Investigation into the Design of Ultra-Wideband (UWB) and Multi-band Antennas

Xiaoning Qiu

Faculty of Engineering

University of Technology, Sydney

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Statement of Originality

I hereby declare that this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis presents my own work and has been written by me. Any help that I have received in my research work and the preparation of this thesis have been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis

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Xiaoning Qiu

Dedication

To my dear parents and relatives,
for their love and patience

Abstract

The rapid development of high speed wireless communications as well as other applications such as microwave imaging place extraordinary demands on spectrums for which ultra-wideband (UWB) and multi-band, e.g.: dual-band, techniques are useful. These UWB and multi-band services require UWB and multi-band antenna designs. Motivated by these applications, we first carried out the investigations on the family of square plate monopole (SPM) antennas for UWB applications. The family of square plate monopole (SPM) UWB antennas yields quite attractive features, viz.: ease of fabrication and freedom of dielectric material selection. Next, we considered the use of coplanar waveguide (CPW) fed printed UWB antenna for compact, body-worn applications. We investigated the antenna performance using empirical optimisation. The work on CPW-fed printed antennas has led to the development of multi-band antennas also.

For UWB antennas, we have first considered the modifications of well know square plate monopole (SPM) antennas. Our approach differs from other similar approaches on SPM antennas published in the literature. We have introduced symmetrical modifications to both bottom and top portions of the SPM antenna element. This has led

to the development of these types of symmetrically modified SPM antennas, viz.: symmetrically beveled SPM (SB-SPM) antenna, symmetrical semi-circular base SPM (SSCB-SPM) antenna and symmetrically notched SPM (SN-SPM) antenna. All these antennas have been empirically optimised using Feko® and the theoretical and experimental results are provided, in the point of view of reflection coefficient, radiation characteristics, phase response of antenna transfer function and time domain response.

For better suiting the compact and body-worn UWB applications, we have investigated the design of CPW-fed printed antenna. We have explored the antenna characteristics using empirical optimisation. The theoretical and experimental results for the completed CPW-fed printed antenna are provided, in the point of view of reflection coefficient, radiation characteristics, phase response of antenna transfer function, group delay and time domain response.

Lately, for multi-band antennas, we have investigated the design of multi-band printed antennas, which are fed by CPW, to suit emerging design requirements. Two CPW-fed dual-band printed antennas for GSM and DCS/PCS as well as DCS/PCS and IEEE 802.11b applications are proposed, which have C-shape and T-shape structures respectively. The theoretical and experimental results for these antennas are provided, in the point of view of reflection coefficient and radiation characteristics.

Due to the use of substrate material for the designs of UWB CPW-fed printed antenna as well as C-shaped and T-shaped dual-band CPW-fed printed antennas, the effects of substrate material tolerances on UWB characteristics and dual-band characteristics are investigated. Furthermore, as these UWB and dual-band CPW-fed printed antennas are the promising candidates for wireless body-worn applications, which include wireless body area network (WBAN), the interactions between them and lossy material, such as human tissue, are investigated, which might help to decide the suitability of them for wireless body-worn applications.

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ASB-SPM	Asymmetrically Beveled Square Plate Monopole
ASN-SPM	Asymmetrically Notched Square Plate Monopole
ASSCB-SPM	Asymmetrically Semi-Circular Base Square Plate Monopole
BW	Bandwidth
CBAS	Cavity-Backed Archimedean Spiral
CDMA	Code Division Multiple Access
CPW	Coplanar Waveguide
CSL	Coupled Slotline
DRA	Dielectric Resonator Antenna
DCS	Digital Cellular System
EIRP	Equivalent Isotropic Radiated Power
FCC	Federal Communication Committee
Feko	FE*ldberechnung bei* K*örpern mit beliebiger* O*berfläche*
FSS	Frequency Selective Surface
GA	Genetic Algorithm
GSM	Group Spéciale Mobile
GPRS	General Packet Radio Service
GPS	Global Positioning System
HFSS	High Frequency Structure Simulator
HiperLan/x	Standards for Radio Local Area Network
HOM	Higher Order Mode
IEEE 802.11a/b/g	Standards for Wireless Local Area Networks (WLAN)
IRA	Impulse Radiating Antennas

LTCC	Low Temperature Cofired Ceramic
LOS	Line of Sight
MB	Megabyte
MoM	Methods of Moments
NMT	Nordic Mobile Telephone
NSI	Near-field System Inc.
OBS	One Beveled Step
ONS	One Notched Step
PCB	Printed Circuit Board
PCS	Personal Communication Services
RF	Radio Frequency
SAR	Specific Absorption Rate
SB-SPM	Symmetrically Beveled Square Plate Monopole
SMA	SubMiniature Version A
SN-SPM	Symmetrically Notched Square Plate Monopole
SPM	Square Plate Monopole
SSCB-SPM	Symmetrically Semi-Circular Base Square Plate Monopole
TEM	Transverse Electromagnetic
UMTS	Universal Mobile Telecommunications Systems
UWB	Ultra Wideband
WBAN	Wireless Body Area Network
WLAN	Wireless Local Area Network
WPAN	Wireless Personal Area Network