Vertical length of Non Uniform Meander Line Antenna
$hn2$	-	Vertical length of Non Uniform Meander Line Antenna
wo	-	Central segment horizontal length
ho	-	Central segment vertical length
H_N	-	Total vertical length for N turns
W_N	-	Total horizontal length for N turns
$Nbit$	-	Number of bits
$hmin$	-	Minimum segment length
$hmax$	-	Maximum segment length
X	-	Input Reactance

H_{max}	-	Maximum vertical length
W_{max}	-	Maximum horizontal length
IFS	-	Iterated Function System
$\boldsymbol{\omega}$	-	Number of Iteration
$\boldsymbol{r}$	-	Scaling factor
e, f	-	Translations of transformation
UWB	-	Ultra Wideband
VSWR	-	Voltage Standing Wave Ratio
d	-	Ground plane
h	-	Horizontal length of meander line antenna
v	-	Vertical length of meander line antenna
dB	-	Desibel
f	-	Frequency
RL	-	Return loss
BW	-	Bandwidth
D	-	Directivity
w_c	-	Copper width
Zo	-	Characteristic Impedance
PEC	-	Perfect Electric Conductor
E-field	-	Electric field
H-field	-	Magnetic field
RCS	-	Radar Cross Section
HPBW	-	Half Power Beam Width
FNBW	-	Full Null Beam Width
n	-	Number of turns of basic meander line antenna

hw	-	Horizontal width of basic meander line antenna
vw	-	Vertical width of basic meander line antenna
t	-	Maximum length of parasitic element
SMA	-	Subminiature version-A (connector)
AUT	-	Antenna Under Test
DUT	-	Device Under Test
GEN	-	Generator
OUT	-	Output
ACQ	-	Acquisition (software)
G_R	-	Received Gain
G_T	-	Transmitted Gain
P_R	-	Received Power
P_T	-	Transmitted Power
dBi	-	Desibel Isotropic

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CHAPTER 1

INTRODUCTION

1.0 Project Background

An antenna is a transducer that transmits or receives electromagnetic waves. In other words, antennas convert electromagnetic radiation into electrical current or vice versa. Antennas generally deal in the transmission and reception of radio waves and are a necessary part of all radio equipment. Based on another source, antenna is defined as an electrical conductor or system of conductors. Antenna can be used in two ways communication, transmitting and receiving. An antenna is a circuit element that provides a transition form a guided wave on a transmission line to a free space wave and it provides for the collection of electromagnetic energy. The most basic antenna is called quarter wave vertical antenna, it is a quarter wavelengths long and is a vertical radiator. Typical examples of this type would be seen installed on motor vehicles for two way communications. Technically the most basic antenna is an „isotropic radiator". This is a mythical antenna which radiates in all directions as does the light from a lamp bulb. It is the standard against which we sometimes compare other antennas.

In transmitting systems the RF signal is generated, amplified, modulated and applied to the antenna. Meanwhile, in receive systems the antenna collects electromagnetic waves that are „cutting" through the antenna and induce alternating currents that are used by the receiver. An antenna ability to transfer energy from the atmosphere to its receiver with the same efficiency as it transfers energy from the transmitter into the atmosphere. Antenna characteristics are essentially the same regardless of whether an antenna is sending or receiving electromagnetic energy.

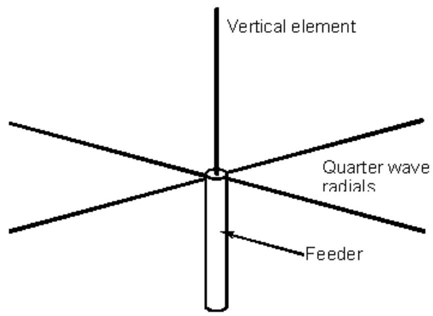

Figure 1.1 Quarter Wave Vertical Antenna [2].

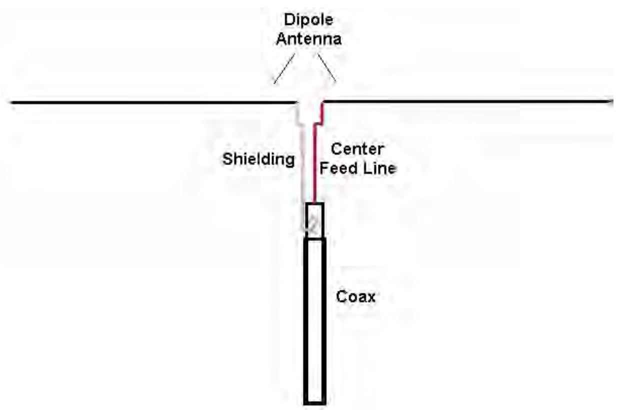

Figure 1.2 Dipole Antenna [2].

1.1 Problem Statement

There are many aspects need to be considered in designing an antenna. The problems that usually found in existing antenna are referred to the size of the antenna. First of all, the size of normal antennas is very huge and increasing the cost expended. The larger antennas are difficult to be located and unable to shift from one place to another place. For example, the Yagi-Uda and parabolic-dish (ASTRO) antennas that found on home rooftops are difficult to remove or relocate [3]. In order to overcome the problem, a meander line antenna could be a best solution to be designed. Meander line antenna is chosen because it is one of the best techniques used to reduce or miniaturize the size of antenna. It is smaller in size and very flexible to be shifted or relocated.

The meander line technique is an effective size to be designed because it consumes smaller area and produced larger volume due to the meandered element. In terms of radiation, an ordinary antenna radiates its signal only in one direction of strongest emission called directivity. The current ordinary antennas have a small scope of directivity and not able to change its directivity itself. In order to obtain a uniform transmission of radiation through the strongest emission, the directivity should be increased. Therefore, designing parasitic element together with meander line antenna can contributes towards good parasitic effect [4]. It enables the changing of its directivity by itself and resulting in higher power gain of antenna.

1.2 Project Objectives

The objective of this project is to design, simulate and fabricate a parasitic meander line antenna at ISM band (2.4 – 2.5 GHz). It is designed to be smaller in size compared to existing antennas and consistently reducing the cost of design. The meander line antenna has been designed to operate at 2.4 GHz as it approaches the industrial, scientific and medical radio bands. Aside from size, the proposed design also emphasize in producing higher directivity as well as it can contributes towards higher gain. The characteristic of antenna with minimum return loss as possible is obtained and considered good and able to perform well.

1.3 Project Scope

The scope of the project is designing the basic meander line antenna then enhances the design by adding parasitic element at low cost of simple structure. The parasitic meander line antenna is designed to operate at ISM band. Then, both of the basic and parasitic meander line antennas are simulated using the Computer Simulation Technology (CST) software. The project continues by fabricating both of the designs on FR-4 printed circuit board by using chemical etching process. The parameters that simulated and measured through the project are the resonant frequency, return loss, directivity, gain, bandwidth and radiation pattern. The fabricated designs are measured with the aid of the equipments such as network analyzer, coaxial cables and signal generator. Then, the comparison between simulation and measurement results of basic meander line and parasitic meander line antenna are presented in the form of report.

1.4 Methodology

First of all, before the project was conducted, the literature review was done by gathering information about existing ordinary antennas. Information regarding the project taken from books, journals and internet resources for better understanding and to find solutions or options. As for next step, the design of parasitic meander line antenna was studied. The process of designing antenna using parasitic element was analyzed. Then, get used to the software and basic skills of it. The software or simulator that used is Microwave Studio CST of Microwave Office. The parameters that obtained from simulation are the frequency, return loss, directivity, gain, bandwidth, radiation pattern and polarization [5].

Besides, the fabrication process is carried out onto FR-4 printed circuit board by using chemical etching technique. The FR-4 board is used because of its material substrates. It is made of woven fiberglass cloth with an epoxy resin binder that is flame resistant. It is versatile high pressure thermo set plastic laminate grade with good