UNIVERSITI TEKNIKAL MALAYSIA MELAKA

Faculty of Electronic and Computer Engineering

DESIGN OF HYBRID RF DIPLEXER AND TRIPLEXER FOR MULTIBAND WiMAX APPLICATION

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Master of Science in Electronic Engineering

2018

DESIGN OF HYBRID RF DIPLEXER AND TRIPLEXER FOR MULTIBAND WiMAX APPLICATION

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

Faculty of Electronic and Computer Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

DECLARATION

I declare that this thesis entitled "Design of Hybrid RF Diplexer and Triplexer for Multiband WiMAX Application" 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 : Muhammad Aizat Bin Sazali

Date : 13/3/2018

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 in Electronic Engineering.

Signature : .....

Supervisor Name : Dr. Noor Azwan Bin Shairi

Date : 13 Mac 2018

DEDICATION

The sake of Allah, my Creator and my Master,

My great messenger, Mohammad S.A.W who taught us the purpose of life,

My beloved parent Sazali and Rohani,

My beloved supervisors Dr. Noor Azwan and Assoc. Prof. Dr. Zahriladha,

My beloved families,

My beloved friends and all the people in my life who touched my heart and soul.

ABSTRACT

Radio frequency (RF) diplexer and triplexer are widely used in wireless communication system. The development of RF diplexer and triplexer are very competing in multiband Worldwide Interoperability for Microwave Access (WiMAX) application. This is due to the high demands of wireless communication system to support multi-services simultaneously. Many RF diplexer and triplexer are designed using common type of the filter. Besides, the preliminary designs are for multi-applications not specifically for multiband WiMAX application. The multiband WiMAX has been implemented around the globe as allocated by the International Telecommunication Union (ITU). Bandwidth of the multiband WiMAX application are varies depending on the countries. Therefore, the proposed RF diplexer and triplexer are developed to cope with the multiband WiMAX bandwidth. This is because of the bandwidth is purposely to allow the data to be transmitted or received based on the frequencies assigned. The proposed RF diplexer and triplexer were designed with three different resonators as to cover the multiband WiMAX bandwidth which were at 2.3, 2.6 and 3.5 GHz. The resonator types were selected based on the bandwidth achieved by the resonator. In addition, the resonators used were based on the coupled lines technique on a microstrip structure due to the flexibility during development processes such as open loop, parallel and folded structures. The proposed RF diplexer and triplexer are based on the hybrid structure which more flexible for the resonators to match with the matching network. By synthesis and analysis on the overall performances of the proposed RF diplexer and triplexer, the specific bandwidths were achieved for multiband WiMAX application. Results showed that the resonators produced bandwidths of 100 MHz for the narrow band with minimum 4 % fractional bandwidth, and 200 to 700 MHz with 10 - 20 % fractional bandwidth for the moderate band. These results showed that the resonators were achieved good agreements to be implemented in multiband WiMAX application.

ABSTRAK

Frekuensi Radio (RF) pendipleks dan triplexer digunakan secara meluas dalam sistem komunikasi tanpa wayar. Pemajuan RF pendipleks dan triplexer adalah sangat berkompetisi dalam perkembangan aplikasi jalur berbilang Worldwide Interoperability for Microwave Access (WiMAX). Ini adalah disebabkan oleh permintaan yang tinggi dalam sistem komunikasi tanpa wayar ke pelbagai perkhidmatan sokongan secara serentak. Banyak RF pendikpleks dan triplexer direka untuk pelbagai aplikasi yang tidak umumnya untuk aplikasi jalur berbilang WiMAX. Jalur berbilang WiMAX telah dilaksanakan di seluruh dunia seperti yang diperuntukkan oleh pihak International Telecommunication Union (ITU). Lebar jalur untuk jalur berbilang WiMAX berbeza bergantung kepada sesebuah negara. Oleh yang demikian, RF pendipleks dan triplexer yang dicadangkan dibentuk untuk menadaptasi lebar jalur untuk jalur berbilang WiMAX. Ini adalah kerana lebar jalur adalah membolehkan data yang dihantar atau diterima mengikut pada frekuensi yang ditetapkan. RF pendipleks dan triplexer yang dicadangkan telah direka dengan tiga resonator yang berbeza untuk meliputi lebar jalur WiMAX pada 2.3, 2.6 dan 3.5 GHz. Jenis bahantara dipilih berdasarkan pada lebar jalur yang dicapai oleh bahantara itu. Di samping itu, resonator yang digunakan adalah berasaskan teknik garisan berganding pada struktur microstrip, hal ini disebabkan oleh fleksibiliti di sepanjang proses pembangunan seperti gelung terbuka, selari dan struktur dilipat. RF pendipleks dan triplexer yang dicadangkan adalah berdasarkan struktur hibrid dimana lebih fleksibel untuk resonator sesuai dengan rangkaian sepadan. Dari sintesis dan analisis, prestasi keseluruhan cadangan RF pendipleks dan triplexer, Lebar jalur tertentu dicapai jalur berbilang aplikasi WiMAX. Hasil kajian menunjukkan bahawa resonator ini menghasilkan jalur lebar sebanyak 100 MHz untuk jalur sempit dengan minimum lebar jalur pecahan 4%, dan 200 hingga 700 MHz dengan lebar jalur pecahan 10-20% bagi jalur sederhana. Keputusan ini menunjukkan resonator ini mencapai kesesuaianuntuk dilaksanakan dalam aplikasi jalur berbilang WiMAX.

ACKNOWLEDGEMENTS

First and foremost, I would like to take this opportunity to express my sincere acknowledgement to my supervisor Dr. Noor Azwan Shairi and my co-supervisor Assoc. Prof. Dr. Zahriladha Zakaria from the Faculty of Electronic and Computer Engineering, Universiti Teknikal Malaysia Melaka (UTeM) for their essential supervisions, supports and encouragements towards the completion of this thesis.

I would also like to express my greatest gratitude to all who have support me during completing my Master of Science in Electronic Engineering. Special thanks to all my friends who have provided assistance at various occasions. I would like to acknowledge the Ministry of Higher Education (MOHE), Universiti Teknikal Malaysia Melaka (UTeM), Faculty of Electronic and Computer Engineering (FKEKK) for scholarships and the research grants.

Special thanks to my beloved mother, Rohani Harun, my beloved father, Sazali Kamarudin, my sister, Nur Hidayah Sazali for their unconditional love, continuous moral supports, encouragement and prayers during completing this project. Last but least, thank you to everyone who had been directly and indirectly involved in the crucial parts of realization of this project. Thank you very much!

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LIST OF ABBREVIATIONS

ADS	-	Advanced Design System
EBG	-	Electromagnetic Band-Gap
IEEE	-	Institute of Electrical and Electronic Engineers
ITU	-	International Telecommunication Union
LTCC	-	Low Temperature Co-fired Ceramic
LTE	-	Long Term Evolution
RF	-	Radio frequency
WiFi	-	Wireless Fidelity
WiMAX	-	Worldwide Interoperability for Microwave Access
WLAN	-	Wireless Local Network Area Networking

LIST OF SYMBOLS

W	-	Width
L, l	-	Length
S	-	Separation
G	-	Gap
V	-	Voltage
I	-	Current
D	-	Diameter
ε_R	-	Dielectric constant
h	-	Thickness
λ	-	Quater wavelength
β	-	Propagation constant
Z	-	Characteristic Impedance
J	-	imaginary part
Ω	-	Angular frequency
Δ	-	Delta or Initialism
Γ	-	Reflection coefficient
T	-	Transmisssion coefficient

LIST OF PUBLICATIONS

1. Sazali, M.A., Shairi, N.A. and Zakaria, Z., 2017. Microstrip Triplexer Design: A Review. *Journal of Telecommunication, Electronic and Computer Engineering (JTEC)*, 9(2-13), pp.81-86.
2. Sazali, M.A., Shairi, N.A. and Zakaria, Z., 2018. Hybrid Microstrip Diplexer Design for Multi-band WiMAX Application in 2.3 and 3.5 GHz Bands. *International Journal of Electrical and Computer Engineering (IJECE)*, 8(1).
3. N. A. Shairi, M. A. Sazali, Z. Zakaria, I. M. Ibrahim, M. K. Zahari, B. H. Ahmad, "Hybird Triplexer Design using Microstrip Coupled Line Resonators for Multiband WiMAX Front End," *7TH IEEE International Symposium on Microwave, Antenna, Propagation, and EMC Technologies (MAPE), 2017.*