ANALYSIS AND MEASUREMENT OF OPTICAL FIBER CHANNEL DOUBLER (OFCD)

ABDUL AZIZ BIN ROZI

This report is submitted in partial fulfillment of the requirement for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) With Honors

Faculty of Electronic and Computer Engineering
Universiti Teknikal Malaysia Melaka (UTeM)

April 2010

UNIVERSTI TEKNIKAL MALAYSIA MELAKA

FAKULTI KEJURUTERAAN ELEKTRONIK DAN KEJURUTERAAN KOMPUTER

BORANG PENGESAHAN STATUS LAPORAN

PROJEK SARJANA MUDA II

Tajuk Projek	ANALYSIS AND MEASUREMENTS OF OPTICAL FIBER CHANNEL DOUBLER (OFCD)
Sesi Pengajian	09/10

Saya ABDUL AZIZ B ROZI

(HURUF BESAR)

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)

DECLARATION

"I hereby declare that this report is result of my own effort except for works that have been cited clearly in the references."

Signature : …….

Name : ....…….

Date : …….

SUPERVISOR APPROVAL

"I hereby declare that I have read this report and in my opinion this report is sufficient in terms of scope and quality for the award of Bachelor of Electronic Engineering (Telecommunication Electronics) with Honours"

Signature : …….
Supervisor's Name : ....…….
Date : …….

DEDICATION

To my beloved father and mother

&

My sisters

For your infinite and unfading love, sacrifice, patience, encouragement and

Best wishes

ACKNOWLEDGEMENT

In the name of Allah, the Most Beneficent, the Most Merciful. First and foremost, all praise to Allah for the incredible gift endowed upon me and for give me the health and strength to enable me finish this thesis towards the right track.

I would like to express my gratitude towards my supervisor Mr. Chairulsyah B Abdul Wasli who helped me a lot in guiding me and the advices given from him in the course of this project. May the sky be your limits for your endeavour.

Also, I would like to thank my lovely parents who always supported me from behind for not given up hope in completing this project report. A wish of thanks also to Prof. Dr. Mohd. Adzir Mahdi for helping hands giving tips in using Optisystem Software.

Finally, i would like to thank Mr Aziz Ramli, Mr Yousri Taibin and Mr Naim from Sigtech Sdn Bhd for allowing me visit the company to do measurements as well as the permission to use the OFCD which most important in this project. Without their help, this project may be unsuccessful. Thank you very much.

ABSTRAK

Projek ini dianalisa dan direka untuk mengkaji komunikasi dua arah dalam satu masa yang sama. Dalam projek ini, komponen utama yang digunakan yang berperanan penting ialah OFCD. Komponen-komponen lain dalam komunikasi optik juga dianalisa supaya ianya bersesuaian dalam rekabentuk komunikasi dua arah dimana jumlah kehilangan kuasa diambil kira. Isyarat pantulan yang dihasilkan oleh system ini juga dianalisa. Cakap-silang jalur-inter dan jalur-intra di model dan di analisa di dalam sistem ini. Peningkatan nilai cakap-silang jalur-intra akan menyebabkan peningkatan dalam nilai kuasa tendangan. Sekiranya keadaan ini berlaku nilai kuasa tendangan akan dikira. Pengiraan juga dilakukan bilamana hingar didominasi oleh hingar terma. Keputusan yang diperolehi menunjukkan nilai kuasa tendangan merosot teruk. Untuk mencegah nilai cakap-silang daripada berlaku, penambahan jalur diantara saluran yang hendak dihantar mestilah mematuhi ITU-T piawaian.

ABSTRACT

The report is prepared from the point of view of designing a bidirectional communication link using OFCD. The various components required for the link are discussed here. Also the performance of the link in terms of the loss penalty and the various types of noise produced is also considered. The bidirectional link using OFCD had been studied in terms of the total loss introduced while constructing the link and the loss margin available using the components. The interference caused or the degradation of the forward signal due to the superposition of the other returning signal is taken into consideration. The crosstalk were modeled and analyzed. The power penalty also was calculated. Calculation was also made to calculate the BER, determination of receiver sensitivity that suits bidirectional link. It was found that the power penalty is worst for the thermal noise dominated case. The gain band between the channels to be transmitted should be according to the ITU-T standards to prevent crosstalk from occurring.

LIST OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

APC	-	Angle Polished Connectors
APD	-	Avalanche Photodiode Detector
ASE	-	Amplified Spontaneous Emission
BER	-	Bit Error Rate
C – Band	-	Optical band from 1530 to 1570nm long
CW	-	Continuous Wave
CWDM	-	Coarse Wavelength Division Multiplexing
dB	-	Decibel
dBm	-	Decibel in miliwatt
DFB	-	Distributed Feedback
DSB	-	Double Side Band
DSF	-	Dispersion Shifted Fiber
DWDM	-	Dense Wavelength Division Multiplexing
EDFA	-	Erbium Doped Fiber Amplifier
FB	-	Fabry Perot
FBG	-	Fiber Bragg Grating
FDM	-	Frequency Division Multiplexing
FWHM	-	Full Width Half Minimum
FWM	-	Four Wave Mixing
Gb/s	-	Gigabits per second
ITU	-	International Telecommunication Union
LD	-	Laser Diode
LED	-	Light Emitting Diode
NRZ	-	Non-Return to Zero
OADM	-	Optical Add Drop Multiplexer
OFCD	-	Optical Fiber Channel Doubler
ORL	-	Optical Return Loss
OSA	-	Optical Semiconductor Amplifier

OTDR	-	Optical Time Domain Reflectometer
PIN	-	Positive Intrinsic Negative
PMD	-	Polarization Mode Dispersion
PCM	-	Pulse Code Modulation
PRBS	-	Pseudo Random Bit Sequence
RFSA	-	RF Spectrum Analyzer
SDH	-	Synchronous Digital Hierachy
SMF	-	Single Mode Fiber
SNR	-	Signal-to-Noise Ratio
SONET	-	Synchronous Optical Network
SOP	-	State of Polarization
SPM	-	Self Phase Modulation
STM	-	Scanning Tune Microscope
SWP	-	Spatial Walk-off Polarization
TDM	-	Time Division Multiplexing
WDM	-	Wavelength Division Multiplexing
XPM	-	Cross Phase Modulation

CHAPTER I

INTRODUCTION

1.7 PROJECT BACKGROUND

Optical Fiber Channel Doublers (OFCD) is a totally passive optical device capable of doubling fiber utilization. It converts fiber optics simplex transmission mode (one fiber in each direction) into full duplex transmission (bi-directional transmission in a fiber). This is achieved without wavelength conversions and without power supplies. OFCD is fully developed from passive optical components, which is its main advantage. The maintenance cost is low, the reliability is high. It introduces new era in optical communications system with duplex communication in a single fiber core. OFCD doubles up fiber utilization without compromising the quality of data transmission and performance. Since it is totally passive device, it is easy to be handled with. Hence, this device provides increased services. On the other hand, no power is required to run this device. On top of that, the number of customers which existing fiber will be increased with this application. There are, of course many advantages of using this device which will be discovered on the latter

stage of this project. This project wills analysis the OFCD from the theoretical and measurement aspects. Also find its advantages and disadvantages. The vast is study literature, design, simulate and test. This device actually had been used widely in today's optical communication technology as a result of huge development of DWM and DWDM technology. Generally, simple communication uses two optical cables; transmit and receive, and vice versa. But the advantage of OFCD is the simplicity of transmission line whereby only one fiber cable used.

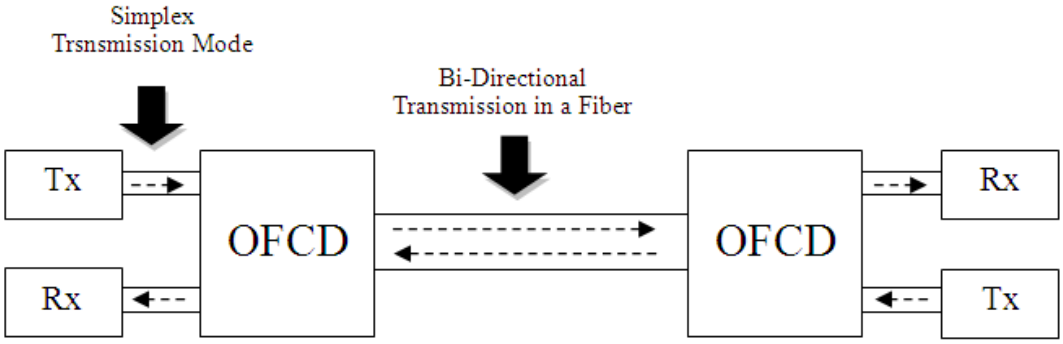

Figure 1.1: Block Diagram of Duplex Optical Communication using Optical Fiber Channel Doubler (OFCD)

The figure above shows the basic duplex communication link using OFCD whereby it uses only one cable fiber. This system is not as complex as usual transceivers system that uses two cable fiber.

1.8 PROBLEM STATEMENTS

Generally, optical communication involving unidirectional line in a fiber which makes up two optical fiber cables to make one connection. If there are many connections to be setup, there will be more cables used. This will increase the cost as the price of optical cable is expensive. To solve this problem, a new device was introduced named Optical Fiber Channel Doubler (OFCD).

The unidirectional communication link system is optically to conduct two ways communication need two fiber optic cables. So, by using two optical fiber

cables for point to point communication is inefficient. This project will save 50% optic cable usage by using an OFCD device.

1.9 PROJECT OBJECTIVES

The objectives of this project that I had underlined are:

i. To analyze the designation of OFCD device

ii. To measure all the parameters which convey the theoretical parts of OFCD

iii. Theoretical study and analysis of duplex optical communication

iv. Simulation of duplex optical communication utilizing single fiber

1.10 SCOPE OF WORKS

Firstly, the project is about literature review studies. Next, the understanding of working principles of OFCD must be taken into accounts theoretically and experimentally. The concept of WDM and DWDM also must be analyzed for as far as these two technologies are concerned and significant to OFCD. All the basic optical communication theoretical parts such as transmitter, receiver, direct detection, digital communication conveying the optical communication and ligthwave communication have to be studied thoroughly. After all the theoretical parts had been studied, the analysis of experiment should be done at SigTech Sdn. Bhd. as the company owned the device. The possible equipment to make measurement are Optical Power Meter, Optical Spectrum Analyzer (OSA) and SDH Analyzer. From the analysis, all the measurement parts need to be done and all the observations include attenuation, insertion loss, excess loss, return loss, polarization dependent loss, isolation, directivity, SNR, centre wavelength and wavelength bandwidth must be manipulated using software, so that it will be clear for presentation to explain all the measurement parts of OFCD. The determination of the receiver sensitivity that suits this link also had been the focus of this project. On

the other hand, the optical power budget must be taken into consideration. The comparison also must be distinguished to show that OFCD is better device for full duplex transmission.

1.11 PROJECT METHODOLOGY

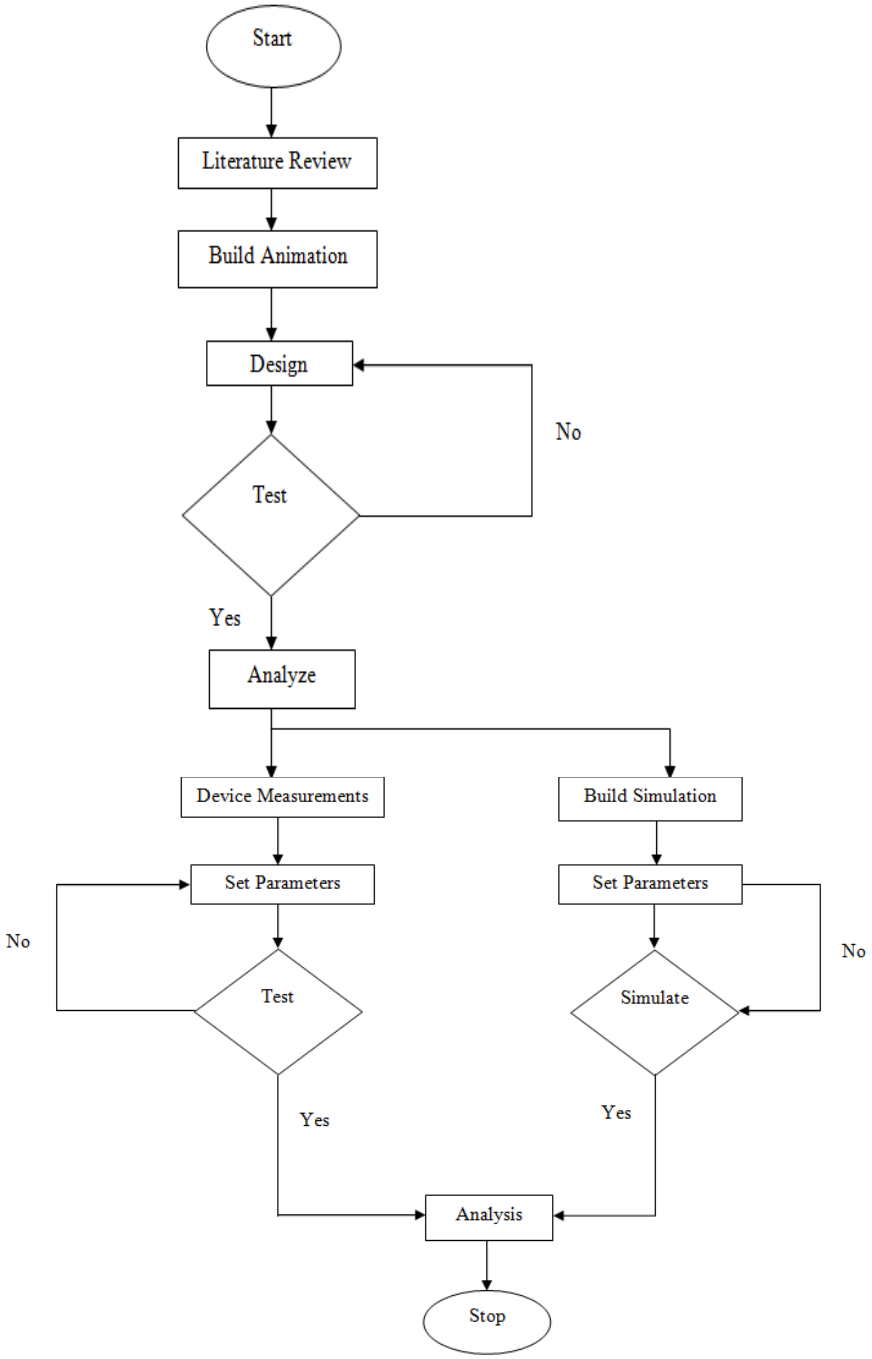

Figure 1.2: Project Flowchart

1.12 EXPECTED OUTCOMES

After the project had been done successfully, the possible outcomes would likely to be the followings:

i. The important parameters of Optical Fiber Channel Doubler (OFCD) as a device that allows transmitted and received signals in one fiber cable
ii. Animation that explains how OFCD works in bi-directional optical communication link
iii. Power measurements at each port of OFCD
iv. Bidirectional link design using OFCD
v. Simulation results of bidirectional link using OFCD

CHAPTER II

LITERATURE REVIEW

2.6 INTRODUCTION

Literature review is important role of any projects as it is fundamental towards completion the research in accordance to gather the information whereas its necessity of a completed project. All the information is collected and studied thoroughly from several of source, such as:

i. Reference Books
ii. Journals
iii. Thesis
iv. Patents
v. Internet
vi. Conference Transcript

After all the necessary information is gathered from those materials stated above, only essential parts are taken into account that related to this project that is

Optical Fiber Channel Doubler (OFCD). The information that is being filtered out will be compiled to be included in this report.

2.7 BACKGROUND STUDY

In any communication system used today, there are two main types of classification distinguished, they are “unidirectional and bidirectional” transmission links. In this project, it is more focused about bidirectional transmission system whereas two transmitted signals to be allowed in one fiber cable. This project also was focusing on the investigation of the possibility of increasing the capacity of transmitted data on bidirectional link.

The main role in this project is Optical Fiber Channel Doubler (OFCD), it plays the most important part in allowing two transmitted signal in one communication link. The device is now used widely in communication system as far as its simplicity for applying it to any types of communication link. With the existence of OFCD, communication system today become more straightforward as it reduces the cost of budget as well as power budget.

OFCD is actually made up of optical circulator which is a passive element that is widely used in the fiber optic system especially involving bidirectional link. The circulator can be used to decouple transmitted and received signals travelling along the same fiber [1].

An optical circulator is a special fiber optic component that can be used to separate powers that travel in opposite directions in one single optical fiber, analogous to the operation of an electronic circulator. An optical circulator is a three port device that allows light travel in only one direction. A further detail of the operations of circulator will be described more on the latter stage of this research report.

Circulator can also be used to achieve bidirectional transmission over a single fiber. Because of its high isolation of the input and reflected optical powers and its