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**TITLE:-” PERFORMANCE ANALYSIS OF WDM (WAVELENGTH-DIVISION MULTIPLEXING) AND DWDM (DENSE WAVELENGTH-DIVISION MULTIPLEXING) TRANSMISSION SYSTEM FOR LONG DISTANCE COMMUNICATION”**

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**DECLARATION**

We declare that this thesis, ” Performance analysis of WDM and DWDM Transmission system for long distance communication” , is our own work, and has not been presented for in any other place, and all sources of materials used for the project have been fully acknowledged.

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***ABSTRACT***

*In this digital era the communication demand has increased from previous eras due to introduction of new communication techniques. As we can see there is increase in clients day by day, so we need huge bandwidth and high speed networks to deliver good quality of service to clients. Fiber optics communication is one of the major communication systems in modern era, which meets up the above challenges.so fiber optic communication utilizes different types of multiplexing techniques to maintain good quality of service without traffic, less complicated instruments with good utilization of available resources . Fiber optic communication can be considered optical communication that combines the methodologies of two communications, and it may be utilized in systems of wired and wireless communication. The fast evolution of Internet traffic and emerging applications can be considered a significant driver for high-capacity and cost-effective optical fiber transmission technologies. From both technical and economic perspectives, the ability to provide potentially unlimited transmission capacity is the most obvious advantage. Fiber optic network is gradually replacing copper network, because of its various advantages, like high speed, high density and high bandwidth. on the other hand, optical transmission distance is affected by various factor including like fiber type, light source of transceivers, frequency of transmission, bandwidth, fiber splicing and connectors loss. Due to this problem the optical signal becomes weak over long distance communication . Fiber optics communication is one of the major communication systems in modern era, which meets up the above challenges.so fiber optic communication utilizes different types of multiplexing techniques to maintain good quality of service without traffic, less complicated instruments with good utilization of available resources . the multiplexing technique are done using. Wavelength division multiplexing (WDM) and Dense Wavelength division multiplexing (DWDM) . this technique of multiplexing network can offer a solution to these problems where the transmission of different signals can be done with a single-mode fiber. The various parameters which give us a measure of how good or bad the transmission is are called as Performance Evaluating parameters. The various Performance evaluating parameters are Bit Error Rate (BER),Q-Factor, Eye diagram Height and SNR.*

*BER should be reduced to assured values, and the Q-factor must be increased. The investigation of WDM with different lengths of fiber at various channel spacing will be simulated using Optisystem software, and the BER receiver performance is measured and analyzed .the value of the Q-factor, and the height of the opening of the eye diagram. Analysis will be carried out to find the expression for signal to ASE noise ratio and will be extended to include to crosstalk due WDM Multiplexers/ Demultiplexers at each WDM node. Performance results in terms of signal to ASE noise ratio and signal to Crosstalk ratio and the system Bit Error Rate (BER) will be determined at a given bit rate. Dense Wavelength Division Multiplexing (DWDM) is an optical multiplexing technology which is used to increase the bandwidth of existing optical networks. The main principle on which it works is transmitting multiple signals of various wavelengths at the of DWDM technology.*

*Key words:-WDM, DWDM,Q-factor, BER,SNR*

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**List of Abbreviation**

BER Bit error rate

CDWDM Coherence dense wave division multiplexing

DEMUX Demultiplexer

DWDM Dense wavelength division multiplexer

EDFA Erbium-doped fiber amplifier

EMI Electro-magnetic interference

ICS Industrial control system

IM Intensity modulation

MSA Multi source agreement

MUX Multiplexer

MZM Mach-Zehnder modulator

NRZ Non-Return to zero

OEO Optical electrical optical

OPM Optical power modulator

RZ Return to zero

RWA Routing and wave algorithm

SMF Single mode fiber

SNR Signal to noise ratio

WDM Wavelength division multiple

**CHAPTER ONE**

**INTRODUCTION**

* 1. **Background**

One of the biggest challenges of modern day’s communication system is the requirement of huge bandwidth. This high bandwidth demand is fulfilled be the expansion of optical communication system [1]. The rapid expansion of optical network created a need to increase the transmission capacity. One of the most popular techniques used to increase capacity is the Wave Division Multiplexing (WDM). The key feature of modern optical communication system is WDM [2]. WDM uses multiple light sources operating at slightly different wavelengths to transmit several independent information streams over same fiber.

 The fast evolution of Internet traffic and emerging applications can be considered a significant driver for high-capacity and cost-effective optical fiber transmission technologies. The technique of the information transmitting between two positions is a fiber optic communication, which is completed by sending light within the optical fiber .This communication system can be used for long distance applications that’s needed a total transmission capacity and increasing cost recovering. Optical transmission systems are popular for maintaining low power for short-to medium-range wireless communications. However, for other applications where transmission distance is large, high power is required. In an optical fiber, various nonlinear effects begin to appear as the optical power level increases. The wavelength division multiplexing (WDM) and dense wavelength division multiplexing (DWDM) technique is used in optical communication for the multiplexing sum of optical carrier signals that have various wavelengths within a single optical fiber. These signals have different laser light wavelengths to carry different signals. They can realize higher data rate, larger capacities, and enhanced flexibility with a comparatively low cost. This upgrade can be easily achieved for these systems, in addition to the bidirectional transmission advantage over a length of the single fiber at both transmitter and receiver. In 1998, the “happening” area in optical communications is Wavelength Division Multiplexing (WDM). This is the ability to send many (perhaps up to 1000) independent optical channels on a single fiber. The first fully commercial WDM products appeared on the market in 1996. WDM is a major step toward fully optical networking. Wavelength division multiplexing (WDM) in fiber optic communication is a technology that multiplexes various light carrier signals on a particular optical fiber using distinct laser light wavelength to perform distinct signals. WDM is frequently applied to an optical carrier called wavelength. This is simply conventional because wavelength and frequency convey the same data, A WDM scheme utilizes a transmitter multiplexer to join together the various signals and a receiver demultiplexer to divide them apart. With the correct fiber type, a device can be installed concurrently and can operate as an optical add drop multiplexer. Erbium doped fiber amplifier (EDFA) are widely used in WDM – DWDM technology that improves optical network ability with optical amplification and works efficiently at high speed without affecting any cost. Wave Division Multiplexing (WDM) systems use a multiplexer at the transmitter to join the signals together and a demultiplexer at the receiver to split them apart. With the right type of fiber it is possible to have a device that does both simultaneously, and can function as an optical add drop multiplexer. The optical filtering devices used have conventionally been etalons, stable solid state single-frequency Fabry–Pérot interferometers in the form of thin-film-coated optical glass. The concept was first published in 1970, and by 1978 WDM systems were being realized in the laboratory. The first WDM systems combined only two signals. Modern systems can handle up to 160 signals and can thus expand a basic 10 Gbit/s system over a single fiber pair to over 1.6 Tbit/s [3]. WDM systems are popular with telecommunications companies because they allow them to expand the capacity of the network without laying more fiber. By using WDM and optical amplifiers, they can accommodate several generations of technology development in their optical infrastructure without having to overhaul the backbone network. Dense wavelength division multiplexing (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). 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 various parameters which give us a measure of how good or bad the transmission is are called as Performance Evaluating parameters. The various Performance evaluating parameters are **Bit Error Rate (BER):** In telecommunication transmission, the bit error rate (BER) is the percentage of bits that have errors relative to the total number of bits received in a transmission, usually expressed as ten to a negative power. **Q-Factor:** Physically speaking, *Q* is 2π times the ratio of the total energy stored divided by the energy lost in a single cycle or equivalently the ratio of the stored energy to the energy dissipated per one radian of the oscillation. Equivalently, it compares the frequency at which a system oscillates to the rate at which it dissipates its energy. **Eye Height:** Eye diagrams show parametric information about the signal – effects deriving from physics such as system bandwidth health, etc. It will not show protocol or logical problems – if logic 1 is healthy on the eye, this does not reveal the fact that the system meant to send a zero. The height of such an eye diagram from bottom to top is called eye height and is a performance evaluation component, the larger the eye height the better is the transmission. **OSNR:** Optical Signal to Noise Ratio (OSNR) is defined as the ratio of optical signal power to the noise power within the system. Higher the OSNR better is the signal reception.

* 1. **Statement of the Problem**

The need of increasing the capacity of data transmitted within the fiber transmission links became a challenge for researcher. Even though optical fiber communication is the best communication system in transmitting high data rate but still users are hungry thus the researchers are pushing to get the highest bit rate. The optical transmission distance is affected by various factors including the fiber type, light source of transceiver, frequency of transmission, bandwidth as well as splices and connectors. This work aims to show the increasing data rate using WDM and DWDM channels by increasing the bandwidth of the channels without using more optical fibers.

 Therefore, the performance of WDM and DWDM optical channels are evaluated using Q-factor, BER and Optical power analyzer and eye diagram Analyzer from the simulation result using Opti System software.

* 1. **General Objective**

The main objective of this thesis is to analysis Performance of WDM and DWDM Transmission system for long distance communication.

* 1. **Specific objective**

The specific objective of this thesis are list as follow

* To analyze Q-factor and BER for different iterative input power for a given optical fiber length and vice versa.
* To analyze Q-factor and BER for different iterative optical fiber length keeping the bit rate and input power of the fiber constant.
* Analyze the optical power of the fiber after the multiplexer and after optical fiber used.
* To determine Signal to Noise Ratio (SNR) values at different stages of the transmission line.
* Analyze the optical spectrum of the fiber after the multiplexer and after optical fiber used.
* Analyze the WDM analyzer of the fiber after the multiplexer and after optical fiber used.
* Analyze the BER for two different BER analyzer of the fiber with Eye diagram of the two BER analyzer for WDM.
* Analyze the BER for two different BER analyzer of the fiber with Eye diagram of the two BER analyzer for WDM.
	1. **Scope**

Scope of this thesis are doing comparative analysis of 8 channels wavelength division multiplexing (WDM) system and 32 channels Dense wavelength division multiplexing (DWDM) system using Optisystem software and different modulation formats (NRZ, RZ) and compensation schemes at different bit rates (10Gbps, 30Gbps and 100Gbps) with standard and dispersion compensated fiber on the basis of Q-factor, eye diagram and bit error rate for fixed gain EDFA and length both type of fiber.

The scope of optical network based services is increasing and it provides better results compared to the traditional networks like circuit switching and packet switching policies. By using optical fibers the nature of transmitting data is high and fast when compare to the above traditional approaches using copper cables, twisted pairs as a communication medium. In the optical networks the data is converted into the bits of light called photons and then transmitted over fibers which are faster than the traditional networks in which the data is converted into the electrons that travel through the copper cable. The data transmission using optical fiber is fast because photons weigh is less when compare to the weight of electrons. And further, unlike electrons, photons do not affect one another when they move in a fiber because they have no electric charge and they are not affected by stray photons outside the fiber. Light has higher frequencies and hence shorter wavelengths, and therefore more bit of transmission can be contained in a length of fiber versus the same length of copper. The optical fiber can carry more communications signals than the large copper cable in the background and over much longer distances.

The demand for bandwidth has been increasing significantly; the network capacity has also increased and applications like Video applications (video download, video telephony), IP telephony, Multimedia applications and remote employment are the main drivers for this increased demand.

Wavelength Division Multiplexing (WDM) and Dense WDM enabling technology for high-speed backbone networks are used in optical networks.

* 1. **Methodology**

For successful completion of this thesis some steps have been followed to carry out different tasks. Different literature was revised relating to this thesis and data had been collected and select parameter which is used for this thesis. Based on this parameter system model was designed. Software’s were selected to develop the software programming.

Problem statement

Literature review

Collection of data

Analyzing data

Developing system model design

Simulate using optisystem software

Performing analysis

No

 Yes

Deriving conclusion

Fig 3.1 Flow chart

**CHAPTER TWO**

**2.1. Literature review**

Suresh K et.al [1] this paper presented a brief survey about the existing approaches in the Routing and Wavelength Assignment (RWA) using Wavelength Division Multiplexing (WDM) and optical cross connect switches which also provides solutions for the security threats in the physical layer of optical fiber networks. Optical networks play an important role in information communication supporting both small-scale and large-scale networks through its capacity of seamless transmission of massive volume of data within a short time period. Routing in the optical networks needs to be dynamic as the wavelengths and its parameters are changing frequently. Based on the analysis carried out over the existing solutions we are proposing an equalized wavelength or power distribution using Wavelength Division Multiplexing (WDM), optical cross connect equalization at the network nodes and power equalization placement in order to prevent jamming attacks and reducing LAR with minimum cost.

[2] Proposed and experimentally demonstrate a novel colorless full-duplex passive optical network (PON) access architecture optical networks (WDM-PONs), in which the mitigation of optical. Utilizing orthogonal codes and correlation receiving methods optical beat interference (OBI) noise caused by Rayleigh backscatter.

E. Kavitha [3] this paper investigates the problem of dynamic wave length allocation and fairness control in WDM optical networks. A frame network topology, with a two-hop path network, is studied for three classes of traffic. Each class corresponds to a source and destination pair. For each class call-inter arrival and holding times are studied. The objective is to determine a wavelength allocation policy to maximize the weighted sum of users of all the three classes. This method is able to provide differentiated services and fairness control in the network. The problem can be formulated using markov decision process to find the optimal allocation policy.

[4] In the optical networks the wavelength division multiplexing technology which multiples a number of optical carrier signals into a single optical fiber using different wavelengths (colors) of a signal. Here different wavelengths carrying separate signals are multiplexed by the multiplexer and then they are transmitted through a single fiber. At the receiver end, the separate signals at different wavelengths are demultiplexer by the demultiplexer and are given to separate receivers. From the receiver side also the signals can be transmitted in the same manner through the same fiber.

Poliak J. et al [5] discussed the proof of-concept demonstration of optical DWDM under worst case atmospheric channel conditions for satellite communications in geostationary orbit. The highest-to-date throughput of 1.72 Tbit/s was transmitted over 10.45 km distance with passive transmitter pointing and active receiver tracking with active single-mode fiber coupling. This throughput was achieved by modulating 16 DWDM channels with encoded 43.01824Gbit/s rate per channel. Furthermore, direct bit-error-rate and signal fluctuations measurements were carried out to assess the link performance. No forward error correction was used. Finally, in each DWDM channel BER values between error-free and BER = 0.5 were achieved, with median BER of 4.4 • 10−7. The normalized variance of the received optical power varied between 0.1 and 3.6.This demonstration served as a basis for development of active single-mode fiber coupling, turbulent channel characterization and future use of DWDM technology for satellite communications.

Ajay K. Sharma et al. (2009) studied robustness of various modulation formats at 40Gbps. The performance is categorized using Q-factor. They investigated non linearity and noise show robustness up to 450 km at 40Gbos. At high rate, CRZ show better results than NRZ, RZ and CSRZ [6].

E. Ciaramella et al., (2009) described the novel idea of 1.28 Terabit/s (32 x 40Gbit/s) WDM transmission systems for free space optical communications. In this paper investigates the improvement in the signal power stabilization is achieved by saturated EDFAs. The results show that when the terminals are fed by common WDM signals they allow enough power budget and margins to support a record high capacity transmission (32×40Gbit/s), with an enormous improvement of stability means six hours with no error burst [7].

Jagjit Singh Malhotra et al., (2010) investigate the Performance analysis of NRZ, RZ, CRZ and CSRZ data formats in 10Gbps. In this paper investigate the performance of NRZ, RZ, CRZ and CSRZ data formats analyzed on the basis of bit error rate (BER), Q2 (dB), OSNR, eye opening performance metrics. The results show that CRZ and CSRZ modulation format is perform better

as compared to NRZ and RZ. The CSRZ has optimal performance according to performance metrics [8].

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T. Sabapathi et al., (2011) described the analysis of bottlenecks in DWDM fiber optic communication system. The author described the Stimulated Brillouin Scattering (SBS), Stimulated Raman Scattering (SRS) and Four Wave Mixing (FWM) in DWDM. In this paper analyze the effect of SBS, phase mismatching and wavelength spacing [10].

Ross Saunders et al., (2011) studied the concept of Coherent DWDM (CDWDM) technology for high speed optical communications. In this paper studied that an initial implementation of 40 Gb/s coherent systems using dual polarization quadrature phase shift keying (DP-QPSK) after that development in the new systems running at 100Gb/s DP-QPSK data rate. In the CDWDM poses some significant challenges in terms such as electro-optic, DSP, ADC/DAC design and fiber nonlinearity [11].

**CHAPTER THREE**

**3. System design and simulation**

**3.1. Wavelength Division Multiplex system design model**

In this thesis we use different parameter to design WDM transmission system. A WDM transmission link transport large amount of data traffic by multiplexing a number of lower capacity wavelength channels onto a single fibre. The use of WDM therefore allows increase in the capacity of long haul optical transmission systems or, decrease in the (10Gbps, 20Gbps, and 30Gbps) with standard and dispersion compensated fibre on the basis of Q-factor, eye-diagram and bit error rate for fixed gain EDFA and length both type of fibre. Generally a basic WDM system has been divided into three parts: (i) Transmitter section, (ii) Transmission link section and (iii) Receiver section.

The parameters are shown as follow by design model.

Pseudo-random bit sequence generation

NRZ pulse generation

MZ modulator analytic

WDM MUX 8x1

CW laser

WDM analyze

Optical fiber

Optical power meter

WDM DEMUX 1x8

Loop control

BER analyzer

Optical receiver

Optical spectrum analyzer

Figure 3.1.System Design Model of WDM

**3.1.1 CW-Laser**

CW lasers operating at different wavelengths, which require the wavelength to be selected for each channel and operate at specific wavelength. This makes the system costly and increase the complexity of network architecture using many spectrum sliced channels. However, the spectrum sliced techniques currently used have dispersion issues due to dispersion compensation techniques used, modulation formats and other spectral related matters. How can make overall performance of the system better and the received signal clarity by choosing best Modulation format in the Wavelength Division Multiplexing Spectrum slicing technique.

The CW-WDM MSA (Continuous-Wave Wavelength Division Multiplexing Multi-Source Agreement) Group, dedicated to defining and promoting specifications for multi-wavelength advanced integrated optics, today announced the release of its first official specification for 8, 16, and 32 wavelength optical sources. The Multi-Source Agreement (MSA) defines laser sources covering three spans in the O-band wavelength grids. These lasers can be used as optical sources for multiple applications such as high-density co-packaged optics, machine learning, and optical computing. Each wavelength grid is defined with enough technical detail to ensure interoperability across the range of applications. The MSA also outlines measurement methods required for standards compliance.

Laser source standard for use in optical transceivers for emerging advanced Data com applications. Laser sources are the critical component in optical communications and having an agreed set of grids creates great opportunities for transceiver and laser suppliers to develop innovative products.

**3.1.2 Pseudo-random bit sequence generator**

The Pseudo random bit sequence can be used to generate a binary sequence of pseudo random bits. The bit sequence can be connected to a binary sequence visualizer so that the output bit sequence can be seen.

**3.1.3 MZ Modulator analyzer**

Mach-Zehnder Modulator (MZM) Wavelength Division Multiplexing (WDM) The basic operation of WDM, is the combination of multiple optical channels with different wavelengths, coming from different optical sources into a single fiber using multiplexers at the transmitter end, and Demultiplexers in the receiver to split WDM channels. Mach-Zehnder modulators(MZM)which can easily operate at 40 Gbps and above, low attenuation dispersion managed fiber, dispersion compensation fiber, low-noise high-gain optical amplification system, very high –speed detector and extremely fast digital signal processing capabilities which make many compensation hardware redundant.

**3.1.4 Optical power meter**

An optical power meter (OPM) is a device used to measure the power in an optical signal. The term usually refers to a device for testing average power in fiber optic systems. Other general purpose light power measuring devices are usually called radiometers, photometers, laser power meters (can be photodiode sensors or thermopile laser sensors), light meters or lux meters.

A typical optical power meter consists of a calibrated sensor, measuring amplifier and display. The sensor primarily consists of a photodiode selected for the appropriate range of wavelengths and power levels. On the display unit, the measured optical power and set wavelength is displayed. Power meters are calibrated using a traceable calibration standard.

**3.1.5 Optical spectrum analyzer**

WDM-aware testing capabilities have been added to optical spectrum analyzers. They offer the I-in-band mode—intelligent setups, optimized on a per-channel basis. The analyzer provides test results with built-in referencing in WDM mode, as well as troubleshooting and analysis.

**3.1.6 WDM analyzer**

WDM Channel Analyzer is a Michelson interferometer-based instrument that measures wavelength and optical power of laser light in the 1270 to 1650 nm wavelength range. Simultaneous measurements of multiple laser lines are performed allowing measurements of dense division multiplexed signals. Each laser line is assumed to have a line width (including modulation sidebands) of less than 5 GHz.

It used for:

* Easy to use for WDM system test in the field
* Measure wavelengths to within 3 pm absolute accuracy (NIST-traceable)
* Simplify transfer of measurement results using the built-in floppy disk drive, printer or the RS- 232 interface
* Rugged and Portable

**3.1.7 Modulation Format**

The non-return to zero (NRZ) has been the dominant modulation format in intensity modulated-direct detection (IM/DD) fiber-optical communication systems for the last years because it is easy to generate, detect and process.

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Figure 3.2.NRZ

The capacity of light wave system, bit rate-distance product, will be improved dramatically using optimal modulation formats compared to non- return to zero (NRZ) format has been the dominant modulation format in fiber-optical communication systems. For convenience refer to NRZ. There are probably several reasons for using NRZ in the early days of fiber-optical communication: First, it requires a relatively low electrical bandwidth for the transmitters and receivers (compared to RZ); second, it is not sensitive to laser phase noise; and last, it has the simplest configuration of transceivers. In recent years, as optical communication is advancing to higher data rates, dense-wavelength division multiplexing (DWDM), and long distance with optical amplifiers, NRZ modulation format may not be the best choice for high capacity optical systems. However, due to its simplicity, and its historic dominance, NRZ would be a good reference for the purpose of comparison. Consequently, non-return-to-zero (NRZ) that has been used for a long time in light wave system is no more an optimal modulation format in the next generation of light wave system. A modulation format that is more tolerant to linear and nonlinear impairments is needed.

A long string of ones or zeros contains no timing information since there are no level transitions. However, the use of highly stable clocks increases system costs and requires a long system startup time to achieve synchronization. In addition, spectral efficiency would be improved using optimal modulation format thus more information could be conveyed per wavelength or more wavelengths can be co-propagated over fibers. In economical view, optimal modulation formats will permit service providers to develop their existing light wave network without overall upgrade and to utilize the most of the existing systems .Thus to save the expenses.

**3.1.8 Optic fiber**

The optical fiber is the most advanced transmission medium and the only one capable of supporting next generation services.



Figure 3.3.Optic Fiber

The main advantages of having a last mile of optical fiber are many: higher bandwidth, longer distances from the central to the subscriber, the more resistance to electromagnetic interference, increased security, reduced signal degradation. Moreover, the fact of using PON technology assumes the elimination of repeaters and optical amplifiers and therefore reducing the initial investment, lower power consumption, less space, fewer points of failure.

**Advantages of optical Fiber Transmission**

**1. Distance**

We can transmit light signal in optical fiber up to 100 kilometers

Without the need of any repeater whether it is active or passive repeater. This shows much better performance of an optical fiber medium when compared to copper and metallic based cables where we can transmit electrical signals to only few kilometers without the need of repeaters.

**2. Bandwidth**

In optical fiber communication infra-red light is used. The bandwidth of installed fiber is very large. In addition to it there is no electromagnetic interference (EMI) in optical fiber.

Optical fiber has three layers and these layers are core, cladding and jacket. Due to these layers optical fibers do not have EMI. Core and cladding have same material but they have different refractive index. Total internal reflection is a mechanism which is used to guide the light along the fiber.

**3. Electrical Isolation**

In electrical system there is always possibility of earth loop (ground loop) which means an unwanted electrical current. Two terminals in an electrical conductor are adjusted to the same potential while the earth or ground is connected to the opposite potential.

Consequently when the current flows through the conductor electromagnetic field is induced.

As a result EMI occurs in electrical conductor. On the other hand fiber optics have three layers, light travels in core and cladding and both have different RI profile due to which there is no cross talk or EMI.

**4. Material Cost**

The material of fiber optic is made from glass. The glass raw material is sand, which is widely available natural resource. Hence, fiber optics costs significantly less than copper. However, the manufacturing process of fiber may cost more than copper.

**5. Performance**

Throughput in fiber optics is very high and losses are very low. Amplifiers and repeaters are used to maintain the power of transmitted signal over channel. Furthermore signal to noise ratio is very good which indicates that performance of optical transmission system is much better than electrical conductors.

**3.1.9 Optical Power Requirements for a Specific BER**

At the outputs of the multiplexer, system parameters that need to be considered include the signal level, noise level, and crosstalk. The bit-error rate (BER) of a WDM channel is determined by the optical signal-to-noise ratio (SNR) delivered to the photo detector.

The digital receiver performance is governed by bit-error-rate. BER is the probability that a bit is identified incorrectly by the decision circuit of the receiver.

In fiber optic communication systems, the error rates usually range from 10-9 to 10-12 .This value depends on the SNR the receiver. The BER can be calculated from the Q-Factor.

**3.1.10 Optical Receivers**

The WS-OR409 optical receiver is a four-output outdoor rain-proof optical receiver. It is suitable for buildings, communities or villages concentrated with many users. The WS-OR719 optical is suitable for multi-port high-level output distribution networks. It can be used with ONU or EOC for triple play.

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Figure 3.4 Four-Output Optic Receiver

The Receiver component serves two functions. First, it must sense or detect the light coupled out of the fiber optic cable then convert the light into an electrical signal. Secondly, it must demodulate this light to determine the identity of the binary data that it represents. In total, it must detect light and then measure the relevant Information bearing light wave parameters in the premises fiber optic data link context intensity in order to retrieve the Source's binary data. Within the realm of interest in this book the fiber optic cable provides the data to the Receiver as an optical signal. The Receiver then translates it to its best estimates of the binary data. It then provides this data to the User in the form of an electrical signal. The Receiver can then be thought of as an Electro-Optical (EO) transducer. A Receiver is generally designed with a Transmitter. Both are modules within the same package. The very heart of the Receiver is the means for sensing the light output of the fiber optic cable. Light is detected and then converted to an electrical signal. The demodulation decision process is carried out on the resulting electrical signal. The light detection is carried out by a photodiode. This senses light and converts it into an electrical current. However, the optical signal from the fiber optic cable and the resulting electrical current will have small amplitudes. Consequently, the photodiode circuitry must be followed by one or more amplification stages.

There may even be filters and equalizers to shape and improve the Information bearing electrical signal. All of this active circuitry in the Receiver presents a source of noise. This is a source of noise whose origin is not the clean fiber optic cable. Yet, this noise can affect the demodulation process.

**3.1.11 Loop control**

A closed loop control system is a set of mechanical or Electronic devices that automatically regulates a process variable to a desired state or set point without human interaction. Closed loop control systems contrast with open loop control systems, which require manual input. A control loop is the system of hardware components and software control functions involved in measuring and adjusting a variable that controls an individual process. Closed loop control systems are widely used in various industry applications including agriculture, chemical plants, quality control, nuclear power plants, water treatment plants and environmental control. Closed loop control systems enable automation in a number of industrial and environmental settings and regulate processes in industrial control systems (ICS) such as supervisory control and data acquisition (SCADA) and distributed control systems (DCS). Unlike open loop control systems or switchable control loops, closed loops don't take input from human operators. This means that other than adjustment by control systems, they operate automatically and independently. In closed loop control, the action is entirely dependent on the process variable. In regards to a heating system, for example, a closed loop might maintain a temperature as a set point, automatically switching on when temperature is below the set point. Open control, in contrast, would enable individuals to set timers and turn instant on heat.

**3.2 WDM Multiplexer and Demultiplexer**

Wavelength Division Multiplexing (WDM) is one of the most common way of using wavelengths to increase bandwidth by multiplexing various optical carrier signals onto a single optical fiber. It combines a series of optical carrier signals with different wavelengths carrying various information and coupled to the same optical fiber for transmission at the transmitting end. At the receiving end, optical signals of various wavelengths are separated by a demultiplexer. This technique of simultaneously transmitting two or many different wavelengths in the same fiber is called wavelength division multiplexing, or WDM. Depending on the direction of the transmitted signal, WDM can be used for multiplexing or demultiplexing.

****

Figure 3.5.MUX and DEMUX of WDM System

**3.2.1 Multiplexer**

The main function of the combiner MUX is to combine multiple signal wavelengths into one fiber for transmission. At the transmitting end, the N optical transmitters operate on N different wavelengths respectively, and the N wavelengths are separated by appropriate intervals, which are respectively recorded as λ1, λ2 … λn. A multiplexer combines these optical wavelengths into a single-mode fiber. Since optical carrier signals of different wavelengths can be regarded as independent of each other (regardless of fiber nonlinearity), multiplexing transmission of multiple optical signals can be realized in one optical fiber. Through multiplexing, communication carriers can avoid maintaining multiple lines and effectively save operating costs.

**3.2.2 Demultiplexer**

The main function of DEMUX is to separate the multiple wavelength signals transmitted in one fiber. In the receiving part, the optical carrier signals of different wavelengths are separated by a Demux and further processed by the optical receiver to restore the original signal. A demultiplexer (Demux) is a device that reverses the processing of a multiplexer.

**3.3 Performance Parameter**

Multiplexer/demultiplexer devices (MUX/DEMUX) are key components in WDM that affect the performance of the entire system.

**3.3.1 Work Band**

Working bands of the multiplexer/demultiplexer. For example, there are three bands of 1550 wavelength: S-band (short-wavelength 1460~1528nm), C band (conventional band 1530~1565nm), L band (long-wavelength band 1565~1625nm).

**3.3.2 Number of channels & channel spacing**

The number of channels is the number of channels the device has to send information. This number can range from 4 to 160 with design enhancements adding more channels. The normal channels are 4, 8, 16, 32, 40, 48, etc. Channel spacing is the center-to-center difference in frequency between neighboring channels. It can be used to prevent inter-channel interference.

**3.3.3 Insertion loss**

Insertion loss is the attenuation caused by the insertion of wavelength division multiplexers (WDM) in an optical transmission system. The attenuation effect of wavelength division multiplexer directly affects the transmission distance of the system. In general, the lower the insertion loss, the less the signal attenuation.

**3.3.4 Isolation**

Isolations refers to the degree of isolation between individual channel signals. High isolation values can effectively prevent crosstalk between signals and cause distortion of the transmission signal.

**3.3.5 Polarization dependent loss (PDL**）

Polarization-dependent loss is the maximum deviation in insertion loss across all input polarization states.

In addition to the above, there are of course other performance parameters that affect the multiplexing/demultiplexing devices, such as operating temperature, bandwidth, etc. Generally, a multiplexer and a demultiplexer are combined into a single device allowing the device to process both incoming and outgoing signals. Or a single output of a multiplexer can be connected through a single channel to a single input of a demultiplexer. But mostly is the combined and complex device for both directions transmission.

**3.3.6 Crosstalk**

The narrow channel spacing in dense WDM link gives rise to crosstalk, which is defined as the feed through of one channels signal into another channel. Crosstalk can be introduced by almost any component in a WDM system, including optical filters, wavelength multiplexers, optical switches, optical amplifiers, and the fiber itself.

**3.5 Dense WDM System Model Design**

Optical spectrum analyzer

Optical power meter

WDM analyzer

Ideal MUX

WDM Transmitter

Optical Fiber

EDFA

Loop Control

Optical receiver

BER analyzer

WDM DEMUX ES

Figure 3.6.DWDM System design model

DWDM is used to transmit optical signals over a long distance (> 100 km), optical fiber amplifiers are needed to compensate the loss of an optical fiber. As the gain bandwidth of an optical fiber amplifier is rather limited, a tight wavelength spacing is needed to put a large number of channels into the gain bandwidth. The dense WDM (DWDM) technology has been developed for long distance transmission systems, fully utilizing the gain bandwidth of erbium-doped fiber amplifier (EDFA). EDFA has optical gain in the C-band and L-band, and for example, a total of 115 wavelength channels are transmitted in one fiber with 100-GHz (~0.8 nm) frequency spacing.

The parameter using during system design model of DWDM transmission system are seen each below.

**3.5.1 Erbium Doped fiber Amplifier (EDFA)**

Erbium-doped fiber amplifier (EDFA) is an optical repeater device that is utilized to boost the intensity of optical signals being carried through a fiber optic communications system. An optical fiber is doped with the rare earth element erbium so that the glass fiber can absorb light at one frequency and emit light at another frequency.

An erbium-doped fiber amplifier (EDFA) is a device that amplifies an optical fiber signal. It is used in the telecommunications field and in various types of research fields. An EDFA is "doped" with a material called erbium. The term "doping" refers to the process of using chemical elements to facilitate results through the manipulation of electrons. The EDFA was the first successful optical amplifier and a significant factor in the rapid deployment of fiber optic networks during the 1990s.

**3.5.2 EDFA Working Principle**

The erbium-doped fiber (EDF) is at the core of EDFA technology, which is a conventional silica fiber doped with Erbium. When the Erbium is illuminated with light energy at a suitable wavelength (either 980 nm or 1480 nm), it is motivated to a long-lifetime intermediate state, then it decays back to the ground state by emitting light within the 1525-1565 nm band. The Erbium can be either pumped by 980 nm light, in which case it passes through an unstable short lifetime state before rapidly decaying to a quasi-stable state, or by 1480 nm light in which case it is directly excited to the quasi-stable state. Once in the quasi-stable state, it decays to the ground state by emitting light in the 1525-1565 nm band. This decay process can be stimulated by pre-existing light, thus resulting in amplification.

**3.5.3 Basic configuration of EDFA**

EDFA configuration is mainly composed of an EDF, a pump laser, and a component (often referred to as a WDM) for combining the signal and pump wavelength so that they can propagate simultaneously through the EDF. In principle, EDFAs can be designed such that pump energy propagates in the same direction as the signal (forward pumping), the opposite direction to the signal (backward pumping), or both direction together. The pump energy may either be 980 nm pump energy, 1480 nm pump energy, or a combination of both. Practically, the most common EDFA configuration is the forward pumping configuration using 980 nm pump energy.

Application of EDFA After learning what is EDFA, and EDFA working principle. Next, we’ll discuss application forms and application fields of EDFA.

Forms of application:

* **Booster Amplifier**

When used as the booster amplifier, EDFA is deployed in the output of an optical transmitter to improve the output power of the multi-wavelength signal having been multiplexed, as shown in Figure 3.7. In this way, distances of optical communication transmission can be extended. This application form places a demand of higher output power on EDFA.

Optical receiver

Optical transmitter

Optical fiber

 EDFA

Figure 3.7.Booster Amplifier

* **Preamplifier**

When used as the preamplifier, EDFA needs the features of low noise and high gain. Being equipped with these features, EDFA can significantly improve the sensitivity of an optical receiver when deployed in the input of an optical receiver, as shown in Figure3.8.

Optical fiber

Optical receiver

Optical transmitter

EDFA

Figure 3.8.Preamplifier

**3.5.4 Fields of application**

EDFA has the following fields of application:

1. EDFA can be employed in the high-capacity and high-speed optical communication system. The application of EDFA is very constructive to deal with the problems of low sensitivity of receivers and short transmission distances owing to a lack of OEO repeater.

2. EDFA can be utilized in long-haul optical communication system. By utilizing EDFA, we can dramatically lower construction cost by increasing the repeater spacing to reduce the quantity of regenerative repeaters. The long-haul optical communication system mainly includes the land trunk optical transmission system and the submarine optical fiber cable transmission system.

3. EDFA can be used in the optical fiber subscriber access network system. If the transmission distances are too long, EDFA will function as the line amplifier to compensate for the transmission losses of lines, thus greatly increasing the number of subscribers.

4. EDFA can be employed in wavelength-division multiplexing (WDM) system, especially dense wavelength-division multiplexing (DWDM) system. Utilization of EDFA in WDM system is able to solve the problems of insertion loss and reduce the influences of chromatic dispersion.

5. EDFA can be utilized in community antenna television (CATV) system. In CATV system, EDFA functions as the booster amplifier to greatly improve the input power of an optical

transmitter. Utilizing EDFA to compensate for the insertion loss of optical power splitters can significantly enlarge the scale of the distribution network and increase the number of subscribers.

**3.5.5 WDM Transmitter**

WDM is an abbreviation for Wavelength-Division Multiplexing, and is now one of the most widely used technology for high-capacity optical communication systems. At the transmitter side, multiple optical transmitters – each emitting at a different wavelength – individually send signals and these signals are multiplexed by a wavelength multiplexer (MUX). The multiplexed signals are then transmitted over one main transmission line (optical fiber cable).

FWAP-1550H Series PON+CATV EDFA Combiner, High power Erbium-Doped Fiber Amplifier, it is the core equipment of three of one net in the optical transmitter system, input 32 ports PON+1port CATV and output 32 ports combined 1550/1490/1310nm. The combined optical each output power: 19dBm. Plug-in dual power supply achieved the function of OLT and CATV 1550nm optical single combined and amplify, having high-cost performance value.

A WDM system uses a multiplexer at the transmitter to join the several signals together and a demultiplexer at the receiver to split them apart.

**3.5.6. Ideal MULTIPLEXER**

Ideal mux or Demux in Optisystem are like black box with function to separates or combines the individual wavelengths. There not practical importance of these components, but for simple simulation purposes we can use them.

Ideal MUX can sure be used in system designs for theoretical purposes. Besides, since the ideal MUX acts like an ideal adder (of course it wouldn’t be that ideal if you set a value for insertion loss), sometimes it can be used to make subsystems and components. This doesn’t necessarily mean all Optisystem users would need to use this component, though the ideal mux multiplexes a user defined number of input WDM signal channels. This model is equivalent to an ideal adder since there is no power splitting and filtering. Using the ideal mux, we will multiplex 32 modulated signals together and we will view the signals in the optical spectrum analyzer and the WDM analyzer.

Running our current setup with the ideal mux having its default values we can check the WDM analyzer and optical spectrum analyzer and we see that there are 32 channels at different frequencies present as we would expect. Double clicking on the ideal mux block opens up the properties of the block. Changing the value of loss changes the insertion loss of the multiplexer. A higher value of loss will result in the output signals having lower power. Calculating the project with a loss of 5 dB causes the signal power to decrease as we can see in the WDM analyzer.

Clicking back on the ideal mux we can also change the number of input ports. Changing it to 36 will add another input port. We can connect that multiplexer port to another modulator so that we will now be multiplexing 36 signals together. We will also make sure to change the frequency of our 36 transmitter so that it does not interfere with the other transmitter. Now when we calculate the program and check the visualizers, we can see that 36 signals are present.

**3.5.6 WDM DEMUX ES**

A demultiplexer for digital media files, or media demultiplexer, also called a file splitter by layman or customer software providers, is software that demultiplexer individual elementary streams of a media file, e.g., audio, video, or subtitles and sends them to their respective decoders for actual decoding. Media Demultiplexers are not decoders themselves, but are format container handlers that separate media streams from a (container) file and supply them to their respective audio, video, or subtitles decoders.

****

Figure 3.9: WDM DEMUX

**Table 3.1 Specification Parameter of WDM**

|  |  |  |
| --- | --- | --- |
| **Section** | **Component** | **Parameter** |
| **Type** | **Value** |
| Transmitter | CW Laser | frequency | (193.1,193.2….193.8)THz |
| NRZ pulse | Rise time | 0.05bit |
| MZM | Extinction ratio | 30dB |
| WDM MUX | Bandwidth | 10GHz |
| Input port | 8 |
| Optical Fiber | SMF | Reference wavelength | 1550nm |
| Length | 50km |
| Receiver | WDM DEMUX | Bandwidth | 10GHz |
| Number of out port | 8 |
| Low pass Bessel filter | Cutoff frequency | 0.75\*10^9Hz |

**Table 3.2 Specification Parameter of DWDM**

|  |  |  |
| --- | --- | --- |
| **Section** | **Component** | **Parameter** |
| **Type** | **Value** |
| Transmitter | WDM Transmitter | Frequency spacing | 100GHz |
| MZM | Extinction ratio | 10dB |
| Ideal MUX | Number of input port | 32 |
| Optical fiber | SMF | Reference wavelength | 1550nm |
| Length | 50km |
| Loop | Loop Number | 2 |
| EDFA | Length | 5m |
| Noise bandwidth | 13THz |
| Receiver | WDM DEMUXES | Frequency spacing | 100GHz |
| Bandwidth | 80GHz |
| Number of output port | 32 |
| Low pass Bessel filter |  Cutoff frequency | 0.75\*10^9Hz |
| Gain | 3 |

**3.6. Advantage of Demultiplexer**

Demultiplexer(Demux) are used in following systems.

* To enable the different rows of memory chips depends on the address.
* To choose different banks of memory.
* To enable different functions unit in the system
* To select different IO devices from data transfer
* Demux also used for synchronous data transmission systems
* Boolean function implementation
* Data acquisition systems
* Combinational circuit design
* Automatic test equipment systems
* Security monitoring systems

**3.7. WDM BENEFITS**

Wavelength Channel Multiplexing (WDM) is important technology used in today’s telecommunication systems. It has better features than other types of communication with client satisfaction. It has several benefits that make famous among clients such as:

**A. Capacity Upgrade**

Communication using optical fibre provides very large bandwidth. Here the carrier for the data stream is light. Generally a single light beam is used as the carries. But in WDM, lights having different wavelengths are multiplexed into a single optical fibre. So in the same fibre now more data is transmitted. This increases the capacity of the network considerably

**B. Transparency**

WDM networks supports data to be transmitted at different bit rates. It also supports a number of protocols. So there is not much constraint in how we want to send the data. So it can be used for various very high speed data transmission applications.

**C. Wavelength Reuse**

WDM networks allows for wavelength routing. So in different fibre links the same wavelength can be used again and again. This allows for wavelength reuse which in turn helps in increasing capacity [3].

**D. Scalability**

WDM networks are also very flexible in nature. As per requirement we can make changes to the network. Extra processing units can be added to both transmitter and receiver ends. By this infrastructure can redevelop to serve more number of people.

**E. Reliability**

WDM networks are extremely reliable and secure. Here chance of trapping the data and crosstalk is very low. It also can recover from network failure in a very efficient manner. There is provision for rerouting a path between a source destination node pair. So in case of link failure we will not lose any data [4].

**3.8. Advantages of DWDM over WDM**

1. Narrow channel spacing or wavelength selection, giving rise to denser channels in the same wavelength range.

2. Reduced Raman crosstalk without required mitigation techniques.

3. Cost effective way of increasing system capacity without introducing more fibers to the system.

4. With selective wavelength spacing, four-wave mixing is possible.

5. Higher number of wavelengths (up to 8) supported.

6. Higher distance capability with Erbium Doped Fiber Amplifier (EDFA). Maximum link distance of~30 km.

7. Repeater or amplification sites are reduced, resulting in a large savings of funding.

8. Maximum number of channels is up to ~40 as of today (theoretically hundreds of channels are possible).

9. For long haul applications, optical amplification is well proven.

10. Very useful as upgrades to already installed systems.

11. Multiple channels of information carried over the same fiber, each using an individual wavelength.

12. Improved noise figure for same given specifications.

13. Signal distortion is less than conventional WDM systems.

14. Secondary market systems are available which can significantly reduce costs.

**3.9. Disadvantages of DWDM over WDM**

1. Requires more space than conventional WDM

2. Higher power consumption (typically 3 times than WDM systems for every transmitter card).

3. High dependence on the dispersion of the deployed fiber.

4. Optical multiplexers and Demultiplexers require custom wavelengths, challenging vendor specifications.

5. Allowed wavelength variation due to temperature change of laser diodes is much lower than WDM.

6. Installation costs are higher than WDM systems.

**CHAPTER FOUR**

**4. RESULT AND DISCUSSION**

In this chapter we discuss about how to use OptiSystem software and discus about simulation layout of WDM and DWDM communication transmission system and about their eye diagram graph its pattern.

**4.1 Optisystem**

Before we simulate the simulation layout of WDM and DWDM transmission system understanding the software which is selective so we use Optisystem software. OptiSystem is a comprehensive software design suite that enables users to plan, test, and simulate optical links in the transmission layer of modern optical networks.

A system level simulator based on the realistic modeling of fiber-optic communication systems, OptiSystem possesses a powerful simulation environment and a truly hierarchical definition of components and systems.

**4.2 Simulation for WDM**

The topology setup consists of 8 channels launched into a single fiber span. Channel spacing is 50 GHz and they are generated in groups of odd and even channels by two PRBS generators, Electrical Signal Generators, and CW laser sources (each with four 100GHz-spaced wavelengths).

Initially all channels have the same polarization state. All even channels before being multiplexed with odd channels are passed through the Polarization Shifter, which rotates the polarization state by a fixed angle. After multiplexing, the signal is launched into a fiber, and then is demultiplexer and sent to 8 receivers followed by BER Testers to measure channel performance (BER and Q-factor) for given polarization state difference between adjacent channels.

**4.2.1 Simulation layout of WDM**

Simulation layout describes about how system is work.



Figure 4.1: Simulation Design of WDM

This diagram shows that the overall system layout of WDM transmission system by using 8 channels and use fiber optic with length of 50 km iterate by the loop control.

As we seen the above design the output of system to be test are the following.

a) Optical spectrum analyzer

b) Optical power meter

c) WDM analyzer

d) BER analyzer



Figure 4.2: Optical Spectrum Analyzer before Optic Fiber.

We measure the optical signal before optical fiber is add and calculate and display optical signals in the frequency domain. It can display the signal intensity, power spectral density, phase, group delay and dispersion for X and Y polarizations.

Optical power meter Used to calculate and display the average power of optical signals. It can also calculate the power for polarizations X and Y before using fiber optic.

This WDM Analyzer calculates and displays the optical power, noise, SNR, frequency and wavelength for each WDM channel before optic fiber used.

Figure 4.7: WDM Analyzer after Optic Fiber.

This WDM Analyzer calculates and displays the optical power, noise, SNR, frequency and wavelength for each WDM channel after optic fiber used.

Figure 4.8: BER Analyzer.

BER Analyzer estimate Q factor, eye opening, eye closure, extinction ratio, eye height, etc. It can also take in account Forward Error Correction (FEC), plot BER patterns and estimate system penalties and margins. The green color indicate the received bit pattern and red implies normalized bit pattern.

**4.3 Simulation for Dense WDM**

This simulation simulates a realistic scenario of a 40 Gbps DWDM link with inter-channel spacing of 100 GHz. 32 individual channels carrying PRBS data are transmitted over a 50 km length of optic fiber. The design objective is to utilize distributed EDFA amplification to compensate for the link attenuation thereby effectively increasing the span in a longer haul link.

Simulated a 32-channel DWDM network with NRZ modulation formats at 40 GB/s. The transmitter section consists of a 32-channel WDM transmitter with starting Frequency of 1555nm and the frequency spacing is 100 GHz.

The receiver is a 32-channel WDM de-multiplexer, with PIN photo detectors and BER testers. The 32-channel multiplexer has been used along with the general Optical fiber. Optical amplifier gain increased up to 20 db. Than frequency spacing of the wavelength is 100GHz. WDM transmitter is use to transmit the signal in to ideal mux .Than passing through the control loop after it was separated. Signals are passed through optical fiber.



From the above DWDM layout we can see the output of

a) Optical spectrum analyzer

b) Optical power meter

c) WDM analyzer

d) BER analyzer

**CHAPTER FIVE**

**5. Conclusion and Recommendation**

**5.1 Conclusion**

This paper discusses the impact of the spectrum slicing technique in WDM and DWDM system and evaluates the performance of different formats of modulations in WDM used in the optical networks. WDM method optimizes the performance and cost issues of the system. Optisystem14 software was used to design, implement and simulate the passive optical system of WDM. In the simulation, the WDM spectrum sliced technique which is running instantaneously eight different channels of 0.5 nm spectral widths is successfully built. The simulated results show that various parameters have been studied considering their effect in the overall system performance and the received signal clarity. The system performance analysis is carried out by using spectrum analyzer considering the BER as the main performance parameter, Q factor and threshold. If Q factor increase the transmission rate is high and eye diagram more opened.

Simulated a 32-channel DWDM network with NRZ modulation formats at 80 GB/s. The transmitter section consists of a 32- channel WDM transmitter with starting Frequency of 1550nm and the frequency spacing is 100 GHz. here used a transmission loop as an optical link with a length of 50 km of SMF and EDFA‘s are used. The receiver is a 32-channel WDM de-multiplexer, with receiver and BER testers. The 32-channel multiplexer has been used along with DCF with the general Optical fiber. Optical amplifier gain increased up to 10 db. Then frequency spacing of the wavelength is 100GHz.

WDM transmitter is use to transmit the signal in to ideal mux .Then passing through the control loop after it was separated. Signals are passed through optical fiber. Here optical fiber used. Which is single mode fiber. Then it was Demux by WDM. After Demux the wavelength than go to optical receiver are used to receive the signal from the WDM Demux .output displayed by the BER analyzer. The BER cure displayed on the graph. The waves distributed uniformly then output is high and quality factor value increases. If quality factor value increases then signal transmission rate is high. If increasing the quality factor data transmitted to the long distance. The results indicate that the worst simulated BER in the chosen samples can be observed for WDM communication transmission system.

Channel 1-1, which corresponds to a quality factor (Q) of 2.99, BER which corresponds to a quality factor (Q) of 2.43, is noticed for channel 1-2. An average BER better than can be observed for the remaining channels. To provide a deeper understanding of Figure 4.9, it is useful to review some of the eye diagram basics and characteristics. The green curve in Figure 4.9 represents the ideal received bit pattern only, while the red pattern represents a normalized pattern for the 2 bits actually received, with the 1 bit “eye-opening” in the center of the display and 1/2 bit to the left and right of the center eye to capture the rise/fall-time transitions.

For DWDM communication transmission system Channel 1-1, which corresponds to a quality factor (Q) of 2.59, BER which corresponds to a quality factor (Q) of 2.47, is noticed for channel 1-2. An average BER better than can be observed for the remaining channels.

To provide a deeper understanding of Figure 4.18, it is useful to review some of the eye diagram basics and characteristics. The green curve in Figure 4.18 represents the ideal received bit pattern only, while the red pattern represents a normalized pattern for the 2 bits actually received, with the 1 bit “eye-opening” in the center of the display and 1/2 bit to the left and right of the center eye to capture the rise/fall-time transitions.

The eye diagram is a useful tool for the qualitative analysis of the signals used in digital transmission. This diagram provides an at-a-glance evaluation of the system performance and can insight into the nature of the channel’s imperfections. Careful analysis of this visual display can give the user a first-order approximation of the signal-to-noise ratio, clock timing.

Several key values can be extracted directly from Figure 4.18, such as the One Level, Zero Level, Eye Amplitude, eye height, crossing point, rise time, and fall time. Then, system performance indicators, such as the Eye Crossing Percentage, signal to noise ratio, eye width, Duty Cycle Distortion, BER, and quality factor, can be directly calculated using simple and direct relations based on the key values.

Finally, it is worth mentioning that today’s manufacturers provide devices that directly display all previous values and system indicators once the system is tested.

**5.2 Recommendation**

Must enhance the existing fiber optic telecommunications technology course significantly through the introduction of computer simulation. To date we have used the software only for demonstrations, we must incorporate laboratory exercises into the university course and most of the exercises will be simulations.

The laboratory exercises are a response to a request from the students for a laboratory component and for at least something close to a hands-on experience. Simulation allows the students to observe the behavior of systems that would be much too costly to provide in a hardware -based laboratory.

DWDM and the system components have been discussed. It is clear that DWDM will definitely reshape the future communication network as it has bandwidth availability which is the need of hour. Various advantages of DWDM make it ideal technology for communication systems. The losses that occur in this system like attenuation loss can be overcome using optical amplifiers but it may result in OSNR problems. Dispersion losses can also be overcome thus increasing transmission distance. So in all DWDM is worthwhile and can be base for future communication.

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