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Design of Point to Point Metro DWDM Network and Its Performance Evaluation

K.Uthayasuriyan and K.Sheela Sobana Rani

***Abstract*—Dense Wavelength Division Multiplexing is a best technology to increase channel capacity and it support for growing bandwidth demands on optical fiber communication. In this technology the optical signal will carry multiple streams of information, each stream as its own unique wavelength. The wavelength effective for DWDM system will be from 1525nm to 1565nm in C Band and from 1570nm to 1610nm in L Band. In this paper we use single mode fiber for length of 110 km at 1550nm to decrease dispersion in signal. The DWDM system analysis is performed using optisystem with flow rate of 10 Gb/s per channel and carried out simulation, EDFA amplifier is used to achieve signal with improved Q-Factor and BER.**

***Index Terms*— Bit Error Rate Parameter, Dense Wavelength Division Multiplexing Network, Erbium Doped Fiber Amplifier, Single Mode Fiber, Quality Factor.**

I. INTRODUCTION

Dense Wavelength Division Multiplexing technology is known as the best technology to transmit optical signals of different frequency (wavelength) in a single optical fiber for long distance communication. With the increasing in traffic rate, the requirement of people depends on quality is higher for communication, so enormous quantity of bandwidth is needed to provide services to the consumers [1].

In DWDM network we can expand the existing network without using new optical fiber. The capacity of the network only varies in end of the systems. By applying 1550 nm or third optical window we can achieve small attenuation in optical fiber.

EDFA amplifier is used to transmit optical signal in a successful way it will amplify the weak signals using laser pumps. Erbium is an element it emits light at wavelength of 1.54µm. Performance of Raman Amplifier is better than EDFA by enlarging the gain bandwidth, eliminating noise and gain characteristics. The combination of both EDFA and Raman Amplifier is under research to utilize the optical bandwidth.

Before planning to design the network we must technically adequate the components like multiplexer, de-multiplexer, and amplifier, for future extension to accommodate changes in network traffic. The basic function of DWDM network is explained in Section II. [2]

Using Simulation software optisystem, a 40 channel point to point approach metro DWDM transmission network model was designed in this paper.

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II. BASIC FUNCTION OF DWDM NETWORK

To avoid loss, the system uses huge bandwidth in fiber. By using the wavelength division multiplexer the signal light source can be send to the single mode fiber with different wavelength for transmission. Each light signal will be spitted depends on carrier signal. SMF fiber is used for long distance communication, for each 50km distance we need amplification for the light signal to achieve the target then it will de-multiplexed and service will be provide to the consumers [3][4].

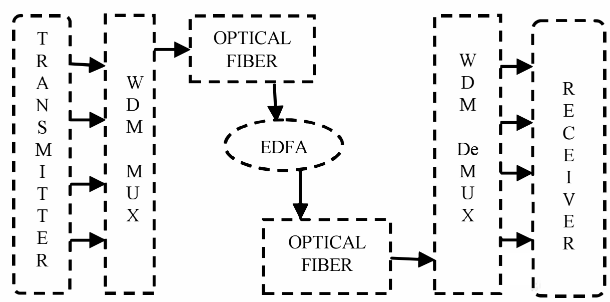

Fig. 1. DWDM System Block Diagram

III. THE 40 CHANNEL DWDM NETWORK

An optical communication system consists of transponder, communication channel and receiver. The function of transponder is to convert a wide pulse optical signal into narrow wavelength of the order of 1.6 nm, then the signals will be send to communication channel. The receiver receives the colored output from the demux and converted into the wide pulse optical signal. The output power level is +1 to -3dBm [5].

A. Transponder

WDM transmitter needs number of transmission lasers to be combined into a single fiber. The type and the number of lasers varies depend on the purpose and application. Here we use WDM transmitter to propagate optical source into a single

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optical fiber, depends on the lambda the laser source will be increased. In DWDM network we can expand the existing network without using new optical fiber. WDM transmitter parameters are shown in Table I.

TABLE I
SPECIFICATION OF TRANSPONDER

Name	Value
Frequency	1555 nm
Frequency Spacing	100 GHz
Power	-5 dBm
Extinction ratio	30 dB
Line width	0.1 MHz
No of O/P ports	40

B. Transmission Line

SMF is a high capacity optical fiber used for long distance communication. SMF was designed for 50Km. After a long haul in optical fiber the signal was attenuated therefore we need a EDFA amplifier. Designing a channel an EDFA was added to equalize the loss after the fiber and near to the receiver. SMF parameter is shown in Table II. In order to calculate the performance based on number of fiber and EDFA spans loop control is used. By using the loop control we can set the number of times the signal will propagate through the components [6] [7].

TABLE II
SPECIFICATION OF SMF

Name	Value
Dispersion Coefficient	16 Ps/(nm-Km)
Dispersion Slope	0.076 Ps/(nm^2-Km)
Non Linear Coefficient	0.35 1/(Km.W)
Linear Loss	0.2 dB/Km
Length	50Km
Attenuation	0.5dBm

TABLE III
SPECIFICATION OF EDFA

Name	Value
Operation mode	*Gain Control*
Gain	*10dB*
Power	*15dBm*
Noise figure	*5dB*
Operation mode	*Gain Control*
Gain	*10dB*

C. Receiver

Optical receiver is a combination of PIN Photodiode and 3R regenerator. It provides the operation on optical fiber communication, which is the important part in fiber optics and depends on the extent will vary. The overall performance of fiber optic communication is depends on Bit Error Rate and Q-Factor. With the standard increase of optical communication in single mode fiber, effects of spontaneous emission and noise in the receiver are partially increasing therefore BER is a important one in optical communication. The important criteria are 10^{-9} for optical receivers. The structure is shown in Fig. 2.

D. Estimation of λ for DWDM network

In the DWDM network estimation of λ is very important. In this scenario, estimation of λ is taken for various cities like A, B and C. the estimation of λ is taken in period of 5 years. For land line users, mobile users, data services, video services λ is estimated. The below TABLE III shown an example scenario of the estimation of λ for DWDM network.

TABLE IV
ESTIMATION OF LAMBDA

Estimation of λ for city A	2009-2014	2015-2019
Land line User	17261	22065
Mobile User	23015	29420
Land line Data Services	5753	7355
Mobile Data Services	11507	14710
Video Services	3452	4413

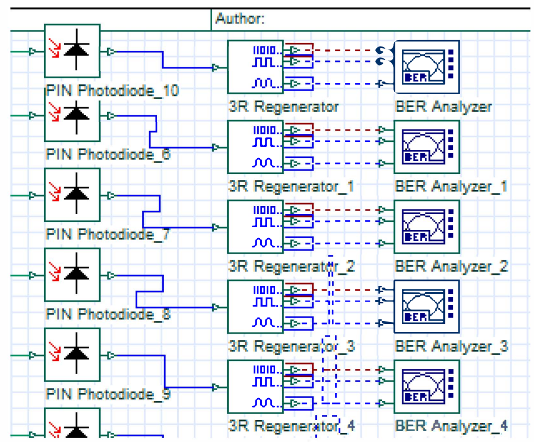


Fig. 2. Structure of Receiver

IV. RESULTS AND DISCUSSION

DWDM system simulation model is shown in Fig 3. In order to control inter symbol crosstalk, 100GHz channel spacing is selected in design [8][9].

A. Spectrum analysis

Optical spectrum analyzer is used to split signals in constituent wave length. The signal is graphically displayed, with power on horizontal axis and wavelength on vertical axis. Spectrum analyzer in the transmitter side and receiver side indicates the spectrum signal of each signal. Each channel the spectrum will be same but it will vary in amplitude due to long transmission. Spectrum signal of transmitter and receiver are shown in Fig. 4, Fig. 5.

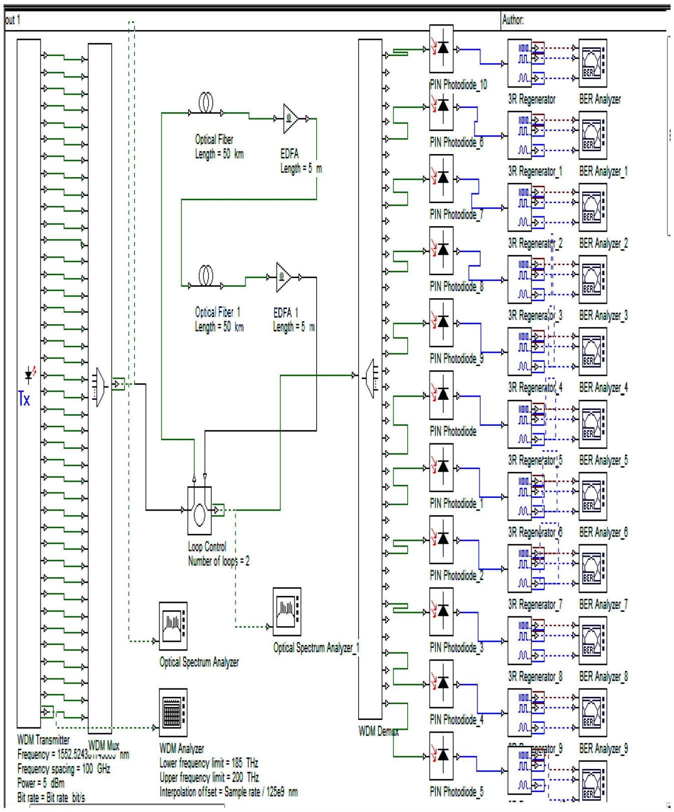


Fig. 3.Simulation Model of 40-Channel DWDM System

B. WDM Analyzer

To verify the system setting here we use WDM analyzer, it will monitor the signal power, noise power, and signal to noise ratio of each channel.

TABLE V TRANSMITTER SIDE SPECTRUM ANALYZER VALUES

Wavelength	Amplitude
Center: 1.5412798485m Start: 1.51897086m Stop: 1.563588836m	Max: -11.48788567dBm Min: -104.2148625dBm

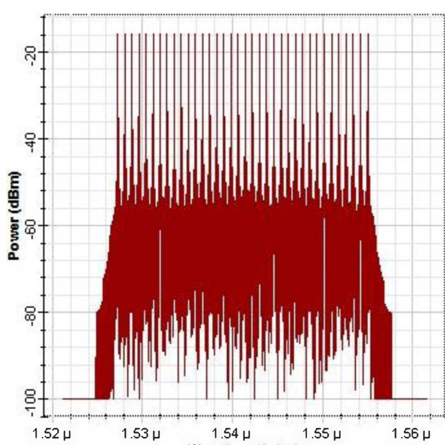


Fig. 4 Spectrum Analyzer of transmitter side

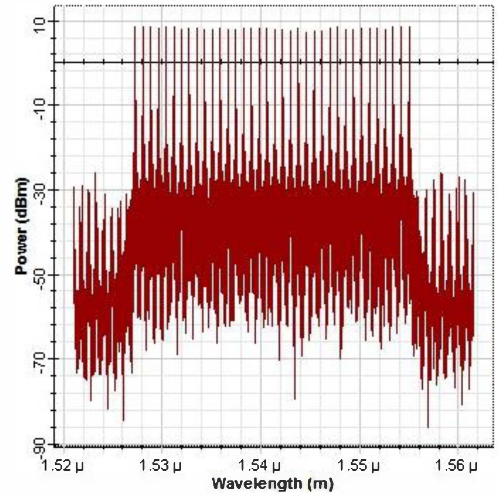


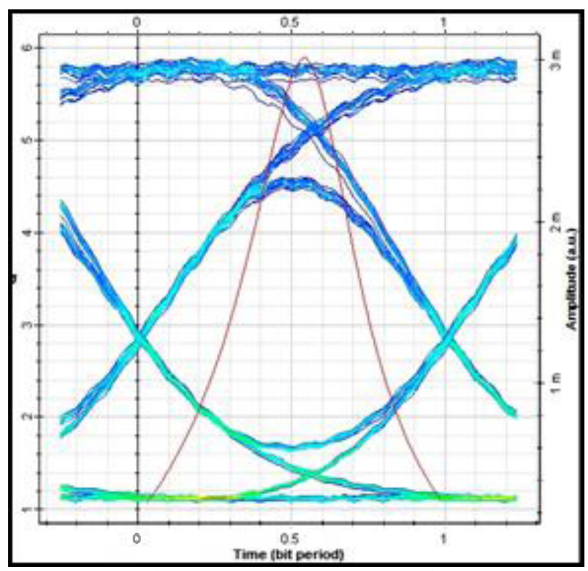
Fig. 5. Spectrum Analyzer of receiver side

TABLE VI
RECEIVER SIDE SPECTRUM ANALYZER VALUES

Wavelength	Amplitude
Center: 1.5412798485m Start: 1.51897086m Stop: 1.563588836m	Max: 13.376644384 Min: -90.89712460

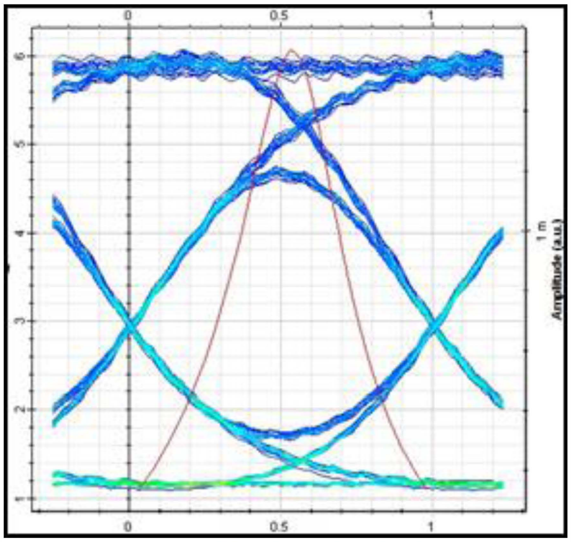
C. Eye diagram analysis

The eye diagram is used to view the performance in digital transmission. The eye diagram provides the instantaneous view by repetitively to achieve good view of its behavior[10].



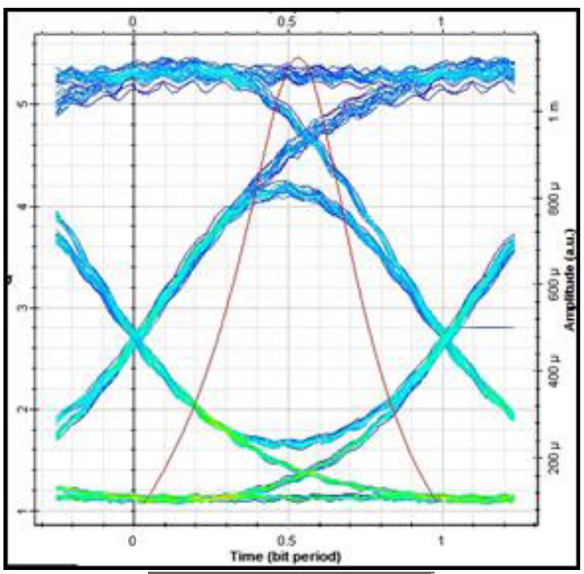
Max. Q Factor	15.7692
Min. BER	3.68362e-009
Eye Height	0.0143276
Threshold	0.0153354
Decision Inst.	0.53125

Fig. 6. Eye diagram analysis of Channel 1



Max. Q Factor	16.06516
Min. BER	6.08531e-010
Eye Height	0.000570498
Threshold	0.000576289
Decision Inst.	0.53125

Fig. 7. Eye diagram analysis of Channel 20



Max. Q Factor	14.74605
Min. BER	4.29252e-009
Eye Height	0.00369511
Threshold	0.00420746
Decision Inst.	0.515625

Fig. 8. Eye diagram analysis of Channel 40

V. CONCLUSION

This paper presents the performance evaluation of Dense Wavelength Division Multiplexing (DWDM) using NRZ modulation schemes. The transmitter section consists of 40 channels, with 5dBm input power and here we use single mode fiber length of 100Km with channel spacing of 100GHz. The Bit Error rate we achieved is 10^{-9} for all channels. DWDM Network of optical fiber communication is designed through optisystem. From the above; WDM transmitter should be used in design of long distance transmission with EDFA and SMF to ensure the communication quality. In future the work will be extended to 80 channel DWDM system and the performance will be evaluated.

TABLE VII
SPECIFICATION OF SMF

Parameters	Proposed Model
No of Channel	40
Q-factor	Channel 1=15.7692
	Channel 4=15.8128
	Channel 8=15.7202
	Channel 12=15.7100
	Channel 16=15.9162
	Channel 20=16.0651
	Channel 24=15.6028
	Channel 28=15.1590
	Channel 32=14.8301
	Channel 36=14.8560
	Channel 40=14.7460
Min. BER	Channel 1=3.68362e-009
	Channel 4=4.02815e-009
	Channel 8=2.89754e-009
	Channel 12=3.5489e-009
	Channel 16=5.2694e-009
	Channel 20=6.0853e-010
	Channel 24=3.5618e-009
	Channel 28=1.5894e-009
	Channel 32=2.5128e-009
	Channel 36=4.0238e-009
	Channel 40=4.2925e-009
Power (dBm)	5
Distance (Km)	100
Dispersion	Negligible

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