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Performance Analysis of 64-Channel DWDM System Using EDFA

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***Abstract*— The Quality Factor, Signal Power and Minimum BER are the key aspects of measuring the performance of an optical system. The purpose of this paper is to find the optimum Launch Power for a 64-bit DWDM system where the above three factors are the most favorable. The system is simulated using Optisystem software to achieve the maximum Quality Factor and Signal Power and at the same time achieve the Minimum Bit Error Rate. Also the Eye Pattern for each case is studied.**

***Index Terms*— Bit Error Rate (BER), Dispersion Compensation Fiber (DCF), Erbium Doped Fiber Amplifier (EDFA), Single Mode Fiber (SMF).**

I. INTRODUCTION

Dense wavelength division multiplexing (DWDM) is a technology that puts data from different sources together on an optical fiber, with each signal carried at the same time on its own separate light wavelength. Using DWDM, up to 80 (and theoretically more) separate wavelengths or channels of data can be multiplexed into a light stream transmitted on a single optical fiber. Each channel carries a time division multiplexed (TDM) signal. In a system with each channel carrying 2.5 Gbps (billion bits per second), up to 200 billion bits can be delivered a second by the optical fiber. DWDM is also sometimes called wave division multiplexing (WDM) [1].

DWDM refers originally to optical signals multiplexed within the 1550 nm band so as to leverage the capabilities (and cost) of erbium doped fiber amplifiers (EDFAs), which are effective for wavelengths between approximately 1525–1565 nm (C band), or 1570–1610 nm (L band). EDFAs were originally developed to replace SONET/SDH optical-electrical-optical (OEO) regenerators, which they have made practically obsolete. EDFAs can amplify any optical signal in their operating range, regardless of the modulated bit rate. In terms of multi-wavelength signals, so long as the EDFA has enough pump energy available to it, it can amplify as many optical signals as can be multiplexed into its amplification band (though signal densities are limited by choice of modulation format).

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EDFAs therefore allow a single-channel optical link to be upgraded in bit rate by replacing only equipment at the ends of the link, while retaining the existing EDFA or series of EDFAs through a long haul route. Furthermore, single wavelength links using EDFAs can similarly be upgraded to WDM links at reasonable cost. The EDFA's cost is thus leveraged across as many channels as can be multiplexed into the 1550 nm band [2].

A single-mode optical fiber (SMF) is an optical fiber designed to carry light only directly down the fiber - the transverse mode. Like multi-mode optical fibers, single mode fibers do exhibit modal dispersion resulting from multiple spatial modes but with narrower modal dispersion.[citation needed] Single mode fibers are therefore better at retaining the fidelity of each light pulse over longer distances than multi-mode fibers.

In double-clad fiber for dispersion compensation, the inner cladding layer has lower refractive index than the outer layer. This type of fiber is also called depressed-inner-cladding fiber and W-profile fiber (from the fact that a symmetrical plot of its refractive index profile superficially resembles the letter W). The bit error rate (BER) is the number of bit errors per unit time. The bit error ratio is the number of bit errors divided by the total number of transferred bits during a studied time interval. BER is a unit less performance measure, often expressed as a percentage.

II. SIMULATION DESCRIPTION

In the above layout, we have simulated a 64-channel DWDM network with RZ modulation format at 40 Gbps. The transmitter section consists of a 64-channel WDM transmitter and multiplexer; the frequency spacing is 200 GHz. We have used a transmission loop as an optical link with a length of 50 km of SMF, 10 km of DCF and two EDFAs. The receiver is a 64-channel WDM demultiplexer, with PIN photo detectors and BER testers.

For SMF of length 50 km and DCF of length 10 km, we have simulated results for various launch powers ranging from 0 dBm to -12 dBm at intervals of 2 dBm. The Q factor, Signal Power and Minimum BER for each case is tabulated and the Q factor curve and Eye Pattern diagram for each case is observed.

It was found out that the launch power of -2 dBm had the maximum Q factor and Signal Power and Minimum BER.

So we kept the launch power constant at -2 dBm and varied the SMF length from 5 km to 100 km and DCF length

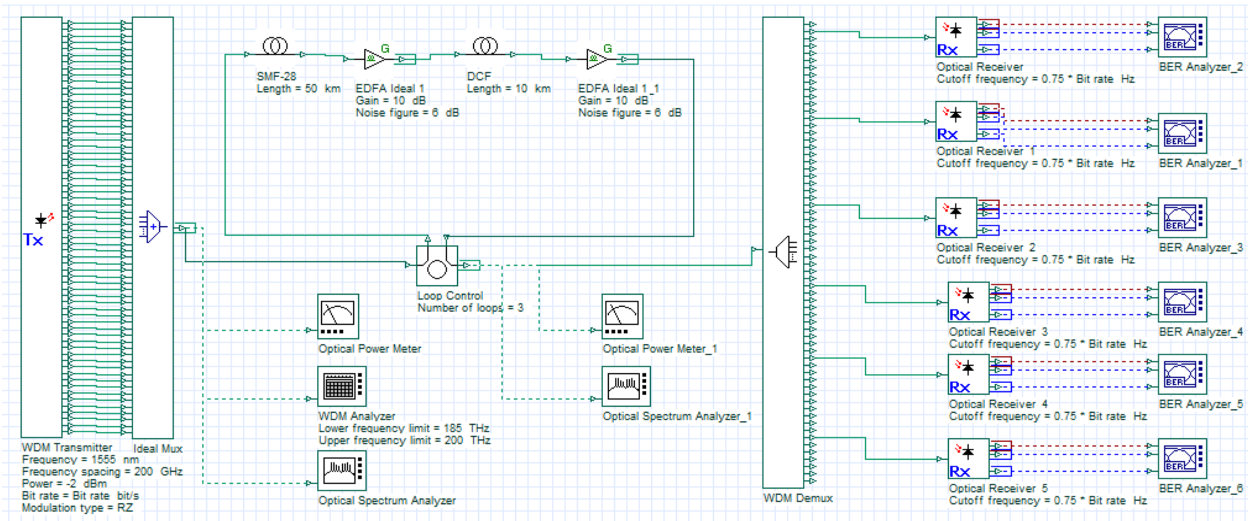

Fig. 1: Schematic Design for 64 Channel DWDM

ranging from 1 km to 20 km. The Q factor and Minimum BER for each case was tabulated.

Table I: Simulation Parameters

Parameter	Values (units)
Transmitter Frequency	1555 (nm)
Power of each channel	-2 (dBm)
Frequency Spacing	200 (GHz)
Modulation Type	RZ
Fiber Length	50 (km)
EDFA Gain	10 (dB)
Bessel Filter Cutoff Frequency	0.75*Bit Rate (Hz)
Number of Loops	3

Table II: Quality Factor and BER at different Launch Power

Launch Power (in dBm)	**Q Factor**	**Signal Power** (in dBm)	**Minimum BER**
0	13.205	13.156	$3.3002\times e^{-40}$
-2	15.9482	11.156	$1.2323\times e^{-57}$
-4	15.2335	9.156	$9.1000\times e^{-53}$
-6	12.2195	7.156	$1.1019\times e^{-34}$
-8	10.4925	5.155	$4.2296\times e^{-26}$
-10	9.0556	3.156	$6.2276\times e^{-20}$
-12	7.7505	1.156	$4.3952\times e^{-15}$

III. SIMULATION RESULTS

The launch power was varied from 0 dBm to -12 dBm and readings were taken at intervals of 2 dBm. The SMF length was kept at 50km and the DCF length was kept at 10km.This was done to find out the optimal launch power where the Q factor and Signal Power are maximum and BER is minimum. Thus the following data observed.

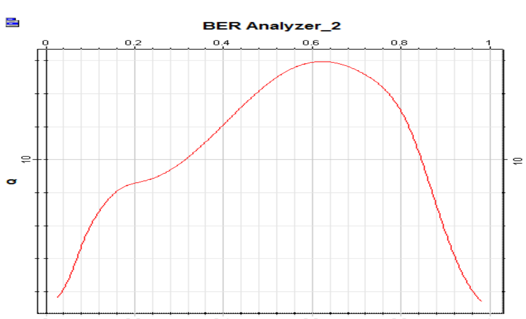

Fig. 2: Variation of Quality Factor with Time

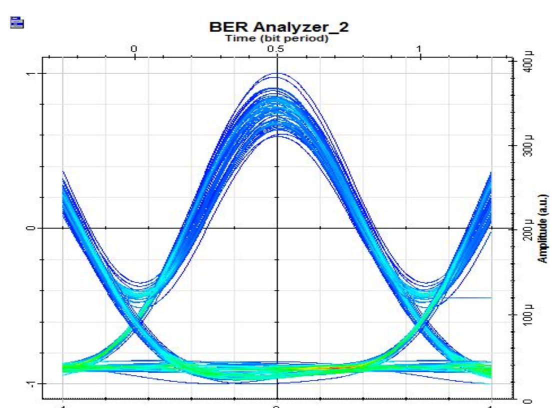

Fig. 3: Eye Pattern

Now, it was found out that the Q factor was maximum at -2 dBm. Thus launch power was kept constant at -2 dBm and the length of the Single Mode Fiber and the Dispersion Compensating Fiber was varied to find out the change in parameters with respect to the change in fiber length.

Table III: Quality Factor and BER at different fiber lengths

SMF Length (in km)	**DCF Length** (in km)	**Q Factor**	**Minimum BER**
100	20	2.6296	0.0042
80	16	8.4658	$1.1983\times e^{-17}$
60	12	13.0454	$2.7371\times e^{-39}$
40	8	17.1500	$2.6301\times e^{-66}$
20	4	18.1291	$7.7755\times e^{-74}$
5	1	20.9020	$2.0777\times e^{-97}$

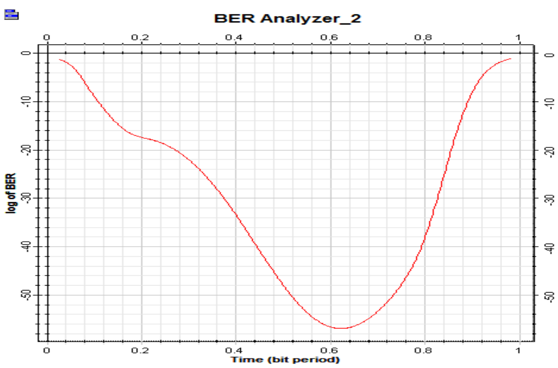

Fig. 4: Minimum BER Curve

IV. CONCLUSION

The launch power of the system was varied from 0 dBm to -12 dBm for each channel keeping the length of the single mode fiber at 50km and that of dispersion compensating fiber at 10km. It was observed that the maximum quality factor of 15.9482 and the minimum bit error rate of 1.2323×e-57 was obtained at a launch power of -2dBm.

It was found that as the Single mode fiber length and the dispersion length fiber length was decreased as the Q factor increased from 2.6296 to a maximum of 20.9020 at a SMF length of 5km and a DCF length of 1km. At the same time the bit error rate was found to be minimum at SMF of length 5km and DCF of length 1km.

DWDM is ready made for long-distance telecommunications operators that use either point–to–point or ring topologies. Operators that are building or expanding their networks will also find DWDM to be an economical way to incrementally increase capacity, rapidly provision new equipment for needed expansion, and future–proof their infrastructure against unforeseen bandwidth demands. The transparency of DWDM systems to various bit rates and protocols will also allow carriers to tailor and segregate services to various customers along the same transmission routes.

Indeed, deployment of DWDM is a critical first step toward the establishment of photonic networks in the access, interoffice, and interexchange segments of today.

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