Performance Analysis of 64 Channels DWDM System Using DCF for NRZ Modulation Scheme at Different Bit Rate with Various Power Levels

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Abstract

Dense wavelength division multiplexing (DWDM) is a crucial optical system that processes multiplexing many distinct wavelengths toward a single optical fiber. In this article, 64 channels DWDM system model with a dispersion compensation mechanism. The dispersion compensation technique limits the pulse broadening effect of transmitted light in the optical link. To solve the dispersion effect, DCF introduced are modelled, analyzed, and performed to investigate the 64 channels DWDM system using DCF for NRZ Modulation Scheme at Different Bit Rate with various power levels. The proposed model for 10 to 40 Gbps using an NRZ modulation scheme with erbium doped fiber amplifier (EDFA) over 40 to 160 km transmission distance of single mode fiber and 8 to 32 km dispersion compensation fiber (DCF). The performance of the designed model is two different input transmitter power levels in terms of bit error rate (BER), Q-factor, eye height and threshold.

Keywords: Dense wavelength division multiplexing (DWDM, dispersion effect, erbium doped fiber amplifier, bit error rate, Q-factor, NRZ Modulation, Optisystem software.

Introduction

WDM system carries multiple wavelengths in a single fiber. Nowadays very high demand for high data transmission capacity so to analyze the more capacity of the system. We have a new technology, i.e. DWDM system, in DWDM system every channel can transmit data of different bit formats and bit rates, independent of others. Also, each channel has committed bandwidth, every single get to at receiver at the same time without change signals parameters as well as bandwidth. DWDM provides transpiring as a physical layer architectonics, expandable and dynamics equipping. In optical fiber communication, the performance is degraded by dispersion effects and non-linear effects. The difference in group velocity of different modes that occurring dispersion in broadening of pulses in time domain using dispersion compensating scheme in placing alternate fiber sections if negative dispersion values is a key technique. Reduce total collected dispersion while extinguishing most non-linear effects. The positive dispersion of a single fiber can be compensated by the large value of the opposite dispersion of DCF. Which essential low nonlinear effect and low insertion loss.

In standard single mode fiber, return to zero (NRZ) and return to zero (RZ) modulation formats are most commonly used and RZ performs well as compared to NRZ modulation format because of more adversely affected in terms of signal degradation due to Kerr nonlinear effects and chromatic dispersion effect in DWDM system.

In this article, we have simulated the 64 channels DWDM system central frequency of the first channel at 193.4 THz with channel spacing 100 GHz using NRZ modulation format with different bit rates and transmission distance. We have analyzed two different input power levels of the DWDM transmitter is -10 dBm and 0 dBm. EDFA is used as an Optical amplifier for help to boost the optical signal to noise ratio (OSNR), and DCF helps to compensate for dispersion effects. This performance analysis characterization of the system is performed using Optisystem software.

System Modeling and Simulation Setup

The performance of 64 channels DWDM optical fiber communication system is designed at 10, 20, 30, and 40 Gbps per channel transmission speed based on the post dispersion compensation technique. The proposed model is simulated by Optisystem software using NRZ modulation format at different bit rates with various power levels to investigate how dispersion altered the performance of the optical DWDM transmitter system.

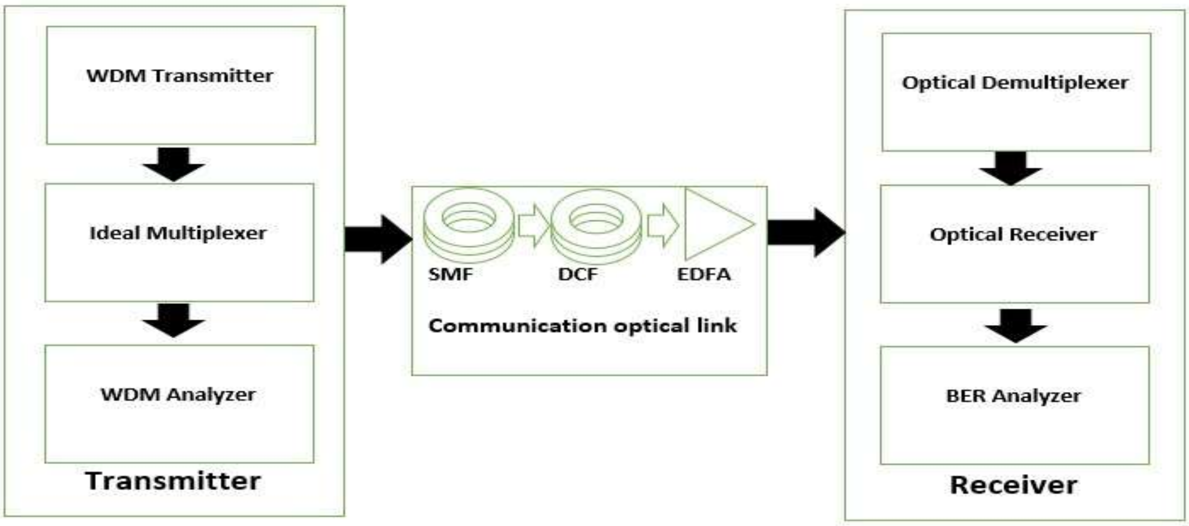


Fig-1 DWDM system modeling

The system model is divided into basic three-section shown in the figure-1. The first section consists of a WDM transmitter, ideal multiplexer, and WDM analyzer. 64 CW laser diode as a source are used for generating various wavelength optical signals with 100GHz frequency spacing. These input optical signals are merged through DWDM multiplexer and allow a single optical fiber consisting of SMF, DCF, and EDFA in the second communication optical link section. The 40km of SMF and 8km of DCF with four loops using loop control. Therefore transmission length is 40km + 8km, 80km + 16km, 120km + 24km, and 160km + 32km using loop control. The EDFA amplifier amplifies the optical signal for batter gain, low insertion loss, and signal capability with an optical link.

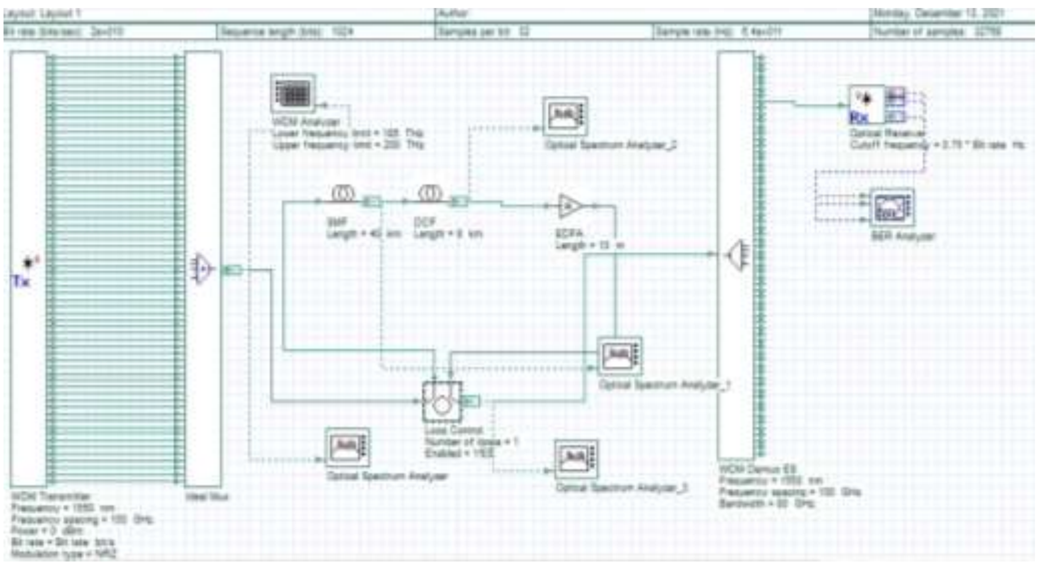


Fig-2 Simulation setup

The last receiver section consists of WDM Demultiplexer to demultiplex the optical signals to 64 different channels. The outputs of demultiplexing signals are given to the optical receiver and pass through the BER analyzer. The whole simulation model of 64x10 Gbps, 64x20 Gbps, 64x30 Gbps and 64x40 Gbps DWDM optical transmission system in figure-2, simulation parameters and fiber parameters in table-1 and table-2 respectively.

Parameters	Value
Data Rates	10, 20, 30, 40 Gb/s
Sequence length	128 bits
Sample per bit	64
Transmitter frequency	193.4 THz (1550 nm)
Reference Wavelength	1550 nm
Input transmitter power	10 dBm
Modulation Extinction ratio	30 dBm
frequency spacing	100 GHz
Communication capacity	64x10 Gbps, 64x20 Gbps, 64x30 Gbps, 64x40 Gbps

Table- 1 simulation parameters

Parameters	SMF	DCF
Fiber Length (km)	40, 80, 120, 160	8, 16, 24, 32
Attenuation (db/km)	0.2	0.5
Dispersion (ps/nm/km)	17	-85
Dispersion slop (ps/nm2/km)	0.075	-0.3
Differential group delay (ps/km)	0.2	0.2
PMD coefficient (ps/nm)	0.5	0.5

Table-2 fiber parameters

Results and Discussion

The performance analysis of the DWDM optical transmission model is simulated on Optisystem software and Q-factor, BER measured by BER analyzer. Therefore a total of 32 simulations are performed using an NRZ modulation scheme with different bit rates (10, 20, 30, and 40 Gbps) and various input transmitter power levels (0 dBm and -10 dBm) to investigate the performance analysis of the proposed DWDM system model.

Theoretically, the acceptable value of the Q-factor is greater than 6 and the bit error rate is less than or equal to 10-9 for the batter optical communication system. After a look over the performance analysis of 64 channels DWDM system with 10,20,30 and 40 Gbps speed per channel for 48,96,144 and 192 km optical fiber link distance with up to the sufficient standards of quality factor and bit rate. The various bit rates correspond to different transmission distances for two different input transmitter power 0 dBm and -10 dBm. Eye parameters (like BER, Q-factor, Eye height, and threshold) are represented in table-3 and table-4.

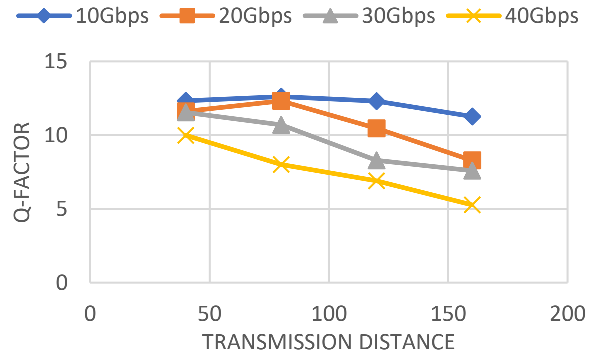
Bit Rate	Transmission Distance		Eye Parameter			
	SMF	DCF	BER	Q-Factor	Eye Height	Threshold
10	40	8	3.04E-35	12.3315	0.00328327	0.0021742
	80	16	8.94E-37	12.6122	0.00329951	0.0021573
	120	24	4.41E-35	12.3013	0.00163991	0.0010948
	160	32	9.59E-30	11.2654	0.00062587	0.0004366
20	40	8	1.64E-31	11.6168	0.00319499	0.0019423
	80	16	3.36E-35	12.3211	0.00322503	0.0018930
	120	24	6.37E-26	10.4617	0.00149506	0.0010598
	160	32	6.00E-17	8.28175	0.00053519	0.0004514
30	40	8	3.90E-31	11.5418	0.00318127	0.0018737
	80	16	5.30E-27	10.6944	0.00291276	0.0019881
	120	24	5.20E-17	8.29905	0.00107751	0.0009229
	160	32	1.62E-14	7.58738	0.00024729	0.0002366
40	40	8	7.75E-24	9.99319	0.00295007	0.0018008
	80	16	6.08E-16	8.00043	0.00260302	0.0021300

	120	24	2.72E-12	6.89224	0.00115151	0.0011651
	160	32	6.91E-08	5.26768	0.00034006	0.0005351

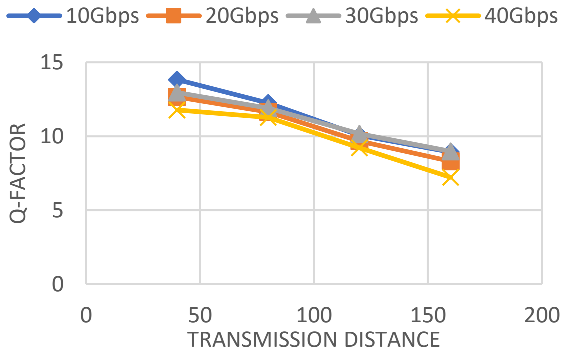
Table-3 For Input Transmitter Power Level -10dbm

Bit Rate	Transmission Distance		Eye Parameter			
	SMF	DCF	BER	Q-Factor	Eye Height	Threshold
10	40	8	8.46E-44	13.8295	0.00438028	0.0031218
	80	16	8.58E-35	12.2479	0.00408483	0.0028446
	120	24	4.17E-24	10.0579	0.00249831	0.0017272
	160	32	2.13E-19	8.92828	0.00139714	0.0010209
20	40	8	5.12E-37	12.6552	0.00423865	0.0028472
	80	16	1.24E-31	11.6422	0.00393454	0.0026345
	120	24	1.94E-22	9.67151	0.00242651	0.0016469
	160	32	4.84E-17	8.30512	0.00127336	0.0009358
30	40	8	1.10E-38	12.9547	0.00421977	0.0029296
	80	16	5.80E-33	11.9005	0.00396473	0.0026858
	120	24	1.46E-24	10.161	0.00244071	0.0017294
	160	32	1.33E-19	8.98169	0.00128613	0.0010994
40	40	8	2.54E-32	11.7768	0.00406609	0.0026979
	80	16	8.87E-30	11.2729	0.00389816	0.0028487
	120	24	1.45E-20	9.2216	0.00238544	0.0018721
	160	32	2.54E-13	7.22165	0.00115014	0.0010913

Table-4 Input Transmitter Power Level 0 dBm.



Graph-1

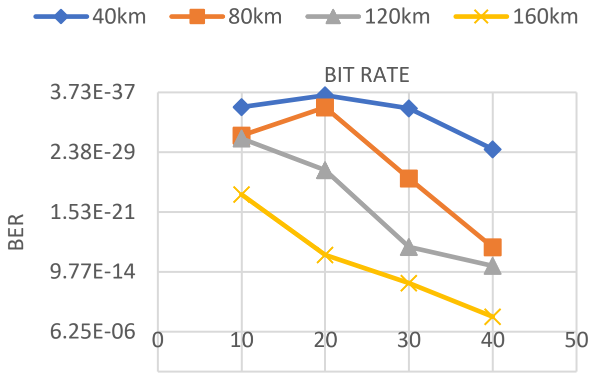


Graph-2

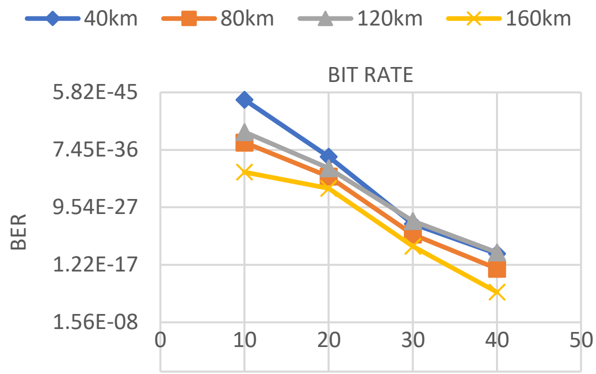
Fig-3 Graph -1 and 2 Q-factor Vs transmission distance with various bit rates for input transmitter power -10 dBm and 0 dBm respectively.

Fig-3 shows both graph Q-factor Vs transmission distance with various bit rates for input transmitter power -10 dBm and 0 dBm and above tables as we increase transmission distance 40km to 160km, the Q-factor decreases, In other word when we increase the bit rate 10Gbps to 40Gbps Q-factor also decreases linearly.

Fig-4 shows both BER Vs Bit Rate with various Transmission Distance for input transmitter power -10 dBm and 0 dBm and above tables as we increase bit rate 10 to 40 Gbps, the BER increases. In other words, when we increase transmission distance 40 to 160km, the bit error rate also decreases.

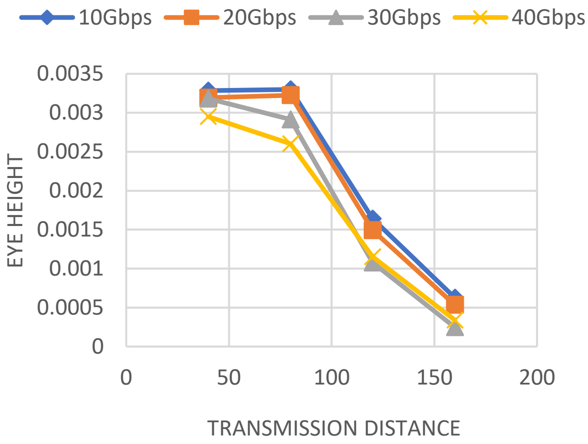


Graph-3

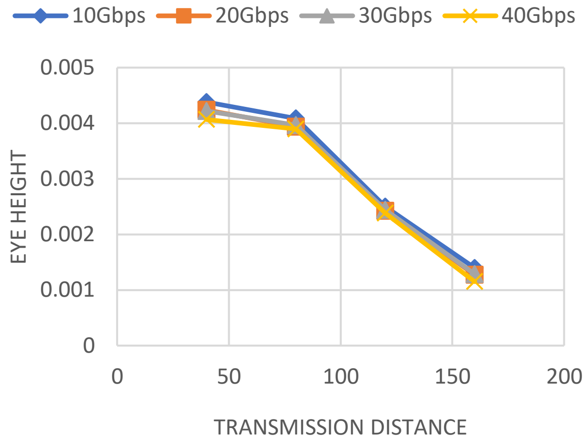


Graph-4

Fig-4 Graph -3 and 4 BER Vs Bit Rate with various Transmission Distance for Input Transmitter Power -10 dBm and 0 dBm respectively.



Graph-5



Graph-6

Fig-5 Graph -5 and 6 Eye Height Vs Transmission Distance with various Bit Rate for Input Transmitter Power -10 dBm and 0 dBm respectively

Fig-5 shows both graph Eye Height Vs Transmission Distance with various Bit Rate for Input Transmitter Power -10 dBm and 0 dBm and above tables. In both power levels, 0 dBm power level gives better performance than -10 dBm in terms of eye height. As we increase transmission distance 40km to 160km, the Eye height decreases. In other words, when we increase the bit rate 10Gbps to 40 Gbps the eye height also decreases rapidly.

Conclusion

The presented work is a performance analysis of 64 channels DWDM system using DCF for NRZ modulation scheme at different bit rates with various input transmitter power levels. The presented model is designed and simulated using DCF having EDFA amplifier concerning to compensate the dispersion effects and attenuation occurrence. The performance of the designed NRZ modulation format is investigate for two different input power levels with various bit rates and lengths of transmission link in terms of Q-factor, bit error rate, eye height, and threshold. Finally, both input transmitter power levels have sufficient performance in terms of eye parameters over NRZ modulation scheme for 10, 20, 30, and 40 Gbps bit rate per channel to obtain errorless transmission over different distances as dispersion reduced to overall simulation. A superior result of 0 dBm input transmitter power level has been observed. A quality factor of 13.8295 and BER of 8.46E-44 as it withholds the optical carrier quality for 10 Gbps bit rate and 40 km transmission distance and increases the value of bit rate and distances in both power levels the eye parameter decreasing linearly. Better value of eye height and threshold shows that ultimately results from reduced dispersion, jitter, and enhanced synchronism in fiber optical communication.

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