UNIVERSITI TEKNIKAL MALAYSIA MELAKA

ULTRA-WIDEBAND BANDPASS FILTER USING U-SLOTTED SUBSTRATE INTEGRATED WAVEGUIDE (SIW) CAVITIES AT 12 GHZ FOR X-KU BAND RADAR APPLICATION

This report is submitted in accordance with the requirement of the Universiti Teknikal Malaysia Melaka (UTeM) for the Bachelor of Electronics Engineering Technology (Telecommunications) with Honours.

by

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ABSTRAK

Ultra-wideband (UWB) substrat pandu gelombang bersepadu penapis lulus jalur yang disyorkan dan direka bentuk menggunakan bentuk slot U substrat pandu gelombang bersepadu dan tambahan lubang untuk aplikasi band X-Ku. Untuk mencapai Ultra-wideband (UWB), slot berbentuk U pada lapisan tembaga di bahagian atas digunakan untuk membentuk menambah bilangan mod baru bagi resonator sambil mengekalkan saiz penapis menjadi kecil. Untuk kesan suapan *h* dan *w*, jika nilai *h* meningkat, peralihan tindak balas frekuensi akan ke kanan. Namun bagi *w*, jika nilai *w* meningkat, jalur lebar masih sama tetapi nilai kekerapan resonan dan kehilangan kembali akan berbeza. Untuk panjang diantara slot bentuk U (*g*), jika nilai g berkurangan, jalur lebar akan berkurangan dan frekuensi "cut-off" beralih kepada nilai frekuensi kecil. Selain itu, sebagai panjang slot bentuk U (*k*) meningkat, peralihan tindak balas frekuensi akan ke kiri dan jalur lebar menjadi lebih kecil. Selain itu, tambahan melalui lubang digunakan untuk mengalihkan frekuensi kepada frekuensi yang lebih tinggi. Dalam reka bentuk penapiis yang dicadangkan ini, substrat yang digunakan adalah Rogers 4350 dengan pemalar dielektrik 3.66 dan ketebalan 0.508mm. Hasil simulasi menunjukkan bahawa penapis mencapai kehilangan sisipan lebih besar daripada -0.405dB, kehilangan kerugian lebih kecil daripada -10.5dB, dan lebar jalur fraktional -3dB sebanyak 60.8%.

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ABSTRACT

An Ultra-wideband (UWB) Substrate Integrated Waveguide (SIW) bandpass filter is proposed and designed using U shape slot Substrate Integrated Waveguide (SIW) cavities and additional via hole for X-Ku band radar application. In order to achieved an Ultra-wideband (UWB), the U shape slots at the top copper layer are used to form a new multiple-mode resonator (MMR) while keeping the size of the filter to be small. For the effect of feed line *h* and *w*, as the value of *h* increase, the frequency response shift to the right. While for *w*, as the value of *w* increase, the bandwidth is still the same but the value of the resonance frequency and the return loss will be different. For the length between U shape slots (*g*), as the value of g decreases, the bandwidth will be decrease and the upper-cut-off frequency shift to small frequency value. Besides, as the length of U shape slots (*k*) increase, the frequency response shift to the left and the bandwidth became smaller. Other than that, the additional via hole is used to shift the center frequency to a higher frequency. In this proposed filter design, the substrate used is Rogers 4350 with a dielectric constant of 3.66 and thickness of 0.508mm. The simulation results show that the filter achieved insertion loss bigger than -0.405dB, return loss smaller than -10.5dB, and 3dB fractional bandwidth of 60.8%.

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DEDICATION

Dedication for my beloved parents, Mr Edward bin Basir and Mrs Nina Triana binti Asril and also my siblings, and my supportive supervisor, Mr Adib bin Othman and my lovely friends and someone that always help me during my degree.

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LIST OF SYMBOLS

G	-	Giga
Hz	-	Hertz
Mm	-	Milimeter
w	-	Width
d	-	Diameter of Metalized Via Hole
$\mathbf{w_{eff}}$	-	Width of Rectangular Waveguide
R	-	Resistor
C	-	Capacitor
L	-	Inductor
h	-	Height
mmW	-	Milimeter-wave
dB	-	Decibel
5G	-	5 Generation
3D	-	3 Dimension
S(2,1)	-	Insertion loss
S(1,1)	-	Return loss
Q	-	Quality factor
K	-	Coupling constant

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LIST OF ABBREVIATIONS

SIW	Substrate Integrated Waveguide
PCB	Printed Circuit Board
EM	Electromagnetic
DGS	Defected Ground Structure
SRR	Split Ring Resonator
ADS	Advance Design System
RF	Radio Frequency
BPF	Bandpass Filter
HMBPF	Half Mode Bandpass Filter
TZs	Transmission zeros
TEBG	Tapered Electromagnetic Bandgap
IoT	Internet of Thinking
UWB	Ultra wideband
FBW	Fractional bandwidth
MMR	Multimode resonator
HFSS	High frequency structure simulator
VSWR	Voltage standing wave ratio

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CHAPTER 1

INTRODUCTION

1.1 Project Background

First proposed in the late 1990s as a post-wall waveguide (J. Hirokawa and M. Ando 1998) or laminated waveguide (U. Hiroshi et al, 1998) for feeding networks in antenna arrays, Substrate Integrated Waveguide (SIW) technology was applied to multiple microwave and millimeter wave components, including post filters (D. Deslandes and K. Wu 2003), cavity filters (H. J. Tang et al, 2005), directional couplers (J.-X. Chen et al, 2006), oscillators (Y. Cassivi and K.Wu 2003), slot panel antennas (L. Yan et al, 2004), six-port circuits (X. Xu, 2005), and circulators (W. D'Orazio and K. Wu 2006). To transmit electromagnetic waves, Substrate Integrated Waveguides (SIW) is used. SIW are planar structures that belong to the Integrated Circuits Substrate family. They can be fabricated on planar circuits such as Printed Circuit Boards (PCB) due to their planar nature and can be integrated with other planar transmission lines such as microstrip. They retain the low loss properties of their conventional metallic waveguides and are widely used as interconnections in high-speed circuits, filters, directional couplers, antennas. The SIW consists of two linear metallic connected with a height of h via dielectric substrate. Through arrays, these metallic contain the electromagnetic fields within the SIW (A. Nasri *et al,* 2014). This emerging guided-wave structure can be made by means of a pair of periodic metalized arrays or slot trenches and looks like two parallel fences with a specific spacing in which EM waves are well confined, as shown in Figure 2.1.1 (Xiao-Ping Chen and Ke Wu 2014). As a filter application, the SIW method can also be integrated and arranged to improve filter performance with other methods such as DGS and SRR. In (Shen et al, 2011).

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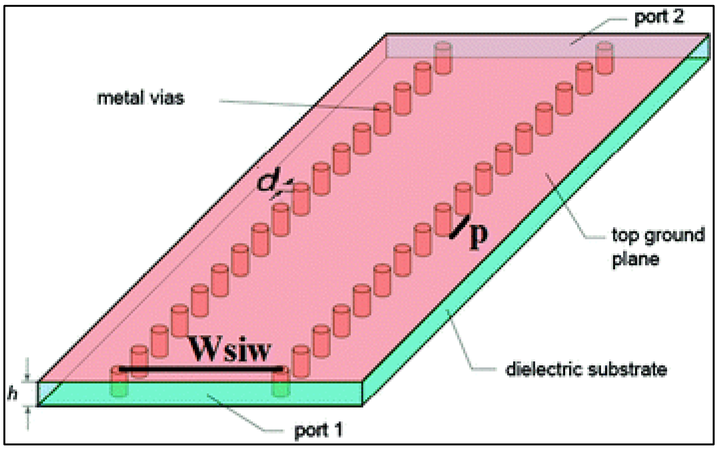

Figure 1.1: Basic SIW filter design

1.2 Problem Statement

Telecommunications is a significant thing in our regular lives in this fresh age of globalization. Telecommunication is the transmission of signs, signals, messages, words, writings, images and sounds or information of any kind by wire radio, optical or other electromagnetic systems. The signal loss always happens when the signal and frequency method is transmitted. The technology is now advancing in telecommunications for radio frequency techniques to reduce signal loss. The microstrip is a element for transmitting the signal that builds in with antenna. Microstrip is a sort of electrical transmission line that can be produced using technology of printed circuit board and used to transmit microwave frequency signals (C. Baranwal, 2017). It consists of a conducting strip separated by a dielectric layer called the substratum from a ground plane. The microstrip was discovered to have reduced energy processing and greater radiation loss. But there is another component that transmits frequency signals much faster and better than microstrip. It is Substrate Integrated Waveguide (SIW). SIW technology is an emerging approach to microwave and millimeter wave components and wireless systems being implemented and integrated. This component is much better from microstrip with greater energy processing capacities and reduced radiation losses (M. Bozzi, 2012). Other than that, by using SIW, the size of the substrate will be small and compact. SIW technique is thus used in this project to develop the bandpass filter that will operate at 12GHz. The range for the X band is 8 until 12 GHz while Ku band is 12GHz until 18GH, 12 GHz lies between X band and Ku band.

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