ULTRA WIDEBAND PLANAR ANTENNA DESIGN

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To my beloved mother, my family wife and children

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ABSTRACT

The main idea of this project is to design, develop and fabricate an Ultra Wideband Planar Antenna on FR4 printed circuit board. As UWB technology is promising for short-range, high data rate wireless communications, high accuracy radar and imaging system, it has recently received great attention in academic and R&D sector for designing an antenna that can be utilized in allocated UWB frequency range of 3.1GHz to 10.6GHz. Furthermore UWB planar antenna has many advantages, including low profile of planar configuration, light weight, smaller in size and robust when mounted on rigid surface. The content in this thesis explains the basic antenna engineering and the method of antenna design and development for all relevant parameter optimization. The results of antenna simulation before fabrication and antenna measurement after fabrication are also discussed.

ABSTRAK

Idea utama projek ini adalah untuk mereka-bentuk, membina serta membuat fabrikasi UWB planar antena pada FR4 papan litar bercetak (FR4 PCB). Oleh kerana teknologi UWB telah memberi peluang yang cerah pada sistem tanpa wayar jarak dekat, sistem radar dan juga sistem imej yang berketepatan tinggi, ia telah mendapat tumpuan daripada pihak akademik dan juga sektor pembangunan & penyelidikan (R&D) untuk mereka-bentuk suatu antenna yang boleh digunakan dalam julat UWB frekuensi 3.1GHz hingga 10.6GHz. Tambahan pula UWB planar antena mempunyai banyak kelebihan termasuklah konfigurasi profil yang rendah, lebih ringan, saiz yang kecil serta ketahanan pemasangannya pada permukaan yang tegar. Isi kandungan tesis ini menerangkan tentang asas kejuruteraan antena, kaedah mereka-bentuk dan membina untuk meningkatkan parameter yang berkenaan pada tahap yang optimum. Keputusan simulasi bagi antenna sebelum fabrikasi dan pengukuran selepas fabrikasi juga dibincangkan.

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LIST OF SYMBOLS

C - Channel Capacity
D - directivity (dimensionless)
D_0 - maximum directivity (dimensionless)
E - Electrical field (V/m)
H - Magnetic field (A/m)
h - Substrate thickness
G - Gain
I - Current
R - Resistance
η - Efficiency
Γ - Reflection Coefficient
λ - Wavelength
ε - Substrate Constant
U - Radiation intensity (W/unit solid angle)
P_{rad} - Total radiated power (W)
L - Patch length
W - Patch width
r - Radius
Z_{line} - Characteristic impedance
Z_{Load} - Load impedance
S - Stub
X_c - Capacitive Reactance
C - Capacitance
f - Frequency
π - phi (3.14)

CHAPTER 1

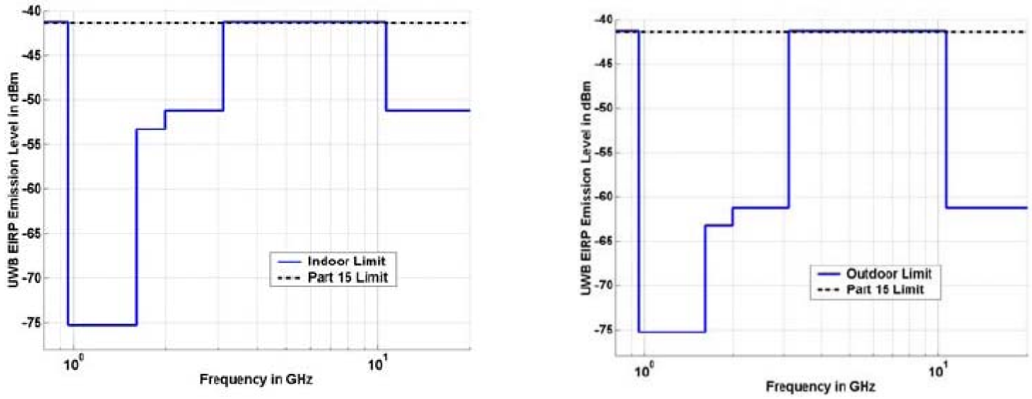
INTRODUCTION

1.1 Overview – UWB Wireless Communication

UWB radio technology has been investigated widely and developed for wireless applications since the 1970s. Potential commercial opportunities for UWB radio technology are expected for communications, imaging, ranging and localization. Recently it has received significant attention in both academia and industry for its benefits, including high data rate, availability of low-cost transceivers, low transmit power, and low interference [6].

UWB antennas are typically used to transmit and/or receive signals with very short pulses, which may be modulated in UWB communication systems such as single-band and multiband [7]. As mentioned, single-band is an Impulse Radio which the pulse width is very narrow and multiband-base is accomplished by OFDM modulation method. The extremely short pulses in the time domain usually occupy ultra-wide bandwidths in the frequency domain with the unlicensed frequency band of 3.1GHz ~ 10.6GHz.

From a communications theory perspective, the most important characteristic of UWB systems is their capability to function at the power-limited level. This is to avoid interference risk from other systems sharing the same spectrum. Figure 1.1 illustrates the usable spectrum permitted under power limitation of the Commission's rules. UWB signals may be transmitted between 3.1 GHz and 10.6 GHz at power levels up to –41.3dBm [6].



(a) (b)

Figure 1.1: FCC Spectral Mask for Indoor (a) and Outdoor (b) [6].

As the unlicensed bandwidth had been approved by FCC, the UWB technology becomes an ideal tool in research field for high data rate and short range-communications in indoor/outdoor wireless applications. However, IEEE organization introduces the standard for low data rate and low power that is IEEE 802.15.4a and standard for high data rate of IEEE 802.15.3a. Thus, this UWB antenna has become a major interest in researching that commercially can be used in imaging system, vehicular radar system, measurement and other communication systems.

1.2 Problem Statement

Conventional planar antenna applied mostly to narrowband system, while achieving wide impedance bandwidth for UWB system becomes main challenging to antenna designer. Very short range communication and high data rate of carrying signal requirements have been emphasized recently on UWB devices for commercial, imaging and surveillance system opportunities. The small structure in size and its low profile characteristics seems to be quite difficult to achieve in the range of wide UWB frequency, so that the antenna optimization should continuously be studied and researched.

1.3 Objective

The objective of this project is to design, develop and fabricate an Ultra Wide Band printed planar antenna for UWB application. The UWB antenna should function at 3.1GHz ~ 10.6GHz of UWB frequency bandwidth and the parameter of S11 return loss should be less than -10dB. In addition, the characteristics and performances of UWB antenna will be researched by the design simulation and measurement.

1.4 Project Scope

The project scope covers from a basic understanding of Micro-strip antenna technology through basic antenna theory and released literature reviews from IEEE journal. The study begins with the basic antenna properties such as polarization, radiation pattern, frequency BW and antenna gain. However in the case of rectangular patch antenna, the shape of radiating patch and partially ground design have been researched to aim the less -10dB of S11 return loss parameter and the broad BW frequency in UWB range. It will be designed and simulated by using CST simulation software, to achieve the design objective and finally will be fabricated on FR4 type of PCB substrate. The antenna then will be measured by using Vector Network Analyzer (VNA) to analyze the S11 return loss performance and the measured result is to be compared with simulated result for S11 return loss validations.

1.5 Project Design Methodology

An UWB Planar antenna design starts with the basic understanding of microstrip and planar antenna configurations and the fundamental theory which leads to antenna development is really essential. Through the literature review, the requirement of this antenna can be obtained by studying its concept, characteristic and the entire performances. The next process is then implemented from this earlier stage to the next final stage of antenna fabrication is illustrated in the process development flowchart.

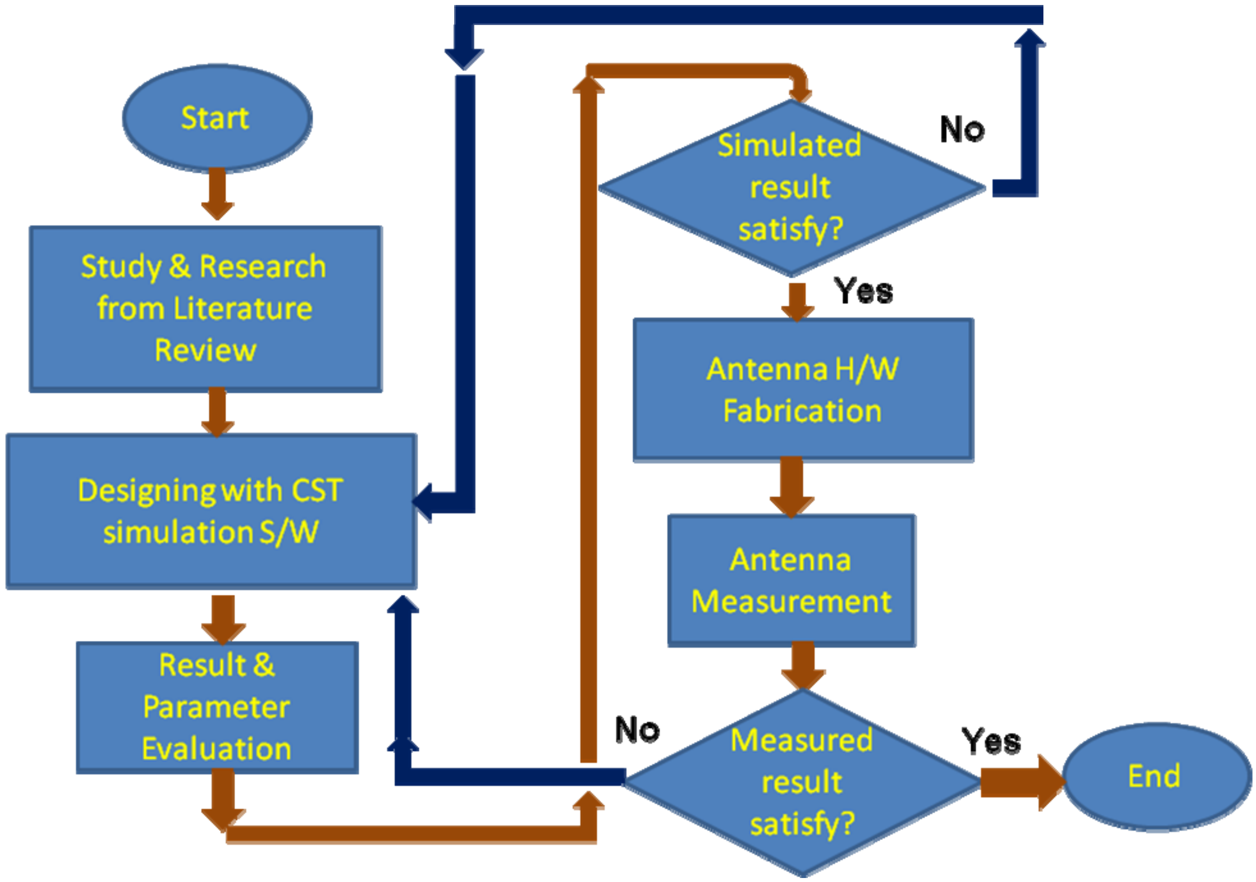


Figure 1.2: Development Flowchart of UWB Planar Antenna Design

1.6 Thesis Outlines

This thesis has five chapters. Each chapter discusses on different issues of the project. The outlines of the project are as follows:-

Chapter 1 starts with the introduction and overview, problem statement, objective, project scope and design methodology to implement the project work.

Chapter 2 introduces the theory behind microstrip antenna, antenna & RF theories, and ultra wideband technology. It also includes the literature review to assist the project.

Chapter 3 explains in detail about the design process and methodology of this project. Additionally, the fabrication process and method of measurement are also presented.

Chapter 4 provides the simulated and measured results. Discussions for both results are also being attached. Comparisons are being made between the simulated results and measured results for the fabricated UWB planar antenna.

Chapter 5 concludes this thesis with the work carried out for this project and the future prospects for its application in integrated RF systems.

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