

**DESIGN AND ANALYSIS OF WAVELENGTH DIVISION  
MULTIPLEXED PASSIVE OPTICAL NETWORK FOR  
FTTX APPLICATION**

This thesis is presented in partial fulfillment for the award of the  
**Bachelor of Engineering (Hons) Electronics (Communication)**

**UNIVERSITI TEKNOLOGI MARA**

**JULY 2012**



**MOHD SYUKRI BIN MOHD HASHIM**  
Faculty of Electrical Engineering  
**UNIVERSITI TEKNOLOGI MARA**  
40450 SHAH ALAM, SELANGOR

**JULY 2012**

## **ACKNOWLEDGEMENT**

**With the name of ALLAH Most Gracious Most Merciful**

Alhamdulillah, praise to Allah Almighty for giving me the will and strength as I went through this Final Year Project. Peace be upon our prophet Muhammad S.A.W, whose has given light to mankind.

First of all I would like to thanks and showing my highest appreciation to my lecturer as a project supervisor, Puan Suhaila Binti Subahir for her kindness, comments, corrections and suggestions in helping me in the worst moments. I felt mostly indebted for priceless tolerate and assistance I received from her.

I would also like to thank and dedicate this project to my family. To my entire classmates those helping and supporting me, thank you so much for giving the kindness and support. Without your support, I believe that I will have a lot of problem and difficulty to complete the project and this thesis.

Special thanks to Dr. Syuhaimi Abdul Rahman from UKM Bangi, Mr. Romly from TM R&D Cyberjaya, Miss Siti Hajar from UniKL BMI, and Madam Anis Sabirin from UNISEL Selangor because motivate me to do this project.

Finally, thanks to all those who have helped me to complete this project whether it is directly or indirectly. I hope that all the help and the kindness that given to me will get a blessing from Allah S.W.T.

Thanks to all of you.

## ABSTRACT

The steady increase in the bandwidth demand for broadband services has increased the volume of generated traffic in our communication networks. Moreover, a further growth in the number of people that need broadband access is forecasted. Legacy copper based networks are incapable to meet this future bandwidth demands and therefore have motivated the need to implement next generation networks. To answer this is with optical networks and a promising technology for these networks is Wavelength Division Multiplex Passive Optical Network (WDM-PON). This project aims to describe the theories, design, and analysis of a WDM-PON access network based on FTTx application simulated in OptiSystem 7.0. The theoretical part of this project is to study in depth on access networks between Active Optical Network (AON) and Passive Optical Network (PON) and decide which the most optimal option to be implemented. Next, the study will looking into the definition of FTTx networks and its configurations, moving to elaborate about the operating principles of WDM-PON and explanation on device required in the system. The design part was carried out by analyzing the transmitter first either directly-modulated which used WDM transmitter (Tx1) or external-modulated transmitter (Tx2). Tx2 consists of CW Laser, NRZ Pulse Generator, Pseudo-Random Bit Sequence Generator (PRBS), and Mach-Zehnder Modulator (MZM). Finally, the analysis part is to find the maximum length and suitable bit rate in WDM-PON design with up to 8 numbers end user. This is done by observing the quality and performance of signal in subscriber Optical Network Unit (ONU) in terms of eye diagram, Bit-Error Rate (BER), Q factor, and total power. At the end of the project, the performance shows that the maximum bit rate that the system can support is 2.5Gbps whereas for the maximum distance is 18km with 8 numbers of user.

# TABLE OF CONTENTS

CHAPTER	LIST OF TITLE	
	<b>DECLARATION</b>	I
	<b>ACKNOWLEDGEMENT</b>	II
	<b>ABSTRACT</b>	III
	<b>TABLE OF CONTENTS</b>	IV
	<b>LIST OF FIGURES</b>	VIII
	<b>LIST OF TABLES</b>	X
	<b>LIST OF ABBREVIATIONS</b>	XI
	<b>LIST OF SYMBOLS</b>	XIII
<b>1.</b>	<b>INTRODUCTION</b>	1
	1.1 INTRODUCTION	1
	1.2 PROJECT OVERVIEW	1
	1.3 PROBLEM STATEMENT	3
	1.4 OBJECTIVES	3
	1.5 SCOPE OF PROJECT	4
	1.6 THESIS OUTLINE	4
<b>2.</b>	<b>LITERATURE REVIEW</b>	6
	2.1 INTRODUCTION	6
	2.2 OVERVIEW OF TELECOMMUNICATION NETWORK	6
	2.3 ACTIVE OPTICAL NETWORK VS PASSIVE OPTICAL NETWORK	8
	2.4 PON TECHNOLOGIES	11
	2.4.1 Asynchronous Transfer Mode PON (APON)	11
	2.4.2 Broadband PON (BPON)	11
	2.4.3 Ethernet PON (EPON)	11
	2.4.4 Gigabit PON (GPON)	12
	2.4.5 Gigabit Ethernet PON (GEPON)	12
	2.4.6 10 Gigabit PON (10GPON)	12
	2.5 WAVELENGTH DIVISION MULTIPLEXING (WDM)	12

2.6	WDM-PON	13
2.7	MAJOR OPTICAL COMPONENTS OF A WDM NETWORK	15
2.7.1	Optical Line Terminal (OLT)	15
2.7.2	Light Source	16
2.7.3	Optical Network Unit/Terminal (ONU/ONT)	16
2.7.4	Photo Receivers	17
2.7.5	Modulators	17
2.7.6	Multiplexer/ Demultiplexer	18
2.7.7	Splitter	18
2.7.8	Amplifiers	18
2.7.9	Fiber	19
2.8	PARAMETERS THAT EFFECT SYSTEM PERFORMANCE	19
2.8.1	Attenuation	19
2.8.2	Dispersion	20
2.8.3	Non-linearities	21
2.9	FTTx	21
2.10	CHARACTERISTICS OF PERFORMANCE ANALYSIS	22
2.10.1	Eye Diagram	22
2.10.2	Bit Error Rate (BER)	23
2.10.3	Max Q Factor	24
2.10.4	Total Power	25
2.11	PREVIOUS WORK	25
<b>3.</b>	<b>METHODOLOGY</b>	<b>27</b>
3.1	INTRODUCTION	27
3.2	FLOW CHART	27
3.3	SOFTWARE USED	29
3.4	DESIGN STRUCTURE	31
3.4.1	Bank Area	32
3.4.2	Residential Area	33
3.4.3	Office Area	35
3.5	DESIGN OF WDM-PON	36