



Faculty of Electronics and Computer Engineering

**DESIGN OF INTEGRATED RECTANGULAR SIW FILTER AND
MICROSTRIP PATCH ANTENNA FOR WIRELESS
COMMUNICATIONS**

Sam Weng Yik

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PATCH ANTENNA FOR WIRELESS COMMUNICATIONS**

SAM WENG YIK

**A thesis submitted
in fulfillment of requirements for the degree of Master of Science
in Electronic Engineering**

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2014

DECLARATION

I declare that this thesis entitled “Design of integrated Rectangular SIW Filter and Microstrip Patch Antenna for Wireless Communications” 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 :

Date :

APPROVAL

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

Signature :

Supervisor Name :

Date :

ABSTRACT

This thesis presents the design and development of an integrated substrate integrated waveguide (SIW) filter and microstrip patch antenna, which utilizes cascaded and multilayered techniques. Integrated method contributes to the reduction of the overall design size in front-end subsystems as well as in manufacturing cost. The first design process was developed using the basic concept of filter with the characteristics of the circuit transformation of lowpass prototype network for filter, antenna and integrated filter and antenna with the sequence procedure as a starting point. The next process involved the designing of Chebyshev bandpass for filter, antenna and integrated filter and antenna at desired frequency based on single- and dual-mode. The second and third design process were developed using planar structure based on SIW technology and patch antenna. The concept of SIW was formulated from a standard conventional rectangular waveguide by a set of design rules. Meanwhile, microstrip patch antenna was designed based on the procedures and techniques in order to integrate with SIW filter. Integrated method using cascaded and multilayer are developed from the combination between SIW filter and patch antenna. Two commercial software programs that were used in the design and development of integrated SIW filter and antenna bandpass filter namely Advanced Design System (ADS) software, and CST Studio Suite software. All designs were simulated, manufactured and measured. The experimental results showed good agreement with the simulated results. The main benefits of the integrated SIW filter and microstrip patch antenna are the reduction of the overall size, ease to fabricate, low in cost and the use of standard printed circuit board process. This new novel of microwave filters is considered suitable and is an alternative solution for 3G, ISM, WLAN and LTE applications without an addition of external common impedance network on the systems.

ABSTRAK

Tesis ini membentangkan reka bentuk dan pembangunan integrasi penapis pandu gelombang berinterasi substrat dan antena tampalan mikrostrip yang menggunakan kaedah lata dan berbilang lapis antara penapis dan antena. Kaedah integrasi dapat menyumbangkan kepada pengurangan saiz keseluruhan reka bentuk dan kos pembuatan dalam bahagian depan subsistem. Proses reka bentuk yang pertama telah dibangunkan dengan menggunakan konsep asas penapis dengan ciri-ciri transformasi litar rangkaian prototaip untuk penapis laluan rendah, antena dan integrasi penapis dan antena dengan mengikut prosedur tertentu sebagai satu titik permulaan. Reka bentuk ini diteruskan dengan lurus jalur untuk penapis Chebyshev, antena dan integrasi penapis dan antenna pada frekuensi yang dikehendaki berdasarkan tunggal- dan dwi-mod. Proses reka bentuk kedua dan ketiga telah dibangunkan dengan menggunakan struktur satah berasaskan teknologi SIW dan tampalan antenna. Konsep SIW digubal dari rumus standard pandu gelombang segi empat tepat konvensional dengan mengikut set peraturan reka bentuk yang telah ditetapkan. Sementara itu, mikrostrip tampalan antenna direka berdasarkan prosedur dan teknik dalam usaha untuk bergabung dengan penapis SIW. Kaedah integrasi menggunakan lata dan berbilang lapis dihasilkan melalui gabungan antara penapis SIW dan antena tampal. Dua program perisian komersial telah digunakan dalam reka bentuk dan pembangunan integrasi SIW penapis dan antena seperti Advanced System Design (ADS) perisian, dan perisian CST Studio Suite. Semua reka bentuk telah disimulasikan, dihasilkan dan diuji untuk membuktikan konsep yang telah direka adalah betul. Keputusan eksperimen menunjukkan persetujuan yang baik dengan keputusan simulasi yang telah dilakukan. Manfaat utama integrasi SIW penapis dan mikrostrip tampalan antenna adalah pengurangan saiz keseluruhan reka bentuk, pemudahan fabrikasi, pengurangan kos dan menggunakan standard proses papan litar yang bercetak. Integrasi ini merupakan sesuatu yang baru dan sesuai digunakan serta menjadi alternatif menyelesaikan untuk aplikasi 3G, ISM, WLAN dan LTE dengan tanpa tambahan galangan di luar rangkaian sistem.

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LIST OF ABBREVIATION

<i>3G</i>	-	Third Generation
<i>EM</i>	-	Electromagnetic
<i>LTE</i>	-	Long Term Evolution
<i>RF</i>	-	Radio Frequency
<i>RX</i>	-	Recieve
<i>SIW</i>	-	Substrate Integrated Waveguide
<i>TE</i>	-	Transverse Electric
<i>TEM</i>	-	Transverse Electromagnetic
<i>TM</i>	-	Transverse Magnetic
<i>TX</i>	-	Transmit
<i>WLAN</i>	-	Wireless Local Area Network

LIST OF SYMBOLS

C	-	Capacitance
L	-	Inductance
R	-	Resistance
ω	-	Angular frequency
ω_c	-	Angular cut-off frequency
ω_o	-	Angular centre frequency
K	-	Impedance inverter
α	-	Bandwidth scaling factor
c	-	Speed of light
λ	-	Wavelength
λ_o	-	Centre frequency wavelength
λ_g	-	Centre guide wavelength
N	-	Number of order(s)
f_o	-	Centre frequency
f_c	-	Cut-off frequency
f_r	-	Resonant frequency
BW	-	Bandwidth
ε_o	-	Permittivity of free space

ϵ_r - Dielectric constant

S - Sensitivity

h - Substrate thickness

LIST OF PUBLICATIONS

Journals:

Zakaria, Z., Sam, W.Y., Abd Aziz, M.Z.A., Jusoff, K., Othman, M.A., Ahmad, B.H., Mutalib, M.A., and Suhaimi, S., 2013. Hybrid Topology of Substrate Integrated Waveguide (SIW) Filter and Microstrip Patch Antenna for Wireless Communication System. *Australian Journal of Basic and Applied Sciences*, 7(3), pp. 24-34. (*Scopus*)

Zakaria, Z., Sam, W.Y., Abd Aziz, M.Z.A., and Ismail, M.M, 2013. The Integration Of Rectangular SIW Filter and Microstrip Patch Antenna Based On Cascaded Approach, *Procedia Engineering*, 53(1), pp. 347-353. (*Scopus*)

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