UNIVERSITI PUTRA MALAYSIA

A PASSIVE OPTICAL ADD/DROP MULTIPLEXER (P _OADM) FOR WAVELENGTH DIVISION MULTIPLEXING (WDM) SYSTEM

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BY

RUZITA ABU BAKAR

Thesis Submitted in Fulfilment of the Requirements for the Degree of Master of Science in the Faculty of Engineering
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To my dearest Mom, Husband and Children

Shafizal Maarof

Nuratiqah

Mohd Haikal Fakhrullah

Uzair Ikram

Mohammad Farhan Syazwan

With Lot of Love

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Master of Science.

A PASSIVE OPTICAL ADD/DROP MULTIPLEXER (P_OADM) FOR WAVELENGTH DIVISION MULTIPLEXING SYSTEM (WDM)

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February 2001

Chairman: Dr. Borhanuddin Mohd Ali

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The revolutionary of optical networks is linked to Wavelength Division Multiplexing (WDM) to provide additional capacity on existing fibre. This creates a vision of an all-optical network where all management is carried out in the photonic layer. Optical Add/Drop Multiplexer (OADM) is one of the important components to realize the WDM technology for optical fibre communication systems. OADM functions as the optical sub-system to facilitate the evolution of the single wavelength point-to-point optical network to the WDM networks by selectively removing and reinserting individual channels, without having to regenerate all WDM channels. This thesis presents prototyping of a novel passive OADM called as Passive Optical Add/Drop Multiplexer (P_OADM). This thesis describes the development, characterisation and analysis of P_OADM to be used in WDM system. Two types of P_OADM have been studied; a P_OADM with single channel drop system and a P_OADM with dual channel drop system. The advantages of P_OADM are lower loses, lower cost of production and easier to customise the channels to customers' demand. In this study thorough characterisation on the components has been performed prior to system development and characterisation. The most important parameters explored are functional test, insertion losses, crosstalk, return loss, and wavelength flexibility. The results testified that P_OADM could be used for WDM system by dropping and adding the intended channel. The test result showed that the P_OADM performed within the acceptable range. The insertion lost measured was at 8.28 dB for single channel input test and 10.30 dB for two channels input test. The crosstalk measured at the drop port was 19.90 dB and 20.32 dB at the output port and the return loss was 4.93 dB. The P_OADM can be improved in term of insertion loss using circulator, or combiner but with slightly higher cost.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk ijazah Master Sains.

PENGELUARAN / PENYISIPAN MASUK PEMULTIPLEKS (P_OADM) PASIF UNTUK SISTEM PEMBAHAGIAN PEMULTIPLEKS PANJANG GELOMBANG (WDM)

Oleh

RUZITA ABU BAKAR

Februari 2001

Pengerusi: **Dr. Borhanuddin Mohd Ali**

Faculti: **Kejuruteraan**

Revolusi gentian optik telah dikaitkan kepada sistem Pembahagian Pemultipleks Panjang Gelombang (WDM) untuk menyediakan keupayaan tambahan keatas gentian optik yang sedia ada. Kaedah ini menawarkan satu lagi visi bagi rangkaian gentian optik keseluruhan di mana semua penyelenggaraan dilakukan pada lapisan gentian optik. Untuk merealisasikan teknologi WDM pada sistem komunikasi gentian optik, beberapa komponen-komponen optik telah dibangunkan. Pengeluaran / Penyisipan Masuk Pemultipleks (OADM) telah menjadi satu komponen yang penting. Ianya berfungsi sebagai satu subsistem optikal untuk mendorong evolusi satu panjang gelombang rangkaian optik titik-ke-titik kepada rangkaian WDM dengan memilih sesalur-sesalur individu untuk di keluarkan dan di sisip semula tanpa perlu untuk menjana semula semua sesalur-sesalur WDM. Tesis ini membentangkan satu rekaan contoh ulong pasif "OADM" yang terunggul dikenali sebagai P_OADM. Penyelidikan yang di jalankan ini berfokuskan kepada pembangunan, pencirian dan

analisis P_OADM untuk di gunakan pada sistem WDM. Dua jenis P_OADM telah diselidiki: P_OADM dengan satu sistem sesalur pengeluaran dan P_OADM dengan dua sistem sesalur pengeluaran. Kebaikan yang ditawarkan oleh P_OADM adalah mempunyai kadar kehilangan kuasa yang rendah, kos pembuatan yang murah dan menawarkan kemudahan melanggan sesalur-sesalur menurut permintaan pelanggan. Dalam penyelidikan ini ujian pencirian yang terperinci telah di kemukakan ke atas komponen-komponen yang digunakan, diikuti kepada pembangunan sistem dan penyelidikan keatas P_OADM secara keseluruhannya. Parameter yang penting dipelopori adalah seperti ujian berfungsi, kehilangan sesipan, cakap silang, "return loss" kehilangan kembali dan kebolehlenturan panjang gelombang. Keputusan-keputusan ujian ini telah menunjukkan bahawa P_OADM berjaya digunakan pada sistem WDM dengan pengeluaran dan pensisipan masuk sesalur yang dikehendaki. Semua keputusan ujian didapati dalam lingkungan julat yang boleh diterima. Ujian kehilangan sesipan didapati pada 8.28 dB untuk ujian satu saluran masukan dan pada 10.30 dB pada dua saluran masukan. Ujian bagi cakap silang pada bahagian penurunan didapati pada 19.90 dB dan pada bahagian keluaran adalah 20.32 dB. Ujian bagi kehilangan kembali pula adalah sangat rendah iaitu sebanyak 4.93 dB. P_OADM boleh di perbaiki dari segi kehilangan sesipan dengan menggunakan "circulator" atau "combiner" tetapi dengan kadar harga yang lebih tinggi.

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I certify that an Examination Committee met on 1st February 2001 to conduct the final examination of Ruzita Abu Bakar on her Master of Science thesis entitled "A Passive Optical Add/Drop Multiplexer (P_OADM) for Wavelength Division Multiplexing (WDM) System" in accordance with Universiti Pertanian Malaysia (Higher Degree) Act 1980 and Universiti Pertanian Malaysia (Higher Degree) Regulation 1981. The Committee recommends that the candidate be awarded the relevant degree. Members of the Examination Committee are as follows:

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Date: 02 MAY 2001

This thesis submitted to the Senate of Universiti Putra Malaysia has been accepted as fulfilment of requirement for the degree of Master of Science.

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Date: 12 JUL 2001

DECLARATION

I hereby declare that the thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at UPM or other institutions.

RUZITA ABU BAKAR
Date: 20/04/2001

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LIST OF ABBREVIATIONS

BS	Beam Splitters
BLSR	Bi-Directional Line Switched Ring
DEMUX	Demultiplexer
EDFA	Erbium Doped Fibre Amplifiers
E-ADM	Electronic Add Drop Multiplexer
EXC	Electrical Cross Connect of Electrical Terminal
FBG	Fibre Bragg Grating
FTTH	Fibre To The Home
FDM	Frequency Division Multiplexing
PMD	Polarization Mode Dispersion
PC	Polarization Controllers
MUX	Multiplexer
P_OADM	Passive Optical Add/Drop Multiplexer
OADM	Optical Add/Drop Multiplexers
OXC	Optical Cross Connect
OSNR	Optical Signal Noise Ratio
TDM	Time Domain Multiplexer
TSA	Time Slot Assignment
TSI	Time Slot Interchange
WDM	Wavelength Division Multiplexer
WP	Wavelength Paths
UPSR	Uni-directional Path Switched Ring

CHAPTER I

INTRODUCTION

1.1 Revolution of Optical Communication System and Devices

Optical networks are high-capacity telecommunications systems based on optical technologies and components that provide routing, grooming and restoration at the wavelength level as well as wavelength-based services. The system can be improved further by use of system, which provide additional capacity on existing fibers. In the modern day world, the optical layer has been supplemented with more functionality, which were once in the higher layers. The optical network is proposed to provide end-to-end services completely in the optical domain, without having to convert the signal to the electrical domain. Transmitting IP directly over WDM has become a reality and is able to support bit-rates of OC-192. It holds the key to the bandwidth surplus and opens the frontier of high-speed telecommunication in the new century.

Optical communication systems have reached its sixth generation, with the employment of optical amplifiers [1]. The evolution of optical communications networks is as shown in Figure 1.1. From 1990 to 1997 the data rates have increased four-fold with each upgrade from 155 to 622 Mb/s; then from 622 Mb/s to 2.48 Gb/s. From 1995 to 2005, the transmission capacity has and is expected to increase to 10Gb/s to cover the boom in the network traffic. Carriers can choose whether to transmit 10 Gb/s in a single fibre using Time Domain Multiplexer (TDM) or alternatively using Wavelength Division Multiplexer (WDM) to transmit four 2.5 Gb/s channels on a single fibre [2].

WDM is currently gaining popular supports all over the world as it offers many advantages over traditional TDM systems that transmit only a single channel [3]. Among others, the advantages include a much higher channel capacity, less fibres to be installed, and channel management flexibility. To implement and realize the WDM technology for fibre-optic communication systems, several new optical components are also being researched and developed extensively [4]. Among the important components in the WDM system are multiplexers and demultiplexers, tunable optical filters, wavelength routers, optical cross-connects, wavelength converters, WDM transmitter and receiver and Optical Add/Drop Multiplexers(OADM).

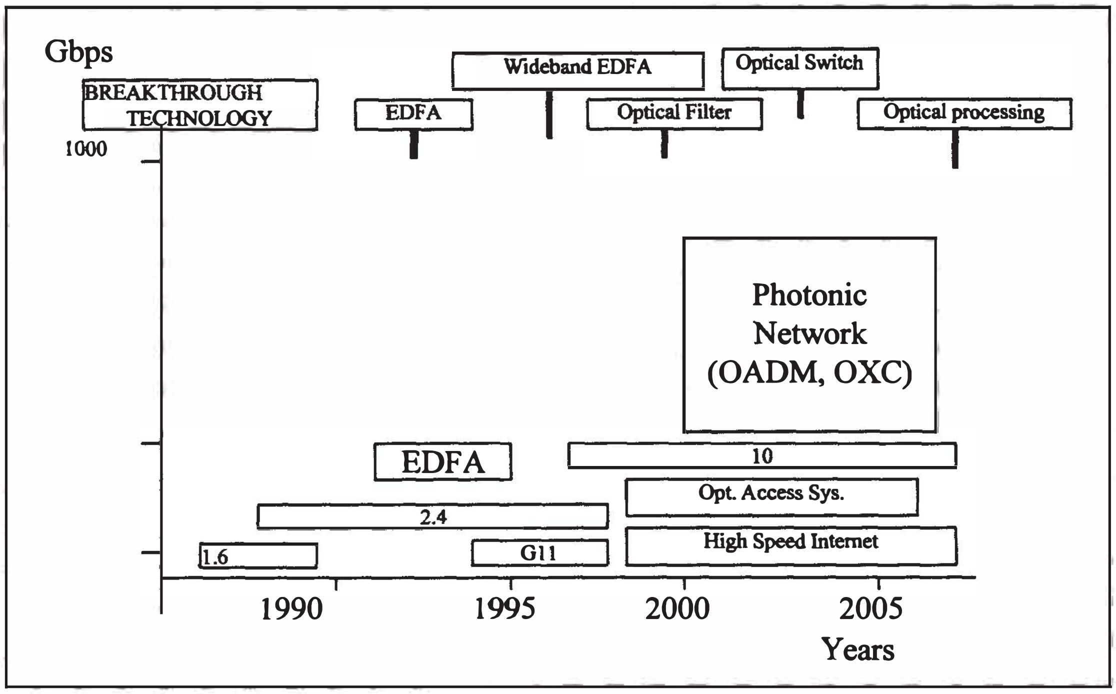

Figure 1.1: The evolution of optical communication networks