Performance Analysis Of Power Optimization Over (32channels×40Gb/s) Based On Optical Network

Received : 7/12/2017 **Accepted : 18/1/2018**

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Abstract:

The input power of an optical transmitter is an important key in WDM networks; therefore these leads to a good output signal at the receiver side. In this article, the (32Channel×40Gbps) total of (1.2Tbps) of bandwidth done in a series of computer simulations, with NRZ modulation format over SSMF link with length is (50km), and power optimization are investigated, and their performances. The (BER = 6.1548×10^{-8}), the average optical power level for all channels is (-26.6449dBm) while the average maximum Q-factors for all 32-channels are (5.2669). The best power for our simulation is (2.5118mW).The Kerr effects on WDM networks that were taken into account, also, the dispersion compensation fiber (DCF) are used to compensating the dispersion and the power loss are substituted by Erbium-doped fiber amplifier (EDFA). The simulation results show that data transmission rates are successfully transmitted with low-cost effective infrastructure with good system performance, and minimizing the probability of error for the whole network is of interest, and the system performance is well in the whole network. Our simulation designed, simulated, tested, and verified by Optisystem package is a license product Canadian company.

Keywords*:* Optimization, WDM, BER, SSMF, DCF.

Introduction:

In this digital era the increasing demand for more bandwidth, appears new technologies increasing in clients we need high-speed network to deliver this requirement. An optical wavelength division multiplexing (WDM) network can contribute to, and provide unlimited bandwidth with minimum costs, for all ranges of fiber optics communication systems services such as Internet access, E-society, fiber-to-the-home (FTTH), voice over internet protocol (VoIP), video, and other multimedia interactions. The WDM plays a key role in current, and future optical network solutions due to its modular upgradability, transparency, flexibility, efficiency, reliability, and dynamic light- path allocation protection [1],[2],[3],[4].

Optical systems with data rates of 10Gbps and higher require precise dispersion compensation and careful link engineering. The WDM enables multiple- shift usage of transmission fibers by coupling several wavelengths into the fibers through appropriate optical filters. However, due to the selectivity of optical filters and limitations, in the wavelength stability of semiconductor lasers, the minimum channel spacing is ≈50 GHz in current commercial WDM systems. To deals with good channel spacing as the international telecommunication union (ITU) grids in industry and investigation must be lead to increase optical fiber transmission rate [5],[6].

The WDM innovation represents a revolution within the optical communications revolution, allowing the latter to continue its exponential growth. The existence and advance of optical fiber communications are based on the invention of the laser, particularly the semiconductor junction laser, the invention of low-loss optical fibers, and related disciplines such as integrated optics. WDM technology is progressing in the rapid manner enabled by new high-speed electronics, the potential bit-rate per WDM channel has increased to 40Gbps and higher. The Raman fiber amplifiers (RA), are being employed in addition to the early Erbium-doped fiber amplifier (EDFA), and there are new fibers, and new techniques for dispersion compensation, and management [7,8]. New designs are being explored that take advantage of the fact that WDM has opened up a new dimension in networking by adding the dimension of wavelength to the classical networking dimensions of space, and time [9].

Specifically, WDM is the current preferred multiplexing/demultiplexing technology for long-haul communications in optical communication networks since all the end-user equipment needs to operate only at the bit rate of a WDM channel, which can be chosen arbitrarily, e.g., peak electronic processing speed. Hence, all the major carriers today devote significant effort to developing and applying WDM technologies in their businesses [10],[11],[12]. Also, the inherent of properties transparency of WDM support many data formats, and future protocols without making any changes. Thus, the throughput is limited by the processing speed in the electronic domain. WDM technologies, on the other hand, are based on all-optical MUX/DMUX; thereby enabling construction of WDM networks where node functionality is supported by all-optical technologies without back and forth optical and electronic conversions [13],[14],[15],[16].

Related Works:

Biswanath 2000 [10], “summarized the fundamental optical-networking approach focus on functionalities of a variety of policy and technology implementations”. Killey et al. 2000 [17], “investigate intrachannel nonlinear property in 40Gb/s WDM communication over standard-fiber links. These property were given away to be potentially more destructive than interchannel XPM by optimizing the amount of recompense". Essa I. Essa 2014 [18],"A show analysis of a WDM structure using an EDFA/RA, with exact importance on BER optimization". Ian Roberts and et. al. 2016 [19]," Optimization of channel powers, total capacity in WDM systems is studied. Using a Gaussian noise nonlinearity model, the SNR in each guide is uttered as a convex function of the channel powers allocation provides very little improvement over a traditional flat power allocation ". Ian Roberts, and et. al., 2017 [20], "A sequence of convex optimizations is employed to obtain a locally optimal solution, along with a bound on the degree of sub-optimality. Optimization results obtained are most accurate for Gaussian-distributed signals, such as probabilistically shaped high-order-modulated signals". Koushik Mukherjee 2017, [21],"investigate different gain flatness techniques for EDFA in order to optimize the WDM performance as well as to achieve a given bit error rate (BER), gain flatness and noise figure of EDFA through optimized fiber length and pump power".

Methodologies:

To present the results of power optimization based on WDM optical systems, a performance of a system with multichannel to observe the transmitter waveform at the end side of the receiver. However, if the bandwidth is reduced too much, there will eventually be inter-symbol interference (ISI), as the waveform takes longer to move from one logic level to another. This results in waveform trajectories that begin to close down the eye. Our results are tested, and verified by using OptiSystem 7.0; a licensed product of Optiwave Corporation (Canadian Based Company).

Our design is to simulate a multi-channel WDM system (32×40Gbps). A multiplexer must be added at the transmitter site to combine all the channels so that they can be transmitted through the optical fibers. Respectively, a demultiplexer must be added at the receiver site which will provide the separation of the channels in the frequency domain and they can be analyzed separately. The schematic diagram for this simulation is shown in “Fig. 1”.

Simulation Scenario Configuration:

In the following subsection will present the network units from transmitter to receiver and all components:

The WDM Transmitter

WDM systems require multiple transmitters and different parameters for each of them. In addition, they also require different modulation schemes and formats. By using multiple components, users can customize designs, but it is time-consuming. The WDM transmitter encapsulates different components, allowing users to select different modulation formats and schemes for multiple channels in one single component. Here by, parameters to characterize the MUX/DMUX components have been outlined.

The most commonly used patterns in digital transmission system testing are ($2^N - 1$) with (N = 7, 10, 15, 20, 23 and 31), these patterns have been standardized by the ITU. The multiplexer output is connected to the loop control components in the second stage of the regime with six loops iterations. The transmitter power is optimized for seven values (0.1, 0.2251, 0.4304, 0.7381, 1.1714, 1.7544, and 2.5118) mW.

Transmission Channel:

The transmission span that consists of "segments" i.e. it is periodic. The "Loop control" component will actually perform the multiplication of segments the necessary number of times. The use of segments stems from the requirement of dispersion compensation. At bit rates as high as 40Gbps, the design of the segment is very important. This means that during the propagation, within one segment, not only is there a strong overlap between the adjacent pulses, but the original bit stream will be totally scrambled due to the dispersion-induced pulse broadening. This regime of propagation, known as "pulse-overlapped", is of very high practical importance, since in this case the impact of the nonlinear effects taking place due to the interaction of the overlapping pulses that belong to one and same information channel (known as intra-channel nonlinearities) is reduced. Then, signals entered to the loop control are launched into the fiber link as standard single mode fiber (SSMF). After that, the signal round trip rewards to the loop control and then enters to the receiver side.

The WDM Receiver:

The WDM receiver design consists of (1 to 32) demultiplexer, and "single-channel" receiver connected to each output port. Each demultiplexer output is connected to optical receiver subsystem it contains one low pass filter, and the 3R regenerator used to reshaping signal. The component properties allow the user to select the internal component parameters. Then, each subsystem outputs connected to the bit error rate (BER) analyzer to be monitored the output signals by BER eye diagram and Q-Factor. The optical 3R regeneration with wavelength conversion will prove beneficial in all-optical networks.

As optical signals travel in fiber link, they can be affected by a number of different factors such as dispersion, attenuation interference from other channels, noise etc... These detrimental effects cause serious distortion of the signal which must be repaired at each node. The optical receiver is connected to the bit error rate BER analyzer to monitor and evaluate transmission performance. Layout properties are shown in Table 1**.**

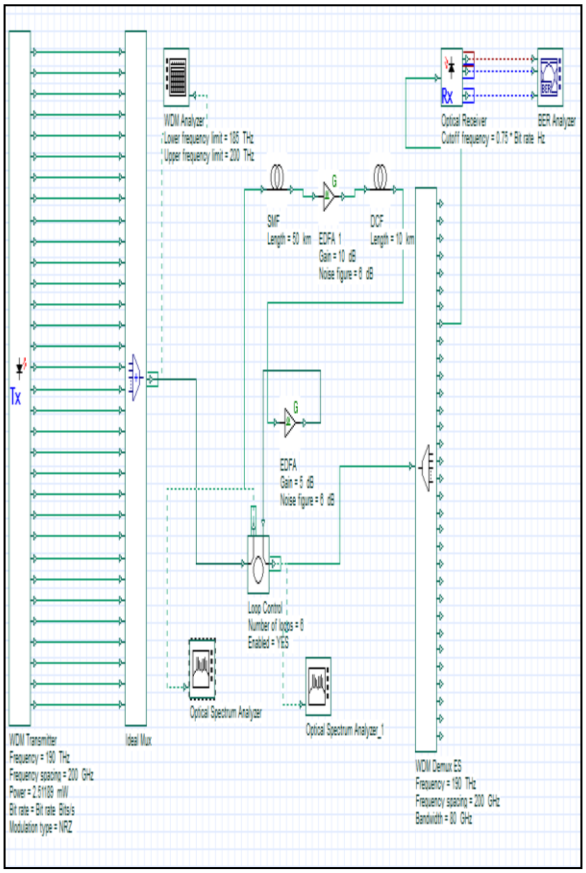

Figure (1): The Main Layout for 32 × 40 Gb/s WDM.

Component	Parameter Name	Value
Fiber	Dispersion	17 ps/nm/km
	Attenuation	0.2 dB/km
	Length	50 km
EDFA	Noise Figure	(6, 6) dB
	Gain	(10, 5)
DCF	Length	10 km
	Dispersion	-85 ps/nm/km
	Attenuation	0.5 dB/km
	Dispersion Slope	-0.3 ps/nm^2/km
WDDM	Channel	32
	Frequency	190 GHz
	Frequency spacing	200 GHz
	Bandwidth	80 GHz
	Depth	100 dB
Optical Receiver	Filter	Low Pass
	Filter Order	4
	Cutoff Frequency	0.7×bitrate
	Photodetector	PIN
WDM Transmitter	Channel	32
	Frequency	190 THz
	Frequency spacing	200 GHz
	Power	(0.1 to 2.5118) mW
	Modulation Format	NRZ
Data	Bandwidth	40 Gb/s
	Sequence Length	64 Bit
	Sample/Bit	256
	Number of Sequence	16384
Wavelength	CW	(1577.85-1527.99)nm

Table 1: Layout Specifications.

Results and Discussion:

Figure. 2 through "Fig. 7" clearly viewed the performance of 32×40Gbps WDM optical system with 100GHz channel spacing and the SSMF is (50km), and the (20km) of DCF. "Fig. 2" to "Fig. 6" will be subsequently described, and discussed:

1) "Fig. 2": Illustrate the input power versus wavelength for 7-iterations; each sketch represents each signal and its power.
2) "Fig. 3": Demonstrate the optical spectral analyzer for all channels when spanning link=0km.
3) "Fig. 4": The optical spectral analyzer for all 32-channels, (red color) power, and (green color) noise added by EDFA after (50km) of SSMF, and the (10km) of DCF.
4) "Fig. 5": Showing the BER analyzer for output channel_8 (191.4THz), after (50km) of SSMF, and the (10km) of DCF, from the BER analyzer, the opening in eye diagram show the output signal is good.
5) "Fig. 6": Showing the Q-Factor for the output channel_8 (191.4THz), after

(50km) of SSMF, and the (10km) of DCF, from the BER analyzer the opening in eye diagram show the output signal is good.

6) "Fig. 7": Show the Q-Factor for the output channel_8 (191.4THz) when span=50km, this worst case.

Therefore, to managing the dispersion in WDM system can be used EDFA to improve degradation in signal. Based on the above figures, the evaluating performance of the system was analyzed using BER; the eye pattern gives a large opening. This means the ISI is low, because the dispersion is constant in SSMF. The width of the opening indicates the time over which sampling for detecting is performed. The maximum eye opening yields the greatest protection against noise. From the BER analyzer, the (BER = 6.1548×10^{-8}), the average optical power level for all channels is (-26.6449dBm), while the average maximum Q-factors for all 32-channels are (5.2669), the total power is (-26.6449dBm), according to the BER analyzer, the best power for our simulation at iteration_7 is (2.5118mW).

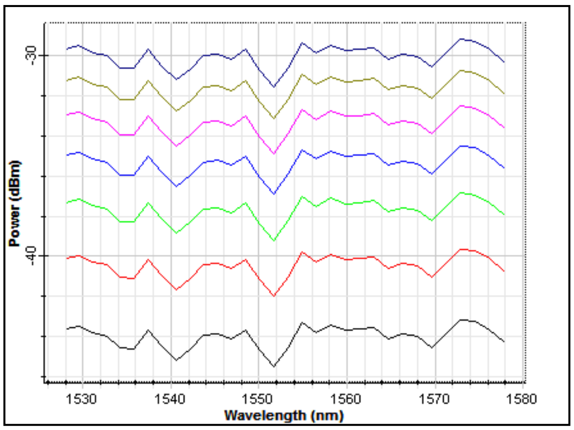

Figure (2): Noise Spectrum for 7-Iterations.

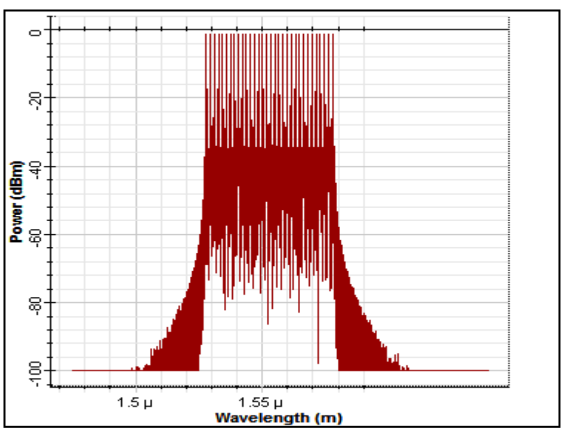

Figure (3): Optical spectral analyzer for all channels when span link=0km.

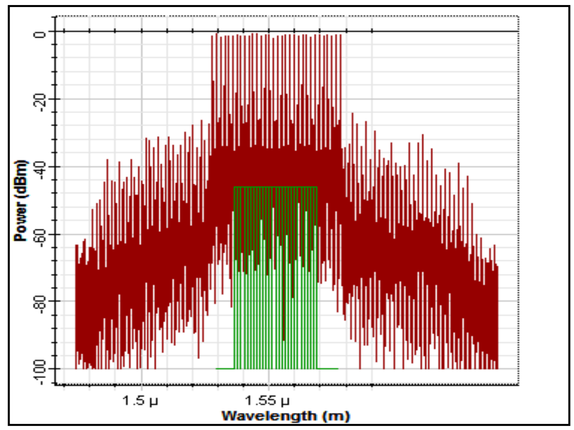

Figure (4): Optical spectral analyzer for all channels when span link=50km.

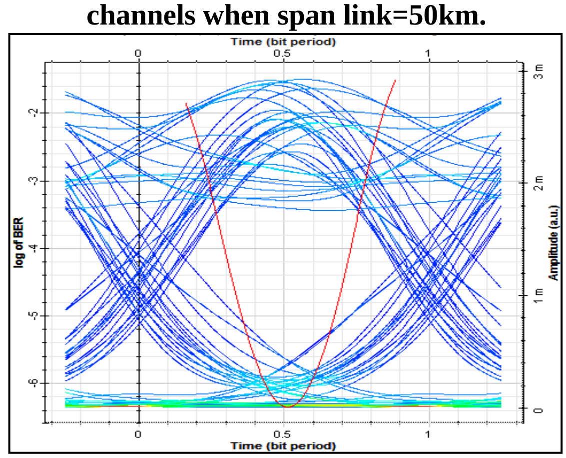

Figure (5): BER analyzer for output channel_8 (191.4THz) when span=50km.

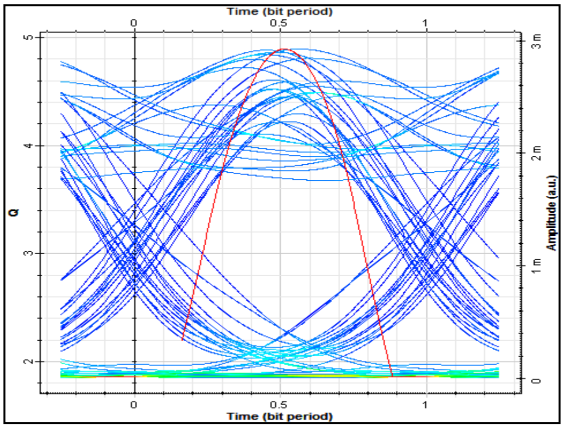

Figure (6): Q-Factor for the output channel_8 (191.4THz) when span=50km.

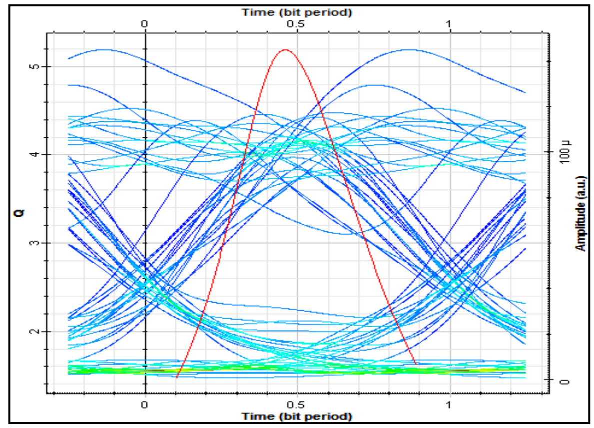

Figure (7): Q-Factor for the output channel_8 (191.4THz) when span=50km, this worst case.

Conclusions:

We demonstrated the input power optimization for (32 × 40 Gb/s WDM) over 50km optical link with minimum system impairments, the presence of (Passive/Active) components should be taken into considerations. The nonlinearities problem and dispersion compensation are managed by an optical amplifier, and dispersion management by DCF as a compensator with the in-line optical amplifiers such as EDFA to improve the optical signal-to-noise-ratio (OSNR), and reduce the nonlinear effects in the transmission system. Simulation results show that a data transmission rates are successfully transmitted, and the WDM systems have good performance, and fully exploit the high speed, low error rate, availability of multiple channels on a single fiber, and the major contribution is the development of the multi-destination communication over the lightwave WDM system. Furthermore, this design is truthfully scalable in terms of usage additional wavelengths or nodes in an effective way.

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