DESIGN AND COMPARISON BETWEEN RING AND L-SHAPE RESONATORS OF MATCHED BANDSTOP FILTER

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This report is submitted in partial fulfilment of the requirements for the degree of Bachelor of Electronic Engineering with Honours

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DECLARATION

I declare that this report entitled "Design and comparison between ring and L-shape resonators of Matched Band-Stop Filter" is the result of my own work except for quotes as cited in the references.

Signature : ....

Author : NURUL NAZLINDA BINTI EFFENDEE

Date : 11 January 2022

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 Bachelor of Electronic Engineering with Honours.

Signature :

Supervisor Name : PROF.IR.DR BADRUL HISHAM BIN AHMAD

Date : 11 January 2022

DEDICATION

To begin, I would want to offer my thankfulness to Allah S.W.T for His guidance and blessing. I would like to dedicate this thesis to my family, particularly to my father and mother, for their unending support, encouragement, and pleading. Additionally, I would like to dedicate my study to Prof. Ir. Dr Badrul Hisham Bin Ahmad, my devoted project supervisor. He had provided me with a great deal of information and aid in completing this project. Also, I would like to express my gratitude to Dr. Mohd Khairy Bin Zahari for his advice and ideas during the design evaluation process. Finally, I would want to dedicate this thesis to all of the lecturers and friends who have assisted and supported me during this process.

ABSTRACT

A wireless communication system is one that transmits data between two points that are not electrically connected. While, a microwave filter is part of every RF communication system's front-end. Noise is big challenge when developing a wireless communication systems or any other microwave-based system. Filtering techniques are one method of preventing noise. At center frequencies of 90MHz, matched band-stop filter were designed in this research using Ring and L-shape resonators. When developing matched band-stop filter, it is challenging to attain a high Q-factor due to the lossy nature of the microstrip. The objectives of this project are to design, simulate, compare and analyze the matched band-stop filter's return loss, insertion loss, and efficiency by utilized Advanced Design System (ADS) software. As an outcome, the ring's return loss and insertion loss are -3.711dB and -9.363dB, respectively, whereas the L-shape return loss and insertion loss are -5.130dB and -12.301dB, showing that the L-shape resonator has a high Q-factor 0.034 than the ring resonator 0.026. So, L-shape resonator have narrower attenuation and are more efficient.

ABSTRAK

Sistem komunikasi tanpa wayar ialah sistem yang menghantar data antara dua titik yang tidak disambungkan secara elektrik. Manakala, penapis gelombang mikro adalah sebahagian daripada setiap bahagian hadapan sistem komunikasi RF. Bunyi bising merupakan cabaran besar apabila membangunkan sistem komunikasi wayarles atau sistem lain yang berasakan gelombang mikro. Teknik penapisan adalah salah satu kaedah mencegah bunyi bising. Pada frekuensi tengah 90MHz, penapis henti jalur dipadankan telah direka dalam penyelidikan ini menggunakan resonator bentuk cincin dan L. Apabila membangunkan penapis henti jalur yang dipadankan, adalah mencabar untuk mencapai faktor Q yang tinggi kerana sifat jalur mikro yang kehilangan. Objektif projek ini adalah untuk mereka bentuk, mensimulasikan, membandingkan dan menganalisis kehilangan pulangan, kehilangan sisipan dan kecekapan penapis henti jalur yang dipadankan dengan menggunakan Perisian Advanced Design System (ADS). Hasilnya, kehilangan pulangan dan kehilangan sisipan cincin dan L adalah masing-masing -3.711dB dan -9.363dB, manakala L ialah -5.130dB dan -12.301dB, menunjukkan bahawa resonator bentuk L mempunyai faktor Q tinggi 0.034 daripada resonator cincin 0.026. Jadi, resonator bentuk L mempunyai pengecilan yang lebih sempit dan lebih efisien.

ACKNOWLEDGEMENTS

To commence, I want to express my gratitude to the Almighty for the grace and direction He has bestowed upon me, as well as to everyone who has been involved in some way with my thesis journey. I would also like to use this occasion to express my gratitude to my beloved project supervisor, Prof. Ir. Dr. Badrul Hisham Bin Ahmad, who has guided, encouraged, assisted, and supported me during this project's completion. Everything he did, to assists me will be remembered for the reminder of my life. A special thanks to all of my lecturers and friends who have supported and mentored me through every stage of the project, from conception to conclusion. Finally, I would want to express my appreciation to my family, particularly both of my parents, who have always been willing and capable of assisting and supporting me to the best extent possible in order to accomplish this thesis.

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LIST OF SYMBOLS AND ABBREVIATIONS

ADS	:	Advanced Design System
BSF	:	Band Stop Filter
BPF	:	Band Pass Filter
BSF	:	Band Stop Filter
BW	:	Bandwidth
CSRR	:	Complimentary Split Ring Resonator
HPF	:	High Pass Filter
LPF	:	Low Pass Filter
MSUB	:	Microstrip Substrate
MCLIN	:	Microstrip Coupled Lines
MLIN	:	Microstrip Line
MSABND	:	Microstrip Bend
RF	:	Radio Frequency
$S_{1,1}$	:	Return Loss
$S_{2,1}$	:	Insertion Loss

CHAPTER 1

INTRODUCTION

1.1 RESEARCH BACKGROUND

Microwaves filters, as well as band-reject and band select components for transceivers and receivers, are essential components in every radio frequency (RF) front-end telecommunication structure, whereas a wireless communication system sends and receives data between two different locations that are not electrically coupled. Noise is one of the most major difficulties in designing a complicated wireless communication system, or any other system that uses microwave frequencies. One of the ways for preventing noise or any other form of the interference signal is to employ filtering techniques[1]. There are four types of filters: Low Pass, High Pass, Band Pass, and Band Stop Filters[2]. The band stop filter is an important part of microwave communication systems, and it is also found in both receivers and transmitters[3][4]. A band-stop filter, also known as a band-elimination filter, a band reject filter, or a notch filter, is a frequency filter that is meant to stop a certain band of frequencies above and below a specified range defined by the component values[2]. A band-stop is a circuit design method used to remove unwanted harmonics and other noise from active circuits such as oscillators and mixers[5]. In an ideal band-stop filter, frequencies between the lower cut-off frequencies, $f1$ and upper cut-off frequencies, $f2$ will be attenuated. Allowing frequencies that fall outside of $f1$ and $f2$ is known as the "pass-band zone". Then the bandwidth of the filter, BW is defined as: ($f2$ - $f1$). As a result, the actual stopband of a wide-band band-stop filter falls between its lower and upper -3dB values, attenuating or rejecting any frequency between these two cut-off frequencies. The basic frequency response of a band-stop filter is shown in Figure 1.1.

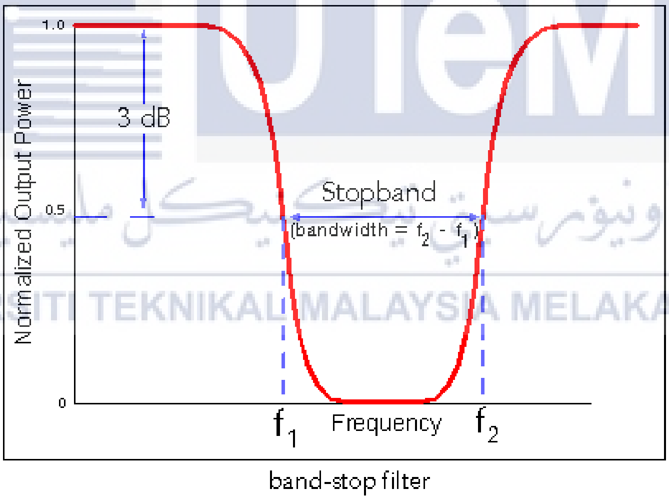

Figure 1.1 Band Stop Frequency Response

Notch filters are a high-Q, very selective variation of the band stop filter that may be used to reject a single or very tiny band of frequencies rather than a wide range of frequencies. In micro strip technology, a high notch depth and selectivity matched band-stop filter may be made with only two lossy low-Q resonators[6] as shown in Figure 1.2.

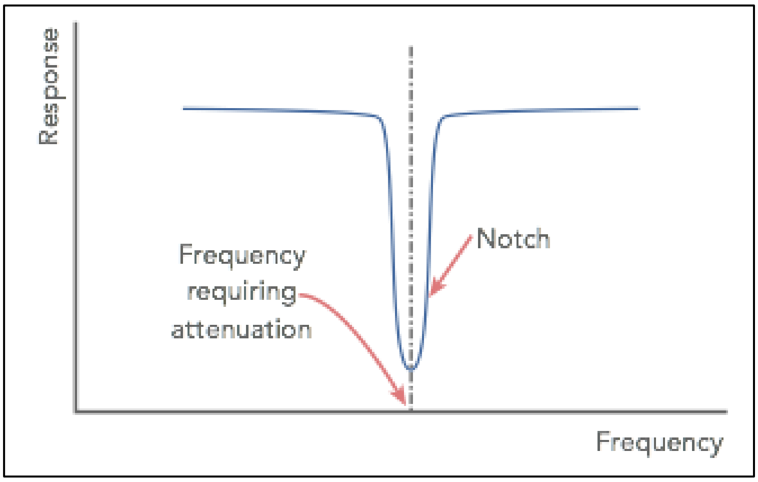

Figure 1.2 Notch Band-Stop Frequency Response

Advanced Design System (ADS) Software will be used to simulate the matching band-stop filter. The performance of S-parameter; Return Loss (S_{11}), Insertion Loss (S_{21}) and unloaded Q factor are computed using the design equations and the frequencies and materials selected.

1.2 PROBLEM STATEMENT

A technique for solving the major demand for ways to separate undesired signals in communication system is to create a matched band-stop filter. As a result, this project will propose the design of a 90MHz center frequency matched band-stop filter with a ring and L-shaped resonator. This is because a matched band-stop filter is an all-pass network, and an ideal lossless all-pass network must pass all frequencies with zero attenuation, hence it must provide a perfect match at all frequencies [6].

It is necessary to priorities the impacts of losses while designing a filter by employing proper design strategies. The researcher employs a variety of approaches, including split ring resonators, defective ground structures (DGS), defected microstrip structures (DMS), ring filters, impedance resonator structures, and photonic crystal filters [1]. Due to the intrinsic nonlinearity of active techniques, their use in filter design is limited.

The lossy nature of microstrip makes achieving a high Q-factor challenging. Therefore, to increase the Q factor of the band-stop limiter, the perfect-notched idea is used [7]. This makes use of two lossy resonator coupled to a 3-dB 90° hybrid coupler with correct coupling factors [7]. The application of low-Q lossy resonators not only results in increased stopband attenuation, but also ensures that the band-stop filter's input and output ports are matched and compact in size.

1.3 PROJECT OBJECTIVES

The objectives of the project are:

1) To design and simulate matched band-stop filter at center frequency 90MHz with ring and L-shape resonators by using ADS software.
2) To compare the design of a band-stop filter between the ring and L-shape resonators.
3) To analyze the Return Loss, ($S_{1,1}$) Insertion loss, ($S_{2,1}$) and, the efficiency of band-stop filter.

1.4 PROJECT SIGNIFICANT

A few expected outcome at the conclusion of this project include the design of matched band-stop filters in the ring and L-shape configurations, the comparison of matched band-stop filter designs in the ring and L-shape, and the analysis of the Return Loss ($S_{1,1}$), Insertion Loss ($S_{2,1}$), and the efficiency of the band-stop filter. At the conclusion of this project, it will be possible to develop a more effective wireless communication system (that is, one that is free of noise), as well as to isolate the signal of interest from the interference signal, as well as to reduce, remove, and filter out noise, harmonics, and spurious signals in a wireless communication system.

1.5 SCOPE OF WORK

The expected outcome at the conclusion of this research work is to develop the design of matched band-stop filters in the ring and L-shape configurations. The project output is to compare designs of matched band-stop filter between the ring and L-shape resonators in terms of S-parameter and the efficiency of the band-stop filters. At the conclusion of this project, it will be possible to develop a more effective wireless communication system (that is, one that is free of noise), as well as to isolate the signal of interest from the interference signal, to reduce, remove, and filter out noise, harmonics, and spurious signals in a wireless communication system.

1.6 REPORT ORGANIZATION

This report is divided into chapters that will describe and discuss specific aspects of this project. This reports contains five chapters. The first chapter discusses matching band-stop filtering, objectives, problem statements, and the scope of the project, an overview of the methodology, and also the arrangement of the thesis.

The second chapter discusses the project's literature review. The project's literature review comprises a description of the perspective and methods utilized in previous research, as well as a discussion of the amount to which a student project is connected to a study and current theory, as well as the concepts employed to solve project challenges. The literature review assists in comprehending the project's fundamental.

The third chapter will discuss the method for the project. The methodology section of the project discusses the method and the processes used to collect data, process and analyses it, as well as model and flow charts.

The fourth chapter discusses the results and discussion of this project, as well as the analysis conducted during the research and development process. This chapter will include all of the data and findings from this experiment.

Finally, the fifth chapter discusses the conclusion and recommendation of future work of the project. This chapter summarizes the project's accomplishments and makes recommendations for further research.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This chapter present the literature on RF filters, which includes various related publications, articles, and past research on this topic. This chapter also includes a discussion of the development made in the design of a matching band-stop filter. The purpose of this project is to design a matched band-stop filter using a Ring-shape and L-shaped resonator with a center frequency of 90MHz.

For this chapter, the literature review is about the multi-information from a different kind of source to collect and find the full requirement to form the perfect matched band-stop filter by using Ring-shape and L-shape resonators. All the information finds from multiple types of sources such as journals, research articles, websites, and gather any information that leads to designing matched band-stop filter. This chapter starts with the basic theory and fundamentals of the filter to isolate the signal to reduce the harmonics and interference signal. One of the purposes of gathering the information of matched band-stop filters is to identify and understand the concept of the previous work and improvise the project.

2.2 WIRELESS COMMUNICATION SYSTEM

The wireless communication system is one that transmits data among two or more locations that are not linked by an electrical conductor [1]. Typically, information is transmitted from a transmitter to a receiver separated by a predetermined distance from the emitter in a communication system. The transmitter and receiver can be situated anywhere between a few meters and several hundred meters apart with the help of Wireless Communication[8]. Once coming up with a sophisticated wireless system, or any other system that is operable at microwave frequencies, noise is a major concern[9]. It is possible to avoid this noise by filtering it out selectivity. A band-stop filter, also known as a notch filter, is a type of filter that is the inverse of a bandpass filter in that it allows the whole band of frequencies to pass through it while only blocking a specific band of frequencies[9]. Figure 2.1 below, shows the block diagram of the wireless communication system.

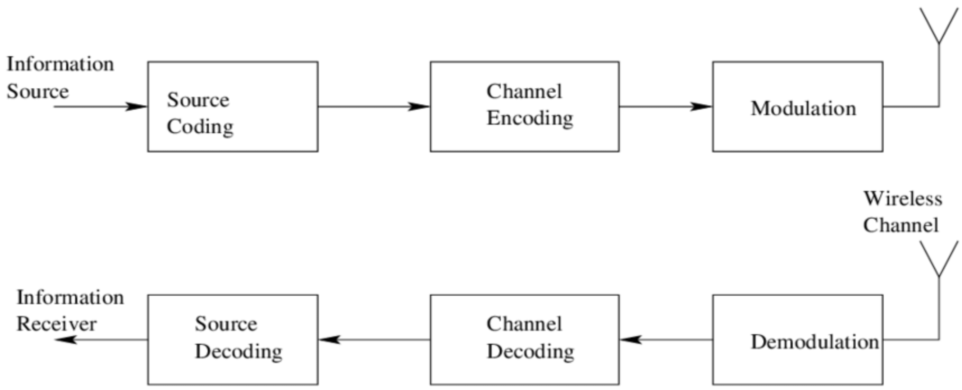

Figure 2.1 Block Diagram of Wireless Communication System

2.2.1 Basic Elements of a Wireless Communication System

A typical wireless communication system can be broken down into three components: the transmitter, the channel, and the receivers[10][8].

Transmission path for Wireless Communication Systems are often formed of the following components: an encoder, an encryption algorithm, a modulation scheme, and multiplexing techniques. To share the valuable bandwidth, the modulated signal is multiplexed with other signals using various multiplexing techniques such as Time Division Multiplexing and Frequency Division Multiplexing[10][8].

In nature, a wireless channel is unexpected, as well as very varied and random in its characteristics. The received signal may be contaminated by errors as a result of interference, distortion, noise, and scattering, etc. which occurs when a channel is prone to these effects[8][10].

The receiver's job is to collect the signal from the channel and recreate it in the same manner as the source signal does. The receiving portion of a wireless communication system consists of demultiplexing, demodulation, channel decoding, decryption, and source decoding. The demodulation techniques receive the signal from the channel and use it to recover the original message signal. The channel decoder is responsible for removing any superfluous information from the broadcast. Considering that the message has been encrypted, the decryption of the signal eliminates the security and reduces it to a basic sequence of bits. Finally, this signal is sent to the source decoder, which decodes it and returns the original message or signal that was transmitted[10][8].

2.3 RF AND MICROWAVE FILTER

In this modernized technology, the microwave filter has the greatest impact and is critical in the design of systems and applications throughout the entire system and application. A growing number of telecommunications applications, such as current wireless communication systems and radar systems, are placing an increasing demand on RF microwave filters[11][12]. In every RF front-end communication system, the RF and microwave filter serves as the fundamental component, acting both as band reject and band select units for both transceivers and receivers[13]. An RF or microwave filter is a two-port network that is used to manage the frequency response at a specific point in an RF or microwave system by providing transmission at frequencies within the pass-band filter and attenuation at frequencies within the band-stop filter. Microwave filters are used in a variety of applications, including wireless base stations, satellite communications, and wideband communication systems[6]. Generally, microwave and radio frequency (RF) filters are used extensively in all of these systems to distinguish between desired and undesired signal frequencies. Figure 2.2, depicted an illustration of a filtering application.

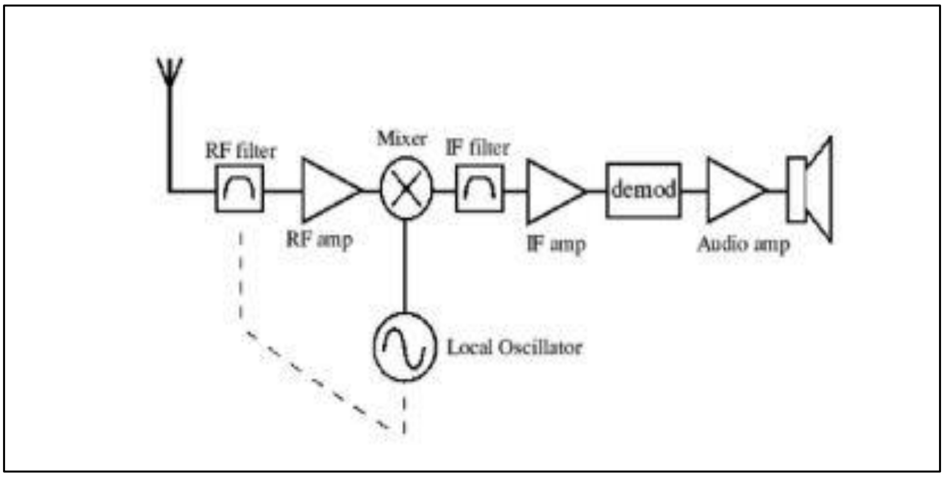

Figure 2.2 RF tunable filter

2.4 APPLICATION OF RF AND MICROWAVE FILTERS

Microwave systems had a significant impact on the generation of the modern era. Civil and military radar systems are one of the many applications for satellite television entertainment. In the world of communications, cellular radio is becoming as common as a standard telephone in terms of usage. Microwave and radio frequency (RF) filters are routinely used in all of these systems in order to discern between desired and undesirable signal frequencies. Filter requirements in cellular radio are extremely high, both in base stations and in mobile devices[14]. Cellular radio has extremely high filtering requirements, which are present in both the base station and the mobile device. Figure 2.3 represents a block diagram of the RF front end of a cellular radio base station.

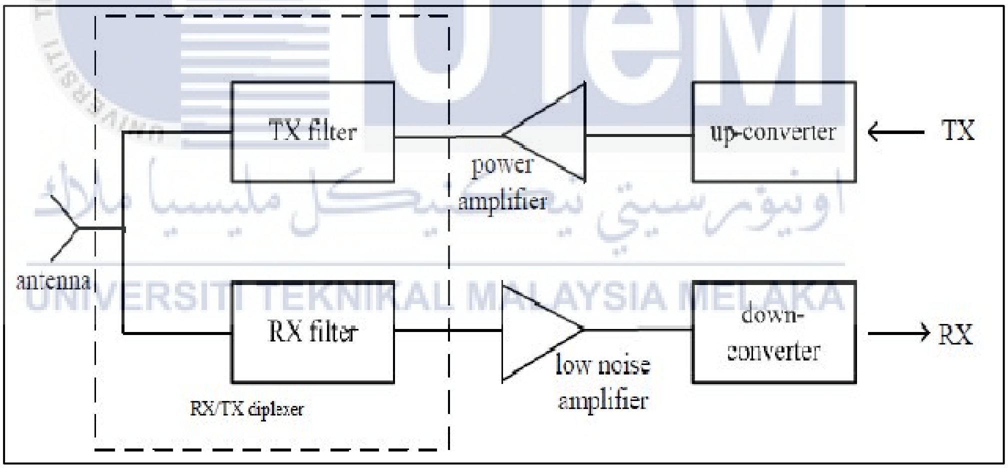

Figure 2.3 Block diagram of the RF front end of cellular radio base station

The systems normally broadcast and receive data at the same time[15]. The primary objective of the front-end filter is to eliminate undesired signals[14]. The radio frequency front end of a cellular base station system is represented in Figure 2.3 above, with the transmitter and receiver filters located after the antenna. The system's additional components include an antenna, a power amplifier, a low noise amplifier, and up-down converter. The telecommunication system's performance may be impaired, and interference may occur as a result of signals from other wireless communication systems currently in use. The band-stop filter is a crucial in microwave design because it suppresses undesired signals across the front-end communication system[16].

2.5 FILTER

Filter with high selectivity is required in a wide variety of applications, including communications transceivers and radar systems[17]. The importance of performance for designing the filter is the characteristic of response, the high selectivity of frequency, and low cost[18]. Filters play a vital role in combining, separating, limiting, and rejecting frequencies within specific spectrum limitations. Low-pass, high-pass, band-pass, and band-stop filters are the four types of RF filters[7]. This filter is employed in the radio system of cognitive radio, for example, to pick signals of interest or reject interfering signals. It is dependent on the radio's surroundings or mode of operation[13]. Furthermore, to somewhat compensate for the loss, a different filter topology might be implemented[19].

2.5.1 Types of Filter Design Techniques

There are two types of filter topologies: passive and active[2][17]. Capacitors, inductors, and, in some topologies, resistors are used as energy generators in passive topologies. Components that require power are included in active topologies[2]. Passive methods such as distortion and active approaches are examples of such techniques[17]. Due to difficulties such as intrinsic nonlinearity, active techniques are only suitable for a restricted number of applications[17]. While the passive techniques use a narrowband band-stop filter with theoretically unlimited stopband attenuation and perfect passband and stopband matching[5].

2.5.2 Type of Filters

Filtering, in its broadest definition, is the process of deleting portions of a signal's spectrum. In all frequency bands, filters are implemented[20] however, there are various fundamental types of filters based on the component of the signal that is eliminated[21].

2.5.2.1 Low-Pass filter

The optimal frequency response of the system is shown in Figure 2.4(LPF) a low-pass filter. The Low-pass filter function is to pass low frequencies from dc to a chosen cutoff frequency while attenuating high frequencies [22], this signifies that the amplitude of signals with frequencies greater than the cutoff frequency has begun to be reduced [20]. Smoothing approaches, such as moving averages, are strongly connected to this Low-pass filter, (LPF).

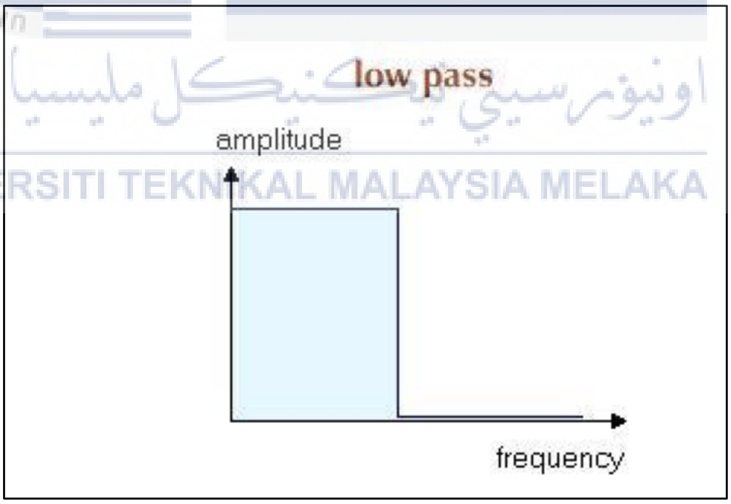

Figure 2.4 Ideal frequency response of Low Pass Filter (LPF)

2.5.2.2 High-Pass Filter

The frequency response of the high pass filter is shown in Figure 2.5 high pass filter (HPF). The purpose of the high pass filter (HPF) is to shut off the low frequencies while allowing the high frequencies to pass through. The first derivative of a function is associated with an HPF [21]. Generally, high pass filters (HPFs) are widely used for directional microphones that have a proximity effect where low-frequency enhancements cause the sound to be distorted when the source is very close [20].

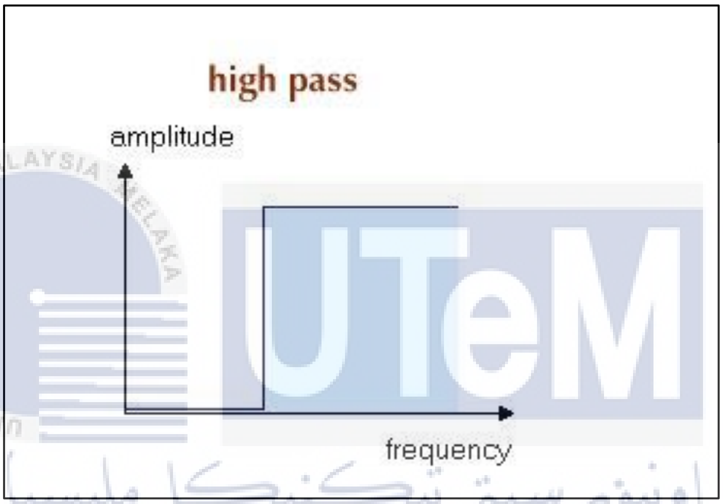

Figure 2.5 Ideal frequency response of High Pass Filter (HPF)

2.5.2.3 Band-pass filter

The optimal frequency response of a band-pass filter (BPF) is generated by a combination of LPF and HPF, as shown in Figure 2.6. Only frequencies within a specific range (band) are allowed to pass through the filter[21]. Any component that is outside of this frequency range is discarded[22]. Particularly, in frequency bands that have the ability to interfere with information transmission[20]

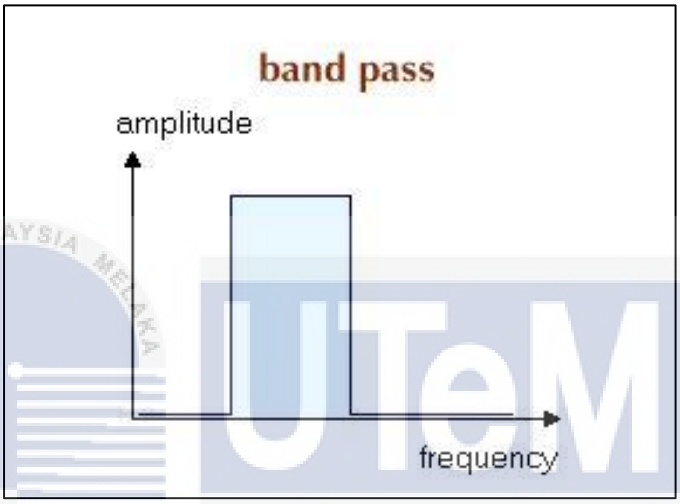

Figure 2.6 Ideal frequency response of Band-Pass Filter (BPF)

2.5.2.4 Band-stop filter

The ideal frequency response of Band Stop Filter (BSF) is shown in Figure 2.7 above. A Band Stop Filter (BSF), also known as band-elimination, band-reject, or notch filter, is a type of filter that is used to eliminate a specific band of frequencies above and below a specified range defined by the component values[2]. The band-stop filter (BSF) is a critical component of any modern communication system. It is critical for filtering out the undesired signals and transmitting the intended signal[23]. When the stop-band is very narrow, the filer is referred to as a band notch filter[5]. Inactive circuit designs such as oscillators and mixers, Band Stop Filter, (BSF) were applied to remove higher-order harmonics and other spurious signals[5]. Additionally, several microwave components, including diplexers and switches are made of Band Stop Filter, which is inexpensive and easily fabricated[18][23].

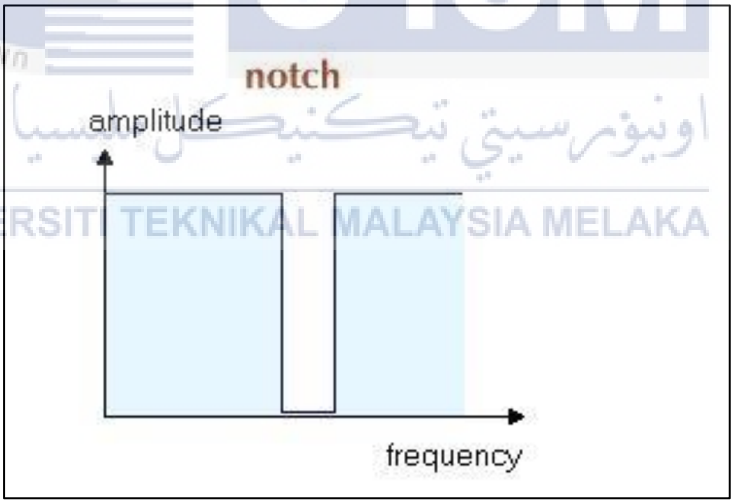

Figure 2.7 Ideal frequency response of Band Stop Filter (BSF)

2.6 MICROSTRIP

Microstrip transmission lines have been widely exploited as essential structures in the recent development of microwave integrated circuits[24]. Microstrip is a type of electrical transmission line that is made with the help of printed circuit board technology. It is used to transmit microwave frequency communications[20]. Microstrip transmission line consists of a conductive strip of width, W, and thickness, t is on the top of a dielectric substrate that has a relative dielectric constant, ε_r and a thickness, h, and the bottom of the substrate is a ground (conducting) plane[15][20] as shown in Figure 2.8 below.

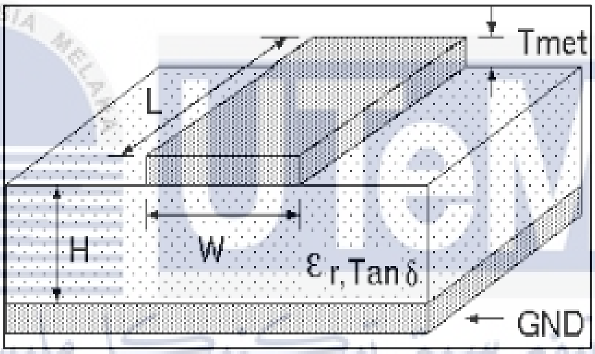

Figure 2.8 Microstrip transmission line structure

The main benefit of a microstrip filter over the stripline is that all active components can be mounted on top of the board[20]. Meanwhile, the lossy nature of the microstrip makes it difficult to achieve a high Q factor[5]. Microstrip RF filters are commonly used in microwave devices transceivers that operate in the hundreds of MHz to 30 GHz frequency spectrum to transmit microwave-frequency signals.[25]. In telecommunications, a transmission line is a specialized cable designed to carry analog AC signals of high radio frequency[20]. The most of the microstrip filters, are designed using the same principle and theories. Some of the concepts of the common filters are unloaded quality factors of lossy Reactive Elements and periodic or non-periodic microstrip line perturbation techniques[7].

2.7 NOTCH FILTER

Notch filters are constantly used to reduce noise and power line interference in communication, control, instrumentation, and biomedical engineering. A notch filter significantly reduces or eliminates a single frequency component from the input signal spectrum while maintaining the amplitude of the remaining frequencies[26]. In other words, these filters are designed to have a high attenuation for the signals within a specific frequency range while transmitting all others without or with the minimal loss[27]. Thus, a notch filter is a band-stop filter with an extremely narrow stopband and two passbands. Figure 2.9 illustrates the amplitude response $H_1(\omega)$ of a typical notch filter.

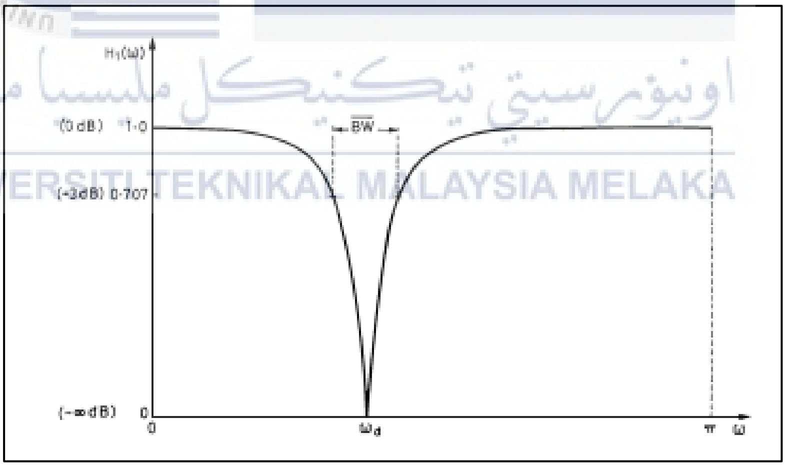

Figure 2.9 The amplitude response $H_1(\omega)$ of a typical notch filter

A notch filter is a band-reject filter with a narrow bandwidth, whereas a band-reject filter with a wide bandwidth is referred to as a band-reject filter[28].

2.8 PERFECTLY MATCHED BAND-STOP FILTER

A matched band-stop filter has an all-pass network characteristic, in which an ideal lossless all-pass network passes all frequencies with zero attenuation, and hence must offer a perfect match at all frequencies (Guyette et al. 2009)[6]. The energy is differently reflected in a microwave filter to achieve frequency selectivity that is restricted by the lossless nature of the technology utilized. The passive technique of implementation results in a narrowband band-stop filter with theoretically limitless stopband attenuation that is exactly matched in both the passband and stopband[5].

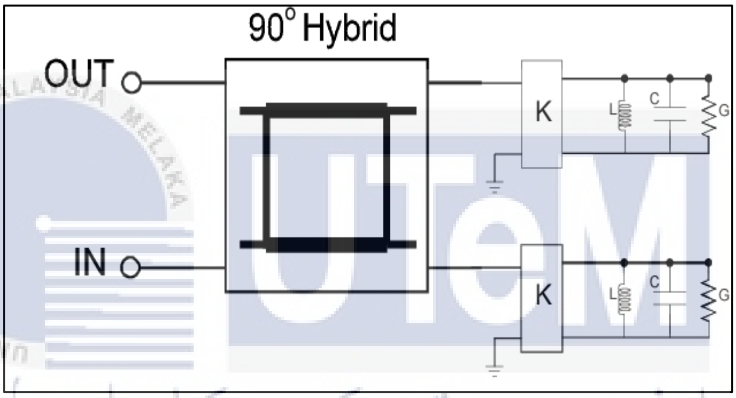

Figure 2.10 Hybrid circuit implementation of a perfectly matched notch filter

The concept of perfect notches is used to increase the Q-factor of a band-stop limiter[5][16]. As illustrated in Figure 2.10, this design employs two identical lossy resonators connected to 3-dB 90° hybrid coupler with the appropriate coupling factors [5][16]. This approach results in a higher stop-band attenuation, is small in size, and is matched at the band-stop filter's input and output ports [16].

Figure 2.11 shows the shape of Single Band Matched Band Stop Filter Design that first demonstrated by Guyette et al. (2005)[6]. This prototype design based on generalized coupled-resonator concept of perfectly matched notch[29].

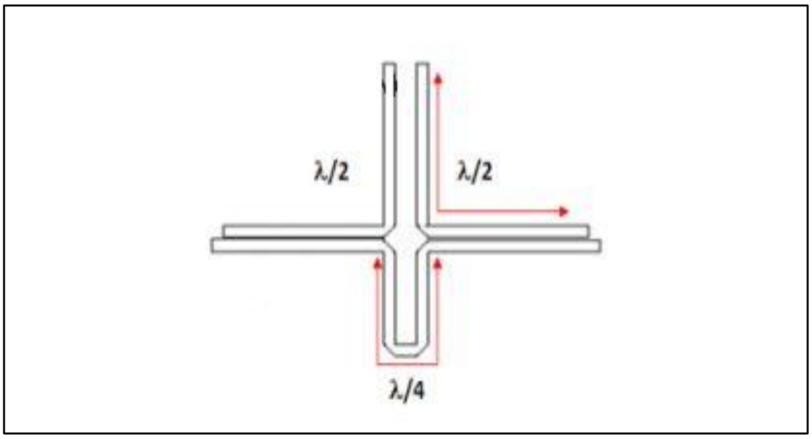

Figure 2.11 Design of a Single Band Matched Band-Stop Filter

2.9 DESIGN CHALLENGE OF MATCHED BAND-STOP FILTER

As investigated by Zahari et al. (2012), the fundamental challenge in the couplings of parallel line resonators to transmission microstrip lines is the variation or tolerance of coupling gap during the fabrication process that generates a little different response between measured results and simulated results. It is demonstrated that the attenuation (or band-stop response) is extremely sensitive to the coupled line's gap size. The tiniest changes in the coupling gap will result in a change in the level of attenuation[6].

Guyette et al. (2005) and Jachowski (2005), following fabrication of the matched band-stop filter, the circuit were tuned utilizing dielectric overlays and/or selective metallization removal to achieve the highest attenuation or notch, most notably at the parallel line resonators to transmission microstrip line couplings[6].

2.10 APPLICATIONS OF MATCHED BAND-STOP FILTER

Band Stop Filters (BSF) are primarily designed used in applications requiring single-band rejection. Dual or multiple-band filters are extremely common at the moment. These filters are expected to be crucial, particularly on board aircraft, and to play a critical role in reducing interference between communication systems caused by coexisting narrowband applications[30].

Band Stop Filters (BSF) are frequently employed in RF and microwave systems to reject undesired blocking and interference signal[31]. In microwave transceivers, band-stop filters are crucial. In wireless communication systems, the current application typically necessitates compact components to meet the mobile unit's miniaturization needs[32]. As a result, a dual-mode half wavelength resonator has been introduced recently, in which a transmission line with an electrical length of 180 is constructed with a shunt stub in the mid-plane to achieve a dual-mode response. This application aims to reduce the size of the filter[32].

2.11 TABLE OF COMPARISON OF BSF PROPOSED BY PREVIOUS RESEARCHERS

The comparison of band-stop filters proposed by previous researchers in order to build matching band-stop filters is listed in Table 2.1. Numerous generic filter theories and design techniques have been proposed in the past by researchers.

Table 2.1 Comparison of BSF Proposed by Previous Researchers

No	Author	Design	Method	Result
1	B. A. Adoum and W. P. Wen.[32]	Construct miniaturized matched band-stop filter based dual mode resonator.	Dual-mode resonator with stepped impedance.	Miniature matched band-stop filter with frequency response centered on 0.99 GHz. S_{11}, has a return loss of -18dB and an insertion loss, S_{21} of -33.70dB.
2	M.K. Zahari, B. H.Ahmad, N.A. Shairi, and P. W. Wong. [29]	Demonstrates a reconfigurable matched band-stop filter.	Half-wave length (λ/2) resonator with gap coupling, parallel with an all-pass nominally-90°-phase-shift element.	High Q-factor and capability to providing a perfectly matched network at 1 GHz center frequency.
3	H. Liu.[33]	A novel defected ground structure broadband band-stop filter.	Complimentary split ring resonators structure (CSRR DGS) and loading stubs line.	Maximum stopband depth reaches 45dB. Band-stop width less than -10dB and low frequency insertion loss, (S_{21}) limited within 1dB.

Table 2.2 Comparison of BSF Proposed by Previous Researchers Continued

No	Author	Design	Method	Result
4	S. Y. M. Hamzah, B. H. Ahmad, and P. W. Wong.[5]	Multiband matched band-stop filter.	Parallel half-wavelength (λ/2) and quarter wavelength (λ/4) resonators with gap coupling in parallel with a nominally 90° phase-shift element.	Frequency response of insertion loss and return loss at 1GHz and 2GHz center frequencies.
5	M. Y. Hsieh and S. M. Wang.[34]	Compact and wideband microstrip Band-stop filter.	Utilizing a single quarter-wavelength resonator with one piece of anti-coupled line terminating in a short circuit.	BSF that strikes a balance between lower-order resonators, good stopband performance, simplicity of construction, and ease of design.
6	A. Gupta, M. Chauhan, A. Rajput, and B.Mukherjee.[35]	Wideband band-stop filter (BSF) for C and X band applications.	Using two types of resonator which is L-shaped and Quad mode resonators.	BSF features a wide stop band of 110% from 3.52 GHz to 12.38 GHz, as well as a high roll-off factor of 1.14.

Table 2.3 Comparison of BSF Proposed by Previous Researchers Continued

No.	Author	Design	Method	Results
7	L. BalaSenthilMurugan, S. A. A. Raja, S. Deeban Chakravarthy, and N. Kanniyappan.[36]	Design of a modified L-shaped resonator band-stop filter for microwave applications.	By increasing bandwidth, by altering the diameter of the L-resonator and cascading the filters.	A conventional 2.45 GHz L-shaped band-stop filter operating at -60 dB attenuation.
8	S. Saxena, S. Porwal, K. Soni, P. Chhawchharia, and S. K. Koul.[4]	Design of band-stop filter utilizing E-shaped dual mode resonator.	Parallel to the microstrip transmission line, an E-shaped resonator and an open stub inverter are used.	At the 6GHz center frequency, a stop band with a high rejection level is used. Extremely useful for situations requiring extremely selective wide band filtering.
9	Y. Luo and Q. X. Chu.[37]	A miniature dual-band stop filter with a higher selectivity.	Coupling between two L-resonator.	The filter has a good selectivity and a compact size.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, the process of designing and simulation of matched band-stop filter using Ring resonator and L-shaped resonator will be discussed. The flow of this project will be describe specifically step by step according to the systematic process. The project has been started by collecting the information of matched band-stop filter from variety of source like, journal, article, textbook, websites and, also gained the knowledge from the experience of people that had done on this project. All the important information about the project will be collect to gain more knowledge which can lead to designing the perfect matched band-stop filter.

3.2 BRIEF DESCRIPTION OF METHODOLOGY

This project begins with a review of the literature and investigation into issues such as band-stop filters, microwave filters, and other topics that are relevant to this project. This literature review is carried out by identifying all of the journals, articles, and books that are relevant to this topic and collecting their information. Following that, all of the procedures for simulating the design in ADS software, as well as the flow for running the simulation, were learned. It is possible to observe the band-stop response for the matching band-stop filter based on the simulation. Finally, the design filter was analyzed between the two types of resonators, ring and L-shape, to see which one performed better.

3.3 FLOW CHART

The flow chart of this project was created to get a clear understanding of how the process of a matched band-stop filter been done. This flow chart method will show the step that had to be through from the beginning until the end of this project in specific and systematic order.

The first step, need to study the title of this project which is the design of the matched band-stop filter. It is important to know the background of the project before going to the next step. Research papers and articles are key to get more information about the matched band-stop filter. The website also can be used as an alternative way to collect extra information and at the same time, it helped in increasing knowledge. With the help of all these sources, the skill and understanding about this matched band-stop filter gaining much higher and it is a positive way before taking the next step.

The next step is to design the matched band-stop filter. The requirement of this project needs to be fulfilled before the final design had been made. The matched band-stop filter will be designed by using Ring and L-shaped resonators and the center frequency will be at 90MHz. The filter characteristic must base on λ/2 and λ/4 resonator with gap coupling as well as good length and width of the resonator, parallel with an all-pass nominally-90°-phase shift element to achieve a high Q-factor.

Next, the designing of the matched band-stop filter need to be added by the setup parameter. The parameter such as Width, (W), Length, (L), and the S-parameter need to be set up first. After done with the setup process, then proceed to the simulation of the design by using an ADS Software.

Advance Design System, (ADS) software is used to simulate the matched band-stop filter according to the right design and setup. The simulation process also need to check whether there had an error or not. If any error occurred, then the simulation need to be fixed. If there is no error occurred, then the simulation can be proceed with the final step verify the simulation result[5].

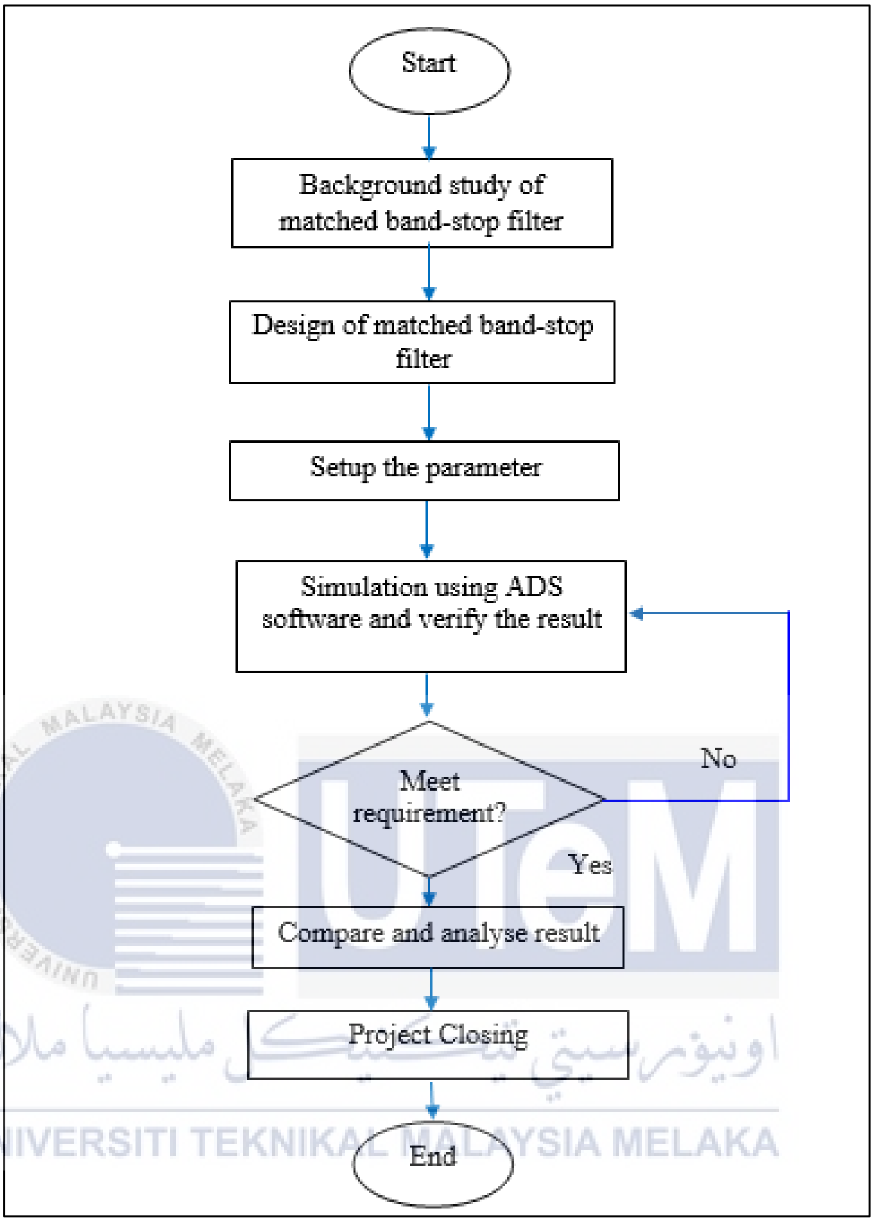

Figure 3.1 Flow Chart of the Project

3.4 ADVANCED DESIGN SYSTEM (ADS)

Advanced Design System, (ADS) from Keysight software that automates the electrical design process for microwave, radio frequency (RF) and high speed digital applications. Circuit envelope, Harmonic balance, transient convolution, Keysight Ptolemy, X-parameter, momentum, and 3D EM simulators are only a few of the most innovative and commercially successful technologies utilized (including both FEM and FDTD solvers). The intent of using these software is to optimize the filter design based on the intended response[25].

3.4.1 Design setup using ADS software

The matched band-stop filter is designed in this project utilizing the Advanced Design System, (ADS) software. The simulation tools was the ADS 2020. In this section, it will show the step of using this software from the beginning until done. For this project, there are 3 major section which was created the schematic of the band-stop filter using Ring shape and L-shape resonator, simulate the resonator and tuning the signal, generate the layout and tuning the signal until the perfect matched band-stop filter is obtained.

Figure 3.2 below, shows the project setup which users need to create a new workspace in order to start the project. In this section, users need to choose the name and the location for a new workspace that will contain the design of the project.

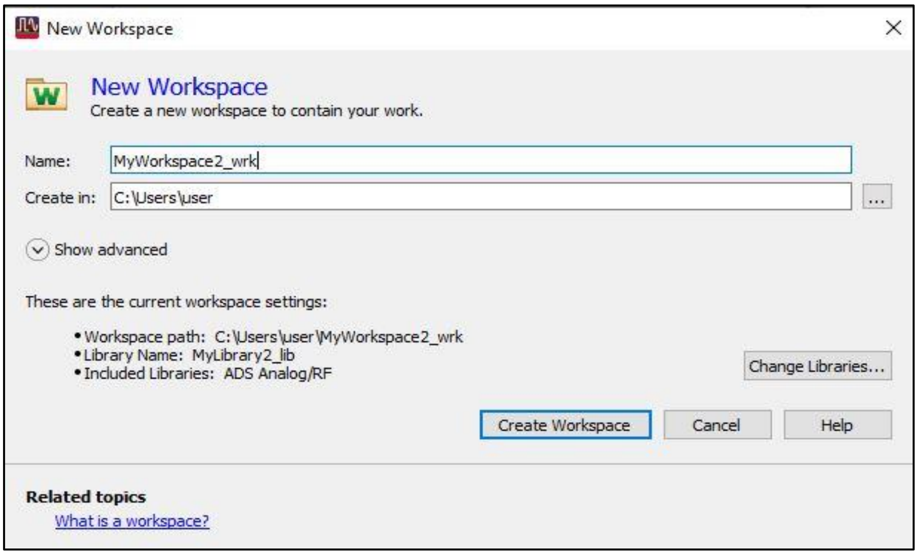

Figure 3.2 New workspace name and location window

Figure 3.3 below, shows the choose layout technology window. In this project, the technology that had been chosen is millimeter layout resolution in order to create a layout or substrate.

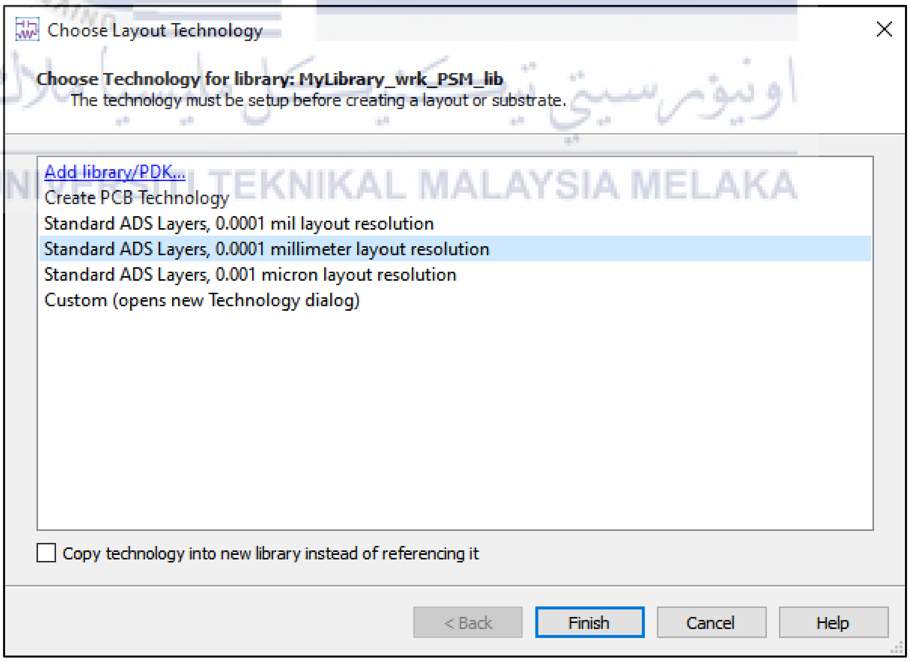

Figure 3.3 Choose layout technology window

After the setup is finish, then the workspace was ready use for design. Workspace is the placed to create the design and simulation of the project. First of all, need to create a new schematic as shown in Figure 3.4 below, in order to design own schematic circuit. In this area, the components can be choose by clicking the type of pallets based on their circuit design.

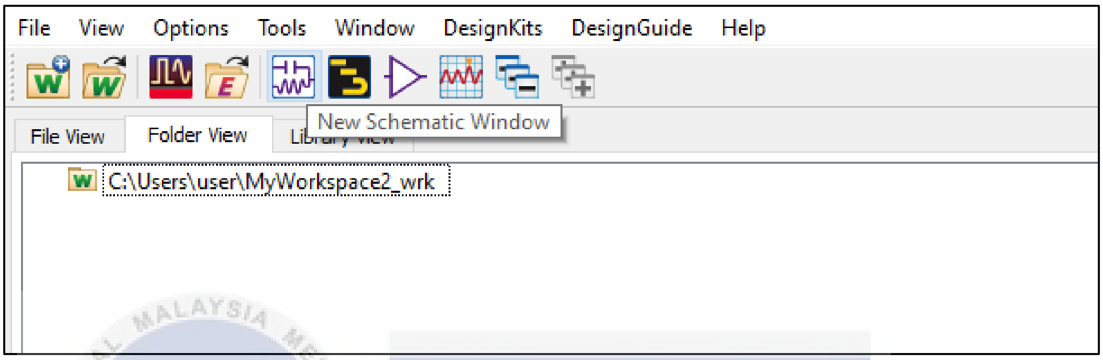

Figure 3.4 New schematic window

The schematic design section is shown in Figure 3.5 below, to design a BSF with Ring resonator, the Tlines-Microstrip been choose. The reason of using this Tlines-Microstrip is that were some component is needed in order to design a schematic circuit of Ring resonator such as Microstrip Substrate (MSUB), Microstrip Coupled Lines (MCLIN), Microstrip Line (MLIN), Microstrip Bend (MSABND) and, Libra Microstrip T-junction (MTEE) as shown in Figure 3.6.

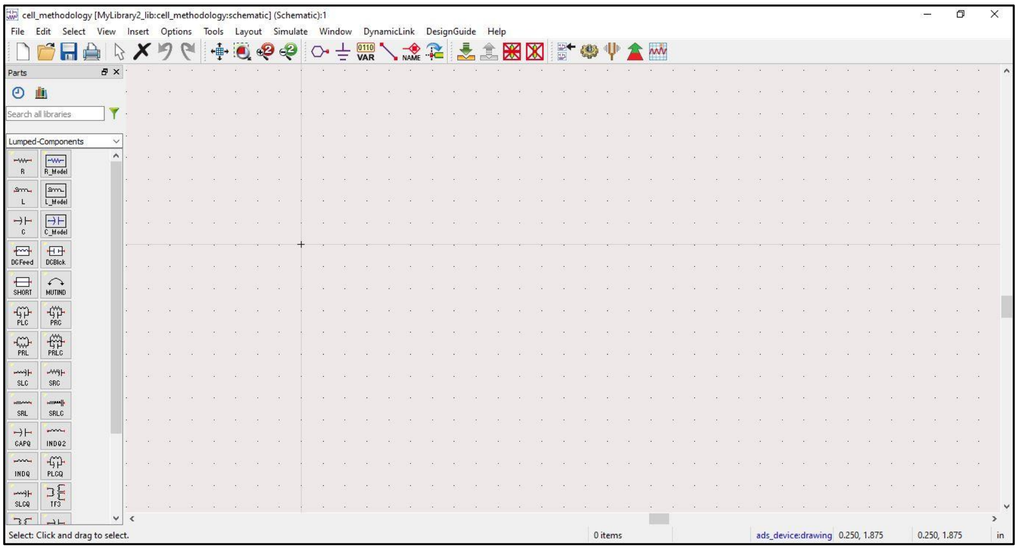

Figure 3.5 Schematic design section

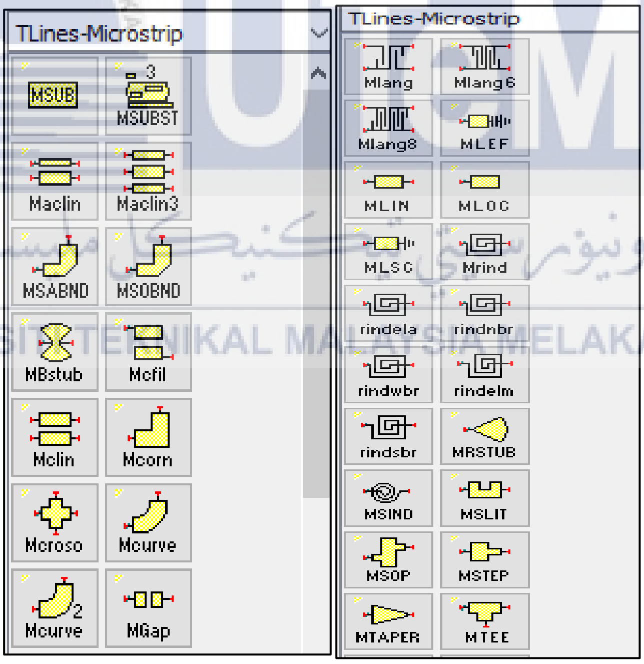

Figure 3.6 Tlines-Microstrip Component

In this simulation also needed two of the component which is the S-parameter and Term. S (scattering) parameter are used to characterize electrical network using matches impedances. While, Term is the port impedance termination for S-parameters. This two components which is S-parameter and Term can be find in pallets Simulation of S_Param as shown in Figure 3.7.

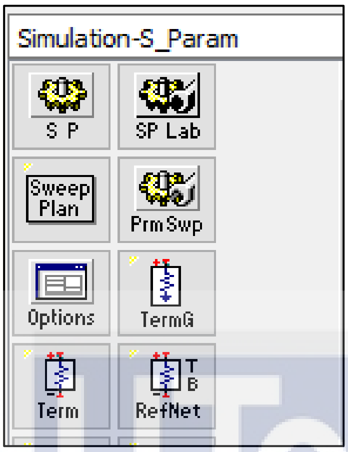

Figure 3.7 Simulation-S_Param Component

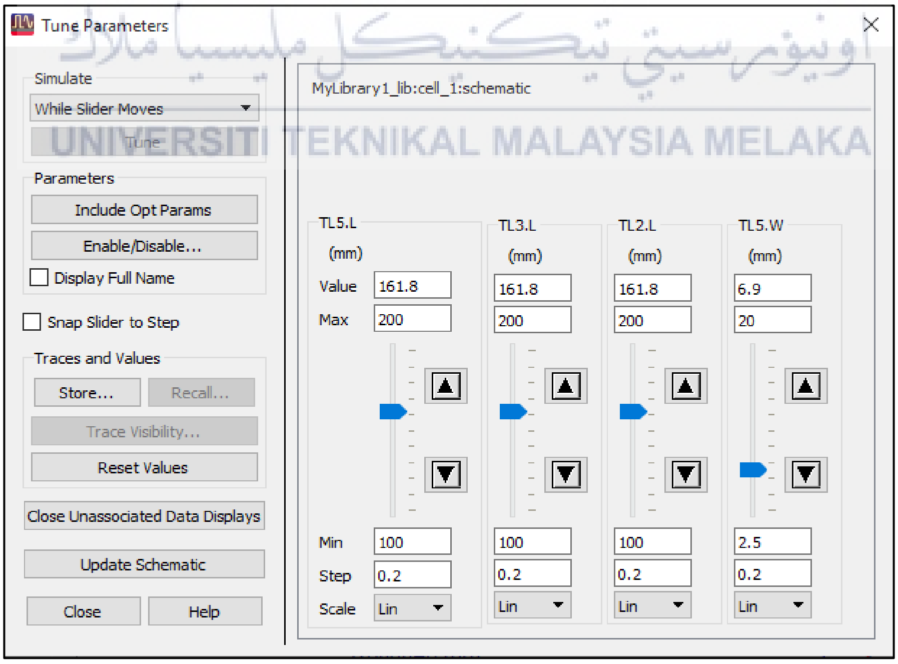

Figure 3.8 Tuning window

The Tuning window shows in Figure 3.8 is important in order to obtain a perfect notch signal. The transmission lines and the width was selected to tune. The purpose of the tuning is to adjust the length of the transmission lines and the width in order to find the optimum slope can cut off-frequency.

3.5 METHOD DESIGN OF MATCHED BAND-STOP FILTER USING RING RESONATOR

Ring resonators are either end-coupled or side-coupled to a microstrip transmission line, depending on the configuration of the system[38]. The matched lossy resonator with ring structure was shown in Figure 3.9 to be side coupling to the microstrip transmission line via a ring configuration. Its total length, measured in terms of wavelength, was equal to one full wavelength, λ at the resonant frequency[31]. That means, for each length of l1, the wavelength was divided by four, resulting in a ring resonator with a square configuration. Also according to[38], an even mode and an odd mode coupling ring resonator with a microstrip line creates two closely spaced, but unique resonant frequencies, which are characterized as the even mode and odd mode coupling frequencies, respectively.

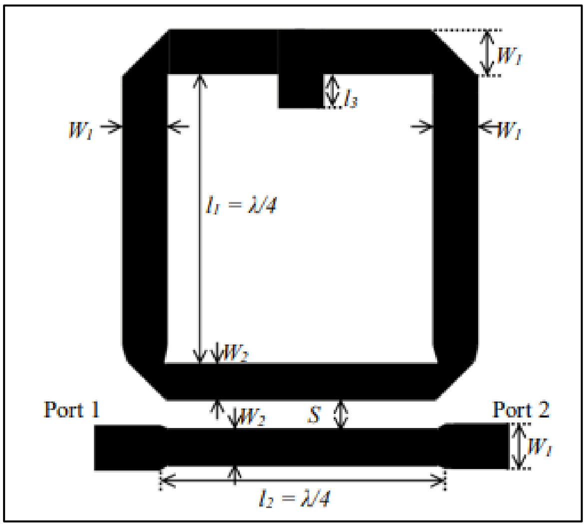

Figure 3.9 Matched lossy resonator using ring structure and its parameters

In dual-mode design, the two modes are coupled together at 90 degrees out of phase, effectively creating a single wave that circulates around the resonator. It is possible to produce a perfect notch by coupling the power coupled off from the resonator at the output to be equal in power and 180° out of phase with that of signal exiting the thru-line at the time of resonant[39].

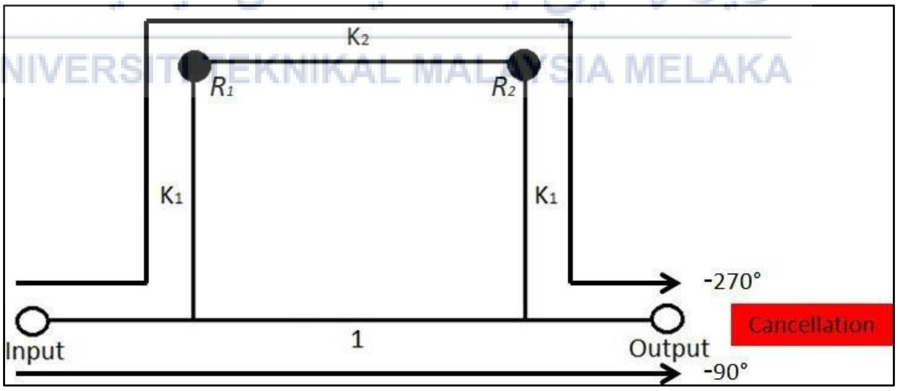

Figure 3.10 Generalized Model of Matched Band-Stop Filter

3.6 DESIGN SPECIFICATION FOR RING RESONATOR

As demonstrated in the following tables, the FR4 board substrate for the MLIN and MCLIN for the ring resonator band stop filter is MLIN and MCLIN for FR4.

Table 3.1 Substrate value for MLIN

Substrate	Value
Er	4.7
Mur	1.0
H	1.60 mm
Hu	3.9e + 34 mm
T	0.035 mm
Cond	5.88e7
Tan D	0.019
Rough	0.00 mm
DielectricLossModel	1.000
FreqForEpsrTanD	1.0e9
LowFreqForTanD	1.0e3
HighFreqForTanD	1.0e12
Z0	50 Ohm
E_Eff	90.00 deg

Table 3.2 Substrate value for MCLIN

Substrate	Value
Er	4.7
Mur	1.0
H	1.60 mm
Hu	3.9e + 34 mm
T	0.035 mm
Cond	5.88e7
Tan D	0.019
Rough	0.00 mm
DielectricLossModel	1.000
FreqForEpsrTanD	1.0e9
LowFreqForTanD	1.0e3
HighFreqForTanD	1.0e12
Z0	50 Ohm
E_Eff	90.00 deg

The width,W, length,L, and coupling spacing, S values for the ring resonator band-stop filter design at 90MHz are listed in Table 3.3. It varies according to whether the filter is MLIN or MCLIN compliant.

Table 3.3 Value of W and L for MLIN and MCLIN for 90MHz

MLIN		MCLIN	
W_1	1.33mm	W_2	1.433mm
S	-	S	0.3mm
L_1	270mm	L_2	420mm

As illustrated in diagram 3.11 below, the configuration and values required for MLIN ring resonator with a central frequency of 90MHz are shown. This part will offer a preview of the selected parameter, with the value being adjusted in accordance with the design of the band-stop filter. Aspects of the parameter, such as its width and length, can be customized. The setup must be meticulous and efficient in order to obtain the best-matched band-stop filter achievable.

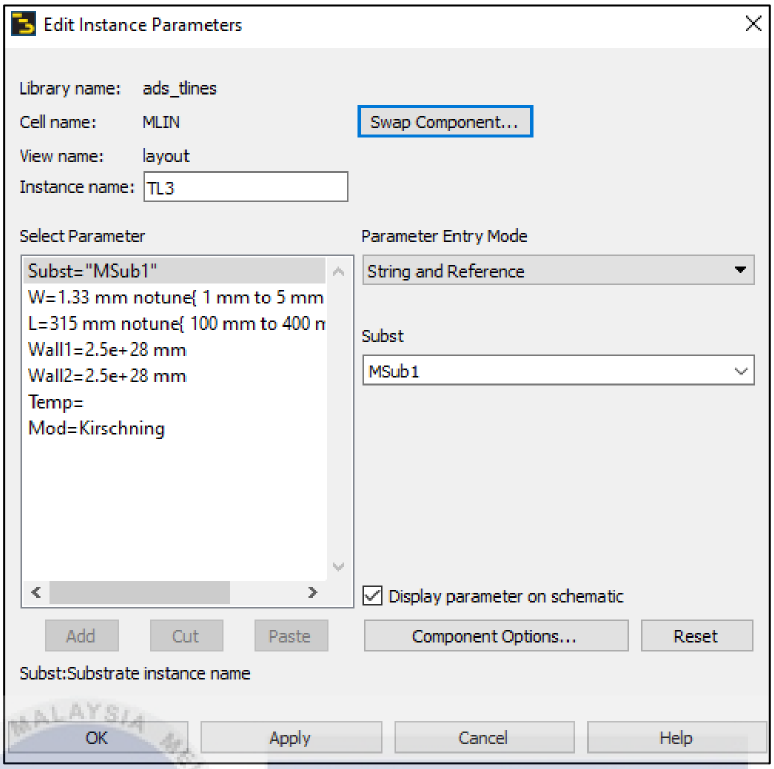

Figure 3.11 Edit instance parameters for MLIN ring resonator at 90MHz

As presented in Figure 3.12, the MCLIN configuration and value necessary for a central frequency of 90MHz are as follows: This section is similar to the MLIN section in that it will preview the selected parameter and allow to adjust the value in accordance with the band-stop filter's configuration. Modifying the width and length of the parameter, as well as other characteristics of the parameter, are allowed. The setup must be meticulous and efficient in order to obtain the perfect-matched band-stop filter feasible.

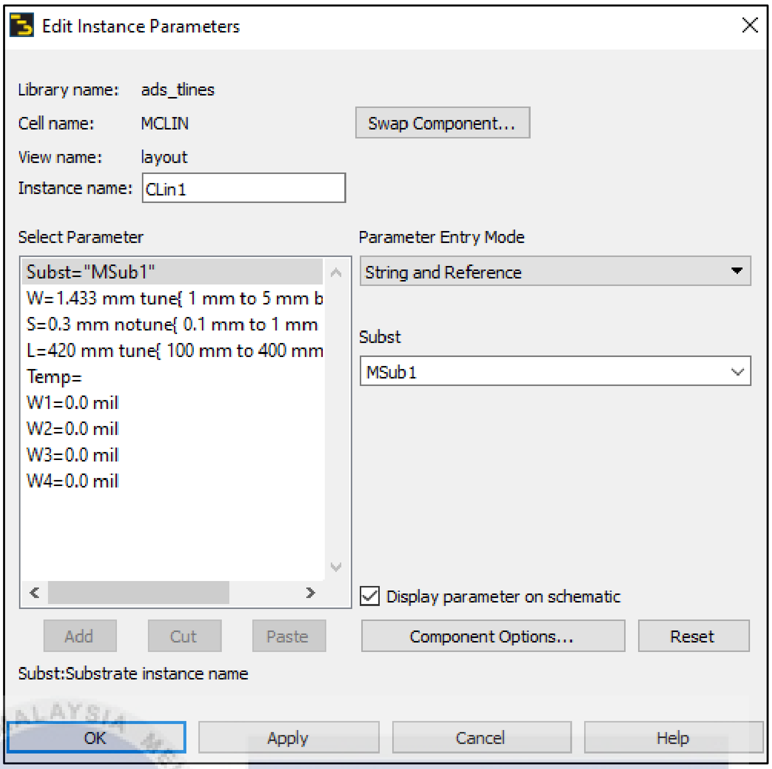

Figure 3.12 Edit instance parameters for MCLIN ring resonator at 90MHz

3.7 METHOD DESIGN OF MATCHED BAND-STOP FILTER USING L-SHAPE RESONATOR

Parallel connected line resonator is a term used to describe the design of a matched band-stop filter that makes use of an L-shape resonator[31][40]. The matched band-stop filter structure is based on L-shape resonator and comprises of two parallel-coupled $\frac{\lambda}{2}$ short circuit transmission lines that provide a nominally 90-phase shift element between the resonator couplings in one structure. Figure 3.13 depicts a coupled resonator design with the required parameter for the matched band-stop filter[39].

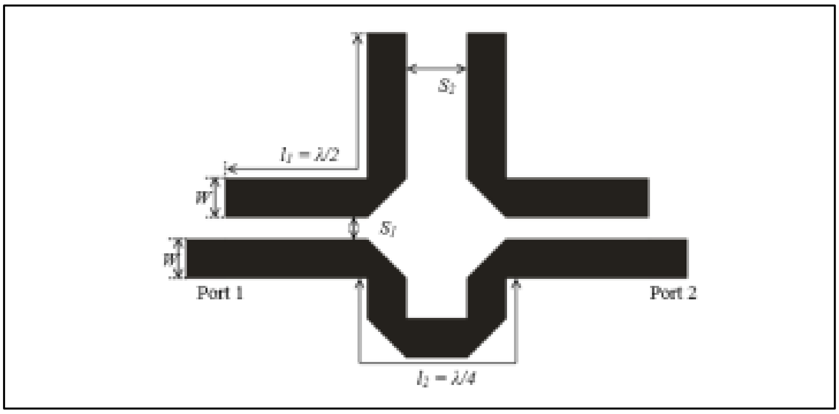

Figure 3.13 Matched lossy resonator using L-shape and its parameters

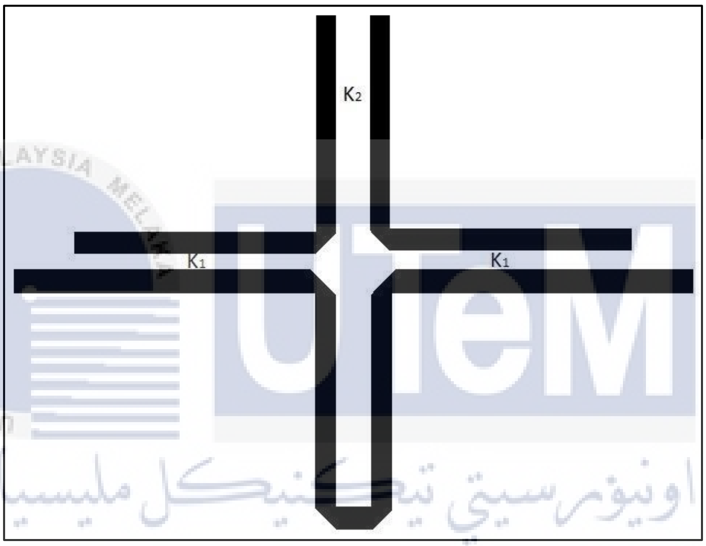

Figure 3.14 Design Structure for L-shape Resonator Matched Band-Stop Filter

Tables 3.4, 3.5 and, 3.6 include the design specifications for a matched band-stop filter based on an L-shape resonator. The reconfigurable matched band-stop filter with a central frequency of 90MHz is developed to this criteria. This project uses a perfectly notch topology with a lossy resonator to provide matched band-stop response between S_{11} and S_{21} at a single resonance frequency. K2 is equal to 1, where 1 is represents a length of 90°. While K1's value is the gap will gradually narrowed to ensure that the two modes can overlap and cancel one other, resulting in a notch band-stop cancellation[39].

3.8 DESIGN SPECIFICATION FOR L-SHAPE RESONATOR

The substrate of FR4 board for MLIN and MCLIN for L-shape resonator band-stop filter is shown in Tables 3.4 and 3.5 below.

Table 3.4 Substrate value for MLIN

Substrate	Value
Er	9.6
Mur	1.0
H	10.00 mm
Hu	3.9e + 34 mm
T	0.150 mm
Cond	4.1e7
Tan D	0.00
Rough	0.00 mm
DielectricLossModel	1.000
FreqForEpsrTanD	1.0e9
LowFreqForTanD	1.0e3
HighFreqForTanD	1.0e12
Z0	50 Ohm
E_Eff	90.00 deg

Table 3.5 Substrate value for MCLIN

Substrate	Value
Er	9.6
Mur	1.0
H	10.00 mm
Hu	3.9e + 34 mm
T	0.150 mm
Cond	4.1e7
Tan D	0.00
Rough	0.00 mm
DielectricLossModel	1.000
FreqForEpsrTanD	1.0e9
LowFreqForTanD	1.0e3
HighFreqForTanD	1.0e12
Z0	50 Ohm
E_Eff	90.00 deg

Table 3.6 shows that for the L-shape band-stop filter design at 90MHz, the values of W and L obtained are different for MLIN and MCLIN, as illustrated in figure below.

Table 3.6 Value of W and L for MLIN and MCLIN for 90MHz

MLIN		MCLIN	
W_1	1.33mm	W_2	1.433mm
S	-	S	0.3mm
L_1	270mm	L_2	420mm

Figure 3.15 shows the setup and the value that is required for MLIN L-shape resonator with a center frequency of 90MHz. The setting for this instance parameters setup are the same as those for the MLIN and MCLIN configurations for a ring shape resonator with a central frequency of 90MHz. This section will display a preview of the selected parameter that allow to adjust the value in accordance with the band-stop filter design. This section can be customized by adjusting the width and length parameters. In order to obtain a perfect matched band-stop filter, the setup must be precise and efficient.

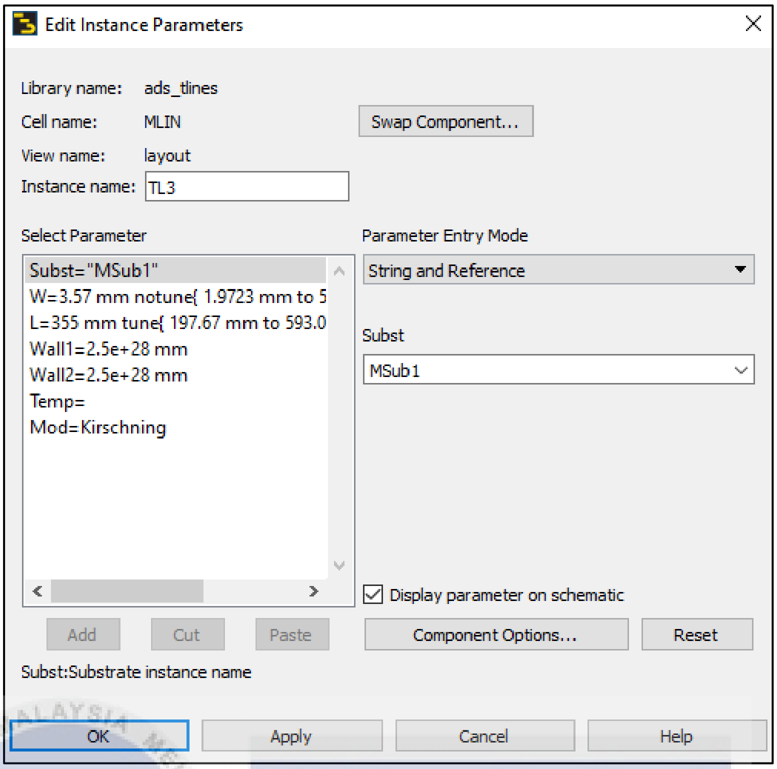

Figure 3.15 Edit instance parameters for MLIN L-shape resonator at 90MHz

MCLIN for L-shape resonator with center frequency of 90MHz is shown in Figure 3.16, along with the setup and value that is required. This instance parameter setting is identical to the setup with MLIN and MCLIN for a ring resonator with a central frequency of 90MHz that was described previously. This section will display a preview of the selected parameter, allows to adjust the value in accordance with the design of band-stop filter. This section can be tune by adjusting the width and length of the parameter. In order to achieve a perfectly matched band-stop filter, the setup must be meticulous in its execution.

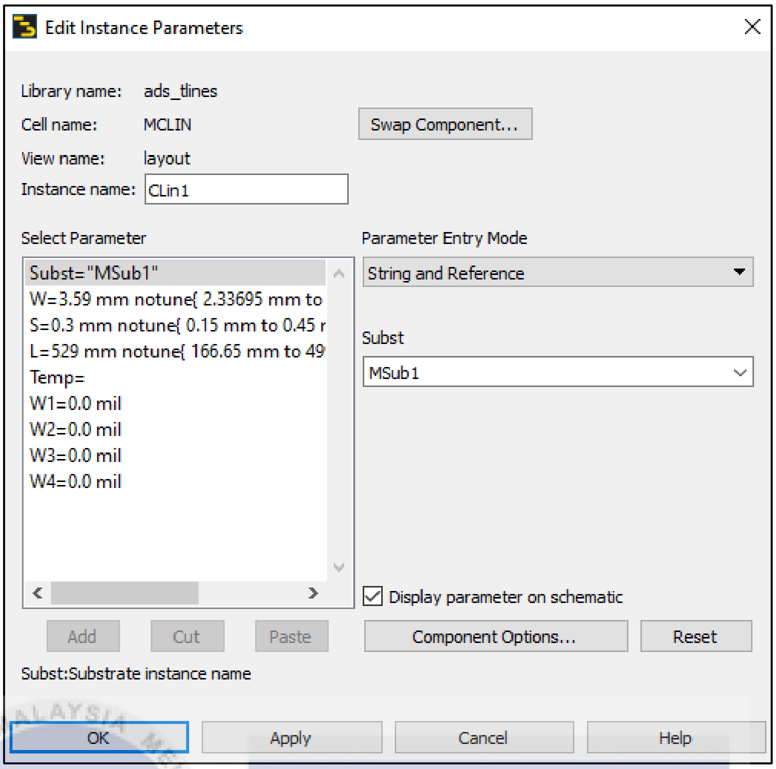

Figure 3.16 Edit instance parameters for MCLIN L-shape resonator at 90MHz

3.9 MODELLING APPROACH

In this project, the design of matched band-stop filter will be accomplished in software. In this scenario, the matched band-stop filter will be constructed by utilized two types of resonators: Ring and L-shape resonators.

The band-stop filter was designed and simulated using the ADS programmer. The center frequency of band-stop filter was the first thing that needed to be adjusted. In this project, the center frequency of band-stop filter is set to 90MHz.

The comparison and analysis result on insertion loss, ($S_{1,1}$), return loss, ($S_{2,1}$), and Q-factor between ring and L-shape will be done for both designs of match band-stop filters from the simulation.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 INTRODUCTION

The purpose of this section of the thesis to discuss the findings of the ring and L-shape resonator band-stop filter projects that were completed. Several sections make up the entirety of this project. The first section is a schematic, in which the circuit must be developed and assembled using the required components; it may be used for both band-stop and non-band stop filters. The second section is a description of the circuit. The second phase is signal tuning, which is critical and demands a concentrated effort in order to obtain a well-matched band-stop filter in the final product. Once the signal has been captured, the project proceeds to generate the layout as well as the tuning technique that will be necessary in this phase of the layout. At the end of the project, a comparison will be made in terms of Insertion loss ($S_{1,1}$), Return loss ($S_{2,1}$), and the Q-factor, which will be used to complete the project.

4.2 RESULT FOR RING RESONATOR MATCHED BSF AT CENTER FREQUENCY OF 90MHZ

The project for the ring resonator matched band-stop filter with a center frequency of 90MHz will be begun from the schematic circuit, in which all of the components must be properly configured before proceeding. Each component has its own set of details that had to be filled in with the appropriate amount of measurements for that particular component. Following confirmation that all of the measurements are accurate, the design of the schematic must be completed in accordance with the design of the band-stop filter, which has a ring-shape. The schematic is depicted in the illustration Figure 4.1 below.

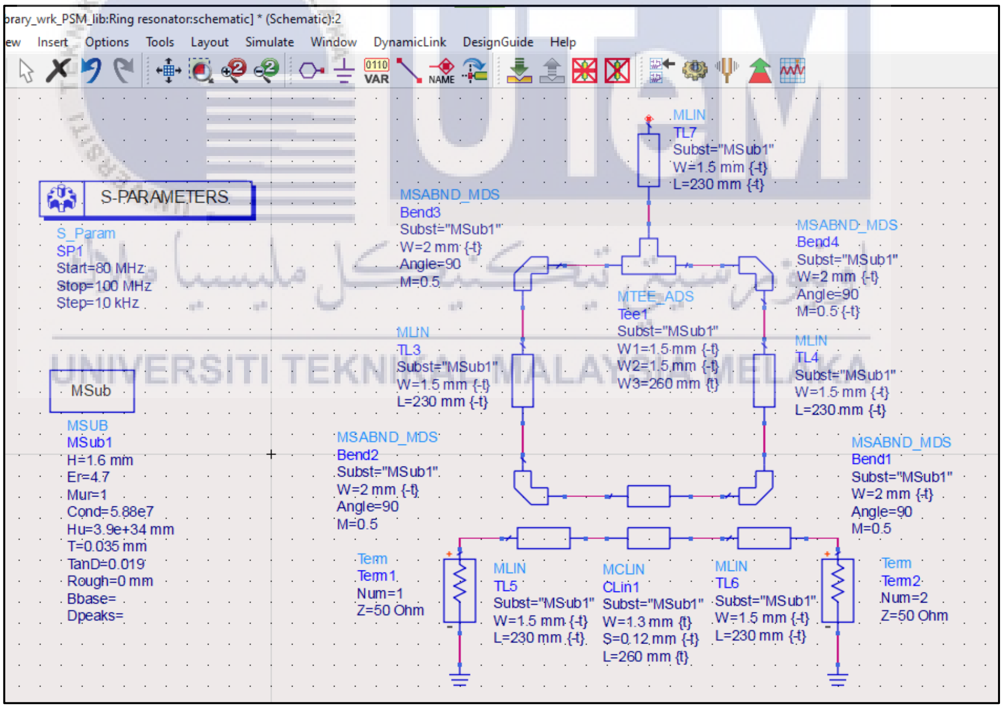

Figure 4.1 Schematic circuit for ring-shape resonator 90MHz

Following that, the tuning procedure that must be followed utilizing the schematic circuit and the response of the matched band-stop filter will be demonstrated. This is the stage of the tuning process when the length of time required to achieve the optimal outcome will be determined. The matched band-stop filter at center frequency of 90MHz response is depicted in Figure 4.2, which follows. The response for Insertion loss ($S_{1,1}$) is -5.158dB. However, the response of Return loss ($S_{2,1}$) does not fall below the minimum -15dB, which is only at -7.108dB at that frequency.

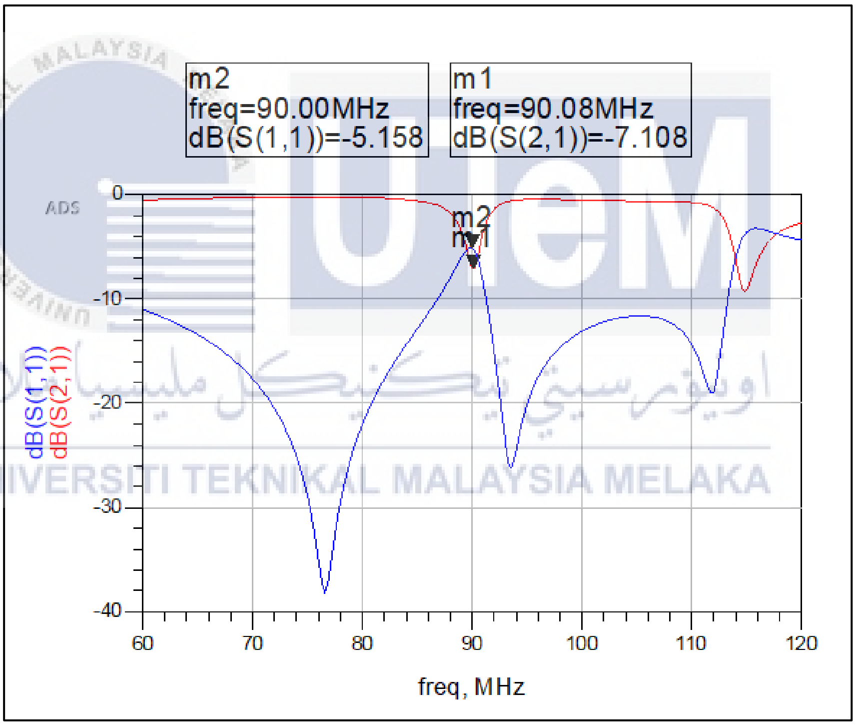

Figure 4.2 Response of the ring resonator matched band-stop filter at 90MHz

The notch of ring resonator as shown in Figure 4.2 above was enhanced by using matched lossy band-stop filter design proposed by Guyette[31][17]. As indicted in the generalized model of matched lossy resonator, the length of the k-invereter coupling, l_2, is the same as the length of the k_3 in this structure. Furthermore, the perfectly matched and high notch response of the ring resonator could be obtained by selecting appropriate the values of k_1 and K_2, where the value of K_1 is controlled by l_3. The values of k_1 and K_2 are controlled by S and W_2, and the values of K_1 and K_2 are controlled by l_3.

After that, the simulation will proceed to the layout part of the process. After the schematic circuit has been generated, the layout component will appear on the layout and configuration of the 90MHz band-sop filter, which was already in the process of being tuned due to the gap coupling.

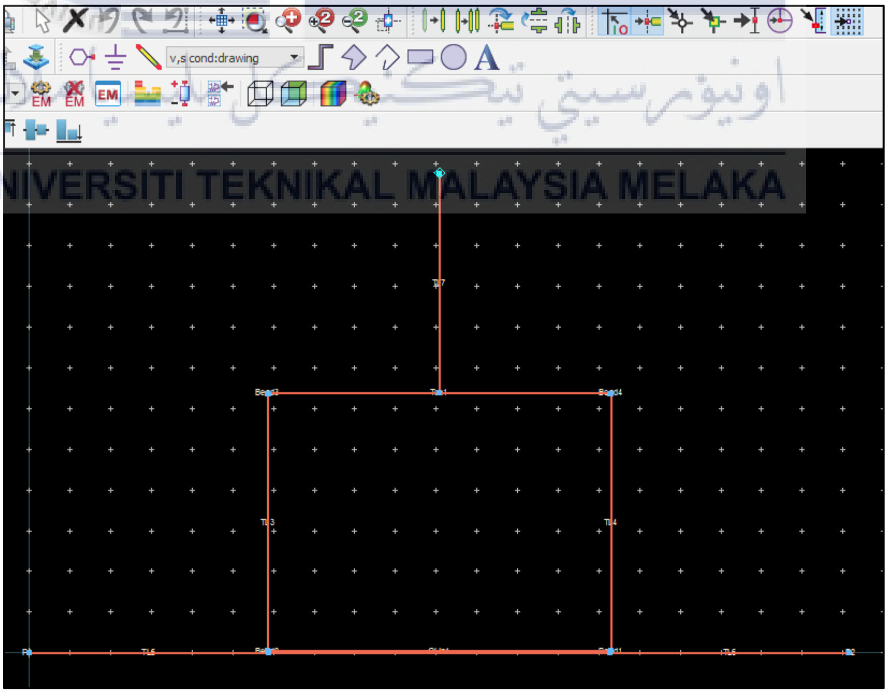

Figure 4.3 Ring layout of matched band-stop filter at 90MHz

4.3 OPTIMIZATION OF RING RESONATOR FOR MATCHED BAND-STOP FILTER

As the response of Return loss ($S_{2,1}$) does not fall below the minimum -15dB, which is only at -7.108 at frequency of 90.08MHz as depicted in Figure 4.2, this part is a process of the optimization the ring resonator response. The simulated frequency response ($S_{1,1}$ and $S_{2,1}$) was plotted in Figure 4.2, from the desired resonator structure parameters were determined;

Table 4.1 The value of MLIN and MCLIN for ring resonator

	MLIN		MCLIN
W_1	1.33mm	W_2	1.433mm
S	-	S	0.3mm
L_1	270mm	L_2	420mm

Thus, the simulated frequency response ($S_{1,1}$ and $S_{2,1}$) in Figure 4.2 was -5.158dB (at 90MHz) and -7.108dB, respectively (at 90.08MHz). Then, in order to optimize the simulated frequency response of the ring resonator's simulated frequency response, the values of MLIN (W_1 and L_1) and the MCLIN (W_2 and L_2) are varied with fixed coupling spacing, S = 0.3mm. Table 4.2 details the changes made to the MLIN and MCLIN's width and length.

Table 4.2 The changed values of the microstrip line and microstrip coupled line

	MLIN		MCLIN
W_1	1.25mm	W_2	1.433mm
S	-	S	0.3mm
L1	275mm	L_2	425mm

From the table 4.2, the value of W_1 was varied from 1.33mm to 1.25mm and the L_1 was from 270mm to 275mm. While, the values of the width is fixed, W_2 =1.433mm, and the value of L_2 was varied from 420mm to 425mm. Figure 4.4 below, shows a matched response ($S_{1,1}$ and $S_{2,1}$) when W_1 value decreasing while, L_1 and, L_2 values was increased. Thus, the simulated notches or attenuation ($S_{1,1}$ and $S_{2,1}$) in Figure 4.4 were -4.973dB (at 90.63MHz) and -7.290dB (at 90.78MHz), respectively. It was observed that the resonant frequency of both return loss ($S_{1,1}$), and insertion loss ($S_{2,1}$) was shifted to the center frequency of ring resonator at 90.63MHz and 90.78MHz by reducing the value of W_1.

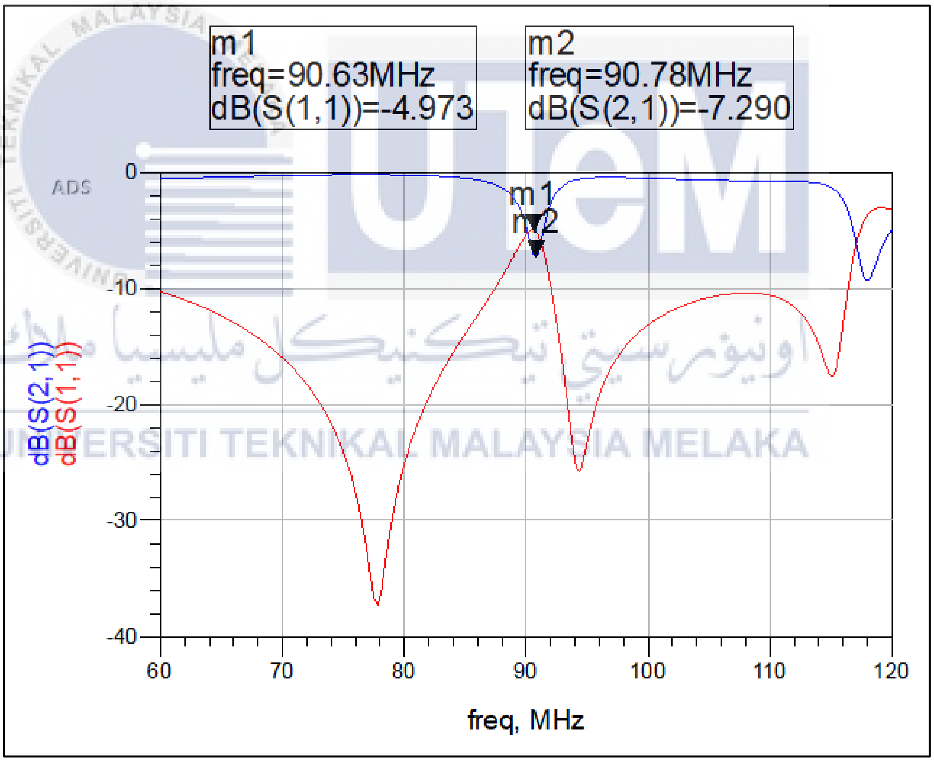

Figure 4.4 Matched BSF response when W_1 is decrease and L_1 and L_2 values was increased

Then, in Figure 4.5 shows the frequency response of matched band-stop filter by increasing the value of W and L of the MLIN and MCLIN with the fixed coupling spacing, S = 0.3mm. In this simulation, the W_1 and L_1 were varied from 1.25mm to 2mm and from 275mm to 530mm, respectively, whereas the W_2 and L_2 were varied from 1.433mm to 2mm and from 425mm to 476mm, respectively. Table 4.3, shows the values of width and length were changed.

Table 4.3 The changed values of the microstrip line and microstrip coupled line

	MLIN		MCLIN
W_1	2mm	W_2	2mm
S	-	S	0.3mm
L_1	530mm	L_2	476mm

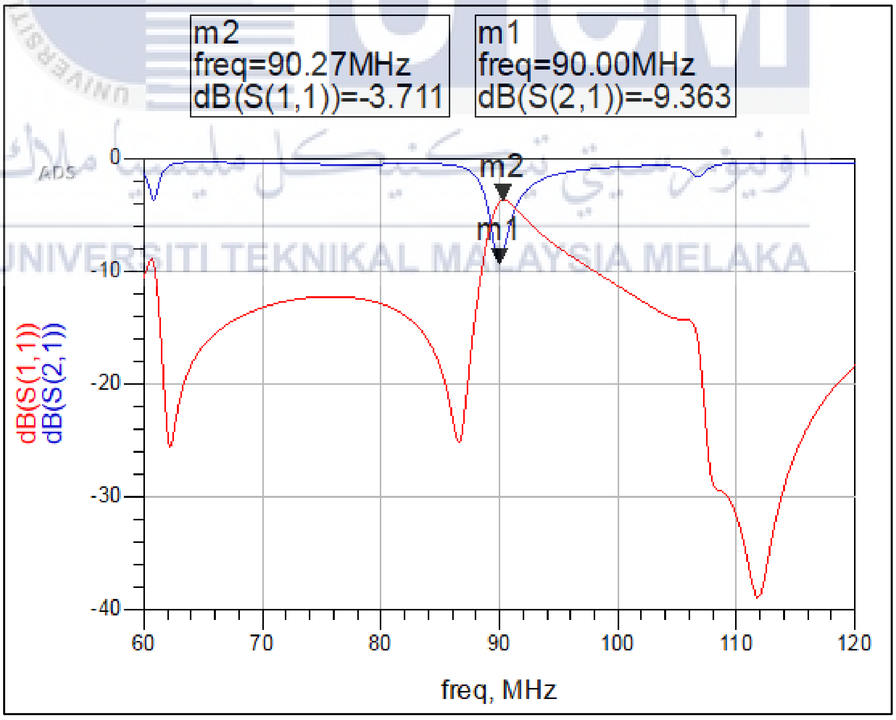

Figure 4.5 Matched BSF response when W and L values for both microstrip line and microstrip coupled line was increased

Thus, the simulated notches or attenuation ($S_{1,1}$ and $S_{2,1}$) in Figure 4.5 were -3.711dB (at 90.27MHz) and -9.363dB (at 90.00MHz), respectively. It was the highest notch were obtained when the $W_1 = W_2$ = 2mm and L_1=530mm, L_2=476mm. However, by reducing the width and the length of the W_1, W_2 and the L_1, and L_2 as listed in Table 4.3, it lowered the notch response.

4.4 RESULT FOR L-SHAPE RESONATOR MATCHED BAND-STOP FILTER AT CENTER FREQUENCY OF 90MHZ

For the result of L-shape resonator of matched band-stop filter, the technique was just same as the ring resonator. The project will be started from the schematic circuit as well as the ring resonator where all the components must be setup properly. Each of the component have their own unique details which had to be filled in with the correct value of measurement. After all the measurement is correct, then it need to be proceed with the design of the schematic based on the design of band-stop filter which is L-shape resonator. The schematic is as shown in Figure 4.6.

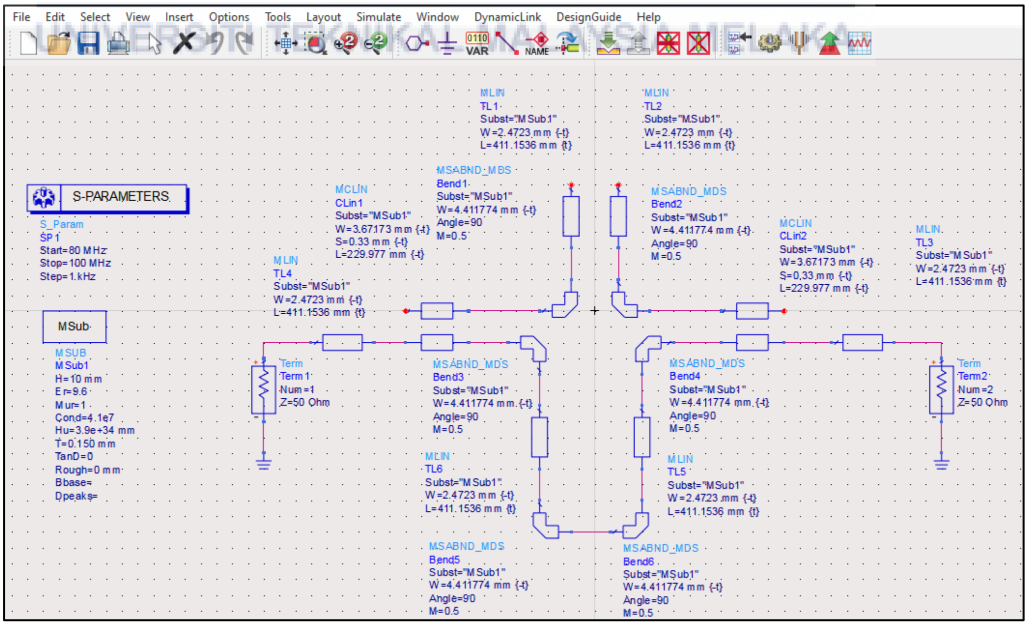

Figure 4.6 Schematic circuit for L-shape resonator at 90MHz

After that, the tuning procedure will be carried out with the help of the schematic circuit, and the response will be displayed. This is the stage of the tuning process when the length of time required to achieve the optimal outcome will be determined. According to Figure 4.7, the signal is as follows: At a center frequency of 90MHz, the signal for Insertion loss ($S_{1,1}$) is less than -10dB, and the signal for Return loss ($S_{2,1}$) is less than -15dB, both of which are below the minimum.

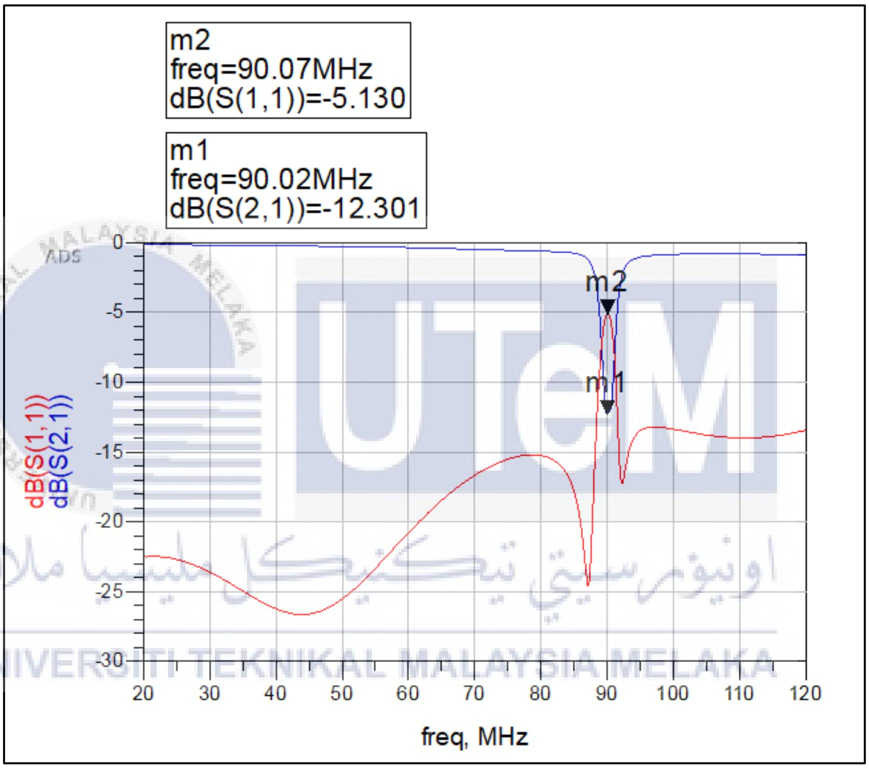

Figure 4.7 Response of the L-shape resonator matched band-stop filter at 90MHz

After that, the simulation will proceed to the layout portion of the process. After the schematic circuit has been developed, the layout component will show up. The L-shape resonator band-stop filter is depicted in Figure 4.8, which displays the layout and shape of the filter. The gap coupling is already in the process of being fine-tuned.

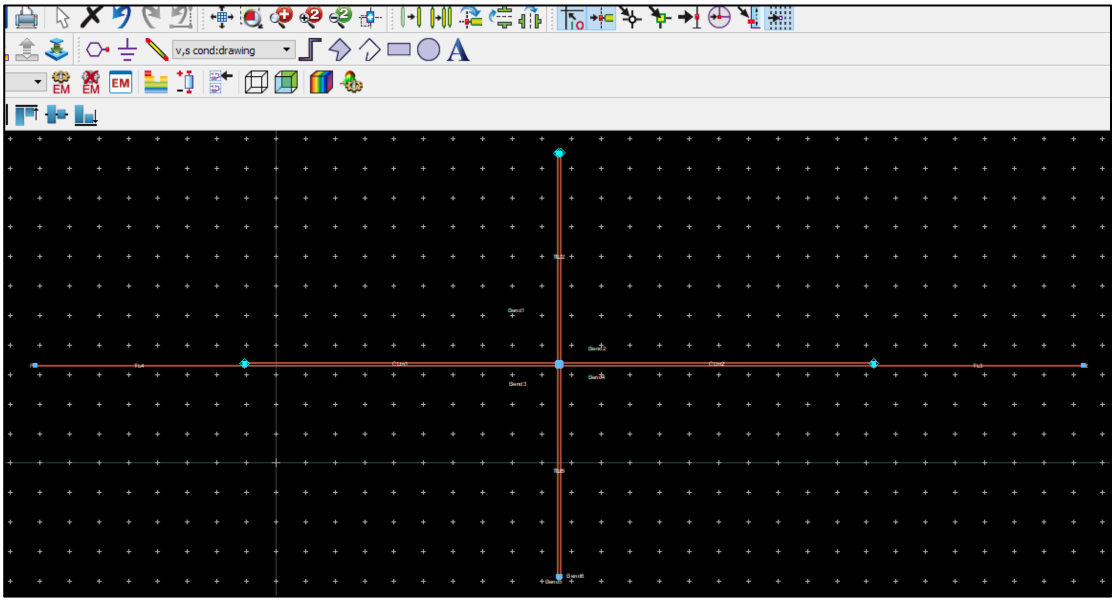

Figure 4.8 L-shape layout of matched band-stop filter at 90MHz

4.5 COMPARISON OF MATCHED BAND-STOP FILTER BETWEEN RING AND L-SHAPE RESONATORS AT CENTER FREQUENCY OF 90MHZ

From the observation, when compared to an L-shape resonator, a ring resonator can significantly minimize the size of a matched band-stop filter's circuit. In accordance with Table 4.4 below, a comparison of matched band-stop filters based on L-shape and ring resonator configurations is shown.

Table 4.4 Comparison of matched band-stop filter based on ring and L-shape resonators

Parameter	Matched Band-Stop Filter based on Ring Resonator	Matched Band-Stop Filter based on L-shape Resonator
Band-Stop Response, Return Loss ($S_{1,1}$), dB	-3.711 (< -10)	-5.130 (< -10)
Band-Stop Response, Insertion Loss ($S_{2,1}$), dB	-9.363	-12.301
Q factor	0.026	0.034

As indicated in Table 4.4, the Q factor for the L-shape resonator is higher than the ring resonator where 0.034 and 0.026 respectively. Thus, the matched band-stop filter based on the L-shape resonator has a high Q factor and gives a narrow attenuation level than the ring resonator, and it is therefore more efficient.

4.6 SUSTAINABLE DESIGN FOR ENVIRONMENT AND SUSTAINABILITY

Environmentally sustainable design, alternatively referred to as environmentally conscious design, eco design, etc. is a concept that governs the development of physical products, the built environment, and services based on ecological sustainability principles.

In this project, the designation of the matched band-stop filter can be employed for an extended period of time without compromising on its long-term viability. Hence, that the band-stop filter is employed to prevent unwanted signals throughout the whole front-end communication system, and it is a vital component of microwave design.

This matching band-stop filter also environmentally sustainable in its design. In light of the designation of the matching band-stop filter, in this project, only software and laptop had been used, both of which are not harmful to the environment and do not release any potentially hazardous radio frequency waves. This project also environmental friendly due to the fact that no paper was used in the completion of this project.

CHAPTER 5

CONCLUSION AND FUTURE WORKS

5.1 CONCLUSION

The project of the matched band-stop filter using the ring and L-shape resonators had been conducted in this thesis. The project development was well executed from which the simulation was the starting point and continue with the generating of the layout of the band-stop filter. The process of this matched band-stop filter only had been analyzed with the comparison between the design and the Return Loss, ($S_{1,1}$), Insertion Loss ($S_{2,1}$) and, the efficiency of the band-stop filter of ring and L-shape at 90MHz since the designation structure was too large in order to be fabricated. However, the comparison of matched band-stop filter between ring and L-shape has been proved, the Return Loss, ($S_{1,1}$) and Insertion Loss, ($S_{2,1}$) for the ring are -

3.711dB and -9.363dB respectively while, the Return Loss, ($S_{1,1}$) and Insertion Loss, ($S_{2,1}$) for L-shape are -5.130dB and -12.301dB respectively, which the L-shape resonator has a high Q factor 0.034 than the ring 0.026 which is L-shape give a narrow attenuation level than the ring. Therefore, L-shape is more efficient than the ring resonators. This matched band-stop filter is one of the future projects in the community of the electronic industry because the capability of this filter can be in so many ways especially in the application regarding the wireless communication and radio frequency (RF) signal.

The theory, design, development, and application of the matched band-stop filter with lossy resonators were discussed in this thesis. To accomplish the project's objective, the matched band-stop filter was built over an extended period of time utilizing both theoretical and numerical methods. With the center frequency set to 90MHz, the tuning signal, layout, and proof of precisely matched between these two types of matched band-stop filters based on ring and L-shape were created.

There had been some difficulties to do this project which had to being take such as manually tuning to optimize the perfect notch performance. This design demonstrates that by utilizing the topology, it is possible to achieve exactly matched insertion and return loss frequencies at all frequencies.

5.2 FUTURE WORKS

The matched band-stop filter is the project that have a very positive potential in industry of the electronics. Nowadays, the electronics part is very important to the community because it being used in daily life. The most common and major part that using this band-stop filter is in wireless application and also the radio frequency (RF) signal. Therefore, the band-stop filter can be present and discuss for the innovation of this future work of this projects. So, there are a few suggestion in future work of the matched band-stop filter.

The design of matched band-stop filter can be design by using a lump filter design. Since the design of this project was too large in order to be fabricated, therefore the lump design filter can be used in order to miniaturize the design of matched band-stop filter in this project proposed.

This project also has to be improved in terms of the filter return loss ($S_{2,\ 1}$) especially for ring resonators of matched band-stop filter due to the optimization for return loss only falling at -9.363dB, and also it needs to have more precision result. This filter (return loss) can be improved by carefully do the simulation of the project with more accurate schematic and have a better tuning signal process. The layout also needs to be considered especially from the tolerance gap of coupling cap between the resonator and the transmission line as this will be effect when the fabrication process and has the difference between simulation and the measurement result. The effect of this gap, is very sensitive because the slightly little gap can have a big changes in the measurement result.

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APPENDICES