A DESIGN OF RECONFIGURABLE FILTERING-ANTENNA FOR ULTRA-WIDEBAND APPLICATIONS

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A thesis submitted
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DECLARATION

I declare that this thesis entitled "A Design of Reconfigurable Filtering-Antenna for Ultra-Wideband Applications" is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature :…………………………………………………...

Name : Ammar Abdullah Hussein Al-Hegazi

Date :…………………………………………………..

APPROVAL

I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Master of Science in Electronic Engineering.

Signature	:………………..
Supervisor Name	: Assoc. Prof. Dr. Zahriladha Bin Zakaria
Date	:………………………..

DEDICATION

To my beloved mother and father

ABSTRACT

Antenna is a main element in the UWB systems to transmit and receive signals. However, there are challenges to meet the requirements for a suitable UWB antenna compare to other narrowband antennas such as high data rate, omnidirectional radiation pattern and wide frequency bandwidth. Since the UWB technology is facing the interference problem with other narrow band signals such as WiMAX, WLAN and HiperLAN, which severely degrade the performance of the receiver in the UWB system, thus the conventional UWB system is integrated with bandstop filter in separated model from the antenna, which leads to increase complexity, cost, weight and loss. Therefore, researchers tend to integrate resonant structure in the antenna design to produce band notch characteristics and filter out unwanted signals using different techniques such as defected ground structure (DGS), defected patch structure (DPS) and resonant structure beside the feedline of the antenna design. However, the disadvantages of these techniques are the excessive band rejection, which rejects needed frequencies, and the fixed band notch whether the interfering signal exists or not, which may reduce the performance of the UWB system, thus producing sufficient and switchable band notch is a challenging issue to improve the performance of the UWB system. Therefore, in this research, a modified monopole antenna is designed to produce UWB bandwidth using microstrip transition in the feedline and block with triangular slot on each side of the circular patch. The modified monopole antenna is integrated with resonant structures to produce band notch characteristics and filter out unwanted signals. Two techniques based on defected microstrip structure (DMS) and two double split ring resonator (DSRR) are integrated with the antenna design individually. The DMS is embedded in the feedline of the antenna design to produce single band notch. The two DSRR are loaded above the ground plane of the antenna design to produce dual band notches. A PIN diode is employed in the resonant structure to achieve frequency reconfiguration. The results show that the modified monopole antenna exhibits wide bandwidth (129.5%) with a return loss better than -15 dB, high frequency skirt selectivity ranging from 3 to 14 GHz, which covers the entire UWB frequency band (3.1-10.6 GHz), peak gain of 5.3 dB and omnidirectional radiation pattern. The new integrations of filtering-antenna using DMS and DSRR provide stable omnidirectional azimuth pattern and sharp band notches, which are sufficient to remove unwanted signals and keep wanted signals. The simulated and measured results show a good agreement, where the proposed filtering-antenna using DMS exhibits wide bandwidth with switchable band notch at 5.5 GHz (WLAN), and the filtering-antenna using two DSRR exhibits wide bandwidth with switchable sharp band notches at 3.5 GHz (WiMAX) and 5.55 GHz (HiperLAN2).

ABSTRAK

Antena ialah satu elemen utama dalam sistem UWB untuk menghantar dan menerima isyarat. Bagaimanapun, terdapat cabaran dalam memenuhi keperluan untuk antena UWB berbandingan antena-antena jalur sempit lain seperti kadar data tinggi, pola sinaran semua arah dan lebar jalur frekuensi yang lebar. Disebabkan teknologi UWB menghadapi masalah gangguan dengan isyarat-isyarat jalur sempit lain seperti WiMAX, WLAN and HiperLAN, yang merendahkan prestasi penerima dengan teruk dalam sistem UWB, maka sistem UWB konvensional diintegrasikan dengan turas jalur batas dalam model yang berasingan dari antena, yang membawa ke perningkakan kerumitan, kos, berat dan kehilangan. Oleh itu, penyelidik cenderung untuk mengintegrasi struktur resonan dalam reka bentuk antenna yang menghasilkan ciri-ciri takuk jalur dan menyingkir isyarat-isyarat yang tidak dikehendaki dengan menggunakan kaedah yang berbeza seperti defected ground structure (DGS), defected patch structure (DPS) dan struktur resonan pada bahagian baris laluan masuk reka bentuk antena. Walaubagaimanapun, kelemahan teknik-teknik ini ialah penolakan jalur yang berlebihan, yang menolak frekuensi-frekuensi diperlukan, dan takuk jalur yang tetap sama ada isyarat gangguan wujud ataupun tidak, yang boleh mengurangkan prestasi sistem UWB, maka menghasilkan takuk jalur yang mencukupi dan boleh ditukar ialah satu isu mencabar untuk meningkatkan prestasi sistem UWB. Oleh sebab itu, dalam penyelidikan ini antena ekakutub diubah suai direka bentuk untuk menghasilkan lebar jalur UWB menggunakan peralihan jalurmikro dalam baris laluan masuk dan blok dengan slot segitiga di kedua belah patch bulat. Antena ekakutub diubah suai diintegrasikan dengan struktur-struktur bergema untuk menghasilkan ciri-ciri takuk jalur dan menyingkir keluar isyarat-isyarat tidak dikehendaki. Dua teknik berdasarkan defected microstrip structure (DMS) dan dua resonator gelang belah berganda (DSRR) berintegerasi dengan antena mereka secara individu. DMS diletakan dalam baris laluan masuk reka bentuk antena menghasilkan tunggal takuk jalur. Dua DSRR dimuatkan di atas satah bumi reka bentuk antena untuk menghasilkan takuk dua jalur. Diod PIN dimuatkan dalam struktur bergema mencapai frekuensi pentatarajahan semula. Hasil keputusan menunjukkan bahawa antena ekakutub diubah suai mempamerkan lebar jalur seluas (129.5%) dengan pekali pantulan lebih baik daripada -15 dB, pemilihan skirt frekuensi tinggi meliputi 3 hingga 14 GHz, yang menutup seluruh UWB frekuensi (3.1-10.6 GHz), puncak keuntungan sebanyak 5.3 dB dan mendapat pola sinaran semua arah. Integrasi baru antenna-menapis menggunakan DMS and DSRR memberikan corak azimut semua arah yang stabil dan tepat takuk jalur, yang mencukupi untuk membuang isyarat-isyarat tidak dikehendaki dan menyimpan isyarat yang dikehendakki. Keputusan simulasi dan keputusan ukuran menunjukkan perjanjian yang baik di mana cadangan antenna-menapis menggunakan DMS mempamerkan lebar jalur yang luas dengan takuk jalur bolehubah di 5.5 GHz (WLAN), dan antena menapis menggunakan dua DSRR mempamerkan lebar jalur yang luas dengan jalur menakuk bolehubah di 3.5 GHz (WiMAX) dan 5.55 GHz (HiperLAN2).

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATION

AUT	-	Antenna Under Test
BPF	-	Bandpass Filter
BSF	-	Bandstop Filter
BW	-	Bandwidth
CLR	-	Coupled Line Resonator
co-pol	-	Co-polarization
CST	-	Computer Simulation Technology
dB	-	Decibel
DMS	-	Defected Microstrip Structure
DGS	-	Defected Ground Structure
DSRR	-	Double Split Ring Resonator
DPS	-	Defected Patch Structure
E	-	Elevation Plane
EM	-	Electromagnetic
GHz	-	Giga Hertz
H	-	Azimuth Plane
HiperLAN2	-	High Performance Radio LAN
HPF	-	Highpass Filter
LPF	-	Lowpass Filter
mm	-	millimeter
NSR	-	Nonuniform Sub Resonator
OC	-	Open Circuit

PCB	-	Printed Circuit Board
RF	-	Radio Frequency
RSS	-	Resonant Stub Structure
SC	-	Short Circuit
SRR	-	Split Ring Resonator
SW	-	Switch
UWB	-	Ultra-Wide Band
VNA	-	Vector Network Analyze
VSWR	-	Voltage Standing Wave Ratio
WLAN	-	Wireless Local Area Network
WiMAX	-	Worldwide Interoperability for Microwave Access
x-pol	-	Cross Polarization

LIST OF SYMBOLS

a_n	-	Incident Wave
b_n	-	Reflected Wave
c	-	Speed of Light
C	-	Capacitance
d	-	Thickness of the Substrate
ε_r	-	Relative Permittivity of the Substrate
ε_e	-	Effective Permittivity of the Substrate
f_o	-	Center Frequency
f_c	-	Cutoff Frequency
λ	-	Wavelength
g	-	Width of the U-shaped slot
I	-	Current
j	-	Imaginary
L	-	Inductance
L_s	-	Length of the Substrate
l_f	-	Length of the Feedline
lg	-	Length of the Ground Plane
ls	-	Length of the Resonant Structure
ls_1	-	Length of the First DSRR
ls_2	-	Length of the Second DSRR