Faculty of Electronic and Computer Engineering

DESIGN OF ABSORPTIVE FILTER INTEGRATED SWITCH USING LOSSY RESONATORS AT 2.4 GHz ISM BAND

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DECLARATION

I declare that this thesis entitled “Design of Absorptive Filter Integrated Switch using Lossy Resonators at 2.4 GHz ISM Band” 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 : Abdullah Mohammed Saghir Zobilah

Date : 29 November 2021

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 : Dr. Noor Azwan Bin Shairi

Date : 29 November 2021 ……..

DEDICATION

To my beloved mother and father

ABSTRACT

Radio frequency (RF) and microwave switches are important components in RF front end, as they control the signal circulation path. Up to now, many different types of RF and microwave switches have been designed. They usually have a very wide passband with no specific band selectivity. With the increasingly complex spectrum environment and the increased communication modes, the traditional design method has the drawback of large circuit size, high impedance matching loss, and high fabrication cost. Researchers have recently become interested in a microwave switch with integrated filtering response, which has the potential to solve these issues. Thus, several research works have been done to develop a filter integrated switch (FIS). Based on the literature, most of the previous studies introduced reflective FISs having a problem of extremely low reflection coefficient at the ports that are not switched to the antenna or called OFF-state ports. In this research work, a reconfigurable resonator-based absorptive filter integrated switch (FIS) was presented for the industrial, scientific, and medical (ISM) band. Three types of reconfigurable resonators were utilized (L-shape, ring, and T-shape resonator). The FIS was made up of two absorptive resonators, reconfiguring between band-stop and band-pass responses, and integrated with a single pole double throw (SPDT) switch. In particular, the FIS circuit was designed for the purpose of switching between the transmitter (Tx) mode and the receiver (Rx) mode, as well as to filter both the transmitted and received signals. A simple mathematical analysis of isolation and insertion loss of filter integrated SPDT switch was discussed. PIN diodes were used as the switching elements for the SPDT switch and to reconfigure between the band-stop and band-pass responses. The band-stop response was the ultimate reason for the isolation between the transmitter (Tx) and receiver (Rx). While the bandpass response was the ultimate reason for selecting the wanted signal. The proposed absorptive FIS design could be used for ISM band applications at an operation frequency of 2.45 GHz. As a result, the proposed FIS design exhibited 2 dB of insertion loss and better than 38 dB of isolation. The measurement results showed a good agreement with the simulation results. Therefore, the key advantages of the proposed FIS design include low insertion loss, high isolation and good reflection coefficient at both ON- and OFF-state ports. In addition, the proposed FIS has an absorptive feature with a smaller number of PIN diodes while maintaining a compact size.

REKA BENTUK SUIS BERSEPADU PENAPIS PENYERAP MENGGUNAKAN PENYALUN HILANG PADA JALUR ISM 2.4 GHz

ABSTRAK

Suis frekuensi radio (RF) dan gelombang mikro adalah komponen penting di bahagian depan RF untuk mengawal peredaran isyarat. Sehingga kini, banyak jenis suis RF dan gelombang mikro telah direka bentuk. Suis-suis ini biasanya mempunyai ciri jalur-lepas yang sangat luas tetapi tiada pemilihan jalur tertentu. Melihat kepada persekitaran frequensi spektrum yang semakin kompleks dan mod komunikasi yang semakin meningkat, kaedah reka bentuk tradisional mempunyai kekurangan dari segi saiz litar yang besar, kehilangan padanan yang tinggi, dan peningkatan kos pembuatan. Para penyelidik baru-baru ini telah berfokus kepada suis gelombang mikro dengan penapis bersepadu, yang berpotensi untuk menyelesaikan masalah-masalah ini. Oleh itu, beberapa kerja penyelidikan telah dilakukan untuk suis bersepadu penapis (FIS). Berdasarkan literatur, kebanyakan penyelidikan terdahulu telah memperkenalkan FIS reflektif yang mempunyai masalah pekali pantulan yang sangat rendah di liang yang tidak beralih ke antena atau dipanggil liang berkeadaan tertutup. Suis bersepadu penapis berpenyerap yang berasaskan resonator yang dapat dikonfigurasi dilaporkan dalam tesis penyelidikan ini untuk jalur industri, saintifik, dan perubatan (ISM). Tiga jenis resonator yang dapat dikonfigurasi telah dipilih iaitu bentuk L, cincin, dan bentuk T. FIS ini terdiri daripada dua resonator berpenyerap, konfigurasi antara sambutan jalur-henti dan jalur-lepas, dan disatukan dengan suis satu kutub dua lontar (SPDT). Secara khusus, litar FIS ini dirancang untuk tujuan pensuisan antara mod pemancar (Tx) dan mod penerima (Rx), serta untuk menyaring isyarat yang dihantar dan yang diterima. Satu analisis mudah matematik untuk pemencilan dan kehilangan sisipan SPDT bersepadu penapis telah dibincangkan. Diod-diod PIN digunakan sebagai elemen peralihan untuk SPDT dan untuk mengkonfigurasi antara sambutan jalur-henti dan jalur-lepas. Sambutan jalur-henti adalah ciri utama prestasi pemencilan antara pemancar (Tx) dan penerima (Rx). Manakala, sambutan jalur-lepas adalah sebab utama untuk memilih isyarat yang dikehendaki dan menghalang isyarat gangguan. Reka bentuk FIS berpenyerap yang dicadangkan ini dapat digunakan untuk aplikasi jalur ISM pada frekuensi 2.45 GHz. Hasilnya, FIS yang dicadangkan menghasilkan kehilangan sisipan sebanyak 2 dB dan pemencilan yang melebihi 38 dB. Hasil pengukuran menunjukkan persamaan yang hampir dengan hasil simulasi. Oleh itu, kelebihan utama reka bentuk FIS yang dicadangkan ini adalah kehilangan penyisipan yang rendah, pemencilan tinggi dan pekali pantulan yang baik di kedua-dua liang berkeadaan terbuka dan tertutup. Selain itu, FIS berpenyerap ini mempunyai bilangan diod PIN yang sedikit disamping mengekalkan saiz litar yang padat.

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