DESIGN PARAMETER INVESTIGATION OF SINGLE MODE SILICON-ON-INSULATOR (SOI) PARALLEL CASCADED MICRORING CHANNEL DROPPING FILTER.

AHMAD SYAHMI BIN BASRI

This Report Is Submitted In Partial Fulfillment of Requirements for the Bachelor Degree of Electronic Engineering (Wireless Communication)

FACULTY OF ELECTRONIC AND COMPUTER ENGINEERING

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

JUNE 2014

UNIVERSITI TEKNIKAL MALAYSIA MELAKA

UNIVERSTI TEKNIKAL MALAYSIA MELAKA
FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN
PROJEK SARJANA MUDA II

Tajuk Projek : DESIGN PARAMETER INVESTIGATION OF SINGLE MODE SILICON-ON-INSULATOR (SOI) PARALLEL CASCADED MICRORING CHANNEL DROPPING FILTER.

Sesi Pengajian : SESI 2013/2014

Saya AHMAD SYAHMI BIN BASRI mengaku membenarkan Laporan Projek Sarjana Muda ini disimpan di Perpustakaan dengan syarat-syarat kegunaan seperti berikut:

1. Laporan adalah hakmilik Universiti Teknikal Malaysia Melaka.
2. Perpustakaan dibenarkan membuat salinan untuk tujuan pengajian sahaja.
3. Perpustakaan dibenarkan membuat salinan laporan ini sebagai bahan pertukaran antara institusi pengajian tinggi.
4. Sila tandakan (√) :

☐ **SULIT*** — *(Mengandungi maklumat yang berdarjah keselamatan atau kepentingan Malaysia seperti yang termaktub di dalam AKTA RAHSIA RASMI 1972)

☐ **TERHAD**** — **(Mengandungi maklumat terhad yang telah ditentukan oleh organisasi/badan di mana penyelidikan dijalankan)

☐ **TIDAK TERHAD**

Disahkan oleh:

(TANDATANGAN PENULIS)

(COP DAN TANDATANGAN PENYELIA)

HAZURA BINTI HAROON
Pensyarah
Fakulti Kejuruteraan Elektronik & Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal, Melaka

Tarikh: 6/6/2014

Tarikh: 6/6/2014

DECLARATION

"I hereby declared this report is result of my own efforts except for works that have been cited clearly in these references".

Signature : ....

Name : AHMAD SYAHMI BIN BASRI

Matrix No : B021110159

Date : ......6/6/2014......................

SUPERVISOR APPROVAL

"I hereby declared 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 (Industrial Electronics) with honors".

Signature : ....

Supervisor's Name : DR HAZURA BINTI HAROON

Date : 6/6/2014

HAZURA BINTI HAROON
Pensyarah
Fakulti Kejuruteraan Elektronik & Kejuruteraan Komputer
Universiti Teknikal Malaysia Melaka (UTeM)
Hang Tuah Jaya
76100 Durian Tunggal Melaka

DEDICATION

I dedicated this project and work to my beloved parent , friends , lecturers, and my supervisor that always support me

ACKNOWLEDGEMENT

Alhamdulillah, Praise to Allah S.W.T for His blessing and guidance have helped me in completing my thesis. With this opportunity, I would like to express my sincere gratitude and fully appreciation to my dedicate supervisors, Dr Hazura binti Haroon and co-supervisor Pn Hanim Binti Abdul Razak in providing their suggestions and ideas throughout my final year project from the beginning until I have fully completion this project. I want to thank to my family especially for my beloved parent for their love, morale support and prayer along my study. Their fully support has given me enough strength and inspiration to make this project and in pursuing my ambition in life as well as to complete this project. I also would like to express my gratitude to all my friends that assisted me upon my selfishness requests with their commitment and support that have helped me directly or indirectly for the completion of this project. All the achievement really proof their support to me and all honors goes to them. I have gained a lot of experience, information and knowledge that it will help me in my future.

Thank You All

ABSTRACT

Microring resonators are a rapidly-developing area of research in photonic devices, and have a wide range of applications including signal processing filters, sensors, lasers, modulators, switches, memory and slow-light elements, and the list of applications and the performance achievements is growing. If the need for short-range optical interconnect technology at the board-to board or chip-to-chip levels grows, it is expected that microrings will play an important role in the photonics device roadmap for the next decade the ring resonator is a key building block of more complex circuits. The main structure of interest in this chapter is the microring filter, which consists of a microring resonator a waveguide bent onto itself in a circular or racetrack shape side-coupled to one or two waveguides (or other microrings).

ABSTRAK

Microring resonator adalah bidang yang pesat membangun dalam penyelidikan peranti fotonik, dan mempunyai pelbagai aplikasi termasuk penapis pemprosesan isyarat, sensor, laser, modular, suis, memori dan elemen-elemen perlahan-cahaya, dan senarai aplikasi dan pencapaian prestasi semakin meningkat. Dalam keperluan untuk jarak dekat teknologi antara sambungan optik di papan untuk menaiki atau cip ke cip tahap tumbuh, ia dijangka bahawa microrings akan memainkan peranan penting dalam fotonik peranti pelan hala tuju bagi dekad akan datang cincin pengayun itu adalah satu blok bangunan utama litar yang lebih kompleks. Struktur utama kepentingan dalam bab ini adalah penapis microring, yang terdiri daripada pengayun microring bengkok pandu gelombang kepada dirinya sendiri dalam satu pekeliling atau bentuk litar lumba sampingan ditambah kepada satu atau dua waveguides (atau microrings lain).

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDIX

LIST OF ABBREVIATIONS

MRR	-	Micro Ring Resonator
SOI	-	Silicon On Insulator
TMM	-	Transfer Matrix Method
CMT	-	Coupled Mode Theory
GUI	-	Graphical User Interface

CHAPTER 1

INTRODUCTION

1.1 Introduction

Established the use of silicon for the Infra lenses, windows and easy detection wavelength is good for many application especially in communication system . Today (2006) made of silicon , the material of choice for the detection of the visible , in particular pixel digital cameras. In some commercial aircraft, the wavelength response of the silicon even extended to the near infrared (1100 nm). Moreover, the great experts are silicon-based material spending physical equipment of the apparatus and the treatment that had been developed for electronic micro circuits to the rapid growth of fiber infrastructure for the transport of information, video and voice respond. There is no doubt about the economic and technical advantages of silicon and it was inevitable that silicon is used when fiber is provided. It might be expected, with the rise of the Internet and data transmission , the need for faster, wider bands , and corresponds to a lower cost of all four material advantages of silicon provided in many application such as for photonics broad band infrared transparency, electronic (low noise, high speed integrated circuits), thermal (high thermal conductivity), structure (platforms and solid packets in three dimensions).

Optical fiber is made of glass (silica), a versatile material, where the viscosity of the glass is endlessly variable with the temperature [1]. At the right temperature, where the glass is soft and malleable, it can easily stretch into a thin fiber. Glass has an incredible optical transparency, thus light can travel through with a very low loss. Glass is usually considered to be brittle, but if the surface of the fiber is properly prepared and protected, it can be almost as strong as steel wire of the same diameter [1]. Thus showing that fiber optic is superior to copper wires. Optical fiber is widely used for data transmission because it can provide secure and reliable connection. The high bandwidth provided by the fiber made it suitable for the transmission of broadband signal such as high speed broadband internet and high definition television (HDTV) [2].

The silicon material properties enable a wide range of electronic and photonic integrated circuits. Current short-term product, including the first business units electro-photonic silicon that - variable optical attenuator electric VOA - and explain basic construction, operations manager and physics devices. Finally, new experimental silicon photonics circuits specified.

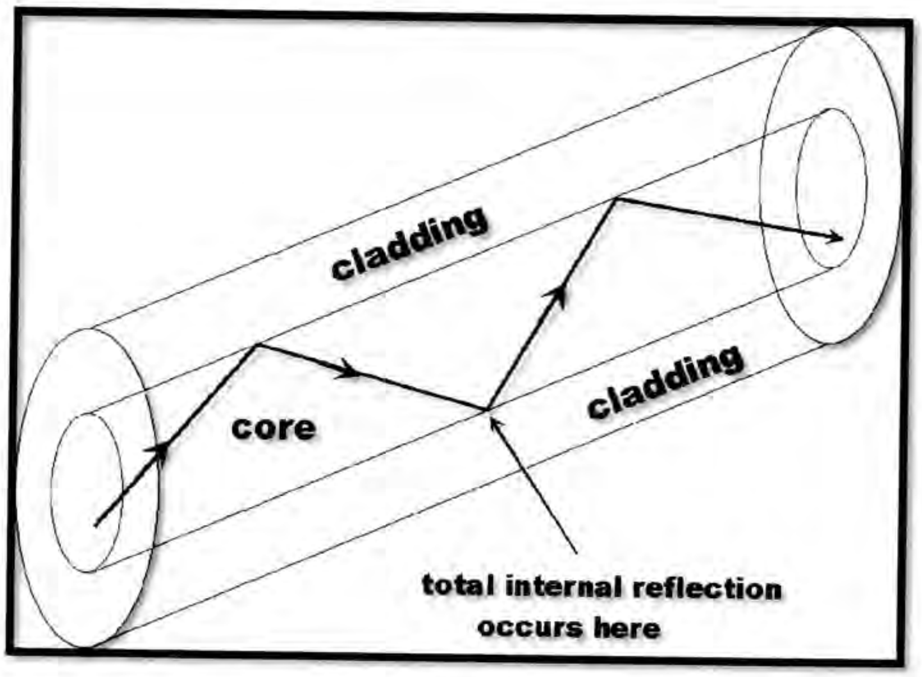

Figure 1.1 Shows light propagate in fiber optic

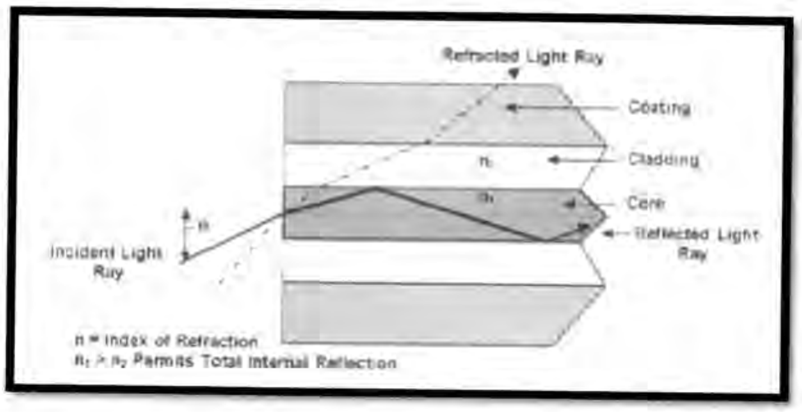

Figure 1.2 Reflection index in fiber cable

Optical fiber is also used in integrated optic. Integrated optic refers to a new generation of opt-electronic system where the use of optical fibers and optical integrated circuit replace the normal wires and cables [3]. The term integrated optic is first used by S.E Miller in 1969, who foresaw the fiber optic technology to be superior to the copper wire [4]. Despite having an upper hand to copper wires, the typical cylindrical fiber optics can no longer fulfil the increasing demand in the rapid growing in telecommunication technology. The demand for higher power, higher nonlinearity, higher birefringence and multiple cores need to be fulfilled [5]. When using with a complicated device, the one dimensional optical fiber is required to be put together in a large bundle causing a disadvantage in miniaturization. Complex optical systems need to connect chips and fibers together via the pigtail, which may cause high loss [6]. In 1991, the idea of photonic crystal fiber (PCF) arose [5]. PCF provide characteristics that ordinary optical fiber cannot. Characteristic such as high nonlinearity, high numerical aperture for the use of multimode fibers, single mode guidance from small ratios hole sizes and asymmetric hole patterns for strong birefringence [7]. All these properties can be achieved from the arrangement of very minuscule closely spaced air holes that go through the entire length of the fiber [7]. Flat Fiber, a planar type of regular optical fiber has been patented by University of Southampton [6]. Flat Fiber is a ribbon like (flat) planar fiber that offers possibilities of an extended length and more flexible substrate than slab waveguide. It also combines the advantages of existing low cost fiber drawing with the functionality of planar light wave circuit. Flat fiber is believed to have the potential for practical applications in the future [4]. Figure 1.3 shows the cross-section of a basic optical fiber, Flat Fiber and photonic crystal fiber.

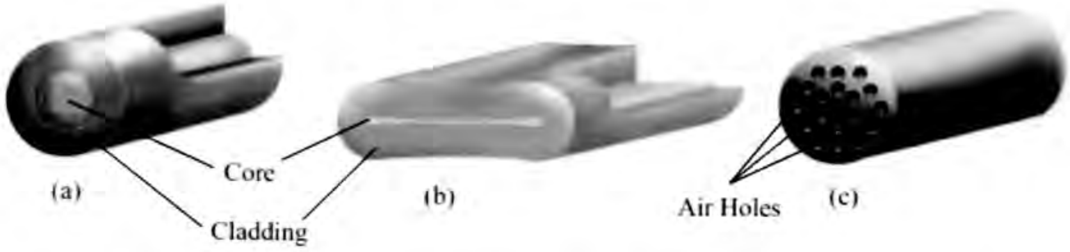

Figure 1.3 (a) Basic optical fiber (b) Flat Fiber (c) Photonic Crystal Fiber

In the table 1.1 shows the comparison between conventional fiber, PCF and Flat Fiber.

Conventional Fibre	Photonic Crystal Fibre	Flat Fibre
Cheap Low loss Almost as strong as steel wire	Have the advantages of conventional fibre High nonlinearity High numerical aperture Design flexibility in core size, shape	Have the advantages of conventional fibre Extended length and flexible compare with planar waveguide Have functionality of planar lightwave circuit

Table 1.1 Comparison between conventional fiber, PCF and Flat Fiber.

Dielectric optical resonators of tiny size are believed for densely-integrated optical components[1]. High-index-contrast micro resonators of low Q are shown, employing microwave design principles, to permit wavelength-sized, low-loss, reflection less waveguide turns and low-crosstalk waveguide crossings. The scrutiny and synthesis of high-Q, high-order micro ring- and racetrack-resonator channel add/drop filters are studied, supplemented by simulation examples. Standing-wave, distributed Bragg resonator filters are additionally described. The discover is fused by a coupled-mode theory approach. Rigorous numerical simulations are validated for the design of high-index-contrast optical "circuits". Consolidated optical constituents are delineated inside a polarization-diversity scheme that circumvents the inherent polarization dependence of high-index-contrast devices. Filters fabricated in intellectual and business scrutiny, and a study of micro ring resonator knowledge, advances and requests are presented.

Integrated Optics has a long past [1,2], yet useful requests of consolidated optics are yet merely a few. Optical constituents in present use are colossal contrasted alongside the wavelength, and this puts a check on their density of integration. By employing constructions alongside a colossal refractive-index difference one could cut the construction size to the order of the optical wavelength. In this check, the constructions resemble microwave constituents that are on the order of a solitary wavelength in size.

Microwave constituents are protected by metallic walls and do not radiate. At optical frequencies we do not own materials alongside the properties of good conductors and hence radiation has to be retained in bounds by proper layout of the structures. Constructions of elevated index difference enable the designer to accomplish radiation quality factors (Q's) that are elevated contrasted alongside the finished (loaded) Q of the structure. The broader the bandwidth of the signals processed by the optical "circuits", the lower is the needed Q. Hence consolidated optics will come into its own in the processing of signals at elevated bit-rates (25 Gb per subsequent and higher). There is a downside to optical constructions of low Q and colossal bandwidth: in order to attain low Q, forceful coupling amid the resonator and the external "access" waveguides is required. This can be attained by transient coupling across extremely slim gaps, but slim lithographically-defined gaps can be a fabrication challenge. Coupled optical resonators can be the basis of wavelength filters alongside flat-top drop reply characteristics that are desirable in telecommunications channel add/drop filter applications. The present state of the fine art permits for the fabrication, in a solitary lithographic pace, of up to sixth-order (or six-coupled-cavity) resonator constructions for 25GHz-bandwidth applications. In difference, business thin-film filters for 25GHz requests are merely obtainable alongside presentation of fourth order resonators, and these need 200-250 dielectric layers to be sequentially deposited.

Microwave design principles are shouted on for the tentative layout of constructions of wanted functionality [3,4]. High-index difference waveguides that prop extremely tiny arcing radii alongside satisfactory radiation defeat are key constituents assisting as both the resonator cavities and the optical interconnects amid assorted structures.

Ring resonators prop degenerate modes of voyaging waves in opposite direction.. If the index difference is elevated, the radii of the rings can be made tiny as maintaining low radiation defeat, thereby bestowing a colossal free spectral scope (FSR). Bragg-reflection resonators own erect wave modes. Two erect wave resonators in cascade can simulate the presentation of a voyaging wave resonator [1]. Radiation defeat is an subject in both cases. In principle, one could considerably cut the radiation defeat of a Bragg resonator by proper choice of core and cladding indices [2], but in exercise the flawless situation can merely be approximated. Band-selective channel add/drop filters could be crafted employing coupled resonators. The filter reply is shaped by the disposition of the resonance frequencies of the coupled resonator arrangement, and its coupling to the external waveguides. Mathematically, this leads to manipulation of the poles of the reply purpose in the complex-frequency plane after engineering the drop seaport response. In the servings that pursue, assorted add/drop filter sketches employing ring and Bragg-reflection resonators are presented. The filter reply is modeled employing coupled-mode theory [5,10-12,26]. Numerical finite-difference Period area (FDTD) simulations gave on the constructions are shown to be consistent alongside this model. The FDTD simulations, seize radiation defeats into report and therefore assist as a check as to the adequacy of the resonator design.

High-index-contrast waveguides own substantial structural birefringence. Hence the reply of the optical routes is normally polarization dependent. As fiber contact requests need polarization autonomy, the mechanism reply have to be made polarization-insensitive. A polarization sensitive reply can be attained by separating the two polarizations of the incoming gesture and rotating one so that both polarizations are processed in identical structures. At the output, one of the polarizations is rotated once more and the two are recombined. This calls for a broadband polarization splitter-rotator. Countless consolidated polarization converters have been counseled [13-16]. The cross-section of high-index-contrast waveguides is tiny and effectual coupling to fibers presents challenges. Ways have been published in the works [2,3]. We present one design established on these proposals.

Figure 1.4 Example of optical filter (Agiltron brand)

Figure 1.5 Example of optical filter (Fianium brand)

1.2 Objectives

The objectives of the project is:

1. To model a single mode Silicon-on-Insulator (SOI) Parallel Cascade Micro ring Channel Dropping Filter using coupled mode theory CMT and transfer matrix method (TMM) based on Matlab software.
2. To study effect of design parameters variations on the performance of Parallel Cascaded Micro Ring Channel Dropping Filter.
3. To Obtain the optimize model for Parallel Cascaded Micro Ring Channel Dropping Filter.

1.3 Problem Statement

Data communications very important in terms to help people finished their task and community nowadays used for entertainment like download movies, play online games , live streaming, chatting , facebooking, and many more. So in term to achieved high speed transmission in large of data, the fiber optic technology is the answer.

There are many types of optical filter in the market and their size are big for regular fiber optic system. Micro-Ring Resonator (MRR) is new technology to replace current optical filter in microchip packet size. In this paper, will discuss about why we used Micro-Ring Resonator (MRR). Also we will discuss about MRR structure , application of MRR, advantages of MRR, features and others.

1.4 Scope Of Project

Final year project will involve Matlab platform. The main purpose of this project is to develop an interface using Graphical User Interfaces in Matlab software. There are no hardware to be used in this project, only the software used.

The project direction is to develop an interface that can simulate a number of parameters in the filter vessel Micro Loop Parallel arrangement using single mode silicon to insulation (SOI) using Matlab code. In this simulation will change the parameter to determine which one is the best combination for optimal results. Design parameters affecting the size of the micro loop, micro-diameter loop, loop micro amount, type and other materials.

The scope of this project is find information related to the project will be designed. Also to understand features and uses on the project especially in micro ring resonator technologies.

1.4.1 Software Design

1. Develop the MRR interface by using Matlab for the tools, source.
2. Involves Transfer Matrix Method (TMM) and Coupled Mode Theory.
3. There will also use the MINITAB and Microsoft EXCELL to analysis data that collect from MRR interface.

1.5 Thesis Plan

The report structure is the detail of the report ingredients or the layout that divided into few chapters. In this reports, there are six chapter were it is introduction, literature review, methodology, results, discussion and conclusion chapters.

First of first, introduction chapter is chapter one. This introduction chapter will cover briefly describe about the background and overview of this project. Besides that, this chapter covers problems statement, objectives, scope of the project, expected outcome and methodology.

Following that, second chapter contains the literature review or research to get information about this project. In order to get the information which is related, there will have many resources can gained from, such as internet, journals, books and etc. Those facts, figure and information that found from the resources will use as references and informative data. This information will used in this project by comparing info and founds the best method and technique that can implement or add in this project.

In chapter three, mainly focuses on the methodology of the way the project is carried out. In here, the step, methods and process of the experiment and planning schedules of projects will discuss more detail. Follow this methodology will get a better view, proper planed work scope and better understanding on project flow.

In chapter four, all the results are observed and all the measurement is recorded. Beside that this chapter will cover the simulation parts by using the proper software. Based on simulation and experiment results, all the data are well recorded.

By that, all the comparison study and analyzing is carried out. The well presentable graph, figure and chart will produce in order to summarized the result part overall. Based on the outcome of all table, graph and chart will be briefly discussed. All testing results are attached with the proper aid of figure and table.

Chapter five is the discussion chapter. In this chapter, the results based discussion will carry out. All the fact and figure is declared with giving proper reasons based on theoretical fact. The interrelationship between the theoretical and practical will detailed. The observed, analyzed, and measured fact is well detailed and declared.