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Improve Quality Factor by Using DWDM Technology for Long Distances and Different Power Levels

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Abstract

In optical fiber communications, data travels from the transmitter to the receiver, where it is collected and converted from optical pulses into electrical signals. The need for bandwidth has grown significantly in recent years. Dense Wavelength Division Multiplexing (DWDM), an advanced multiplexing technology that allows multiple signals to be delivered simultaneously at different wavelengths in the same channel, has been developed to meet the demand for higher capacity and faster data rates. There is a decrease in signal quality as a result of the pulse expansion caused by the scattering. During long-distance transportation, scattering should be minimized. In this research, The DWDM link model uses OptiSystem 18. The DWDM design uses 48 channels, 200 GHz channel spacing, and a bit rate of 40 Gbps for each channel The link length used is 240 and 300 km, using SMF (Single Fiber Mode) and DCF (Dispersion Compensation Amplifier). The research was performed with differences in laser power of 0, 3, and 5 dBm. From the results of the analysis carried out, changes in power changes affect the performance of the system using the MRZ (Mach Zander rate) produced by a CW-10 dB laser. The laser power values correspond to the standard Q-factor and BER (Bit Error Rate) values. The highest Q-factor is 23.266 and BER is 4.66232e-0120, while the lowest Q-factor is 14.9477 and BER is 7.89923e-051. Research has shown The more laser power is used, the better the system's performance.

Publisher : Middle Technical University

Keywords: DWDM; Modified Duo Binary Scheme; MRZ; SMF; DCF; Q-Value; BER.

1. Introduction

The development of internet reach and usage encourages the development of service provision through the transmission of fast data and large capacity, such as cloud-based services over optical fiber. Fiber optics is currently a very good choice to be used as a transmission medium because it has a very large bandwidth capacity and a very fast transmission speed. Capacity optimization in optical fiber is carried out through the process of multiplication of channels in one transmission medium. There are several multiple methods of optical fiber communication, such as TDM (Time Division Multiplexing) and WDM (Wavelength Division Multiplexing), which in the next generation will develop into a technology called DWDM. DWDM technology is considered the most superior as a multiplexing medium because this technology can divide channels into different wavelength regions so that this technology is more accessible than division based on time in TDM [1]. To support DWDM transmission media performance, technique selection delivery such as external modulation and channel encoding can be implemented. There are different types of coding channels, such as NRZ (No Return to Zero) and RZ (Return to Zero). The selection of the coding format is intended so that a high-performance maximum is obtained. Modulation format and channel encoding can have an impact on signal quality, media delivery speed, and dispersion effects [2]. DWDM Technology is a technique for transmission that utilizes light with a wavelength that is used as an information channel. So that after the multiplexing process, the entire length of the wave can be transmitted through a medium optical fiber, but the transmission distance between transmitter and receiver is too far to make the signal power level in the system DWDM decrease. This is certainly very detrimental because of the presence of losses along the path [3]. So it takes an optical amplifier to overcome this because it can amplify signal strength attenuation. The research discusses improving 10 Gbps DWDM optical link performance for optical communication at high speeds. This study discusses the performance of optical links at 10 Gbps DWDM by comparing Q-factor and BER results using 2 types of channel coding. This research uses 32 channels with 100 GHz channel spacing and a length of 50 km of optical link and DCF. In this study, channels 1, 8, and 16 became the Q-factor, and BER parameters were observed. The simulation result is based on the Q-factor and BER better NRZ coding values. It has researched optical amplifiers, hybrid EDFA-Raman, and found that EDFA has better performance in terms of noise figure than the Raman amplifier. According to research, the Q factor will decrease the longer the optical fiber and the higher the bit rate, but it will eventually increase due to the nonlinearity of the optical fiber [4]. Before the transmission, it is extremely important to investigate the system's parameters. At long distances, attenuation and dispersion are two challenges that optical signals face. To overcome this problem, it uses EDFA and DCF. EDFA is extensively used because of its compatibility with optical fiber and also for its low insertion loss and high gain [5].

Nomenclature

DWDM	Dense Wavelength Division Multiplexing	GHz	Gigahertz
Gbps	Gigabit per second	SMF	Single Mode Fiber
DCF	Dispersion compensating fiber	CW	continuous wave
MRZ	Mech-Zehnder Modulator	Q-factor	Quality factor
BER	the minimum bit error rate	TDM	Time-division Multiplexing
WDM	wavelength division multiplexing	NRZ	Non-Return Zero
RZ	Return to Zero	EDFA	Erbium-saturated fiber amplifier
RoF	Radio over Fiber	Nm	Nanometer
DE mux	DE Multiplexer	SONET	Synchronous Optical
SDH	Synchronous Digital Hierarchy	LED	light-emitting diodes
RF	Radio Frequency	PRBS	Pseudo-Random Bit Sequence
ASE	Amplified Spontaneous Emission	PD	Photo Detector
PIN	Positive Intrinsic Negative	Op-Amp	Operational Amplifier

The EDFA operates on a wave band of 1550nm. Fiber also suffers from dispersion due to fiber material, so dispersion has to be minimized by some methods, but installing the DCF is one of the methods to compensate for the dispersion due to SMF. DCF is also more mature and not easily affected by bandwidth and temperature [6]. The MZM was used as an external modulator in the RoF system. Furthermore, they chose the Q-factor as an evaluation metric for their proposed system and based it on (10, 20, and 30) km distances. Furthermore, different extinction ratio ranges ranging from 10 to 30 dB with a 5 dB spacing were considered in the evaluation. The results showed a direct relationship between the extinction ratio and the Q-factor, as well as a reverse relationship between the Q-factor and the distance. The best results were obtained when the extinction ratio and distance were set to 30 dB and 30 km, respectively [7]. DWDM link modeling and simulation using three EDFA schemes, namely booster amplifier, in-line amplifier, and preamps. The results of the research analysis conducted, state that the booster amplifier scheme has performed the best among the three EDFA schemes. Q-factor the maximum value is 7.70079 and BER which is the most optimal value is 5.58823 x 10-15 at length 72 km link, 10 Gbps bitrate, and RZ line coding [8]. perform an analysis of the DWDM system simulation. On sending side uses CW Laser, receiving side uses a PIN detector, and use of EDFA amplifier and Raman on transmission. The simulation is carried out with a distance link are 60, 100, 120, 150, and 170 km. Simulation results stated EDFA had a good performance at a long link of 60 km, while Raman can provide performance that is good at a distance of 150 km [9]. Researchers suggested looking into an RoF-based system with several fiber cable lengths (5, 20, and 60 km) and different channel spacing scenarios. The system consists of four transmitters, with the first channel selected at a frequency of 1552.50 nm and the other three channels separated by 0.4 nm. The bit rate was 1 Gbps, while the chosen bandwidth was 10 GHz. Optisystem software would be used to analyze the eye diagram, Q-factor, and Min BER parameters. In addition, a method for using the optical amplifier to improve the received signal quality for the proposed system after transmission in the case of a 60 km distance was described. The efficiency of the suggested system has enhanced as a result of this optimization [10]. This study discusses the performance of DWDM systems based on Q-factor and bit-parameter BER. Our proposed design model uses a bit rate of 40 Gbps. The design uses 48 channels with external modulation and direct detection. The sender side, uses a CW Laser, while the receiver uses a PPE detector. The channel spacing used is 200 GHz.240, and the 300 km link length consists of 50km of SMF and DCF for 10 km. As for the addition of EDFA, which is used as a signal amplifier in the DWDM transmission system, this research was conducted with power variations on the transmitter side with values of -5, -3, 0, 3, and 5 dBm. Through this research, it is hoped to analyze the performance of DWDM on the Q-factor. parameter and BER simulated via OptiSystem 18.0 software.

2. Architecture

The DWDM technique is used to multiplex optical signals in the 1550 nm band to take advantage of the capabilities (and cost) of EDFAs at wavelengths between 1525 and 1565 nm or 1570 and 1610 nm. The block diagram depicts the DWDM physical layer functions. Fig. 1 shows a four-channel DWDM schematic. Every optical pathway has its wavelength. A wavelength is defined (typically measured in nanometers). A variety of wavelengths can be used. At a given wavelength, the effective light is tightly centered on its central wavelength. The signal is generated by a laser that is solid-state and emits stable light with a narrow bandwidth that transports digital data modulated as an analog signal. When the signals are merged and sent through an optical fiber, they can use a variety of optical wavelengths. Multiplexing and DE multiplexing both have some inherent loss. This is a loss proportional to the number of channels that can be reduced with optical amplifiers by simultaneously boosting all wavelengths without electrical conversion.

Crosstalk has an impact on signal transmission, and optical signal loss must be taken into account in fiber optic transmission. These effects can be mitigated by adjusting variables like channel separation, wavelength tolerance, and laser power levels. Over a transmission link, the signal may need to be optically amplified. The received signals are separated from the multiplexed signals at the receiving end. It is technically more difficult. In addition to these functions, a DWDM system must have client-side interfaces to receive input signals. This function is handled by the transmitter. On the DWDM side, there are interfaces to the optical fiber that connect DWDM systems. A DWDM terminal multiplexer Each data signal includes a wavelength-converting transponder, an optical multiplexer, and if required, an optical EDFA. Each wavelength-converting transponder receives an optical data signal from the transmitting layer, such as synchronous optical networking [SONET/SDH] or another type of data signal, converts it to an electrical signal, and then re-transmits it using a 1,550 nm band laser at a specific wavelength. These data signals are then combined using an optical multiplexer to create a multi-wavelength optical signal that can be transmitted over a single fiber (e.g., SMF-28 fiber). A local transmit function may or may not be included in the terminal multiplexer. EDFA for multi-wavelength optical signal power amplification.

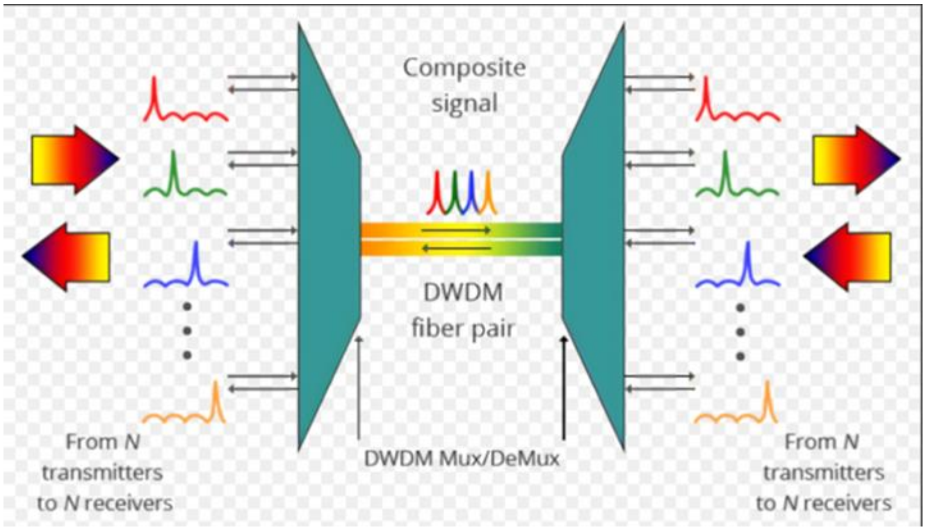

Fig. 1. Block Diagram of DWDM

2.1. Diodes Laser

Lasers generate light by amplifying radiation through stimulated emission. This is known as "Light Amplification via Stimulated Emission." Lasers frequently outperform LEDs in terms of power output. A laser diode's light output can reach 100 mW, allowing it to transmit data over long distances. Lasers also have the narrowest spectral width and the most bandwidth, making them ideal for long-distance fiber optic links. Laser Diode Advantages and Disadvantages.

2.1.1. The Advantages of Laser Diode

- A Straightforward and Cost-Effective Design.
- Excellent Optical Strength.
- Light Production Is Precisely Controllable.
- It Is Resistant to High Temperatures.
- Enhanced Modulation Capability.
- High Coupling Efficiency
- The Spectral Width Is Limited To 3.5 Nm.
- It Has the Capability of Transmitting Optical Output Powers Ranging From 5 To 10 Mw.
- Ability To keep intrinsic layer properties for long periods.

2.1.2. Disadvantages of Laser Diodes

- A speckle pattern appears at the fiber's end as two coherent light beams add or subtract their electric fields based on their relative phases.
- At high transmission rates, the laser diode is extremely sensitive to overload currents. When the laser must operate continuously, a high drive current results in unfavorable thermal characteristics, necessitating the use of cooling and power stabilization.

2.2. Modulation

In telecommunications applications, lasers and LEDs are modulated using either direct modulation or external modulation.

2.2.1. Direct modulation

Fig. 2 shows a laser diode that is used for direct modulation. The output power of the device is directly proportional to the input drive current in this modulation type. This means that when "1 (binary one)" is transmitted, light is emitted from the device, but no light is emitted when "0 (binary zero)" is transmitted. Advantages: This optical modulation is straightforward. It is less expensive because no complex circuitry is used in the modulation process. Disadvantages: This method is slower than indirect or external modulation. It can be used at frequencies lower than 3 GHz.

2.2.2. External modulation

Fig. 3 depicts the use of an external device to modulate the intensity or phase of the light source when it comes to external modulation. The light source remains illuminated while the external modulator acts as a "shutter" controlled by the data being transmitted. External modulation is commonly used in high-speed applications such as long-distance telephone or cable TV headends. External modulation is much faster than internal modulation and can be used with higher-power laser sources. The disadvantage is that dealing with the high-frequency RF modulation signal is more expensive and necessitates complex circuitry.

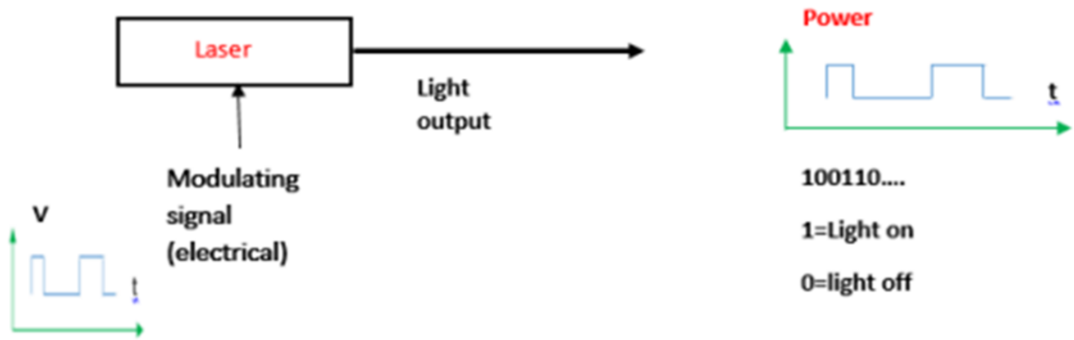

Fig. 2. Laser diode used as optical direct modulation

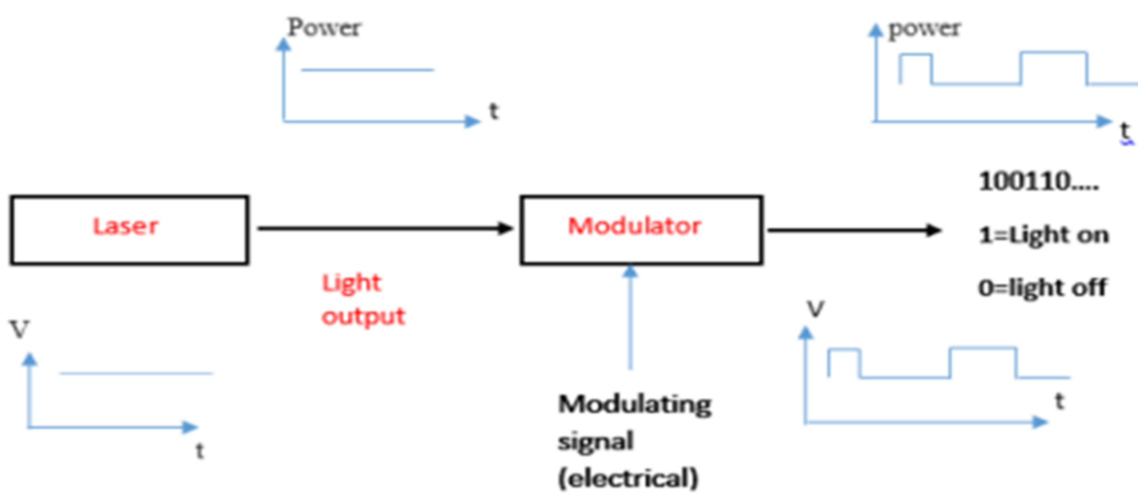

Fig. 3. A laser diode is used as an optical external modulator

2.2.2.1. Pseudo Random Bit Sequence (PRBS) Generator

It is a component that generates a PRBS according to the selected operation modes. Furthermore, the bit sequence is designed to approximate the characteristics of random data. As a result, the output signal here is in binary format. The most important parameters to be considered are the bit rate value and the operation mode selection that is used to control the algorithm used in the generation procedure and have been selected by default to be Order of (k). It is worth mentioning that the selection of Order (k) is used to generate a sequence with a period of 2k-1.

2.2.2.2. *Pulse Generator*

The NRZ generator component is a pulse generator that is used for encoding the bit sequence that has been generated by the PRBS generator. It is a component that is used for the generation of pulses from the previously generated bit sequence. There are several coded signals to be generated. One of the most utilized formats is the NRZ-coded signal. Several important parameters were related to the initialization of NRZ pulses, such as the amplitude, which represents the peak-to-peak amplitude, the bias, which represents the offset of the DC pulse, the position, rise time, and falling time.

2.2.2.3. *Mack Zander Modulator (MZM)*

The Mach-Zehnder modulator is a two-wave interferometer, consisting of two arms, each receiving half of the initial light power. In his arms, a relative phase shift between the two signals is applied using one or two electro-optical cells each arranged in an arm. This phase shift is converted into a variation in the intensity of the optical signal by the interference between the phase-shifted signals from both arms. Fig. 4, the left part, shows a diagram of an MZM. In its ideal form, e MZM is characterized by its described transfer function, in its ideal form, by eq (1).

$$E_s = E_C \ \mathrm{COS} \left[\!\left[\pi \, \frac{(V1-V2)}{(2 \, .V\pi)} \right]\!\right] \, .e^{-i\left[\!\left[\pi \, \frac{(V1+V2)}{(2 \, .V\pi)} \right]\!\right]} \qquad (1)$$

Ee represents the electric field of the input optical signal, continuous because it comes directly from the laser source. Es represents the electric field of the output signal, likely to exhibit amplitude or phase modulation. V1 and V2 are the control voltages of the electro-optical cells, applied to each of the arms of the MZM. An MZM is characterized by its voltage $V\pi$, which represents the voltage, or the differential voltage, to be applied to the MZM to obtain a phase shift of π between the two arms. $V\pi$ is typically about 5 V. For simplicity, we have assumed here that the transfer function has a maximum when the applied voltage differential is zero. However, it is not always the case. Depending on the modulator model, its temperature, and the output channel of the considered modulator, the maxima of the transfer function can correspond to other voltage values. In the remainder of the thesis, if nothing is specified, we will implicitly assume that a zero applied voltage corresponds to a maximum of the intensity transfer function of the Mach-Zehnder modulator. The transfer function in the intensity of the MZM modulator is sinusoidal with a half-period Vπ, as represented in the right part of Fig. 4. In the general case, this transfer function includes a phase term. This term can be likened to chirp. However, if we take V1=-V2, this chirp is zero. "We speak in this case of a "push-pull" configuration, that is to say, we act on both modulator arms oppositely. In this case, the amplitude transfer function is alternately positive and negative. When it is negative, it does not appear in the intensity transfer function, but the change of sign can be likened to a phase shift of the signal. π. The in-phase transfer function of an MZM in configuration "push-pull" is also shown on the right side of Fig. 4. To perform an electro-optical modulation by Mach-Zehnder, the signal electrical input is first amplified using an amplifier microwave, which generally gives an amplitude equal to Vπ or 2Vπ depending on the format to be generated. This electrical input signal is applied to the MZM at a voltage called the bias voltage, or bias Vb (bias in English). The bias is a parameter determinant in the same way as the amplitude of the electrical signal, which strongly influences the characteristics of the modulated signal. All the modulated optical signals that have been studied during this working thesis, whether numerically or experimentally, have been obtained using these Mach-Zehnder modulators.

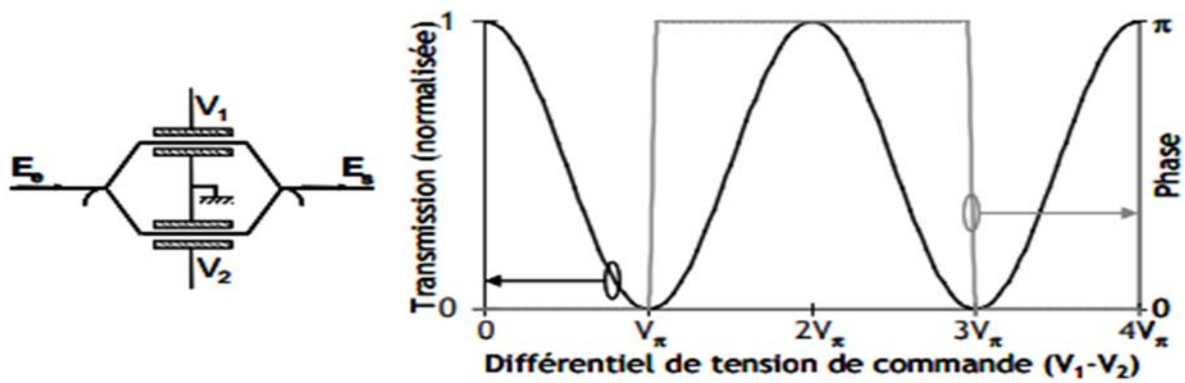

Fig. 4. Block diagram of a Mach-Zander modulator (left) and its function of intensity and phase transfer (right) in push-pull configuration

2.3. The optical amplifier

2.3.1. Single-Mode Fiber

Geometric optics cannot be used to model a fiber with a core diameter of fewer than ten times the wavelength of the propagating light. It must instead be analyzed as an electromagnetic structure through the solution of Maxwell's equations as reduced to the electromagnetism wave equation. Electromagnetic analysis may also be required to comprehend behaviors like speckles that occur when coherent light propagates in a multi-mode fiber. The fiber, as an optical waveguide, supports one or more confined transverse modes through which light can propagate along the fiber. Single-mode or mono-mode fiber is a fiber that only supports one mode. The wave equation can also be used to model the behavior of larger-core multi-mode fibers, demonstrating that such fibers support more than one mode of propagation (hence the name). If the fiber core is large enough to support more than a few modes, the results of such multi-mode fiber modeling roughly agree with geometric optics predictions. According to the waveguide analysis, the light energy in the fiber is not completely confined to the core. Instead, a significant portion of the energy in the bound mode travels as an evanescent wave in the cladding, particularly in single-mode fibers. The most common type of single-mode fiber has an 8–10 micrometer core diameter and is intended for use in the near-infrared.

2.3.2. Erbium-doped fiber amplifiers (EDFA)

These amplifiers are widely used in systems currently in use, and they are still widely studied in the field of research. The EDFAs have allowed, when they appeared, to significantly increase the capacity of the systems' optical transmission. Their principle is based on stimulated emission. The Erbium Er^{3+} ions introduced into the doped fiber are excited using a continuous pump signal at 980 nm or 1480 nm, and thus find themselves at a higher energy level, depending on the wavelength of the pump. After a first thermal de-excitation towards an intermediate level, the Erbium ion can return to its ground state in two different ways: through spontaneous emission or stimulated emission. If hede-excites by spontaneous emission, it emits a photon of energy corresponding to the energy difference between the two levels. If it de-excites by stimulated emission, this must first be induced by a photon from an incident optical signal, in this case, the optical signal that we are trying to amplify. This photon interacts with this exciting Erbium ion, which thereby de-excites by emitting a photon identical to that of the incident signal and which contributes to the amplification of the signal. The Erbium ion is particularly suitable for carrying out this amplification operation by emission stimulated because the energy differences between its quantum states are comparable to the energy values corresponding to the wavelengths of the telecom window.

At the level of an EDFA, the optical signal is amplified thanks to stimulated emission-induced signal photons on Erbium ions. But erbium ions also generate optical power through spontaneous emission. This is emitted randomly, and a fortiori is not correlated with the incident signal. It is therefore a source of optical noise. Moreover, this noise, once generated, also propagates with the amplified signal in the fibers located after the amplifier and will be amplified just like the signal in the amplifiers that will follow in the line and which will also generate their contribution to this spontaneous emission noise. This parasitic contribution due to the emission of spontaneous noise of EDFAs, which increases during propagation, is called emission noise amplified spontaneous emission or ASE (Amplified Spontaneous Emission) noise. It is one of the fundamental limitations faced by transmission systems, which predominates when the optical signal is of low power. We will discuss this in the following paragraphs.

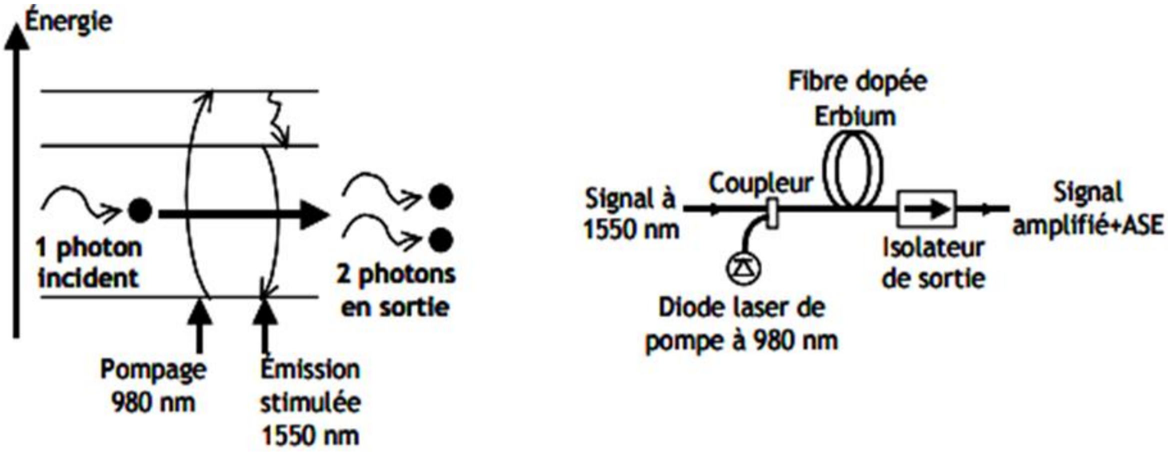

Fig. 5. Operating principle and diagram of an Erbium doped fiber amplifier

2.3.3. Dispersion Compensation Fiber (DCF)

The core radius of conventional SMF is large (5–6 m), and zero dispersion occurs around 1300 nm. Operation around 0 at 1300 nm results in very low pulse broadening, but higher attenuation than at 1550 nm. To take advantage of the low-loss window around 1550nm, new fiber designs with zero dispersion around the 1550nm wavelength region were developed. These fibers are known as Dispersion Compensation Fibers (DCF) and have a core with a triangular refractive index profile. In silica-based fibers, DCFs operating at 1550nm can achieve zero dispersion and minimal loss.

2.4. Receiver Part This part will include the following components

2.4.1. DeMultiplexer (DEMux)

On the receiving end, a multiplexer is frequently used in conjunction with a complementary demultiplexer. When multiple traffic channels need to be transported between multiple sites, these mux /demuxers maximize the use of dark fiber while minimizing operating costs. An inverse multiplexer, also known as a demultiplexer, divides a data stream into multiple lower data rate communication links. An inverse multiplexer differs from a demultiplexer in that its multiple output streams are interconnected, whereas the latter's are not. In contrast to a multiplexer, an inverse multiplexer divides one high-speed link into multiple low-speed links, whereas a multiplexer combines multiple low-speed links into one high-speed link. Demultiplexers, for example, are used to combine several Integrated Services Digital Network (ISDN) channels into a single high-rate circuit when a higher rate connection than a single ISDN connection is required. This is especially useful in areas where higher-speed circuits are unavailable. An alternative to an inverse multiplexer is to use three separate links with data sharing between them. Packets in IP networks could be sent in round-robin mode.

2.4.2. Photo Detector (PD)

A photodetector is a device that converts the signals from the light form into electrical forms so they can be amplified and processed. The PD is as essential an element of any fibre optic system as the optical fibre or the light source. PDs can dictate the performance of a fiber optic communication link. The semiconductor-based photodiode is the most utilized detector in fiber optical systems. for several reasons related to its lower cost and smaller size. Furthermore, the most common type of semiconductor utilized is the PIN PD, which can be seen in Fig. 6. Quantum Efficiency, Responsiveness, Response Speed, Bandwidth, and Noise Equivalent Power (NEP) are all characteristics of PIN PD.
PIN PD is reverse-biased and has an intrinsic (higher doped) semiconductor region between a p-doped and an n-doped region, as shown in Fig. 7. Because there are no free charges in the (i)-region, it has a higher resistance and receives the majority of the reverse-biased voltage. Because the (i)-the region is usually wide, incoming photons have a higher probability of absorption there than in the (p) or (n)-regions.

Fig. 6. PIN Photo Detector

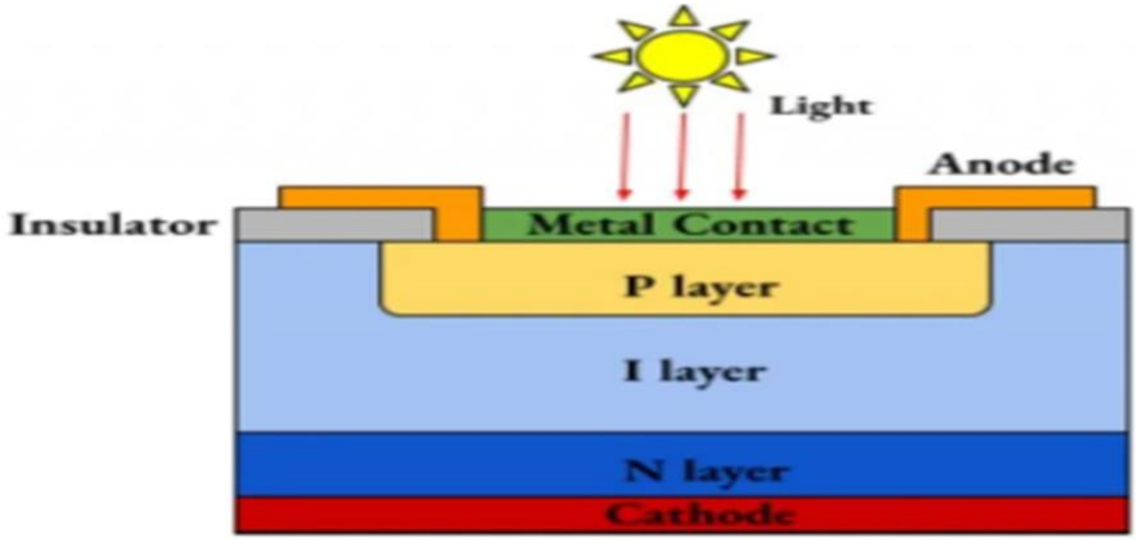

Fig. 7. PIN Semiconductor regions

2.4.3. Filter

A stopper A frequency selective circuit, commonly referred to as a filter circuit, is a kind of circuit that is employed to remove some input signals based on their frequencies. Depending on the type of filter being used, a filter circuit permits some frequency signals to flow through without attenuation or amplification while attenuating others. The two main categories of filters are optical filters and electrical filters. And under these two branches, there would be a wide range of types to be utilized based on the proposed application. Furthermore, based on their concentration, there would be two types, which are passive and active filters. For the first type, as it's known, would use passive components such as capacitors, resistors, and inductors, which don't need any external source of energy. Meanwhile, for the second type, it would make use of the same passive components along with the other active-based components such as the Operational Amplifier (Op-Amp) and the transistors. The most important parameter to be handled by utilizing the filters is the cut-off-frequency value.

2.4.4. The BER analyser

Is used to calculate the BER of the received signal and the quality factor, as well as to display the eye diagram. The proposed system is depicted in Fig. 8. It is used to demonstrate the effect of fog, rain, and snow on the operation of the optical communication system. The Optisystem simulator is used to validate the schematic model. Considering the turbulent atmosphere, the proposed system is also compared to the traditional DWDM-SISO. The received signal's quality factor is calculated under various weather conditions by varying the transmission distance between the transmitted and received stations. As shown in Eq 2, the quality factor is related to BER.

$$BER = \frac{1}{2}\ \text{erfc}\left[\!\left[\frac{Q}{\sqrt{2}}\right]\!\right] \approx \frac{1}{\sqrt{2\pi}}\ .\ \left(\frac{e^{\frac{-Q}{2}}}{Q}\right) \qquad (2)$$

Where:
BER denotes the bit error rate of the received signal and Q denotes the received signal's quality factor.

3. System Model Modification

Fig. 8 depicts the schematic diagram of the high-speed DWDM-based optical transmission system. OptiSystem software is used to simulate the introduced model. 48 channels with a channel spacing of 200 GHz are multiplexed and transported over an optical link in this work. Each channel can transmit data at a rate of 40 Gbps. The 50 Gbps data is encoded with a modified Duo binary encoder and optically modulated with a Mech Zender modulator (MRZ) derived from a CW laser with a power of (5 dBm).
Any communication system is divided into three parts: the transmitter, the communication channel, and the receiver section. The transmitter section of this system consists of three components: the WDM transmitter, the ideal MUX, and the WDM analyzer. The WDM system transmitter generates laser signals of a particular wavelength. The multiplexer couples different wavelengths together before combining them into SMF. The EDFA is used to increase profit. For long distances, the EDFA is used. A DCF is used to reduce the effect of dispersion, with a 0.5 dB/km attenuation. A demultiplexer is used on the receiver side to distribute the optical signal to wavelength selectors. The optical signal is received using an optical receiver, and the simulation results are visualized using a BER analyzer in terms of q-factor, BER, and so on.

4. Simulation Setup Model

At 40 GB/s, a 48-channel DWDM network with RZ modulation formats was simulated. The transmitter is a 48-channel WDM transmitter with a starting frequency of 1550nm and a frequency spacing of 200GHz. A transmission loop with a length of 50 km of SMF, 10 km of DCF, and two EDFAs was used as an optical link here. The receiver is a 48-channel WDM de-multiplexer with PIN photodetectors and BER testers. The 48-channel multiplexer has been used along with DCF and the general optical fiber. Optical amplifier gain was increased by up to 20 dB. The frequency spacing of the wavelength is 200 GHz. A WDM transmitter is used to transmit the signal in an ideal mux. Then, passing through the control loop after it was separated Signals are passed through an optical fiber. Two types of optical fiber are used here. One is a single-mode fiber and the other one is a dispersion-compensating fiber. Then it was demuxed by WDM. After de-muxing the wavelength, it goes to the photodiode. BER optical receivers are used to receive the signal from the WDM de mux output displayed by the BER analyzer. The BER curve is displayed on the graph. The waves are distributed uniformly when output is high and the quality factor value creases. If the quality factor value increases, the signal transmission rate will be high.

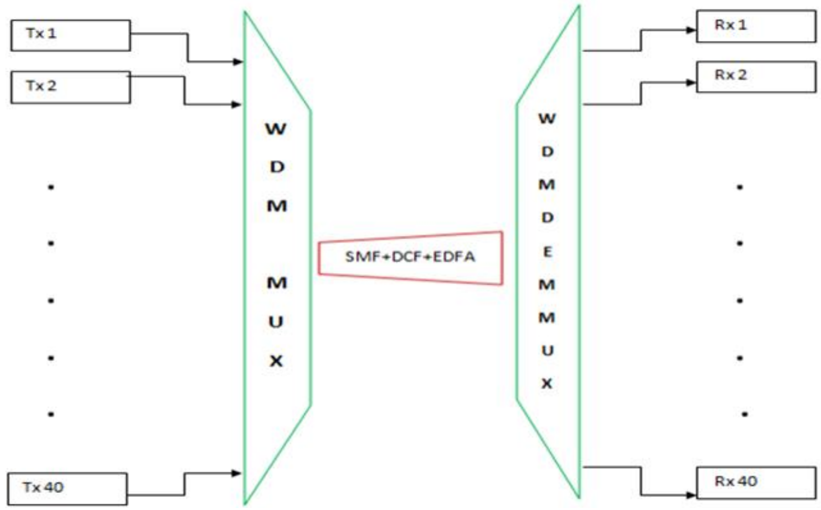

Fig. 8. 48 X 40 Gbps Transmission System

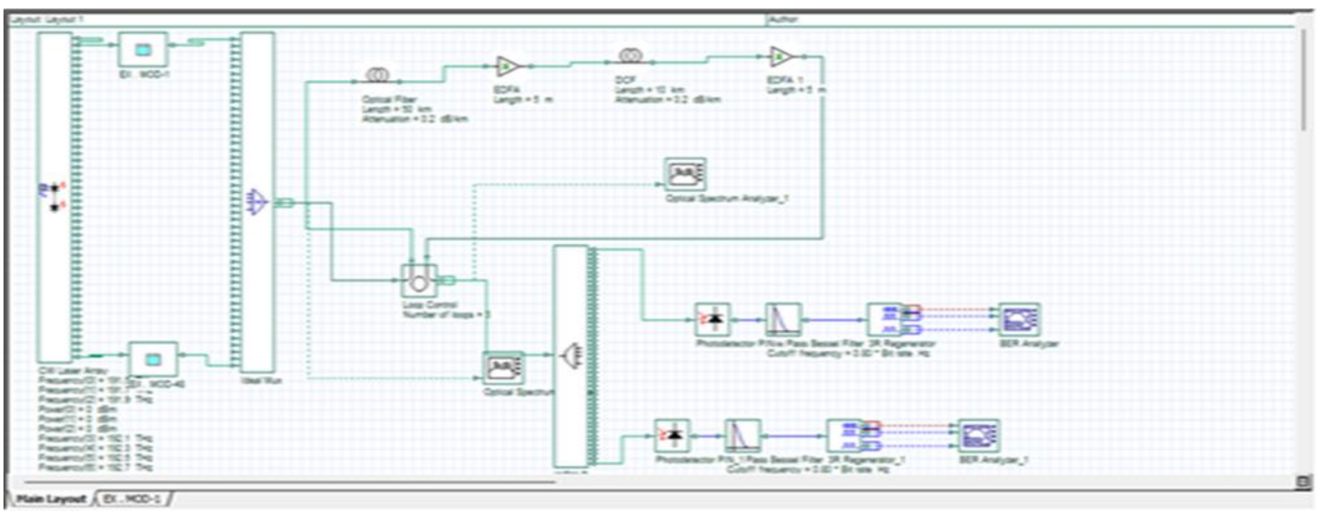

Fig. 9. Schematic layout of DWDM

5. Result

In this section, you will examine the effect of a traffic light before proceeding to the SMF. The BER analyzer employs long-distance frequency spacing and power levels to investigate a different effect. The results are presented in terms of Q-factor, BER, eye height, and so on.

5.1. BER analysis at various power levels at long distance

Now consider the DWDM system at various power levels of SMF: Perform analysis to improve system quality and change the power level from 5 dBm to 0 dBm.

5.2. Using an analysis with a 5 dBm input power for a 240 Km distance

Again, increasing the input power up to 5 dBm, the maximum Q-factor and minimum BER are shown in Fig. 10.
In Fig. 10, the maximum quality factor is 23.266 and BER is 4.66232e-0120 when the input launch power is 5 dBm.

5.3. Using an analysis with a 3 dBm input power for a 240 Km distance

Again, increasing the input power up to 3 dBm, the maximum Q-factor and minimum BER are shown in Fig. 11. From the figure, it is shown that the q factor 21.3011 is increased by increasing the power level and the minimum BER is 5.45614e-101.

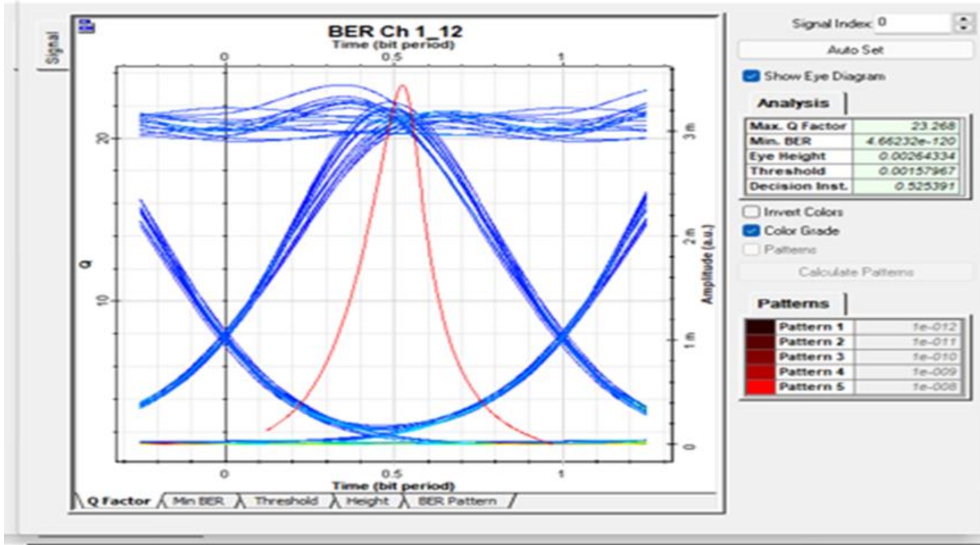

Fig. 10. Eye diagram (BER analyzer at 5 dB, and a distance of 240 km)

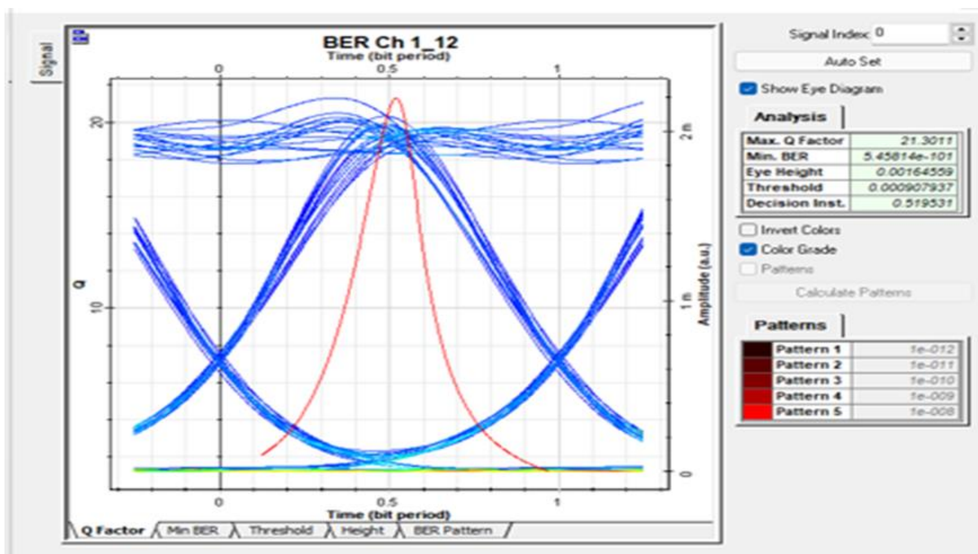

Fig. 11. BER analyzer at (3 dB, and a distance of 240 km)

5.4. Using an analysis with a 0 dBm input power for a 240 Km distance

Again, increasing the input power up to 0 dBm, the maximum Q-factor and minimum BER are shown in Fig. 12. In Fig. 12, the maximum quality factor is 18.0352 and BER is 5.13176e-073 when the input launch power is 0 dBm.

5.5. Using an analysis with a 5 dBm input power for a 300 Km distance

Again, increasing the input power up to 5 dBm, the maximum Q-factor and minimum BER are shown in Fig. 13. In Fig. 13 the maximum quality factor is 19.6431 and BER is 3.30142e-066 when the input launch power is 5 dBm.

5.6. Using an analysis with a 3 dBm input power for a 300 Km distance

Again, increasing the input power up to 3 dBm, the maximum Q-factor and minimum BER are shown in Fig. 14. From the figure, it is shown that the q factor 17.836 is increased by increasing the power level and the minimum BER is 1.8564e-071.

5.7. Using an analysis with a 0 dBm input power for a 300KM distance

Again, increasing the input power up to 0 dBm, the maximum Q-factor and minimum BER are shown in Fig. 15. From the Fig. 15, it is shown that the q factor 14.9477 is increased by increasing the power level and the minimum BER is 7.89923e-051.

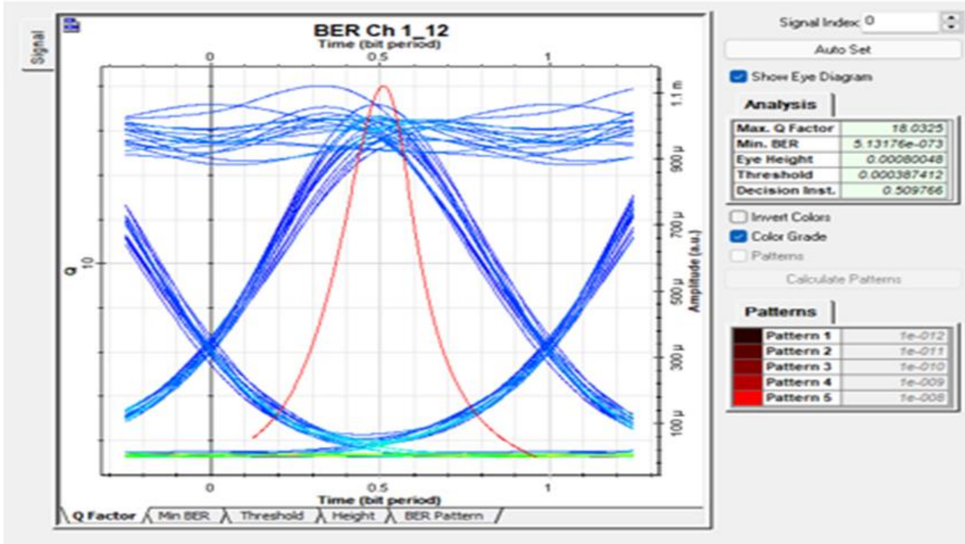

Fig. 12. Eye diagram (BER analyzer at 0 dB, and a distance of 240 km)

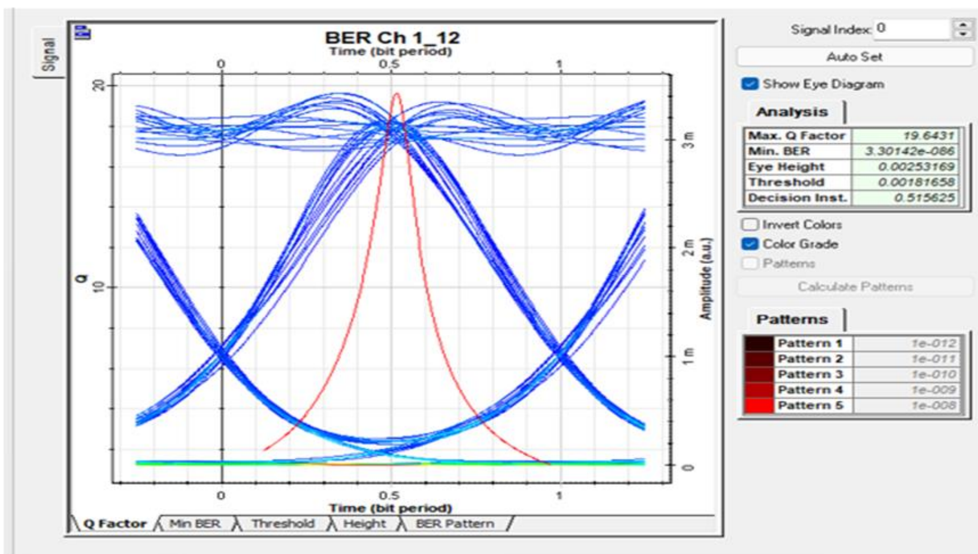

Fig. 13. Eye diagram (BER analyzer at 5 dB, and a distance of 300 km)

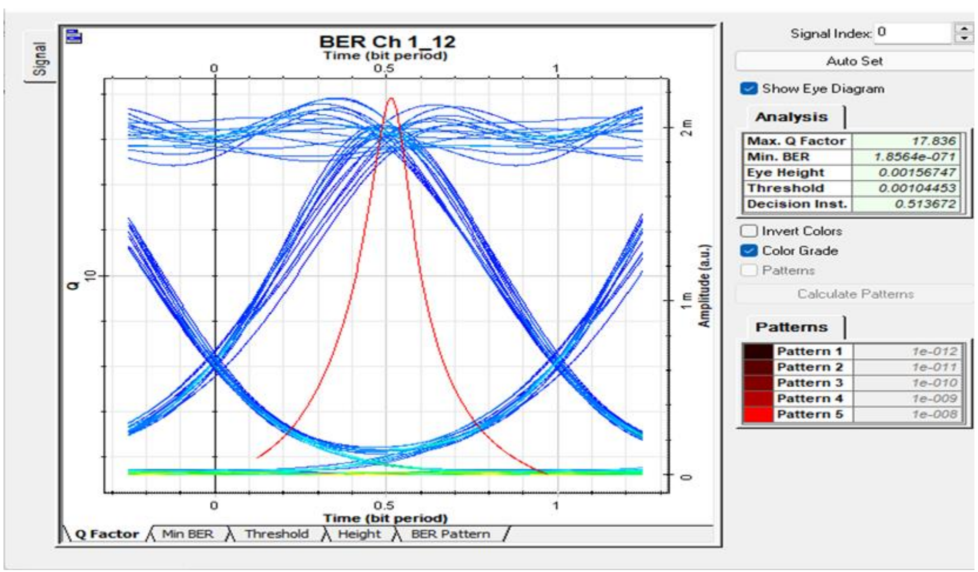

Fig. 14. Eye diagram (BER analyzer at 3 dB, and a distance of 300 km)

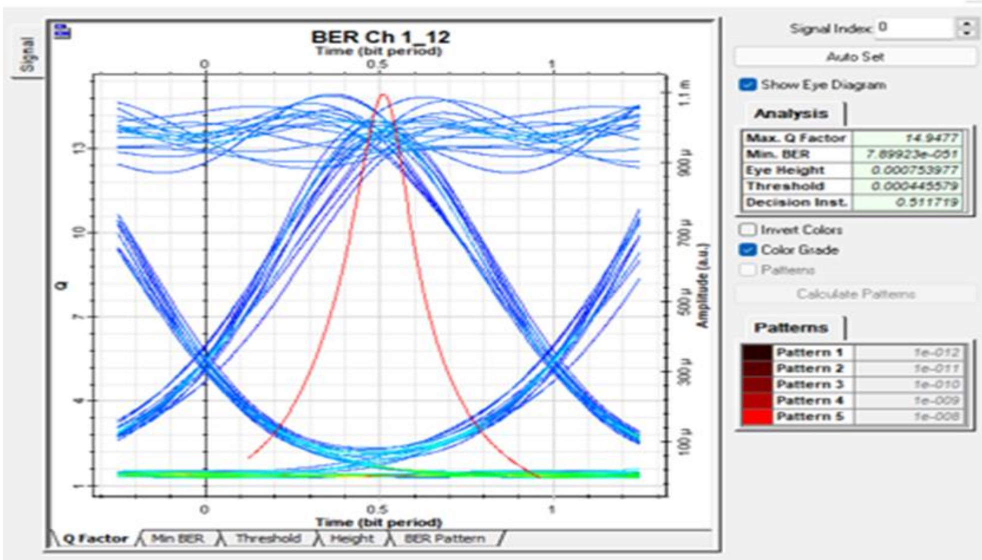

Fig. 15. Eye diagram (BER analyzer at 0 dB, and a distance of 300 km)

6. Conclusion

In this paper, a scheme for a DWDM system is proposed to support higher data rates towards bit-tera data transmission to telecommunication networks. The proposed system was in place. When using 48 channels * 40 Gbps, it can achieve a bit rate of 1.92 Tbps in terms of variable power and variable distance. Different distances of 240 and 300 km and power levels ranging from 5 dBm to 0 dBm will be considered for system performance. and Min BER will be considered and obtained. From our charts and using Optisystem 18 software. The results of the eye chart showed a higher indicator of the quality of the received signal at different distances. The result of the analysis indicates a direct presence. The relationship between distance, power, and minimum BER is found to increase with increasing transmission distance. It will increase the error value inside the transmitted bits. Meanwhile, the Q factor showed reverence with increasing distance, which reduces the effect of the quality of the transmitted signal. The use of both EDFA and DCF to improve and reduce the system dispersion compensation effects is proposed. As a result, the proposed system showed higher reliability and the ability to adapt to our proposed DWDM systems and demonstrate that WDM works. The modified binary scheme in this work is proposed to have the lowest power of 18.0352 and the Q factor is received with a maximum power of 23.266. As we increase the power in ascending order, the Q factor goes up. Similarly, the results of the above experiment show that the Q factor is 23.266 at 240 km and 17.836 at 300 km with an acceptable BER.

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