




**SYNTHESIS OF MICROWAVE FILTER WITH
FINITE DISSIPATIVE LOSS**

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DECLARATION

I hereby declare that this project report entitled "Synthesis of Microwave Filter With Finite Dissipative Loss" is based on my original work except for citations and quotations which have been duly acknowledged. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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*Specially dedicated to
my beloved parents for their caring support and to all my lecturers who guided me
throughout completing this design.*

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ABSTRACT

This project presents a procedure for synthesizing microwave filters with finite dissipative loss. The performance of microwave filters is depending on the Q factor of resonators. The high Q factor of resonator is leading to high performance of the filters. However, high Q factor of resonator is leading to expand its physical volume and expensive technologies. In order to solve the problem of the expansion of physical volume, the Q factor is decreased with finite dissipation element are used. Yet, it causes the degradation of the performance of the filter. Therefore, the main objective is synthesizing filter by using technique loss compensation which allow for realization of filter with lossy responses that equivalent to lossless responses although at an increased of insertion loss and return loss. This technique enables filter with finite unloaded Q_u factor to be directly synthesized while maintaining the desired selectivity in the passband. Hence, the microwave filter can be designed with low resonators, which will significantly contribute to the reduction of its physical volume with retain the sharp characteristic of filter response. In this project, the technique of filter synthesis based upon reflection-mode hybrid technique. Besides that, the numerical designs are also demonstrated and finally the tables of prototype element values for the function are also provided. The technique of filter synthesis with finite dissipative element would be useful for application where the increased loss can be tolerated as well as reduction of physical volume; thus, its useful in designing microwave filter for receiver systems such as in a satellite input multiplexer (IMUX).

ABSTRAK

Projek ini membentangkan prosedur untuk mensintesis penapis ketuhar gelombang mikro dengan kehilangan lesap terbatas. Prestasi penapis gelombang mikro bergantung kepada faktor Q resonator. Q faktor yang tinggi meningkatkan prestasi penapis. Walau bagaimanapun, faktor Q tinggi menyebabkan pengembangan isipadu fizikal dan memerlukan aplikasi teknologi yang canggih. Dalam usaha untuk menyelesaikan masalah pengembangan isipadu fizikal, penggunaan faktor Q akan diaplikasikan apabila unsur pelepasan terbatas digunakan. Namun, ia menyebabkan kemerosotan prestasi penapis. Oleh itu, tujuan utama pensintesisan penapis yang menggunakan teknik pampasan kehilangan adalah untuk merealisasikan penurasan dengan respon berkehilangan yang bersamaan dengan tidak kehilangan respon walaupun peningkatan kerugian sisipan dan kerugian pemulangan. Teknik ini membolehkan penapis dengan terbatas terbeban, Q_u faktor disintesis secara langsung. Dengan demikian, pada masa ia dapat mengekalkan pilihan yang dikehendaki dalam “passband”. Oleh itu, penapis gelombang mikro boleh direka dengan resonator yang rendah, yang nyata akan menyumbang kepada pengurangan volum fizikal dengan mengekalkan ciri-ciri karakter respon penapis yang berkesan. Dalam projek ini, teknik sintesis penapis akan berdasarkan mod teknik hibrid refleksi. Selain itu, reka bentuk angka juga ditunjukkan dan ini akan disambung dengan jadual nilai elemen prototaip fungsi. Teknik sintesis penapis dengan unsur lesap terbatas akan berguna dalam aplikasi di mana peningkatan kehilangan boleh ditolerasikan berserta dengan pengurangan isipadu fizikal. Oleh itu, ia sangat berguna dalam merekabentuk gelombang mikro penapis untuk sistem penerima seperti dalam penerima satelit pemultipleks (IMUX).

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LIST OF ABBREVIATIONS

ADS	Advanced Design Software
SIW	Substrate Integrated Waveguide
Q_u factor	Quality factor
CST	Computer Simulation Technology
LPF	Low Pass Filter
HPF	High Pass Filter
BPF	BandPass Filter

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CHAPTER 1

INTRODUCTION

This chapter presents the motivation of the project, background, objective as well as the problem statement of the project. It also briefly explains on the scope that will be covered and the summary of methodology for this project. Lastly, the thesis outline will be presented for this project.

1.1 Project Background

Microwave filters play an important role in various aspects of the application along with the rapid development of wireless communication systems. The application of microwave filters such as terrestrial communication, satellite communications, earth stations, and radar system. The application of the microwave and RF filters are used in all these systems in order to discriminate between wanted and unwanted signal frequencies. Good examples for the former applications are mixers and multiplexer. Therefore, a consequence of the continuing evolution of standards in communications caused the filter performance requirements are becoming increasingly difficult to meet. Theoretically, high resonator Q (unloaded quality factor) is needed in order to get the high performance of lossless filters which are leading the costly filter and expansion on physical volume of the filters [1]. Therefore, a low resonator Q with loss called as lossy filter is needed so that to have a low cost and thus reduction of physical volume of the filters.

The background of this project is there have many synthesis of lossless filter from polynomials which generates extensive tables of their associated component values for various types of filters so that design procedure by synthesis process is not required for the designer. However, the synthesis of lossy filter to generate the tables of their associated component values is limited currently compared to the lossless filters. Therefore, the importance of this project is introduced to synthesis the technique of lossy filter with finite dissipation element which is have a low resonator Q factor and it will focus mainly on Butterworth and Chebyshev filter in order to generate the component values to bring the convenience to the filter designer to skip the synthesis process which is time consuming and thus have the shorten path to design of the lossy filters.

1.2 Problem Statement

Over the past decade, the explosive growth in wireless personal communication and other portable receiver and transmitter application as generated a significant market for low-loss, smaller size, lightweight, and lower cost filters. The design of high performance with highly selective filters which requires high Q resonators will contribute to significant physical volume or expensive technologies. However, there have certain application focuses of demand for smaller size, lower cost and higher performance in microwave filters has increased. Therefore, they try to design a lossy filter with finite dissipation element which has a low Q resonator to achieve the reduction of physical volume. Nevertheless, there have an issue with using low Q resonator which is degraded in the performance of the filter. The effect of losses on a bandpass filter is to round the passband and hence reduce selectivity. With this, it is possible to design purely passive filter to have a sharp, selective response even with low Q resonators by applied the technique known as predistortion.

1.3 Project Objective

In this project, the main objective is to overcome the aforementioned problems, which introduce the miniaturization technique for microwave filters in such a way as minimizing unloaded Q resonator to obtain a small physical volume of microwave filters and make them behave like high Q resonators with high performance by applied the passive loss compensation techniques to retain a sharp characteristic in the frequency response.

The objectives of this project are summarized as follows:

1. To synthesized the technique for microwave filters by introducing dissipative element and to design a lossy filter with minimizing unloaded Q factor of the resonators without degrading the filter performance.
2. To generate a table of element values for the filter prototypes according to the degree respectively.

1.4 Project Scope

The scope that covered in this project involves the synthesis technique and the software tools that needed in simulation. In order to run this project smoothly, the type of techniques had been studied so that the procedure that involved in each technique can be understood. The techniques include Classical Predistortion, Predistortion Reflection-Mode, Reflection-Mode Hybrid and Even- or Odd-Predistortion. Moreover, there is involving 90% in mathematical of synthesizing the technique for the microwave filter with finite dissipative loss. Besides that, it is necessary to get familiar with the software on simulation such as Maple of the mathematical process and Advanced Design System Software (ADS) of the circuit simulation in order to compare between the Maple simulation and ADS simulation based on the frequency response. However, part of procedure to obtain the hardware is not covered in this project. The technique will be applied to produce a Butterworth Lossy filter. However, Chebyshev Lossy filter will be proceed as well if time available.

1.5 Summarize of Methodology

Before starting the project implementation, the literature review is carried out to gain some information from journals, articles and reference books to study on the nature of microwave filters. In order to implement this project, all the techniques of loss compensation that involved of synthesis the microwave filter with finite dissipative loss have been study. For the simulation part, software Maple and Advance Design System (ADS) are chosen to simulate the results that obtained and the comparison will be done to ensure the element values that obtained from the mathematical modeling is correct so that to get the desired performance as the expected result for the filter.

1.6 Organization of Report

This thesis is structured into several chapters as follows:

Chapter 1 is describing the project background of this project which is the purpose for starting this project. Next, it describes the problem statement and the objectives of this project means that the target that have set to achieve in this project. Lastly, the chapter 1 is closed up with the methodology and the scope of the project to shows the step and taken to complete the goal and stated clearly of the scope that covered and not covered in this project so that the process of the project will not out of focused.

In Chapter 2, the overview of the general knowledge of the filters and the literature study of the predistortion technique of the microwave filter to the details of each technique and the procedure that involved. Besides that, review of some published journals on various titled predistortion techniques is the main discussion of this chapter. To ease the job of reading and understanding, this chapter is divided into few sections based on the subtitle and each technique of loss compensation technique.

Chapter 3 focuses on the project implementation which discusses details on the procedure involved of each predistortion technique of the lossy filter. The most important tools on top view of the project flow is the flow chart of this project which can clearly explains on the process flow during the project implementation.

Chapter 4 is presents on the results that regarding to each technique that have been done. The results of each table of transfer functions and their associated component values of the filters carried out based on each technique. The performances of each technique are examined based on the frequency response of the microwave filters. The orders of the Butterworth and Chebyshev Filters will applied by each type of the predistortion technique and summarize into the table.

Lastly, chapter 5 concludes this project and recommendation for the future works can be done to improve the performance of the microwave filters.

CHAPTER II

LITERATURE REVIEW

2.1 Basic Filter Types

The ideal filter network is a network that provides perfect transmission for all frequencies in certain pass-band regions and infinite attenuation in the stop-band regions. Such ideal characteristics cannot be obtained, and the goal of filter design is to approximate the ideal requirements to within an acceptable tolerance [2]. Filters are used in all frequency ranges to provide as nearly perfect transmission as possible for signals falling within desired pass-band frequency ranges, together with rejection of those signals and noise outside the desired frequency bands. It is sometimes wanted a selectively circuit in filtering one frequency or range of frequencies out of a combine of different frequencies in a circuit. Therefore, a circuit designed to perform this frequency selection is called a filter.