MICROWAVE PLANAR BANDPASS FILTER WITH IMPROVED UPPER STOPBAND

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To my beloved late Mak and Ayah, my family and my wife - idayati
for your love and support

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ABSTRACT

Ultra wide-band (UWB) is gained by achieving microwaves bandwidth with equal or more than 500 MHz values. Recent studies focus more on the application of this UWB to fulfill user demand especially in telecommunications nowadays who's concerned about size of tools and the amount of energy usage. These aspects must put into consideration when purchasing tools for various activities in the field. The use of this ultra-high bandwidth could easily expose to harmonic existence at high frequency which could lead to degradation of systems performance. Thus this project would emphasis on the effort of designing and improving existing microwave bandpass filter based on previous works that could overcome the issue in its first harmonic. Technique chooses include a various flaws form at the back of microstrip planar. All filters have been simulated and the results have been reviewed. In conclusion, frequency at the first harmonic can be reduced in order to improve interference dismissal at high frequency.

ABSTRAK

Lebar jalur ultra (UWB) kian terkenal disebabkan kejayaan memperoleh sekurang-kurangnya 500 MHz lebarjalur. Penyelidikan hari ini banyak tertumpu kepada aplikasi UWB ini kerana ia memenuhi kehendak pengguna terutamanya dalam bidang telekomunikasi yang mementingkan saiz perkakasan dan jumlah penggunaan tenaga. Aspek ini perlu diberi pertimbangan wajar apabila merancang pembelian peralatan untuk pelbagai kegunaan terutamanya aktiviti di lapangan. Penggunaan aplikasi UWB mudah terdedah kepada kewujudan harmonik frekuensi tinggi yang akan menyebabkan kemerosotan prestasi sesebuah perkakasan. Oleh itu, projek ini memberikan tumpuan kepada usaha merekabentuk dan menambahbaik penapis mikrojalur yang sedia ada berdasarkan kerja terdahulu yang berupaya mengatasi masalah tersebut terutama pada harmonik pertama. Teknik yang dipilih melibatkan pelbagai bentuk kecacatan pada bahagian belakang penapis satah mikrojalur. Kesemua penapis telah berjaya direkabentuk, disimulasi dan dianalisis. Kesimpulannya, harmonik tak dikehendaki pertama dapat dihapuskan untuk penambahbaikkan kepada penyingkiran hingar pada frekuensi tinggi.

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LIST OF ABBREVIATIONS

BW	-	Bandwidth
RL	-	Return Loss
IL	-	Insertion Loss
SWR	-	Standing Wave Ratio
VSWR	-	Voltage Standing Wave Ratio
VSWR1	-	Voltage Standing Wave Ratio in Port 1
UWB	-	Ultra Wide Band
CPW	-	Couple Planar Waveguide
BPF	-	Band Pass Filter
LPF	-	Low Pass Filter
HPF	-	High Pass Filter
DFG	-	Defected Ground Structure
ND	-	No Defected Ground Structure
RD	-	Rectangular Defected Ground Structure
SD	-	Square Defected Ground Structure
DD	-	Dumbbell Defected Ground Structure
OCLD	-	Open Close Loop Defected Ground Structure
N-OCLD	-	Open Close Loop No Defected Ground Structure
R-OLCD	-	Open Close Loop Rectangular Defected Ground Structure
S-OCLD	-	Open Close Loop Square Defected Ground Structure

D-OCLD	-	Open Close Loop Dumbbell Defected Ground Structure
PCB	-	Printed Circuit Board
MPC	-	Microstrip Planar Circuit
CDSIR	-	Coupled Double Step Impedance Resonator
OLDGS	-	Open Loop Defected Structure
SISLR	-	Stepped Impedance Stub Load Resonator
FCC	-	Federal Communication Commission
MMR	-	Multi Modes Resonator
PI-SIRs	-	Pseudo-Interdigital Stepped Impedance Resonator
CDGS	-	Conventional Defected Structure
CSIR	-	Conventional Stepped Impedance Resonator
IMPED	-	Impedance
Max	-	Maximum
Min	-	Minimum

LIST OF SYMBOLS

Γ - Reflection Coefficient

S_{11} - S-Parameter at Port 1

S_{21} - S-Parameter at Port 2 to 1

C_{11} - Effective Capacitance at Port 1

C_{22} - Effective Capacitance at Port 2

f_L - Lower Cut-Off Frequency

f_H - High Cut-Off Frequency

f_o - Resonant Frequency

P_L - Power Load

P_{in} - Power Input

V_{max} - Voltage Maximum

V_{min} - Voltage Minimum

Z_0 - Characteristic Impedance

Z_{0o} - Odd-mode Characteristic Impedance

Z_{0e} - Even-mode Characteristic Impedance

$Y_{in,ood}$ - Odd-mode Characteristic admittance

$Y_{in,even}$ - Even-mode Characteristic admittance

c_o - Odd-mode Resulting Capacitance

c_e - Even-mode Resulting Capacitance

λ_{gm} - Guided wavelength

eff_e - Even-mode Dielectric Constant

eff_o - Odd-mode Dielectric Constant

ε_e - Effective Dielectric Constant

ε_r - Dielectric Constant

Ω - Ohm

Δ - Fractional

ns - Nanosecond

dB - Decibel

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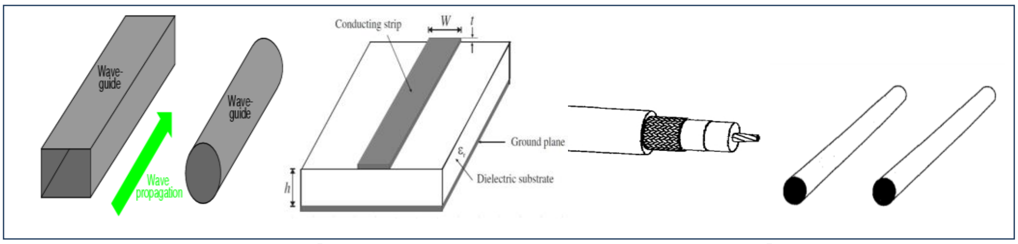
CHAPTER 1

INTRODUCTION

1.1 Project Background

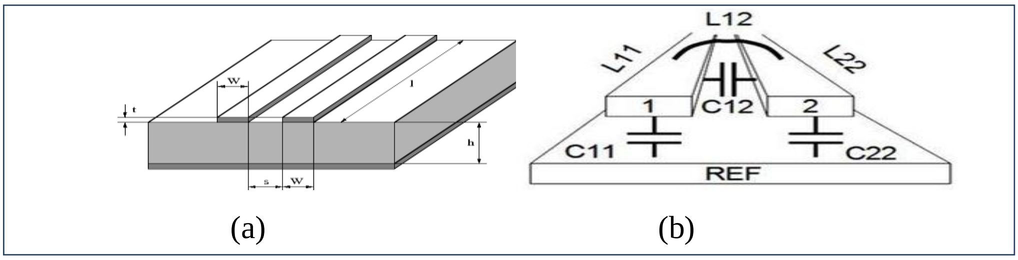
Basically, the delivery of power in an electronic system needs a connection of two wires between the source and the load. At low frequencies, power is considered being delivered to the load through wire. However, power is in electric and magnetic fields at high frequencies which is electromagnetic wave guided from place to place by a physical structure known as Transmission Line. There are several types of transmission lines available such as Two-Wire Lines, Coaxial Line, Waveguide (Rectangular, Circular) and Planar Transmission Lines as shown in Figure 1.1. The most popular is microstrip as found in the planar transmission because it is easy to design and fabricate [1].



(a) (b) (c) (d)

Figure 1.1: Types of transmission lines (a) Waveguide (b) Planar (microstrip) (c) Coaxial line (d) Two-wire lines [2]

A ‘coupled line’ configuration consists of two transmission lines placed parallel to each other and in close proximity as shown in Figure 1.2(a). The electrical characteristic can be completely determined from the effective capacitances between the lines and velocity of propagation on the line in the transverse electromagnetic (TEM) propagation [1]. The equivalent circuit element of Figure 1.2(b), C_{12} represents the capacitance between the two strip conductors, while C_{11} and C_{22} represent the capacitance between one strip conductor and ground. C_{11} and C_{22} are equal when the sizes of strip conductors are identical and location relative to the ground conductor [3].



(a) (b)

Figure 1.2: The diagram of coupled lines (a) Coupled microstrip or three-wire coupled (b) Equivalent circuit network [2]

In a coupled microstrip line, even and odd modes are two different modes of propagation excited due to coupling of electromagnetic field as shown in Figure 1.3(a) and (b). The currents in the strip conductors are equal in amplitude for both modes. Even and odd modes are differentiated by direction only where same direction in even and opposite direction in odd [1].

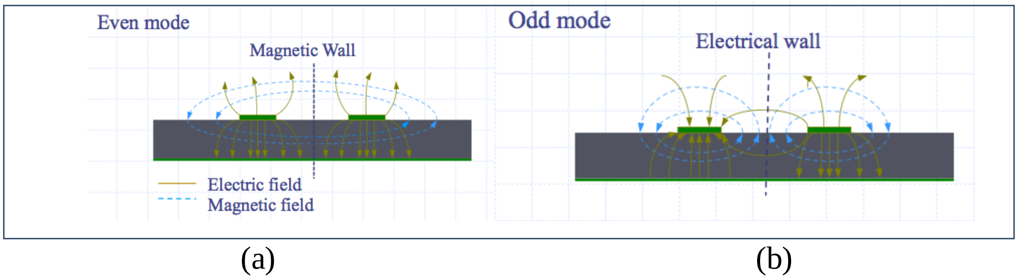


Figure 1.3: The modes of propagation (a) Even mode (b) Odd mode [4]

A bandpass filter is a combination of high and low pass filters with specific frequency range to pass, but not permitted to pass the lower and higher frequencies. The frequencies are attenuated at the edge of outside the passband region due to two cut-off frequencies f_L and f_H.

High Pass RL filter with a roll-off frequency f_L and a Low Pass RC filter with a roll-off frequency f_H is cascaded to realize a bandpass frequency response, with that f_L less than f_H.

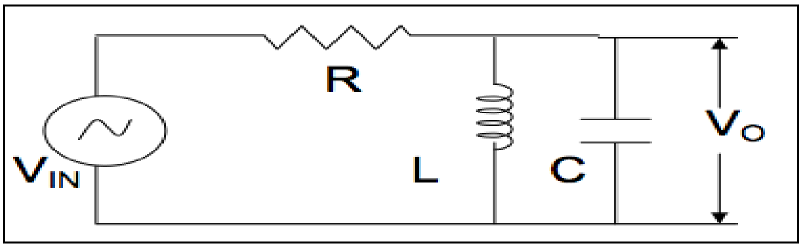


Figure 1.4: Circuit Diagram for a Bandpass Filter [2].

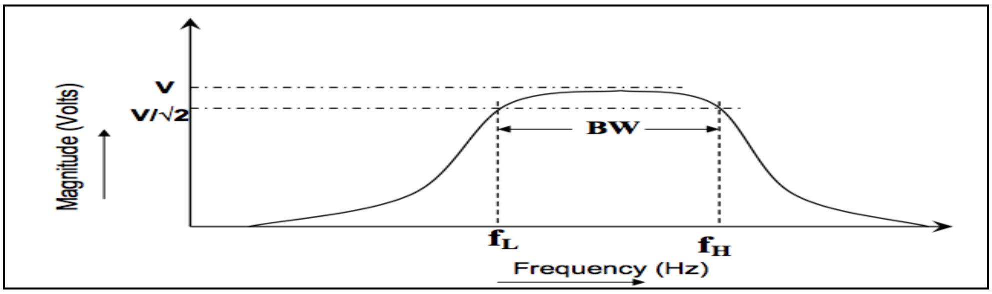


Figure 1.5: Frequency response of a Bandpass filter [2].

Ultra wide-band (UWB) is gained by achieving microwave bandwidth with equal or more than 500 MHz values. Federal Communication Commission (FCC) has allocated for unlicensed ultra wideband devices with frequency band 3.1-10.6 GHz about 7500 MHz of spectrum frequency. The UWB technology has huge opportunity in the design of modern application such as vehicular radar, through-wall imaging, medical imaging, indoor and hand-held systems [5].

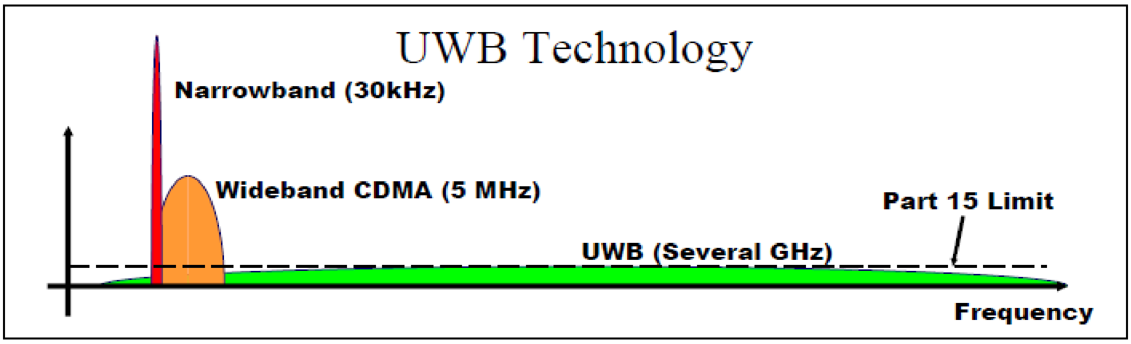


Figure 1.6: The diagram of UWB Technology [3]

Recently, different methods and structures have been used to develop new Ultra Wide-band Bandpass filter (UWB-BPF) such as multi-mode resonator (MMR), pseudo-interdigital stepped impedance resonators (PI-SIRs), combining low pass and high pass filter etc [6],[7]. However, filter design for UWB applications face many challenges. One general problem is to avoid electromagnetic interference with many other existing narrowband communication systems.

Therefore, one method to eliminate the interferences is by having defected ground structures, DFGs, which disturb the shield current distribution in the ground plane. The defect in the ground of the microstrip can give rise to increasing effective capacitance and inductance that results with higher impedance, band rejections and slow wave characteristics [8].

1.2 Problem Statement

In many applications, the presence of harmonics will degrade the overall system performance. Hence the harmonics need to be adequately suppressed. Traditionally, harmonics are filtered using separate filter circuit, hence this undesirably increase the bulkiness of the whole system circuitry. Thus, a selected microwave planar filter designed can be further modified in order to improve the upper stopband performance.

1.3 Objectives

The objective of this project is to design a microwave planar bandpass filter with emphasis on upper stopband performance and to employ modification into the bandpass filter structure for better stopband.

1.4 Scope of Project

The project is a continuation of a previous work [8]. It is further improved with different DFG structures. The designed filters are then simulated and investigated in terms of its return loss and insertion loss responses. The configuration of the ground layer is modified by integrating defected structure to improve the upper stopband region. Circuit simulations are carried out using CST Microwave Studio®. The performances of all the results are analysed to monitor the harmonic suppression in the upper region.

1.5 Thesis Layout

The content of the thesis is organized into five (5) chapters. The introduction and overview of the project are described in the first chapter. The second chapter presents relevant brief theory and literature reviews related to the behaviour of UWB Bandpass filter and DFG structure. The design methodology is presented in chapter three. Simulation results obtained are analysed and discussed. The final chapter concludes the thesis and identify some areas for recommendation and future work.

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