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LOSSY RESONATOR WITH HIGH Q FOR SWITCHABLE ABSORPTIVE BANDSTOP TO BANDPASS FILTER

Mohd Khairy bin Zahari

Doctor of Philosophy

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LOSSY RESONATOR WITH HIGH Q FOR SWITCHABLE ABSORPTIVE BANDSTOP TO BANDPASS FILTER

MOHD KHAIRY BIN ZAHARI

A thesis submitted
in fulfillment of the requirements for the degree of Doctor of Philosophy

Faculty of Electronic and Computer Engineering

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

2018

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DECLARATION

I declare that this thesis entitled “Lossy Resonator with High Q for Switchable Absorptive Bandstop to Bandpass Filter” 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 the candidature of any other degree.

Signature :……………………………………
Name :Mohd Khairy bin Zahari
Date :……………………………………

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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 Doctor of Philosophy

Signature :………………………

Supervisor Name :Prof. Dr. Badrul Hisham bin Ahmad

Date :……………………...

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DEDICATION

To my beloved mother and father

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ABSTRACT

New developments in the design of the switchable microwave filters in some cognitive radio system are essential to meet the ever increasing demands to discriminate between wanted and unwanted signals. There also has a demand for miniaturization of microwave communications systems. A compact design can be achieved through the implementation of planar microstrip technology. However, conventional electronically tunable bandstop filters suffer performance degradation due to the finite unloaded Q of the resonators and also the loss associated with the switching elements. Therefore, two low Q lossy resonator filter topology has been implemented where the topology can be used to partially compensate for the loss where a high Q absorptive bandstop filter can be achieved. The filter consists of $\lambda/2$ resonator with K-inverter, parallel with an Allpass nominally-90°-phase-shift element. A frequency agile bandstop filter based on this topology has been developed, but such filters as well as conventional switchable bandstop filters encounter performance degradation in terms of tuning bandwidth and stopband bandwidth due to the frequency dependant losses and couplings. Through this thesis a new switchable microwave filter is investigated and developed, where this filter is able to switch from high Q absorptive bandstop response (ON state) to bandpass response (OFF state). This switchable filter is designed using four different types of resonator which are parallel coupled, dual mode ring, stepped impedance dual mode and T-shape. The parallel coupled resonator consisted of two low-Q lossy resonator connected with 90° wavelength and with correct k-inverter to produce high Q absorptive bandstop response. T-shape resonator consisted of T resonator coupled with 90° wavelength. While for the dual mode ring resonator structure is composed by two degenerate modes or splitting resonant frequencies, where the ring can be excited by perturbing stub. For stepped impedance resonator, the structure is consisted of the stepped impedance resonator with mid-plane of via hole and connected with 90° wavelength to achieve the high Q absorptive bandstop response. The filters are integrated with switching element, such as PIN and a varactor diode to switch the filter response and biasing circuit is needed to make the PIN or the varactor diode working properly. The absorptive bandstop filter operates at 2.4 GHz where S_{11} is below than 15 dB and S_{21} has high selectivity with the narrow bandstop response with high Q factor. The unloaded Q factor of the absorptive bandstop filter is more than 60 for measuring and 150 for simulation. For a bandpass response, the response depends on the filter structure. Where, each resonator produced different character of a bandpass filter. The dual mode bandpass response for stepped impedance, was achieved by switched 'OFF' the PIN diodes, where the insertion loss, S_{21} 4.9 dB, return loss, S_{11} is below 15 dB, and passband bandwidth is 200 MHz at centre frequency of 2.35 GHz. A good agreement is observed between simulated and measured results. The benefits of this filter is not only can produce a bandpass response, but also high quality factor in bandstop response which offer a better performance and high selectivity. The outcomes of the proposed switchable filters may facilitate improvements and the solution in cognitive radio.

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ABSTRAK

Perkembangan baru dalam reka bentuk penapis gelombang mikro boleh ubah dalam sistem radio kognitif adalah penting untuk memenuhi permintaan yang semakin meningkat digunakan untuk mengasingkan antara isyarat yang diingini dan yang tidak diingini. Permintaan yang tinggi untuk saiz yang kecil. Walau bagaimanapun, penapis jalur batas elektronik boleh-laras konvensional mengalami kemerosotan prestasi Q kerana tanpa beban terhingga daripada peresonan dan juga kehilangan yang berkaitan dengan unsur-unsur pensuisan. Oleh itu, dengan menggunakan topologi dua kehilangan rendah Q peresonan digunakan untuk mengimbangi sebahagian kehilangan untuk menghasilkan penapis jalur batas yang mempunyai faktor Q yang tinggi. Rangkaian kehilangan semua lepas menunjukkan konsep dan reka bentuk tindak balas jalur batas padanan sempurna pada semua frekuensi. Penapis ini berdasarkan kepada λ/2 peresonan dengan gandingan jurang, selari dengan semua lepas ukuran-90° elemen peralihan fasa, yang boleh dioptimumkan untuk mencapai faktor-Q yang tinggi. Frekuensi tangkas penapis semua lepas berdasarkan topologi ini telah dibangunkan, tetapi penapis yang sama digunakan pada penapis semua lepas suis konvensional menghadapi kemerosotan prestasi dari segi penalaan lebar jalur dan batas jalur keluasan-jalur disebabkan oleh kekerapan kebergantungan-kehilangan dan gandingan. Didalam thesis ini, penapis gelombang mikro boleh ubah dikaji dan dibangunkan, di mana penapis ini dapat menukar dari penapis penyerap jalur batas kepada lulus jalur. Penapis boleh ubah ini direka menggunakan empat jenis peresonan, yang pertama ialah gandingan selari, dwi mod cincin, impedans langkah dwi mod dan bentuk T. Peresonan gandingan selari terdiri daripada dua peresonan kehilangan Q rendah yang disambungkan dengan 90° panjang gelombang dan faktor k-penyongsang yang betul untuk menghasilkan faktor Q tinggi jalur batas. Peresonan cincin dwi mod terdiri daripada dua mod merosot atau frekuensi salunan membelah. Peresonan impedans langkah terdiri dari impedans langkah pertengahan satah melalui lubang dan disambungkan kepada 90° panjang gelombang untuk mencapai sambutan menyerap. Penapis yang diintegrasikan dengan PIN dan varactor diod yang sesuai akan digunakan. Penapis gelombang mikro jalur batas menyerap beroperasi pada 2.4 GHz mana S_{11} *adalah di bawah 15 dB dan* S_{21} *mempunyai pemilihan tinggi dengan tindakbalas jalur batas sempit dengan faktor Q yang tinggi. Faktor Q untuk batas jalur serapan pada ukuran ialah diatas 60 manakala simulasi ialah atas 150. Untuk respon lulus jalur, ia bergantung kepada struktur penapis gelombang mikro itu sendiri. Dua mod lulus jalur untuk impedans langkah dihasilkan apabila PIN diod dimatikan. Dimana* S_{11} *dibawah 15 dB dan* S_{21} *4.9 dB dengan jalur lulus lebar jalur ialah 200 MHz pada frekuensi 2.35 GHz. Persetujuan yang baik dipatuhi antara keputusan simulasi dan diukur. Manfaat penapis ini bukan sahaja dapat menghasilkan respon lulus jalur, tetapi juga faktor Q tinggi dalam respon jalur batas yang menawarkan prestasi yang lebih baik dan pemilihan tinggi. Hasil daripada penapis yang boleh ditukar boleh dicadangkan bagi memudahkan penambahbaikan dan penyelesaian dalam radio kognitif.*

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LIST OF ABBREVIATIONS

RF	-	Radio Frequency
UAV	-	Unmanned Aerial Vehicle
CR	-	Cognitive Radio
TL	-	Transmission Line
YIG	-	Yttrium Ioran Garnet
DBS	-	Direct broadcast satellite
PCS	-	personal communication systems
SC	-	Switched Capacitor
LTD	-	Charge Transfer Device
PDA	-	Personal Digital Assistant
QoS	-	Quality of Service
dB	-	Decibel
VSWR	-	Voltage Standing Wave Ratio

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