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COLLEGE OF ENGINEERING

EVALUATION THE PERFORMANCE OF OPTICAL TRANSMISSION NETWORK USING RADIO OVER FIBER TECHNOLOGY

A PROJECT

SUBMITTED TO THE COUNCIL OF THE COLLEGE OF ENGINEERING IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DIPLOMA DEGREE IN *ENGINEERING/ ELECTRICAL ENGINEERING*

BY

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SUPERVISED

PROF. DR. HAIDER JABBAR ABD

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بسم الله الرحمن الرحيم

اللَّهُ نُورُ السَّمَاوَاتِ وَالْأَرْضِ ۚ مَثَلُ نُورِهِ
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سورة النور (الآية ٣٥)

صدق الله العلي العظيم

Supervisor Certificate

I certify that this research **(EVALUATION THE PERFORMANCE OF OPTICAL TRANSMISSION NETWORK USING RADIO OVER FIBER TECHNOLOGY)** written by **Suhir Amaakhan Yahia** has been prepared under my supervision at the College of Engineering, University of Babylon, as a partial fulfillment of the requirements for the Diploma Degree in Engineering/ Electrical Engineering.

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Date: / / 2022

In view of the available recommendations, I forward this Project for debate by the Examining Committee.

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Date: / / 2022

The Examining Committee's Declaration

We certify that we have read this thesis **((EVALUATION THE PERFORMANCE OF OPTICAL TRANSMISSION NETWORK USING RADIO OVER FIBER TECHNOLOGY)** written by **Suhir Amaakhan Yahia** and, as Examining Committee, examined the student in its content, and that in our opinion it is adequate as a research for the Diploma Degree in Engineering/ Electrical Engineering.

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Dedication

To

my beloved mother and wonderful father; the origin of my success

my dearest husband and kids

my dearest sisters and brothers

I dedicate this work

Suhir
2022

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First and foremost, all praise and thanks are due to Almighty Allah who has granted me the capacity to accomplish this work.

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Abstract

In order to improve the performance of optical fiber communication systems, this study presents modulation techniques for radio over fiber communication systems. Most of the modulation techniques proposed to achieve this goal are a combination of traditional modulation methods. Modulation technologies that combine techniques such as pulse amplitude, quadrature amplitude modulation, QAM DPSK modulation are applied to various optical communication systems models. Using simulation results, a new study illustrates and distinguishes between various types of modulation techniques. The results include information on received power. For studying proposed models, this paper provides a comprehensive analysis of a Wavelength Division Multiplexing (WDM) optical transmission system using Radio over Fiber (RoF) technological. The research was used in optical networks to combat the effects of nonlinearity, chromatic dispersion, and signal loss. Fiber Bragg Grating (FBG) has been implemented in a 4-channel WDM transmission system network at 10Gb/s speed to compensate for dispersion and nonlinear distortion. The use of erbium doped fiber amplifiers (EDFA)has also in order to make things better the transmission system's quality of service. In Digital RoF, modulation types such as DPSK and QAM are also discussed. We compared our results with those of previous studies by looking at constellation diagrams, received optical power, modulation types, fiber dispersion, channel spacing variation, and laser power. The most prominent results came to obtain good measurements, reduce non-linear noise, and maintain signal strength using the amplifier.

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Lists of abbreviations

Abbreviation	Description
BS	Base Station
BSU	Base Station Unit
CO	Central Office
CS	Control Station
CW	Continuous Wave (constant wave) laser
DPSK	Differential Phase Shift Keying
DR	Dynamic Range
EAM	Electro Absorption Modulator
EDFA	Erbium Doped Fiber Amplifier
GSM	Global System for Mobile Communication
Ife	Intermediate Frequency
LiNb O3	Lithium niobate (non naturally)
LO	Local Oscillators
MU	Mobile Unit
MZM	Mach-Zehnder Modulator
NF	Noise Figure
OFC	Optical Fiber Communication
OFDM	Orthogonal Frequency Division Multiplexing
QAM	Quadrature Amplitude Modulation
QCM	Quadrature Carrier Multiplexing
QPSK	Quadrature Phase Shift Keying
RAU's	Remote Antenna Units

RF	Radio Frequency	
ROF	Radio Over Fiber	
RS	Radio Frequency	
RS	Remote Station	
SCM	Sub Carrier Multiplexing	
SCM	Sub Carrier Multiplexing	
SMF	Single Mode Fiber	
UMTS	Universal Mobile Telecommunication Service	
WDM	Wave Length Division Multiplexing	

Chapter One

Introduction and Literature Survey

1.1 Introduction

The requirements of high speed data transfer is skyrocketing due to increase in the network technology and the internet that demands fast data communication. High speed data transmission and large bandwidth necessities can be fulfilled with the use of optical communication where light signal is used for sending and receiving data [1]. Optical fiber gives many advantages over other transmission medium. It offers faster data transmission and lesser signal losses as compared to copper cabling. High bandwidth efficiency and low attenuation characteristics of optical fiber provide large number of applications for long distance transmission system. In optical fiber communication system, Radio Frequency (RF) signal processing offers low attenuation losses due to which it is faster than the other transmission media for longer transmission distances. Radio over Fiber (RoF) technology provides the good solution for above mentioned requisites. It uses fiber-fed distributed antenna network and provides a microcellular network system to enhance the performance of the system A transmitter, channel and a receiver constitutes the optical communication system. The message is encoded into an optical signal by the transmitter, optical fiber is used to transmit the signal, and the message is converted back into original electrical signal at the receiver end. [2].

1.2 Radio Over Fiber (RoF)

Radio frequency signals are transmitted from a central station to remote antennas via optical fiber using RoF technology Remote Antenna Units (RAUs). Fiber optics are used to transmit light signals that have been modulated with radio frequency (RF) signals. The combined process of RF and optical communication is termed as RoF system. RoF provides higher optical bandwidth for transmission and accommodates large number of users for signal transmission [3]. This technology is used for transfer, control and timely delivery of data traffic over the wireless network. Figure (1-1) shows the distribution of RF signal from a Central Office (CO) to RAUs [4]. The RF signal generated at the Control Sation (CS) is modulated via analog or digital modulation techniques and then transmitted through analog optical fiber link [5]. For optical modulation approach direct intensity and external intensity modulation techniques can be used depending on their advantages or disadvantages [6]. The attenuation loss is negligible in signal transmitted through an optical fiber link in comparison to conventional transmission medium.

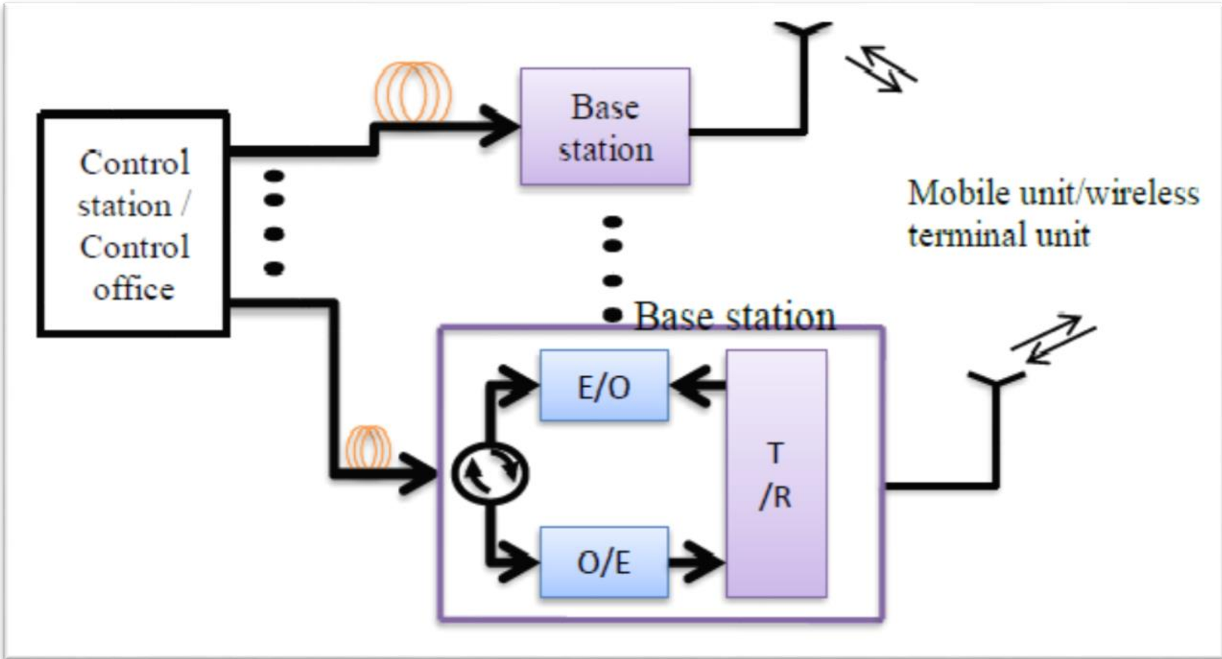

Figure (1-1) General ROF System

The photo detector at the Base Station (BS) uses detection techniques to recover the RF signal that was transmitted (BS),which undergoes Optical to Electrical conversion process. Then signal is radiated by the antenna units after the necessary amplifications. The antenna placed at base station unit (BSU) is used for the transmission of signal between mobile unit (MU) and BSU [7]

Due to centralized configuration it is easy to install and maintain RoF system. It is cost effective to use several base stations for sharing the expensive components. Erbium doped fiber (EDFA) can be used for amplification due to its large dynamic range, high power transfer efficiency, low noise figure, relatively flat gain and an independent polarization. It is appropriate amplifier for long distance data transmission system. The power consumption is decreased by directly modulating RF signal to the optical fiber. Low dispersion fiber (single mode fiber) with modulated RoF sub carriers multiplexing (SCM) combination can be used to achieve linear system.

1.3 Modulation In RoF

There are two different approaches used for the optical modulation rocess where the modulating signal's characteristics determine how much optical power a semiconductor laser emits.

1. Direct Intensity Modulation:

In Direct Intensity Modulation, the semiconductor laser is modulated directly, by modulating the excitation current [8, 9]. Depending on the data being transmitted, the driving current for a semiconductor laser can be modulated directly. Modulation of the intensity The linear operation of the system can be achieved through the use of direct detection. Light intensity output power is given as:

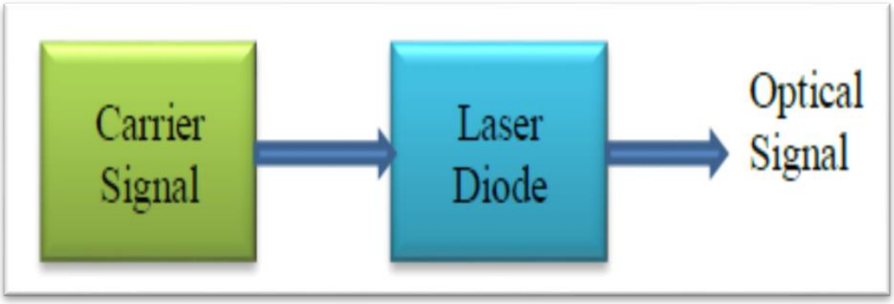

Figure (1-2) Directly Intensity Modulation

2. External Intensity Modulation:

In this scheme, the carrier signal generated by CW laser is modulated according to electrical signal and gives the optical output as shown in figure(1-3) .

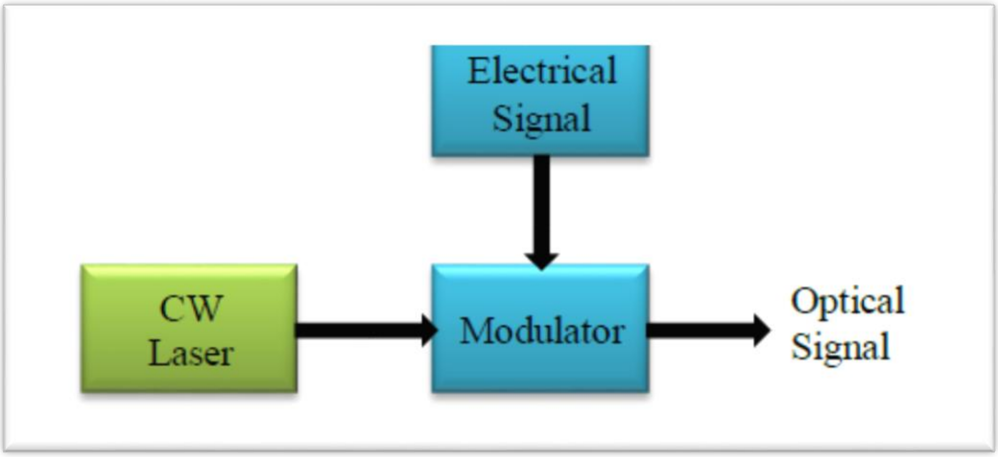

Figure (1-3) External Intensity Modulation

The use of LiNbO3 external modulator gives higher performance for wide bandwidth and high-speed optical communications. MZM and Electro Absorption Modulator (EAM) are commonly used for external modulation. EAM is based on the absorption of a semiconductor material.

MZM, on the other hand, relies on the refractive index changing in response to an external electric field [10, 11].

External modulation technique can operate at high frequency (mm-wave) and provides better performance than direct modulation technique [12, 13]. Quadrature phase shift keying (QPSK), Differential PSK (DPSK) and Quadrature amplitude modulation (QAM) digital modulation techniques can also be used for modulation process [14, 15].

1.4 Benefits of Redio Over Fiber

RoF technology has a number of advantages and benefits, including the following:

1. Low Attenuation Loss

The attenuation of signals transmitted through optical fiber is well-known, especially when compared to signals transmitted through wireless medium. In order to reduce the need for repeaters, optical fiber should be used instead. Impedance rises with frequency, which causes very high losses in transmission lines because of absorption and reflection losses in open space. [16]. As a result, in order to transmit long-distance transmission of high-frequency radio signals, specialized regeneration An apparatus is needed. Each base station transmits mm-wave signals that have been converted from baseband or IF signals. In order to achieve up conversion at each BS. raise-performance local oscillator (LO) are required this results in an extremely complex BS that must meet stringent performance standards. Since optical fiber has low loss, it can be used to distribute RF signals and simplify the BS at the same time. [16, 17].

2. Large BandWidth

optical fibers are capable of transmitting enormous amounts of data. Low attenuation transmission windows exist at 850, 1,310, and 1,550 nm wavelengths, respectively. An SMF optical fiber's combined bandwidth for all three windows exceeds 50 terahertz. Faster signal processing is possible because of the large optical bandwidth, which is simply not feasible in electronic systems [17]. It is therefore possible to easily carry out Filtering, mixing, and up- and down-conversion are some of the more demanding microwave functions. RoF technology employs a technique known as Subcarrier Multiplexing (SCM) to increase bandwidth utilization in analog optical systems.

3. Easy Installations and Maintenance

LOs and related RAU equipment are typically not required with most RoF techniques. RoF systems keep expensive and complex equipment generating RAUs at the very top of the process easier to use. Aside from their high price and power consumption, high-frequency electrooptical modulators and electronics should be avoided at the CS. As a result of their high manufacturing and maintenance costs, downlink transmission techniques of similar complexity are also discouraged. Multiple RAUs share the same Equipment that can modulate and switch located at the head end [18]. Smaller and lighter RAUs can be produced as a result of this installation and maintenance costs are effectively reduced by this arrangement. BSs that are easy to install and require low maintenance costs are critical for RoF systems because of the need for large numbers of BSs. The cost of energy consumption, site leasing, and site acquisition is reduced due to the BSs' simplicity. Since the current cellular system is experiencing an ever-increasing demand for new services, RoF systems will have to adapt to accommodate a wider range of traffic characteristics in the future. Since service provider need to the maintain aquality of their services and remain financially viable, a pricing strategy must be devised [17,18].

4. Reduced consumption of Electrical Power

engergy transfer efficiency can also be measured by the amount of electricity used for each unit of information (Joules per bit). Access network power consumption is calculated based on segmentation and should be considered as an important factor in network infrastructure design when comparing Average access rate (Watts/Mbps) for each user. Data from manufacturers on various types of typical hardware's energy consumption, which can be found online, it is possible to calculate the system's energy consumption at various access rates.This perspective provides a better platform for predicting Equipment that can modulate and switch rising. It is important to take into account the CS's optoelectronic and electrical components in order to maximize the power efficiency of a RoF system [19]. The BS design offers the greatest potential for energy savings because it consumes raise to 70% of the total power used by commercial cellular system. Power consumption of BSs is critical because many BSs are needed to provide service. The BS consumes more power when the transmition power or load traffic is increased. Power consumption models for both uplink and downlink use RoF's model, which takes into account as well as the methods used in both directions for transmitting power or cell coverage. [19, 20].

5. Dynamic Resource allocation

It would be a waste of resources to allocate permanent capacity in areas with frequent changes in traffic loads, but dynamic capacity allocation avoids this. Macro-diversity transmission and mobility are additional signal processing functions., can be performed at the centralized head end [21]. Due to the centralization of RF functions at the head end (modulation, switching and so on), peak capacity can be dynamically allocated. It's possible to allocate more resources to a particular area (such as a shopemall) and then redistributed to another areas during off-peak hours (such as densely populated residential neighborhoods) in RoF system of distribution for GSM traffic By using the WDM technique, wavelengths can be allocated whenever necessary [20, 21].

1.5 Limitation of RoF technology

SMF-based RoF system can be limited by chromatic dispersion, which may also lead to raised RF carrier phase noise [21]. Modal dispersion severely limits the bandwidth and range of a link's data transmissions. in RoF systems based on multi-mode fibers.. Since distributed modulation formats like Quadrature Amplitude modulation (QAM) can be used in digital radio systems (e.g. WLAN and UMTS), even though the RoF transmission system is analog (QAM).The fact of the matter is that this should be taken into consideration. Orthogonal frequency division multiplexing, also known as QAM (OFDM). Since the modulation and light detection in RoF are analog, it can be considered the analog transmission systems. As end, signal flaws as well as noise and distortion are a problem in both analog and RoF system [22]. The RoF links have lower noise figures and lower dynamic ranges as a result of these flaws. It is critical To use mobile (cellular) communication systems, the RF power received by base stations (BSs) by MUs can vary widely, i.e., it can be much higher from one cell to another, even though they are located in different cells, than from one cell to another. [21, 22].

1.6 Literature survey

This section includes the most relevant literature on ROF technology in optical fiber transmission networks with various compensating methods. This topic has been proposed and discussed by numerous researchers. An overview of the previous researchers can be found in the section that follows.

In 2015 Jung,et.al. [23]

An in-building wireless backhauling comparison of analog and digital radio-over-fiber (RoF) systems was conducted with a nonlinear channel condition. On both RoF links, we demonstrated Wi-Fi-compatible optical multicasting and measured the error vector magnitude (EVM) performance of transmitted wireless signals. In the demonstration, the digitalized In comparison to its analog counterpart, the RoF system's performance with EVM (3.75 percent) was consistent, whereas the optical link's performance was highly variable.

In (2018). Rashed,et al.[24]

High-capacity optical communication systemslow biterrorrates, and signal-to-noise ratio factors are given preference for fiber communication systems in modern enterprise infrastructures .To meet the enormous demands access to high-bandwidth wireless networks and fiber-optic radio (RoF) communication technology, which integrates radiofrequency and opticalfibertechnologies, ROF technology has been developed and used in multiple Microwave, satellite, and mobile communication systems, as well as broadband services, are examples of communication applications. optical fiber transmission of radio frequency signals is made possible by the radio wave frequency signal modulating the ray light, which is then transmitted via optical fiber. The advantages of radioover fibertransmission technologysuch as flexibility, bandwidthand capacity, have made it an essential part of most communication infrastructure. A single central office (CO) connects multiple base stations (BSs) to form a radio over fiber communication system, and the CO manages switching, routing, and other aspects of network operations (OAM). Radio frequency signals are assigned to the base stations via a fiber link, on the other hand. Additionally, CO generates and transmits opticalradio frequencysignals to basestations. Photo detectors in basestations were used to convert optical signals to electrical signals at the receiver end.

In 2019 Hadi, M. U., et al. [25]

An A-RoF architecture system at the downstream link shows the typical schematic framework. The baseband signal is typically upconverted to an RF signal in this case. The electrical - Optical (E-O) conversion block transforms the RF signal into an optical signal before transmitting it over the optical link. In the receiver, the RF signal is converted back to electrical form using an optical-to-electrical (O-E) conversion block. The antenna then picks up this signal and sends it out.

In 2020 Rahman, S., Ali ,et al.[26]

Mobile networks in the future will be able to transmit large amounts of data at high speeds thanks to access networks via the internet via cloud computing (C-RANs) In 2017, these products are expected to be available. The C-capabilities RAN's are managed by an integrated layout of fiber optics and radio network, but this needs to be improved from an economic and scalability perspective. RoF fronthaul is a promising candidate for C-RAN architectures, but the distortions caused by nonlinearity impairment (NLI) Modulating laser linear distortion and orthogonal frequency division multiplexed signal PAPR must be addressed from the power amplifier's perspective. Researchers have devised a DSPreceiversolution to mitigate theeffects of high PAPR and NLIs. is presented. An extensive set of simulations are carried out to evaluate the performance of the proposed receiver under There is a wide range of transmission input power levels, various quadruple amplitude modulation (QAM) formats, optimized filtering at the receiverend, and different channelspacing between optical WDM channels. Using simulations and theoretical models, the presented solution for RoFtransport consumes less power, is better at long distances, supports higher modulation formats, and transports more WDM channels when NLIs and DLs are present. With a total data rate of 100 Gb/s over 16 WDM channels, transmissiondistances up to 10 km are investigated, demonstrating the suitability of the proposed receiver for use in future C-RAN fronthaul networks.

In 2021 - Kumar, S., Sharma, S., et al [27]

RoF and WDM technology work together to make cellular communication more accessible even in outlying areas. When using wavelength division multiplexing (WDM), data is sent through a single optical fiber at multiple wavelengths. A single optical fiber is used to transmit multiple wavelengths of light at the same time, and they are separated at the end [8]. In turn, this leads to an improved optical communication system in all its guises, thanks to the increased data rate and system capacity, greater flexibility, lower costs, and a more straightforward network design. WDM RoF applications were examined by Kim et al., using SOA to implement frequency up conversion using the FWM effect. They found that upconverting eight channels simultaneously was possible with almost zero crosstalk and no errors. When it comes to a broadband wireless access network, WDM RoF technology is clearly superior.

In 2021 Jain, D., & Iyer, B.[28]

The proposed system uses a carrier frequency of 100 GHz and a data rate of 10 Gbps for four channels of WDM-RoF. The data is sent over a single-mode optical fiber with a length ranging from 30 to 70 kilometers using a WDM multiplexing scheme. Many metrics are used to evaluate the system performance including the eye diagram, the Q factor and the SNR/BER. With an eye height of 0.364 meters at 70 kilometers, the SNR for each of the four channels was reported as 61.41 decibels, 60.36 decibels, 56.33 decibels, and 51.5 decibels. In terms of BER and Q factor, the values at 70 km of optical fiber length are 3.153e9, 1.48e8e8, 2.42e10e9, and 2.1546e9 for the four channels. In comparison to existing 60 GHz systems, the proposed 100 GHz scheme outperforms them by an order of magnitude.

1.7 Statement of the RoF

Many problems, including chromatic dispersion; signal losses; and nonlinear effect, remain unresolved by researchers and has significant impact on the optical communication network performances. They are two type of the nonlinear impacts. The first is the interaction of light wave with phonon, the second is due to the refractive index's dependence on applied electric field strength. In WDM system, they effects restrict the distance between the nearby wavelength channel, limit the maximum power on the all channels, and maybe limits the maximum bit rate,

1.8 Project's Objectives

The following are the main goals of this project:

1- Improve the signal's performance by studying and analyzing the use of WDM, EDFA, and SOA techniques in the optical fiber communication system. Optisystem version "19" software can be used to design and simulate a multi-channel optical fiber system with a

WDM compensator. By using a trial and error method, the quality factor of the signal can be determined.

2 - A simulation-based comparison of the effects of an amplifier vs. one that isn't.

1.9 Project Organization

This project is organized in five chapter as follow: -

- chapter one presents an introduction to optical communication system and key development of the optical fiber, types of modulation in RoF. Also, this chapter includes advance of RoF in addition to the aims and organization of thesis.
- Chapter two describes theoretical backfround about fiber, why use fiber optical , study the different nonlinear effects that make polarization combiner an ideal device to use, applications of the optical networks. Also, different types of architecture for implementing different modulation forms are also discussed.
- Chapter three includes the research methodology employed to investigate the proposed technique to send multi signals in same link. It illustrates the schematic diagrams for conventional WDM technique and the proposed system simulation design and details for all parameters which are used for each technique.
- Chapter four discusses Simulation Results
- Chapter five represents the conclusions and future work.

Chapter Two

Theoretical Background

2.1 Overview of Optical Fiber Communication System

Light is used to transmit data and voice over long distances via glass or plastic fibers in accordance with the transmission sequence, in optical fiber. Electrical signals are used to encode information, which is then converted into visible light signals. The fiber is a conduit for light. Electrical signals are generated from light signals by a detector. electrical signals are decoded and turned into useful data. The fiber is passive and does not contain any kind of active component. The basic fiber optic communication system is shown in figure (2.1) [29].

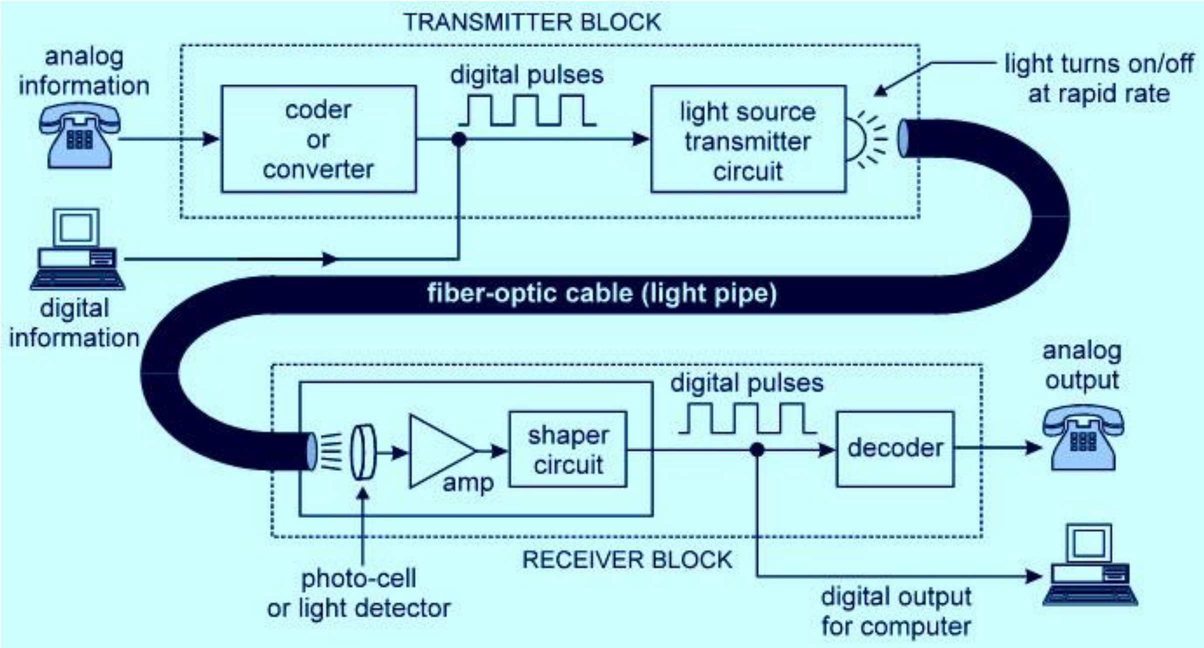

Figure (2-1) Basics fiber optics communication system

2.2 Reason to Use Communications

- Today's communication infrastructure relies on optical fiber as its foundation
- The Optical Fiber Carries:
  - Long-distance calls are almost always
  - Most internet traffic (Dialup, DSL or Cable)
  - Most television channel (Cable or DSL)
  - At 6.4 Tb/s, one fiber can carry 100 million simultaneous conversations.
  - Optical fiber was essential to the information revolution.

2.3 Type of RoF Transmission systems

- In **RF over Fiber** architecture, to transmit data over the optical link, a high-frequency RF (Radio Frequency) data signal is imposed on the light wave signal prior to the optical link's transmission. As a result, wireless signals are transmitted optically to base stations directly frequencies that are very high from optical to electrical at the base stations before they are amplified and radiated by an antenna. There are no frequency up/down conversions required at the base stations thus making the implementation simple and relatively cost-effective.

- In **IF-over-Fiber** architecture, Before being transmitted over the optical link, an IF(Intermediate Frequency) radio signal of lower frequency (less than 10 GHz) is used to modulate light. The base station must first convert the signal to RF before it can be transmitted through the air.[33]

2.4 QAM (Quadrature Amplitude Modulation)

QAM (Quadrature Amplitude Modulation) is the modulation technique that combines phase and amplitude modulation into a single channel is known as modulation. By modifying the amplitude and phase of the carrier wave, QAM effectively doubles the available bandwidth Other names for QAM include "quadrature carrier multiplexing," or QCM.

One of the fundamental principles of QAM is the use of quadrature modulation to directly modulate the carrier wave. Quadrature refers to a phase difference of 90 degrees between two carriers with the same frequency. There are two kinds of signals: the in-phase "I" signal, and the quadrature "Q" signal. A sine wave (i.e.) can be used to represent one of the carrier signals, while a cosine wave (i.e.) can be used to represent the other (i.e). Two carrier signals are modulated at the source and demodulated (i.e. separated) at the destination, but they are transmitted together at the source. The signal is demodulated using a coherent detection method.[34]

1. Digital Quadrature Amplitude Modulation (QAM)

"Quantized QAM" is a common term used to describe digital QAMs, which are used in a wide range of radio communication systems, from cellular to Wi-Fi. Amplitude- and phase-modulated schemes can't compete with the higher data rates provided by digital QAM.

It is possible to use different points to define the values of phase and amplitude in digital QAM schemes. A diagram like this is called a constellation chart. So the set of message points in a constellation diagram. A constellation diagram can be used to implement QAM. Using a square grid with equal horizontal and vertical distances, the constellation points are arranged in the constellation diagram. A Euclidean distance is the smallest distance between the points in the constellation. The most common QAM formats are 16-QAM (2^4),3^2-QAM (2^5),64-QAM (2^6), 128-QAM (2^7) and 256-QAM (2^8). The bit sequence mapping for a 16-QAM is shown below in the constellation diagram Since binary data in digital communications typically has two states0 or 1the number of constellation points in the grid is usually a power of 2. For example, 2, 4,8,16,32........... Using a 16-QAMsignalthe binary values associated with each position are depicted in a diagram. There are 4-quadrants where a single continuous bit stream can be represented as a sequence, and each quadrant can be divided into four groups.

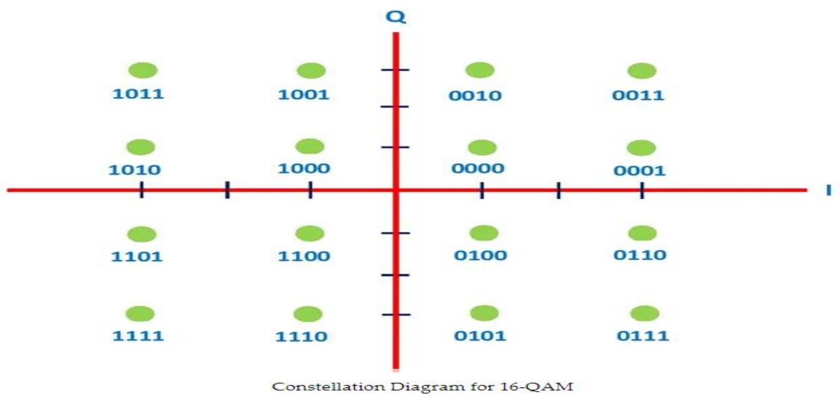

Figure (2-2) Constellation Diagram

Due to the fact that 2 QAM and 4 QAM are considered to be the same as BPSK (i.e. Binary Phase Shift Keying) and 4 QAMis the same as QPSKa 16 QAM is considered to be the lowest order QAM (i.e. Quadrature Phase Shift Keying). As a side note, the performance of 8QAM is nearly identical to that of16 QAM, so it is not widely employed.[34]

2. Quadrature Amplitude Modulation Channel

Many radio communications and data delivery applications make use of QAM channels, a variety of QAM formats. For a variety of applications and industry standards, various QAMs channel variants are employed. Let's pretend that we want to send a 4-bit symbol over QAM. This implies that N is equal to four and that there are 24 = 16 different symbols that could be used. Thus, the QAM system is capable of producing 16 distinct signals. A 16-QAM is the technical term for this. As a result, we can modulate the carrier signal using 16-QAM to achieve the desired effect. 16-QAM32-QAM, 64-QAM128-QAM, and 256-QAM are some other QAM formats and channels to consider.

The number of QAM symbols or states is determined by the number of binary bits per second.

"symbol" refers to a combination of amplitude and phase. The no. of possible symbols for QAM channels is

$$M = 2^N$$

3. Advantages of QAM

QAM's benefits include the following:

- QAM has a low error probability.
- QAM is capable of delivering a large amount of data at a high rate. In order for the carrier signal to carry the desired number of bits. As a result, wireless communication systems primarily employ it.

QAM doubles the amount of available bandwidth.

Communication channel capacity can be more than doubled when sine and cosine waves are used together in a single channel.[34]

4. Disadvantages of QAM

Some of the disadvantages of QAM include:

- Noise can affect amplitude changes in QAM.
- Due to the presence of amplitude in QAM, the linear amplifier must be used in order to maintain linearity in a radio transmitter. This type of amplifier consumes more power and is less efficient.
- More bits per symbol is possible, but in higher order QAM formats, the constellation points are closer together, is more sensitive to noise and results in data error.
- Even in the higher order QAM formats, the receiver has a hard time decoding correctly the signal. There is a decreased level of noise sensitivity. As a result, only high signal-to-noise ratios necessitate the use of higher-order QAM.[34]

5. Application of QAM

Some of the applications of QAM include:

- QAM technique Because of the increase in the bit data rate, it is widely used in radio communications.
- QAM is used in applications ranging from short range wireless communications to long distance telephone systems.
- QAM is used in microwave and telecommunication systems to transmit the information.
- The 64QAM and 256QAM are used in digital cable television and cable modem.
- QAM is used in optical fiber systems to the increase bitrates.
- It is used in many communication systems like Wi-Fi Digital Video Broadcast (DVB)and WiMAX.
-

2.5 Differential PhaseShiftKeying

Definition: Differential phaseshift keying (DPSK) is the acronym for this technique. Phase modulation is a method of transmitting data by changing the phase of the carrierwave. In this case, the phase of the modulated signal is shifted e to a previous signal element. The earlier element's low or high state influences the signal's phase. The demodulator does not need a synchronous carrier for this type of phase-shift keying. It is possible to alter the binary bit input series so that the next bit is dependent on the previous bit. Because of this, the receiver uses the previous bits it has received to detect the current bit. The DPSK waveform is depicted in the image above. As can be seen from the above waveform, the signal's phase willnotbe inverted or otherwise altered once the data bit is set to'0.' The phase of the signal will be inverted as soon as the data bit is set to'1'.

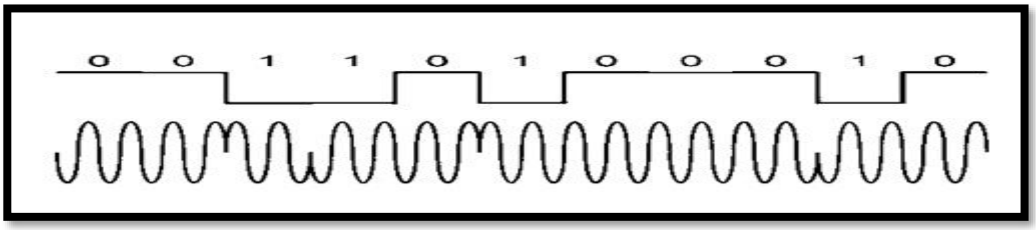

Figure (2-3) DPSK waveforms

In the above wave forms the high state is represented by an ’within the modulating signal & the low state represented by a modulating signal.[35]

1. Dpsk Advantages and Disadvantages

The advantages of DPSK include the following.

- • There is no need for carrier signals at the end of the receiver circuit for this modulation. This eliminates the need for multi-circuit architectures.
- DPSK modulation has a lower bandwidth requirement than BPSK modulation.

Wireless communication relies heavily on non consistent receivers because they are simple and inexpensive to build.

The disadvantages of DPSK include the following.

- DPSK has a higher bit error rate or chance of error than BPSK.
- The noise interference in DPSK is greater.
- Two consecutive bits are used in this modulation, one for the input and one for the output. As a result, the error in the primary bit causes the error in the next bit, and the error continues to spread.

2. The application of DPSK

The applications of *differential phase-shift keying* mainly include wireless communications like RFID, WLANs, and Bluetooth. The famous application among them is Bluetooth wherever alternatives of DPSK has been used like 8-DPSK, and π/4 – DQPSK modulation [35]

2.6 Optical Transmission Losses

The optical communication system can be limited either by dispersion or attenuation.

- **Attenuation:**

  It is a transmission loss used to determine the maximum transmission length of optical signal. Attenuation is a wavelength dependent parameter. At 1.5µm wavelength modern optical fiber offers 0.2 dB/km attenuation loss. For a fiber link, attenuation and connector losses can be expressed [18] as:

$$Optical\ Losses = 2(NLc + ML\,sp + \ \alpha Lf)dB$$

Where NLc denotes the connector losses, MLsp denotes the losses due to splicing and α denotes the attenuation in dB/km.

- **Dispersion:**

The widening of pulse duration while travelling along a fiber is known as dispersion. This widening of pulse width will interfere with other pulses and thereby produces the Inter Symbol Interference (ISI) [19]. Due to this occurrence, the amount of data transmission and the spacing between pulses will be limited. In order to avoid broadening of pulses, the bit rate (BT) must be less than the reciprocal of the pulse duration as given below:

$$\mathcal{BT} \leq \frac{1}{2}\,\tau \qquad \ldots\ldots\ldots\ldots \quad (3)$$

Where 2τ is the pulse duration

- **Chromatic dispersion**

Chromatic dispersion occurs due to finite spectral line width of the optical source. There is almost zero dispersion in the low attenuation region at 1330 nm. Dispersion limits the bandwidth or information carrying capacity of a fiber [20]. In optical source, first order dispersion results in change of the phase in each sideband. The phase change relative to the carrier is given as:

$$\varphi = \frac{1000\,\pi\, Lf\; Dt\;(\lambda)\lambda c^2 F^2 Rf}{c} \qquad \ldots\ldots..(4)$$

Where, Lf represents the fiber link length, φ represents the first order dispersion, λc represents the central wavelength, FRF represents the RF frequency and Dt represents total dispersion coefficient. To overcome dispersion, smaller core diameters fiber can be used but it allows less number of modes. Also, no modal dispersion is allowed using single mode fiber.[18]

2.7 Essential Components of Optical Fiber Communication OFC

- **Transmitter:** The transmitter is where the E/O is generated and converted. Generally speaking, lasers and light emitting diodes generate light and serve as the source of intensity for communication .
- **Channel:** To transmit optical signals, a waveguide is used in the cable, which is made up of glass fibers. Inside of the optical fiber is well-protected by the fiber's coating of optical fiber. The main principle of communication inside optical fiber is total internal reflection, and the thinness of the fiber, including the core and clad, is an advantage. Additionally, a light-blocking jacket has been employed to aid in TIR as well as provide security.
- **Receivers:** Light can be converted into electrical signals using the photoelectric effect in the photo-detector component of receivers. [38] The semiconductor dependent is the most widely used PD. The two most common types of photodetectors used in optical communication are known as PIN and avalanche.

2.8 WDM system for RoF communication

A key component of optical communications expansion is WDM. As a result of WDM, the system has become more flexible and the network design has become simpler. Using a single fiber, multiple wavelengths can be sent to the system, increasing its capacity. An enormous increase Multiple wavelength division multiple access (WDM) systems can offer a significant increase in data rate.wavelengths, where each wavelength has its own distinct channel. optical spectrum is divided into multiple channels in WDM.Each channel can be used to send and receive data in both directions at once [36]

The WDM system allows each wavelength to be preserved as a distinct channel on which different wavelengths can be transmitted simultaneously.

Carrying data is possible. If you think of a WDM multiplexer as a passive device, you'd be correct:

combined in a single fiber with various wavelengths. RoF signals can now be distributed using WDM technology. became more important recently. WDM allows fiber bandwidth to be effectively exploited.Semiconductor lasers have several drawbacks, including the inability to select appropriate optical filters and the inability to maintain wavelength stability. Commercial WDM must have a minimum channel spacing of 50 GHz. In this case, this channel spacing is appropriate. be lowered to 50 GHz or lowered to 25 GHz, allowing for the use of hundreds of channels.[10] Figure 1 depicts the optical WDM network in which the wavelength has been substituted. each transmitter transmits at a different frequency and a different wavelength the ones who receive [37]. It is possible to transmit various frequencies using WDM without encountering any interference. broadcasting on the radio [38]. dense wavelength division multiplexing (DWDM) and DWDM are two types of WDM systems.

As a data carrier in the WDM technique, N optical wavelength numbers can be used as a WDM multiplexer to combine with an optical fiber; at the receiver, aWDMdemultiplexer can be used to separate these wavelengths into individual channels In order to prevent the optical carriers from overlapping, the gap between wavelengths controls the channel spacing [13], which is unique to each wavelength.Optical subcarrier multiplexing (SCM) is a complementary technique that can be used to increase bandwidth efficiency in optical systems. Multiple radio frequency RF signals are multiplexed in the frequency domain and then transmitted at a single wavelength in a RoF system using SCM technique. With the use of SCM and WDM, high-speed optical transmissions can be achieved with high optical bandwidth efficiency and high dispersion tolerance. This setup is more noise-sensitive, but there is a drawback in the form of a cap on the maximum subcarrier frequencies and data rates that can be used.

Multiplexing with a wide range of wavelengths.

WDM's most important features are as follows:

- **Capacity upgrade**. With WDM, a fiber network's capacity can be greatly increased.
- **Transparency**: each optical channel in Any transmission format can be supported by WDM., which is an important feature.
- **Wavelength routings**: the application of wavelength sensitive optical devices enables the design of communication networks and switches to incorporate wavelength.
- **Wavelength switching**: wavelength-routed networks have a fixed fiber infrastructure, whereas wavelength-switched networks allow for optical layer reconfiguration. To put it simply,

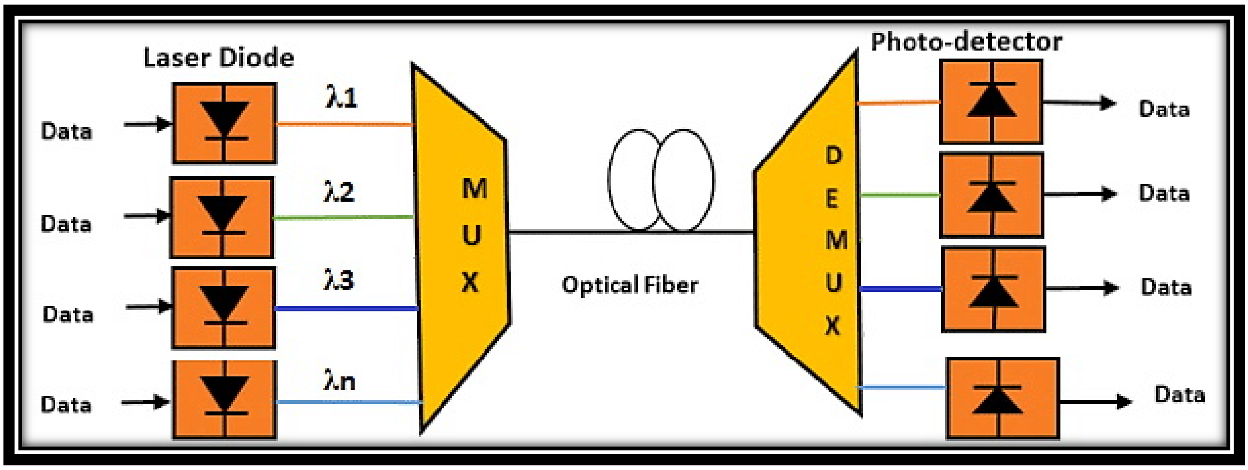

Figure 2-4 configuration of typical WDM transmissions system including the wave

2.9 OPTICAL AMPLIFIERS

In fiber optic communication systems, fiber losses are a major factor in limiting transmission distance. The optical signal is amplified directly by optical amplifiers rather than being transferred to an electrical medium for amplification. High gains, wide bandwidths, high output power characteristics, and low noise levels make optical amplifiers the preferred choice. Erbium-doped amplifiers, ytterbium-doped amplifiers, and Raman amplifiers are the three types of amplifiers. For an optical amplifier's main parameter of optical gain, wavelength and beam intensity at any given point are critical factors. Wavelength and density are directly correlated with the reinforcing medium and material [36], respectively. Doping various elements in optical amplifiers allows for the amplification of a wide range of signals, from visible light to infrared wavelengths, in the range of 450-750 nm. Erbium and ytterbium are the most commonly used doping elements. This characteristic is influenced by how many and what kind of additives are used in the manufacturing process of the optical fiber. An optical signal source, pump laser, and a doped fiber carry information in the EDFA and SOA optical amplifier systems. The erbium and ytterbium ions in an amplifier are stimulated to a higher energy level in order to begin the density inversion process. The non-feedback laser signal's wavelength determines the optical gain that can be achieved.[39]

2.10 Erbium-doped fiber amplifier

It is possible to increase the power of optical signals transmitted over fiber optic cables by using an optical repeater device known as Erbium-doped fiber amplifier (EDFA), Erbium, a areas earth element, is added to an optical fiber so that it can absorb one frequency of light and emit a different frequency of light.

- **EDFA Working Principle**

The EDFA technology relies on the erbium-doped fiber (EDF), a conventional silica fiber. If a suitable wavelength of light energy is used to stimulate the Erbium to a long-lived intermediate state (between 980 and 1480nm), then it decays back to its original ground state by emittings light at a wavelength between 1525 and 1565 nm. It is possible to excite Erbium to a quasi-stable state either by using 980 nm light to induce an unstable short lifetime state, or by using 1480 nm light to excite Erbium directly to a quasi-stable state. When it reaches the quasi-stable state, it emits light in the 1525-1565 nm range, which signals the decay back to the ground state. It is possible for this decay process to be amplified by the presence of pre-existing light. EDFA workings principles is shown in the figure .

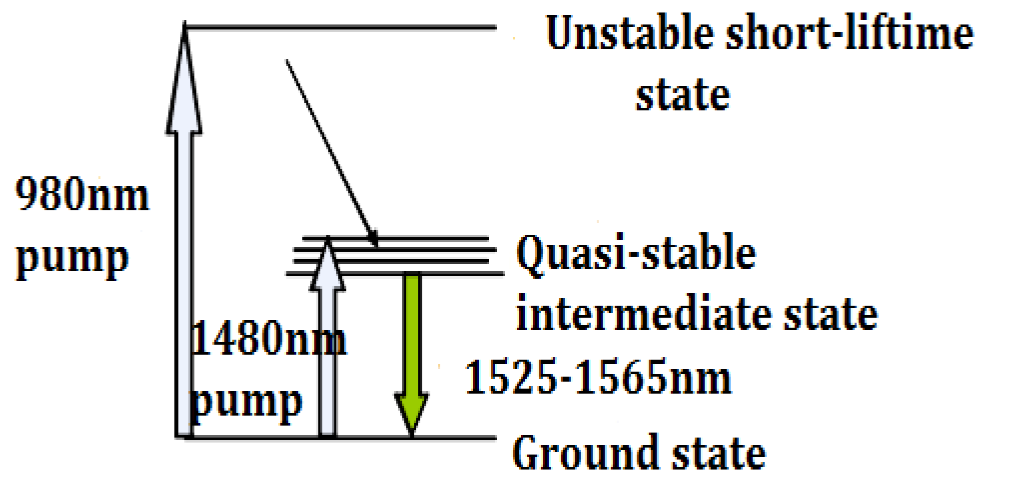

Figure (2-5) principles EDFA workings

2.11 The Basic of Semiconductor Optical Amplifier (SOA)

The semiconductor is used as the gain medium in SOA optical amplifiers, which are designed optical devices can be used in general applications to compensate for the loss. If you're using a fiber-pigtailed component, you're likely to use semiconductor optical amplifiers that operate at wavelengths between 0.85 nm and the 1.6-nm and can generate gain of up to 30 dB. It's possible to use the single mode or polarization maintaining fiber input/output semiconductor optical amplifier at a wavelength of 1310 nm;1400 nm; 1500 nm; and 1600 nm.

- **Work SoA amplifiers are based on a simple principle**

Since SOA lacks feedback, its operation is fundamentally the same as a semiconductor laser's. Light emitted by SOAs is amplified because of the stimulated emission. For this reason, these electrons return to their resting state as a result of photon loss when light passes through them. As a result, the optical signal is amplified by the stimulated photons, which have the same wavelength as optical signals.[40]

Chapter Three

The propose systems

3.1. Introduction.

However, the (FBGs) filter and amplifier (EDFA, SOA) will be used in this work to compensate for the dispersion that occurs in an optical fiber system (multi-channel) during its normal operation, which has been explained in chapter two. The two methods are compared in a research project. For the without's efficient work, the power is considered a constraint. Amplifier and with amplifier (EDFA) and (SOA). All the simulations are done in Opti- System 19.0 simulator software.

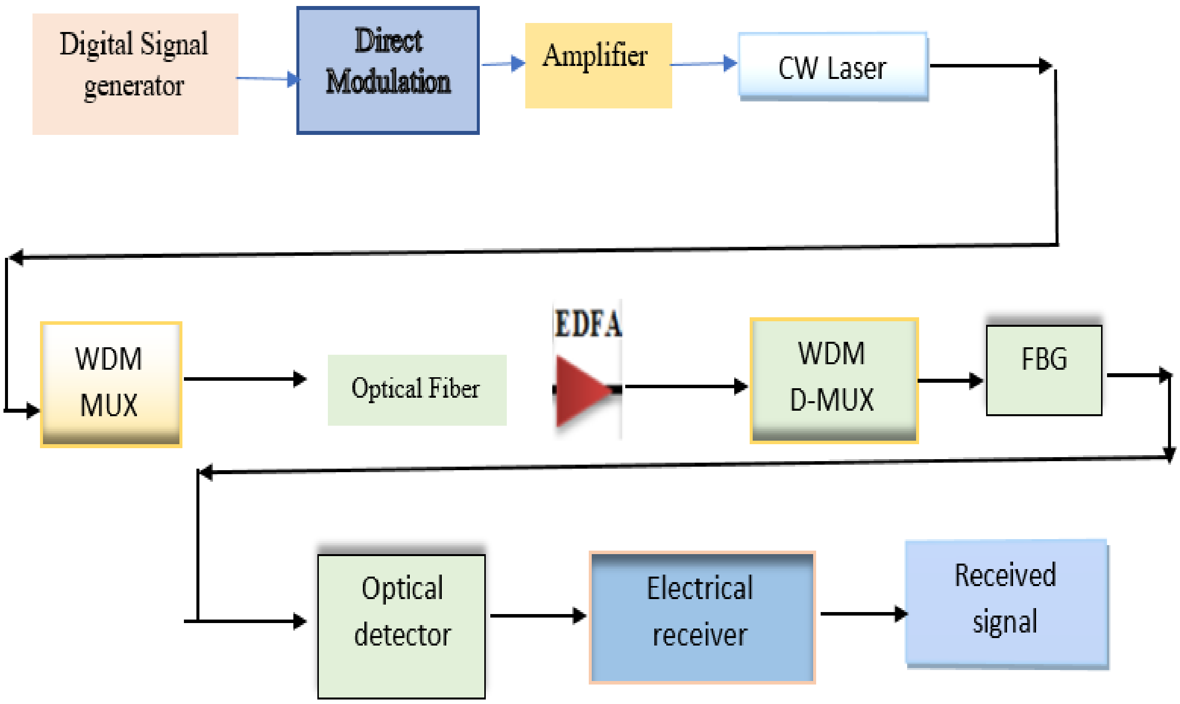

Fig. (3-1) A a schematic for the proposed system

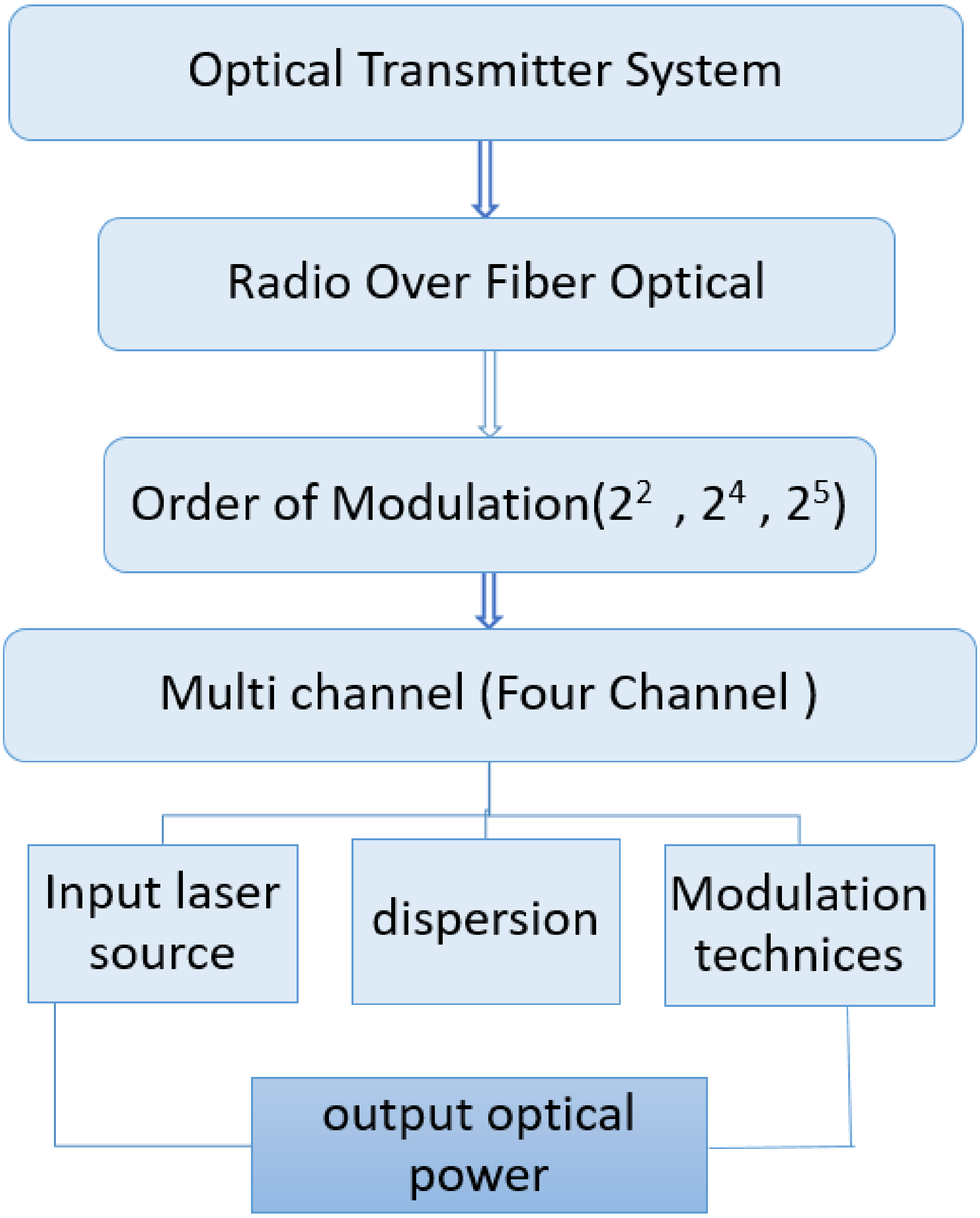

Figure (3-2) methodology of the whole project

3.2 Proposed transmission system

In order to evaluate the influence of polarization combiner in mitigating the fiber nonlinearity, this chapter presents the design and simulation of:

i. Multi-channel (WDM) QAM without amplifier and with amplifier (EDFA ,SOA)

ii. Multi-channel (WDM) DPSK without amplifier and with amplifier (EDFA ,SOA)

In the following sections, the proposed system is simulated and analyzed using Optisystem19 commercial software. A brief description of the Opti system program is provided in chapter two.

3.3 Proposed system design using (QAM)

In this part design circuit about [QAM circuit without amplifier, with amplifier] which includes transmitter, optical link, receiver

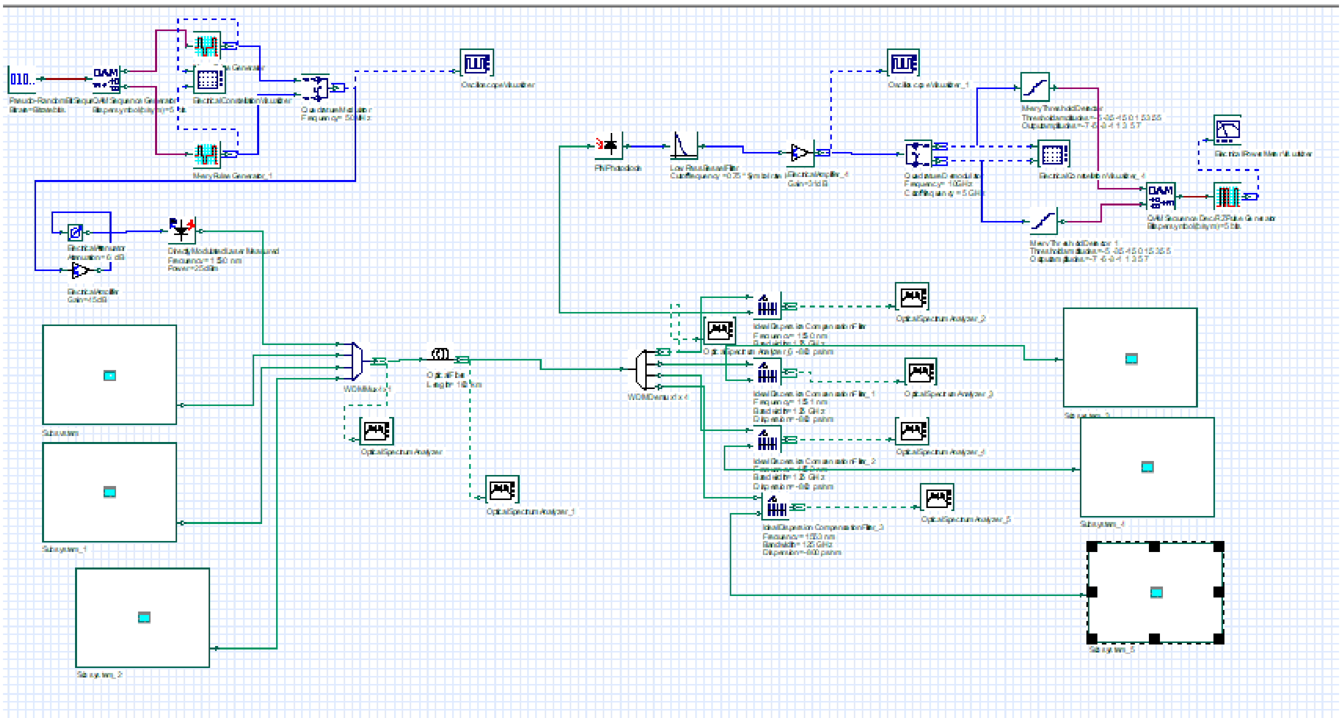

Figure (3-3) Quadrature Amplitude Modulation without amplifier

3.4 QAM Coder Transmitter

Including in this section translator circuit generator signal [PRBS], Quadrature modulator, Electrical Amplifier, Electrical Attenuator, and Directly Modulated Laser are all components of the QAM coder.

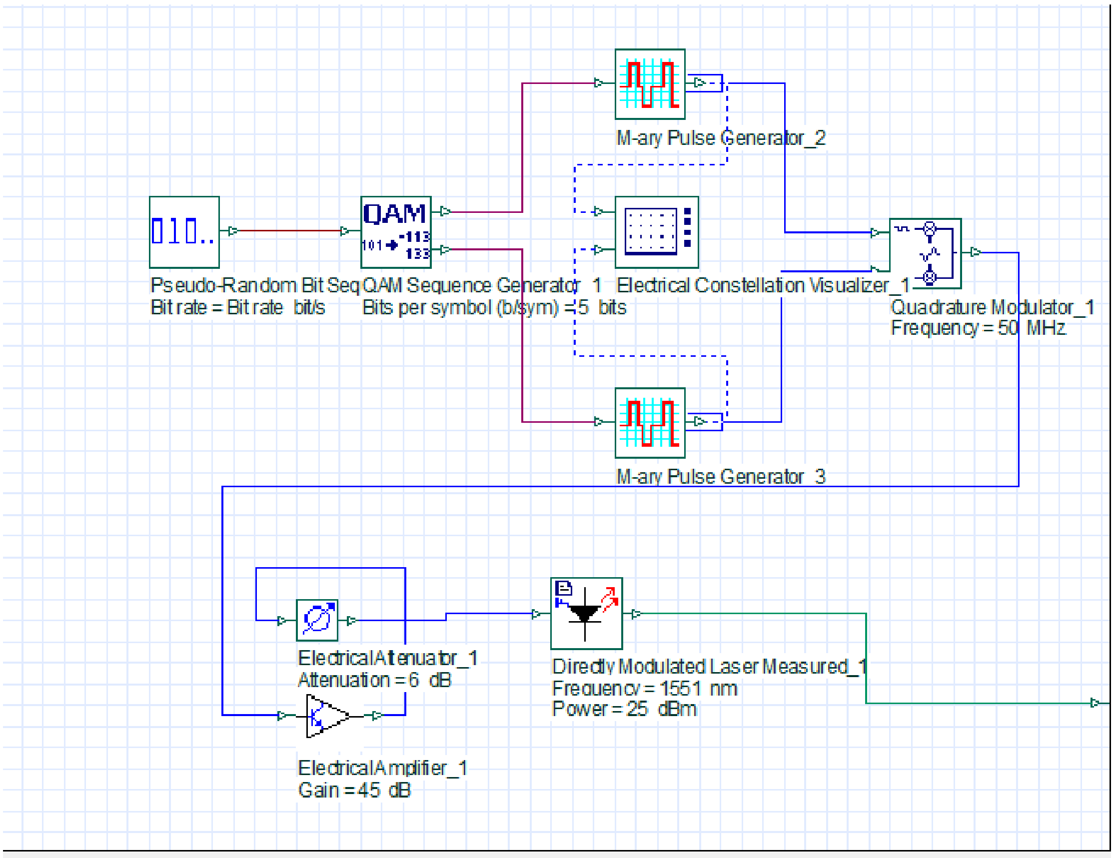

Figure (3 -4) Transmitter QAM Without amplifier

- **A-Pseudorandom Binary Sequence Generator (PRBS)**

m-sequences, or maximum length binary sequences, are common in communications systems as a pseudo-random source of data. In spite of their mathematical properties resembling random data they are deterministic, easy to generate, verify, and synchronize.

- Quadrature Amplitude Modulation coder

Quadrature amplitude modulation is In modern telecommunications, this is the name given to the an analog modulation method family that is related to the digital modulation method family.

- **Quadrature Modulator**

To use I/Q signal modulation, this term is used. I and Q carriers can be used to implement quadrature phase shift keying.

- **Electrical Amplifier**

When a low voltage, current, or power signal is fed into an amplifier, the waveform features are preserved.

- **Electrical Attenuator**

Signal amplitude reduction is the goal of the electrical components. without significantly compromising the integrity of that signal. they can be found in RF and optical systems.

- **Directly Modulated Measured**

Direct Modulation is when the current, before it reaches the laser diode, is altered in order to meet the application's specific needs. Laser diode drivers are used to apply the modulation signal generated by a function generator to the laser's drive current.

3.5 WDM (Wavelength Division Multiplexing)

When multiple wavelengths (or colors) of light are used to transmit data over a fiber-optic medium, it is known as Wavelength Division Multiplexing (WDM).

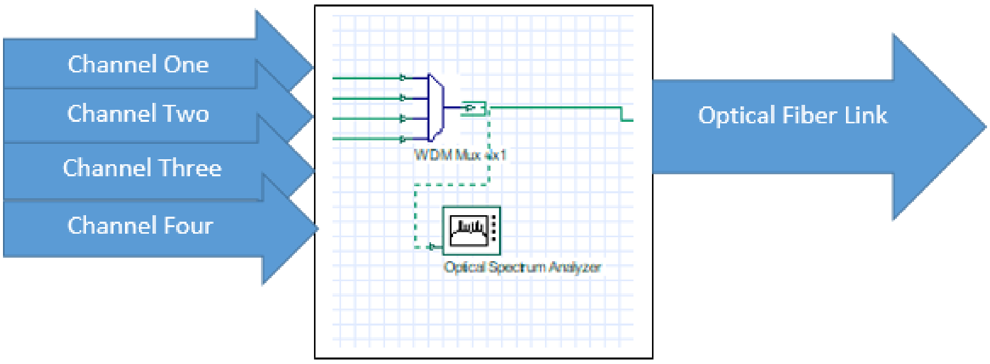

Figure (3-5) Transmitter WDM

Table (3.1) QAM Transmitter Parameters.

Parameter	Value	units
Bit rate	10e + 009	Bit / s
Sample rate	640e + 009	H Z
Sequence length	128	BIT S
Samples per bit	64	
Number of samples	8192	
Wave length	1550	N m
Input signal power	10	dB m
Line width	0.1	M HZ
WDM		
Band width	10.0	G H Z
Insertion loss	0.0	dB
Dep th	100.00	dB
Filter type	Bessel	

3.6 Optical fiber Link

- **Optical Fiber (With Amplifier , without Amplifier)**

Optical fiber technology, which uses light pulses to transmit data. A fiber optic cable can have anywhere from a few to hundreds of these glass fibers. The core of the glass fiber is surrounded by another layer of glass, known as cladding.

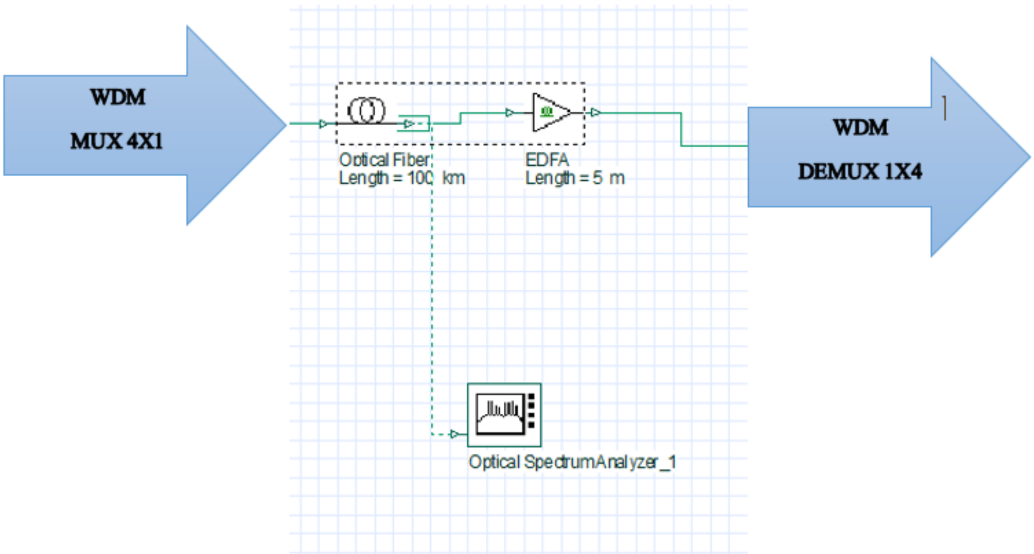

Figure (3-6) Optical Fiber Link

- **Erbium Doped Fiber Amplifier**

After the signal is propagated through the optical fiber it suffers attenuation, so Erbium, Doped Fiber Amplifier (EDFA) is used for enhancing the optical signal's power. For the purpose of amplifying optical signals, DFAs use a doped optical fiber as their gain medium. Fiber lasers are a close relative of these.

Table (3.2) Optical Fiber Link Parameters

Parameter	Value	units
Optical Fiber parameter		
A ttenuation-	00.2	dB
Dispersion,.	16.75	Ps/nm/km
Dispersionslope	Constant	
Birefringencetype	Deterministic	
PMD coefficient	0.05	Ps/sqrt (k)
Nonlinearities,		
EDFA parameters		
Gain	10.0	dB
Noisefigure	5.0	dB
Noise center frequency	1550.0	nm
Noise band width	70.0	nm

3.7 WDM Demux 1x4

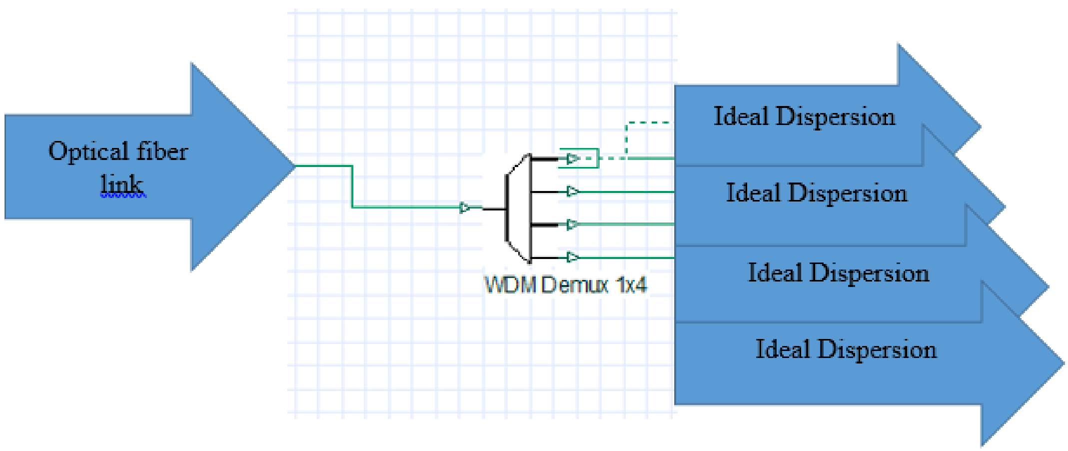

Figure (3-7) Receiver link

- **Ideal Dispersion Compensation Filter (FBG)**

  An FBG, or fiber Bragg grating, is a microstructure that can be etched into the core of a single mode fiber. An interference pattern in the fiber's core is generated using a phase mask and a UV laser beam shining transversely across it.

3.8 QAM Receiver

In this part continue PIN detector, QAM sequence, RZ generator, low-pass Bessel filter, electrical amplifier, quadrature demodulator, m-ary threshold detector,

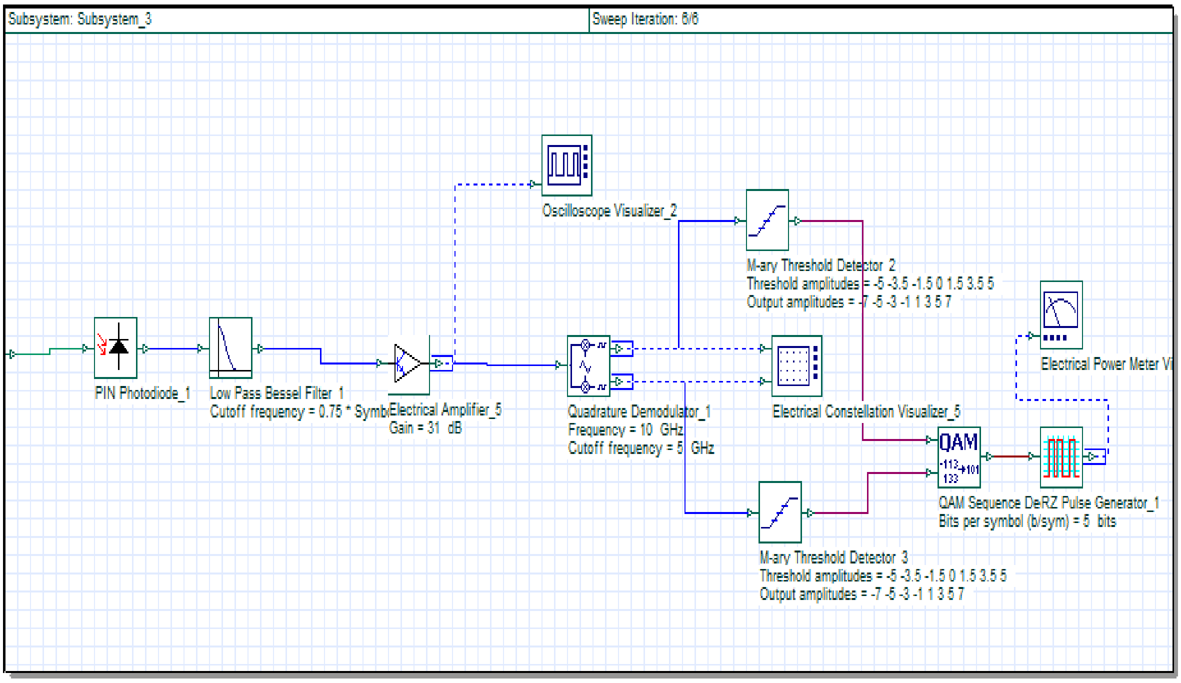

Figure (3-8) Receiver QAM

- **PIN Detector**

  any gadget that can amplify and process electricity by turning light signals into electrical signals.

- **Low Pass Bessel filter**

In terms of the filter's name is derived from its Bessel polynomial, and the cut-off frequency is determined by the filter's transfer function. The ultralow frequency range has a filter group delay of

- **RZ generation pulse**

coded return to zero pulses are generated by the generator, which is based on an input digital signal It's important to use the terms "digital" and

Table (3.3) Receiver Parameters

Parameter	Value	units
Emission frequency	1550	nm
Power	25	dBm
Linewidth	1	MHZ
Low Pass Gaussian Filter parameter		
Filter cutoff frequency	Bit rate,	HZ
Insertions Loss	0	dB
Depth,.	10 0.0	dB
M-ary Threshold Detector Parameters		
Decision instant	0.5	

3.9 Proposed system design using (DPSK) (Differential phase shift keying modulation)

In this part we talk about [DPSK circuit without filter, with filter] which includes transmitter, optical link, receiver

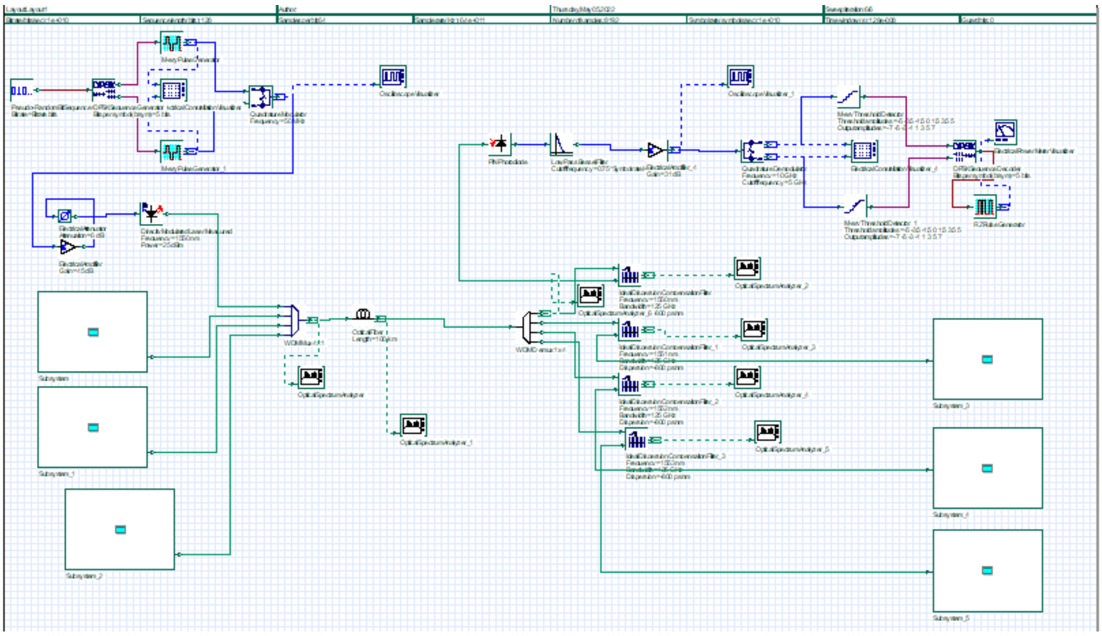

Figure (3-9) Differential phase shift keying modulation Without Amplifier

- **DPSK Coder Transmitter**

Technique for transmitting data by changing the phase of a carrier wave Confusing phase shifts in BPSK and QPSK can occur due to channel effects, such as modulation shifts.

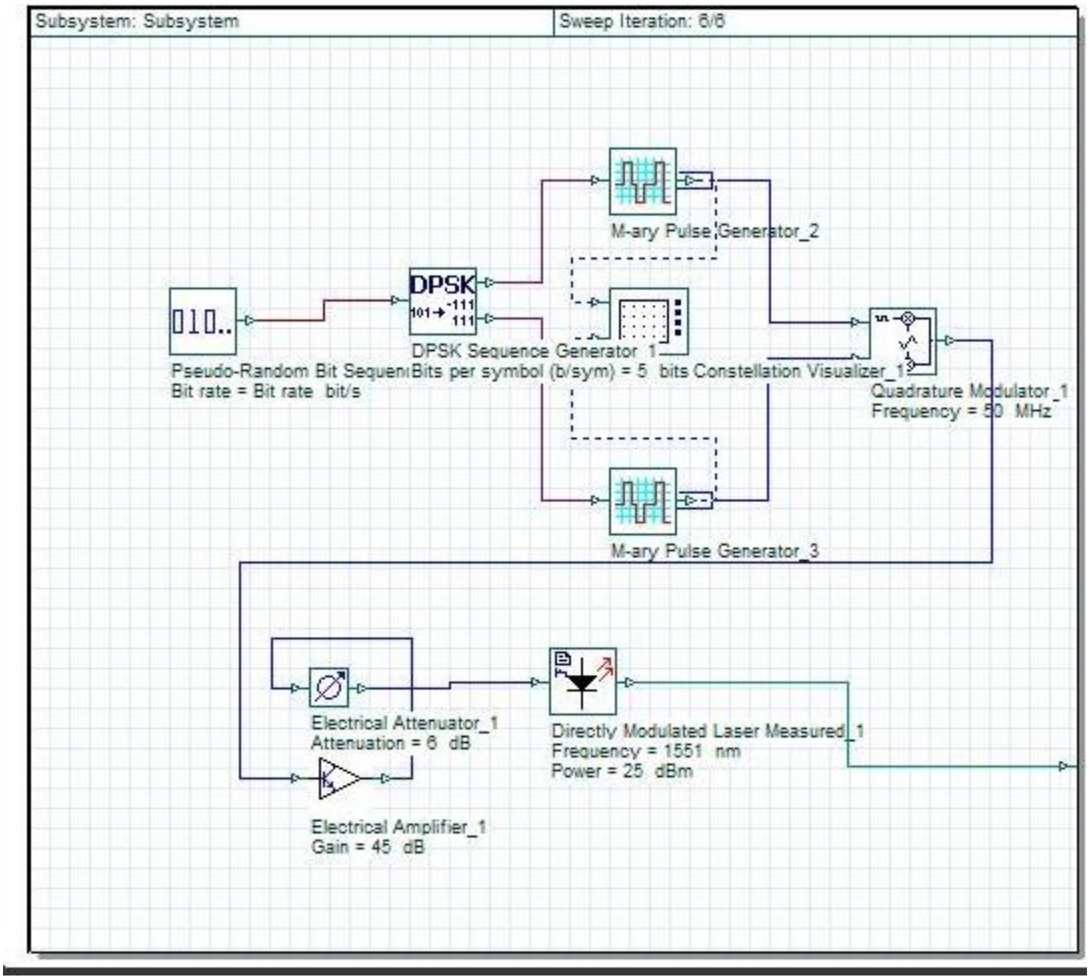

Figure (3-10) DPSK Transmitter

3.10 Optical fiber Link (DPSK with Amplifier without Amplifier)

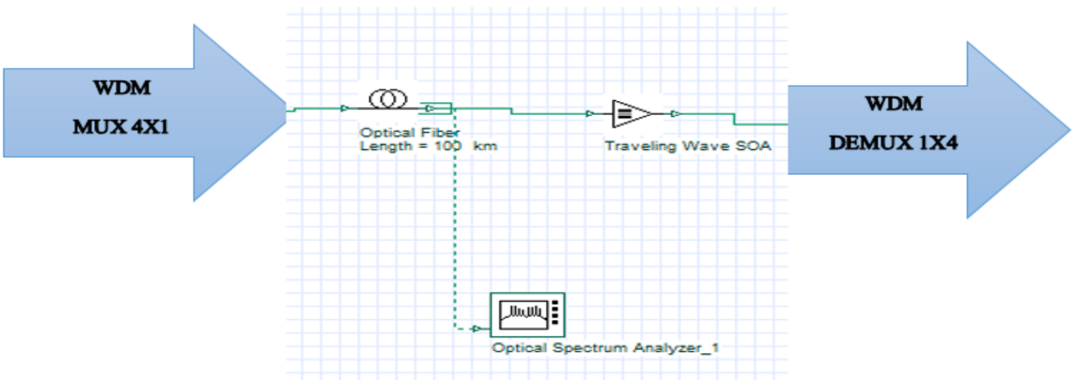

Figure (3-11) Optical Fiber Link with SOA amplifier

- ## Travailing Amplifier with SAO

Performs amplifiers based on the concept of traveling wave semiconductors (SOA). To describe the electrical field, the wave equation is used, and carrier density is described by using the rate equation. This approximation has been utilized. Such a model can be used to explain how CW and optical pulsed signals are amplified.

3.10 WDM Demux 1x4

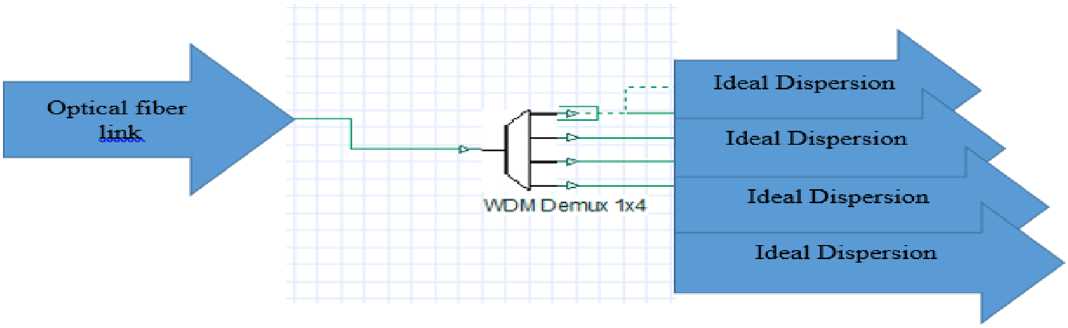

Figure (3-12) WDM Demux

3.11 DPSK Receiver

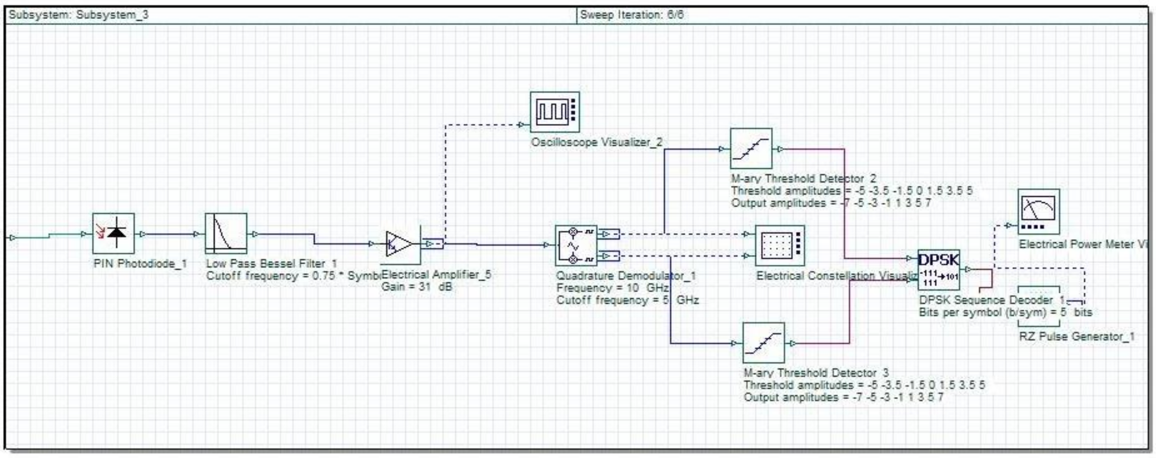

Figure (3-13) DPSK Receiver

Chapter Four

Results and Discussion

4.1 Introduction

In this chapter, all the simulation results of the proposed system will be presented in the third chapter, which includes the results of the proposed system QAM, DPSK

4.2 Proposed System QAM modulation (Result of QAM)

- **Electrical constellation Visualizer**

When comparing digitally modulated signal transmission Performance and visualizing interference and distortion, of digitally modulated signal a Constellation Diagram can be useful.

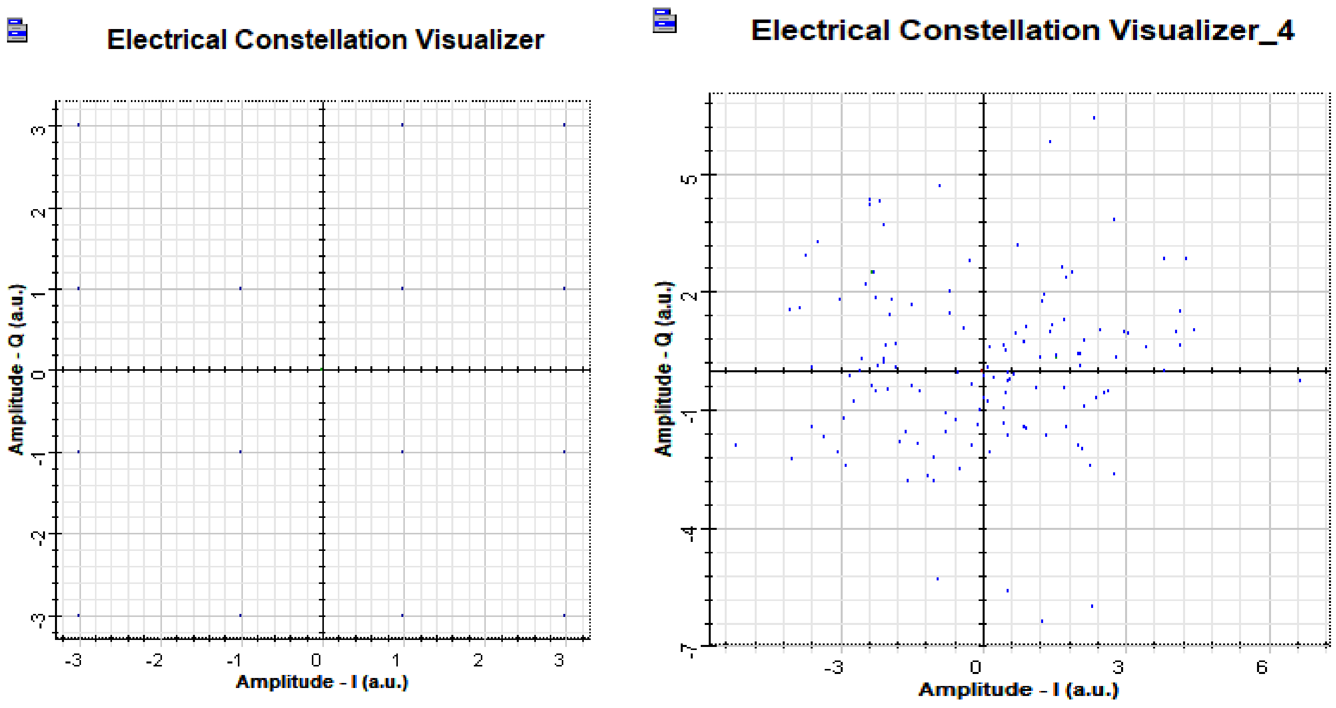

Figure 4-1: Cancellation of the transmitted signal: (a) using QAM (b) using QAM received

- **Effect of type of amplifier on output power**

For long-distance transmission, compensating for signal attenuation in the fiber is essential. Different optical amplifiers have been developed and put to use because of this, such as the Semiconductor Optical Amplifier (SOA) or the EDFA For a fiber length of 100 kilometers, various amplifier types have varying effects on output power. Table 1 clearly shows that EDFA provides a better result for output power that varies for 2optical channels compared to output power values without amplifier, with EDFA and with SOA amplifier.

Table (4-1) Effect of type of amplifier on output power(QAM)

Effect of type of amplifier on output power (QAM)			
Type amplifier	**Without amplifier(dBm)**	**EDFA(dBm)**	**SOA(dBm)**
Output power channel one	**23.665**	**23.700**	**23.403**
Output power channel two	**23.856**	**23.446**	**23.735**

- **Effect of laser on output power**

The output optical power of a laser diode is directly proportional to the driving current. Nonlinear effects must be considered and their impact on these systems minimized in the process of deploying broadband (>=10 Gbps optical channel) in the system. As a result, nonlinear effects now account for the majority of the performance of optical fiber-based long-distance broadband communication systems.

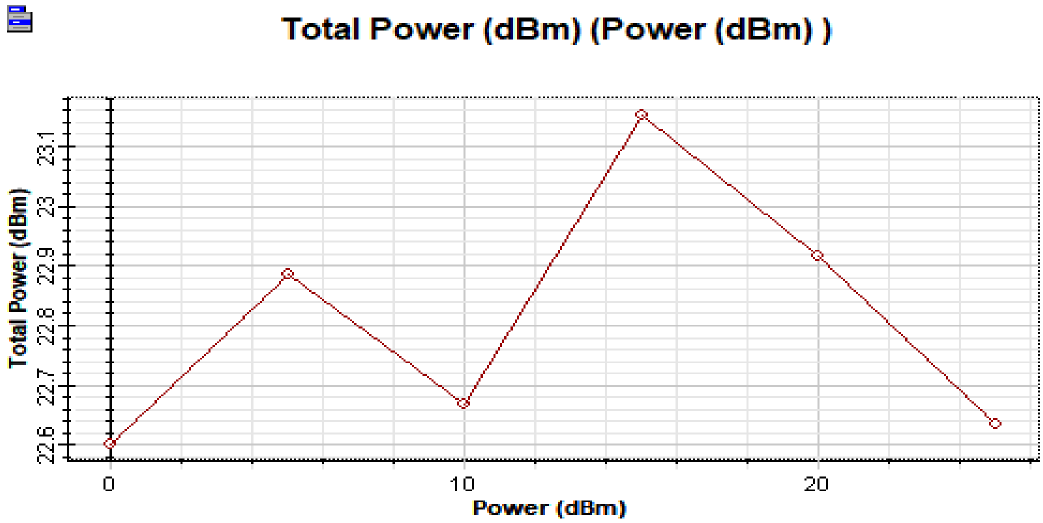

Figure (4-2) Effect of laser power on output power (with EDFA) using QAM

- **Dispersion of Fiber optical**

When dispersion travels through a fiber, the pulse width widens It is possible to interfere with adjacent pulses (bits) on an optical fiber channel by increasing a pulse's width to a point where it causes inter symbol interference, bit spacing dispersion, and the maximum transmission rate to be reached. Examples of dispersion include substance dispersion as well as chromatic dispersion. The dispersion in the channel was the subject of this investigation. As can be seen in Figure (4-3), fiber dispersion can range from as low as 1ps/nm/km up to as high as 16.75ps/nm/km. When the dispersion parameter is increased, the nonlinearity effect is lessened.

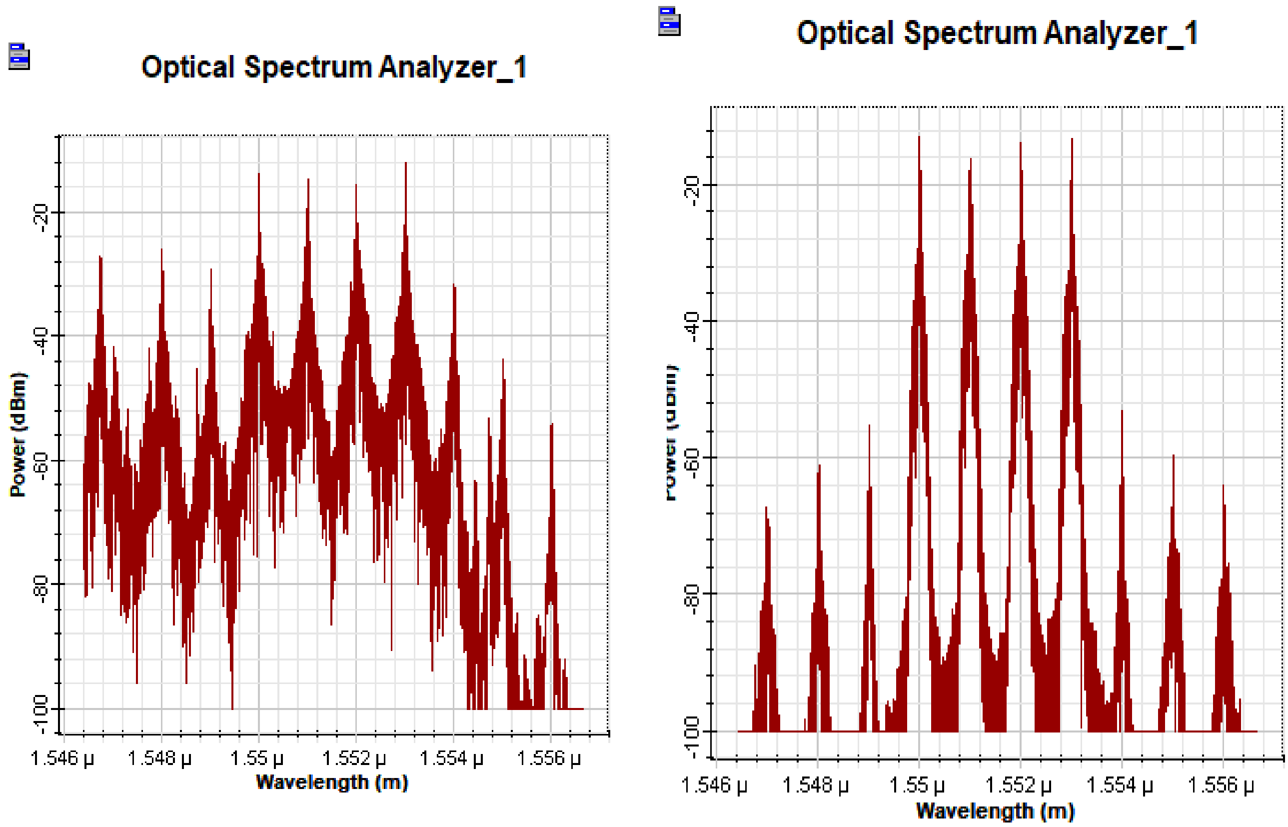

Figure (4-3) Optical spectrum at the fiber when of fiber is set QAM (a)1PS/nm/km (b)16.75PS/nm/km

- **Ideal Dispersion Compensation Filter (FBG)**

Low insertion loss, better coverage, and high resistance to Radio Frequency Interferences, it can help to eliminate the additional pulses generated by the nonlinear effect

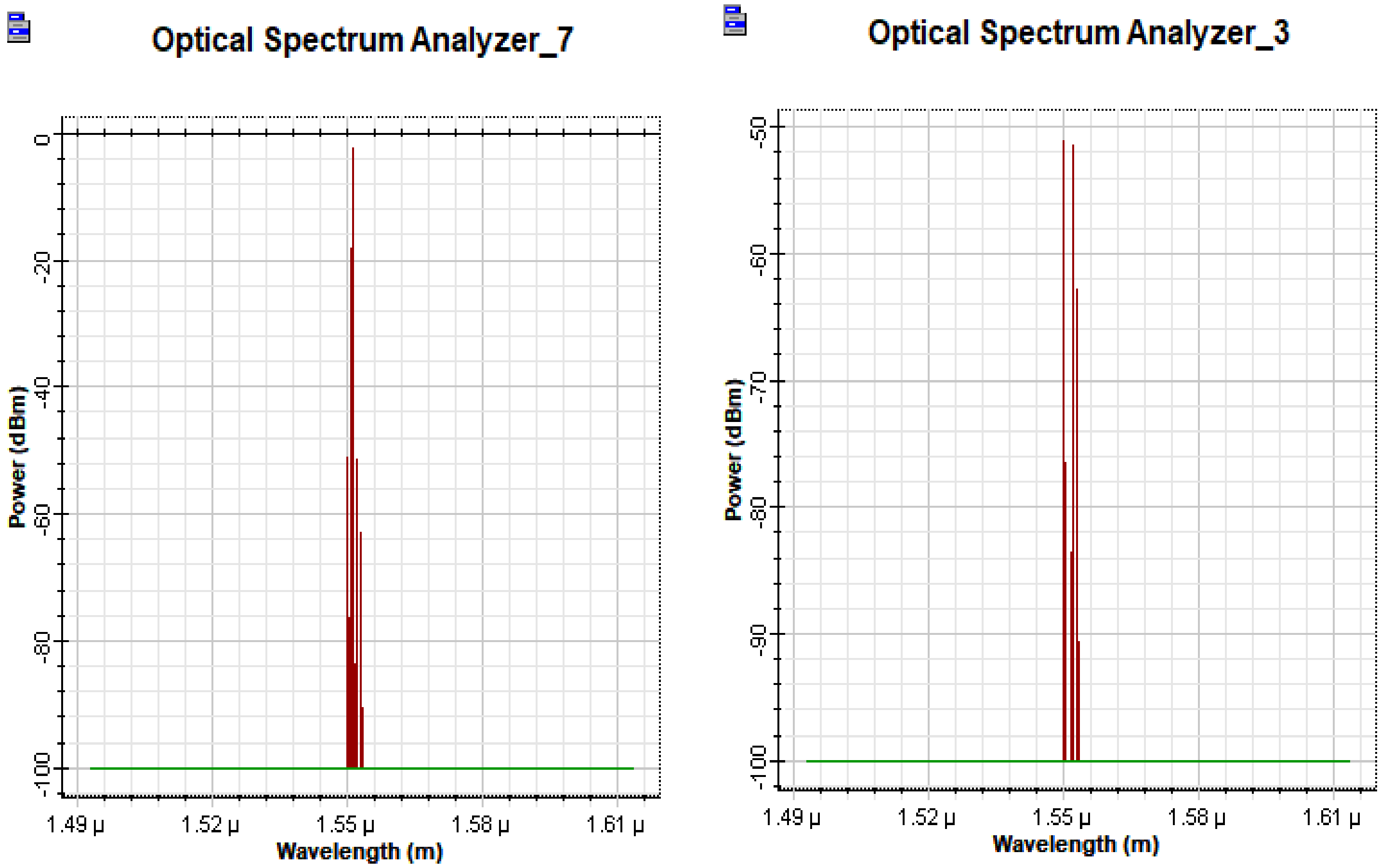

Figure (4-4) Effect nonlinear at spectrum receiver 2nd channel QAM (a) without FBG (b) with FBG

- **Amplifier Optical (EDFA)**

Designs Er-doped fiber amplifiers by considering numerical solutions of the rate and the propagation equations under stationary conditions. The model includes amplified spontaneous emission (ASE) as observed in the amplifier Erbium Doped Fiber. However, this module allows you to select forward and/or backward pump, as well as the pump power values

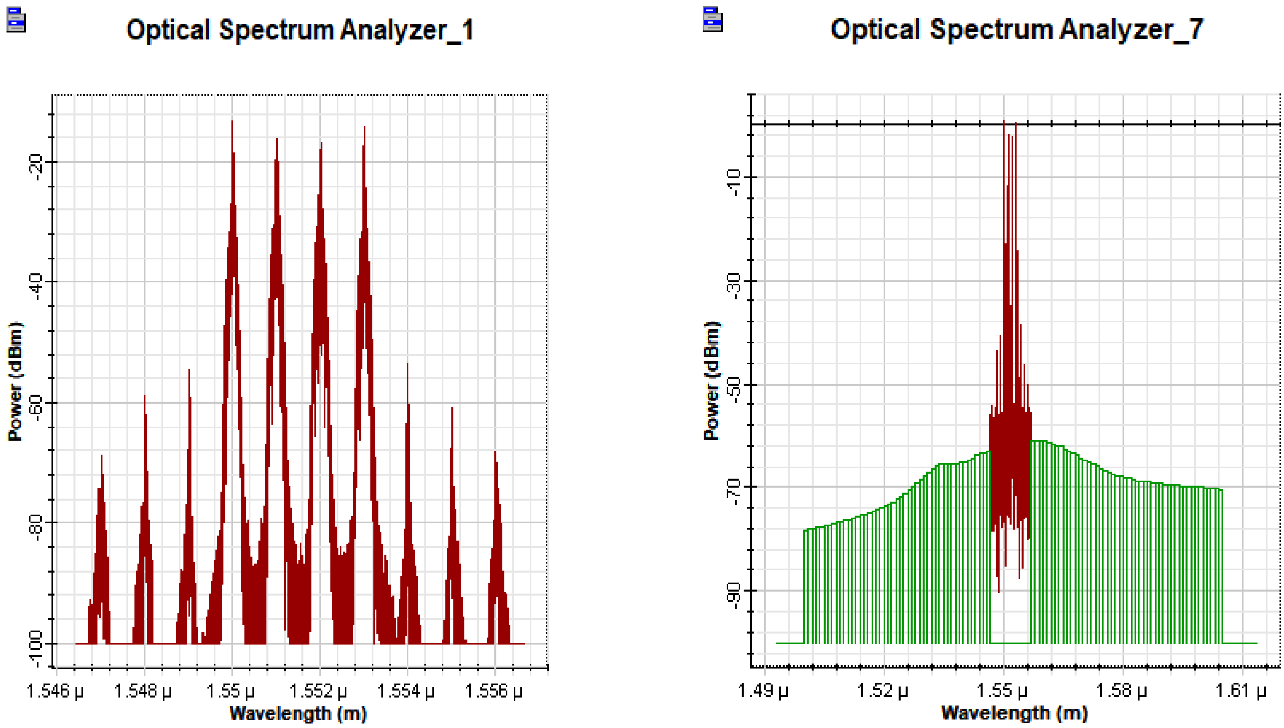

Figure (4-5) Effect amplifier optical (a) before EDFA (b) After EDFA

4.3 Proposed System DPSK modulation (Result of DPSK)

- **Electrical constellation Visualizer**

Differential Phase-Shift Keying (16DPSK, 32DPSK, and 64DPSK) where all symbols lie on one circle and have the same optical power in the ideal case,

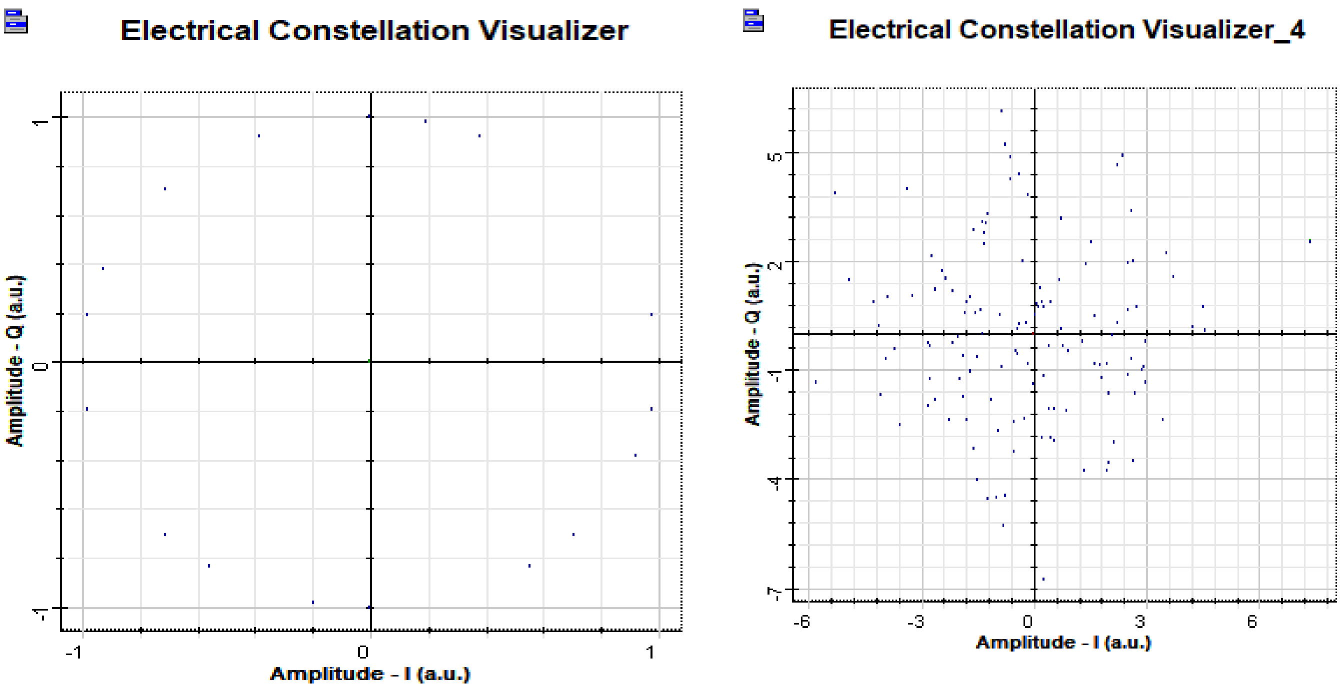

Figure (4-6) Cancellation of the transmitted signal (DPSK) Transmitter and Receiver

- **Effect of type of amplifier on output power**

the fiber inversion level increases with the EDFA length position this if the fiber inversion level increases the output amplified signal also increases, that is an inversion level is depends upon the pump power and wavelength

Table (4-2) Effect of type of amplifier on output power (DPSK)

Effect of type of amplifier on output power (QAM)			
Type amplifier	**Without amplifier(dBm)**	**EDFA(dBm)**	**SOA(dBm)**
Output power channel one	**23.792**	**23.906**	**23.769**
Output power channel two	**23.377**	**23.362**	**22.902**

- **Effect of laser on output power**

  Power scaling of a laser is increasing its output power without changing the geometry, shape, or principle of operation. Power scalability is considered an important advantage in a laser design. Usually, power scaling requires a more powerful pump source, stronger cooling, and an increase in size.

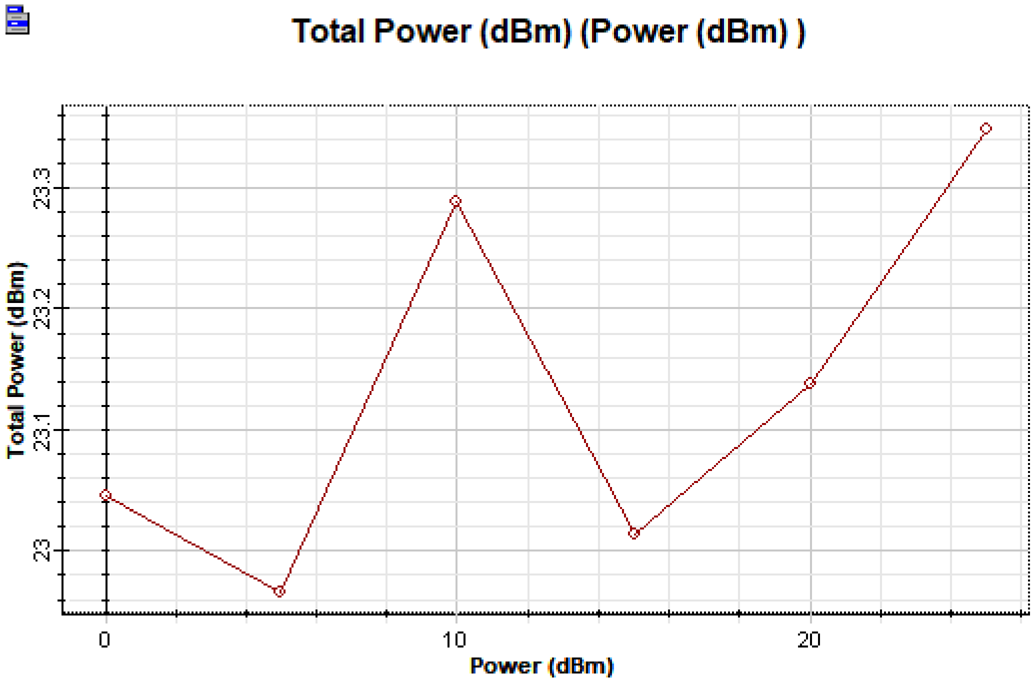

Figure (4-7) Effect of laser power on output power (with EDFA) using DPSK modulation

- **Dispersion of Fiber optical**

Optic material's refractive index with different wavelength. The higher the index, the slower the light travels. Waveguide dispersion is due to the distribution of light between core and cladding

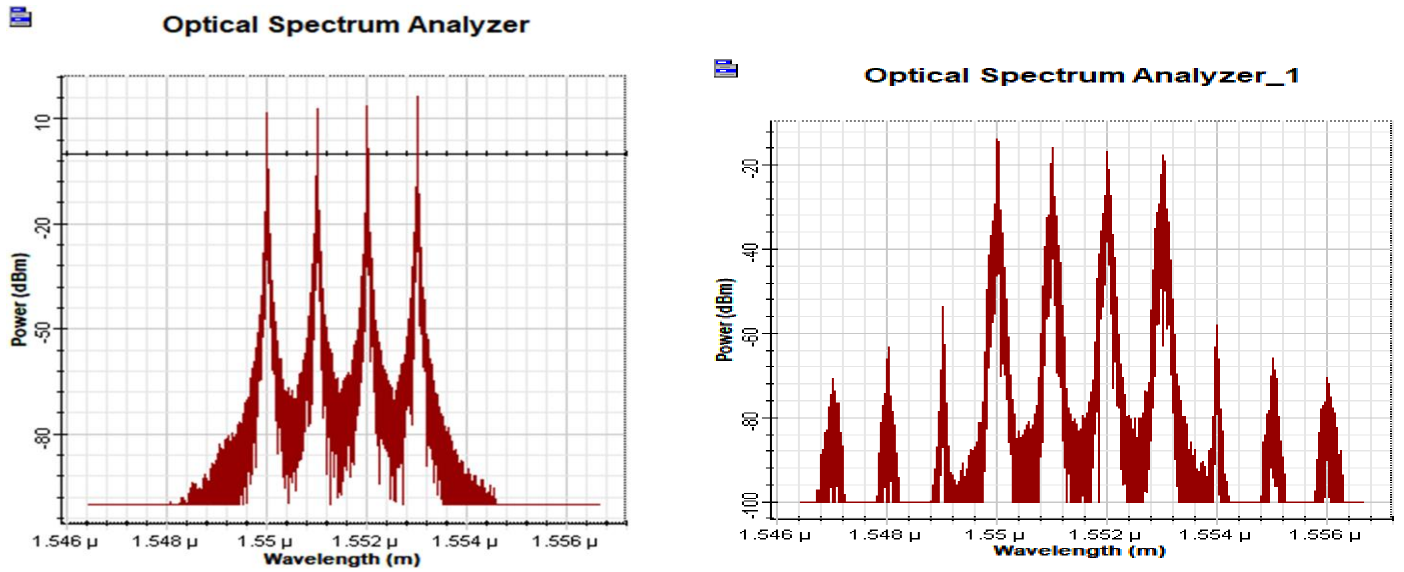

Figure (4-8) Optical spectrum at the fiber when of fiber is set DPSK (a)1PS/nm/ km (b)16.75PS/nm/km

- **Ideal Dispersion Compensation Filter (FBG)**

Low insertion loss, better coverage, and high resistance to Radio Frequency Interferences, it can help to eliminate the additional pulses generated by the nonlinear effect

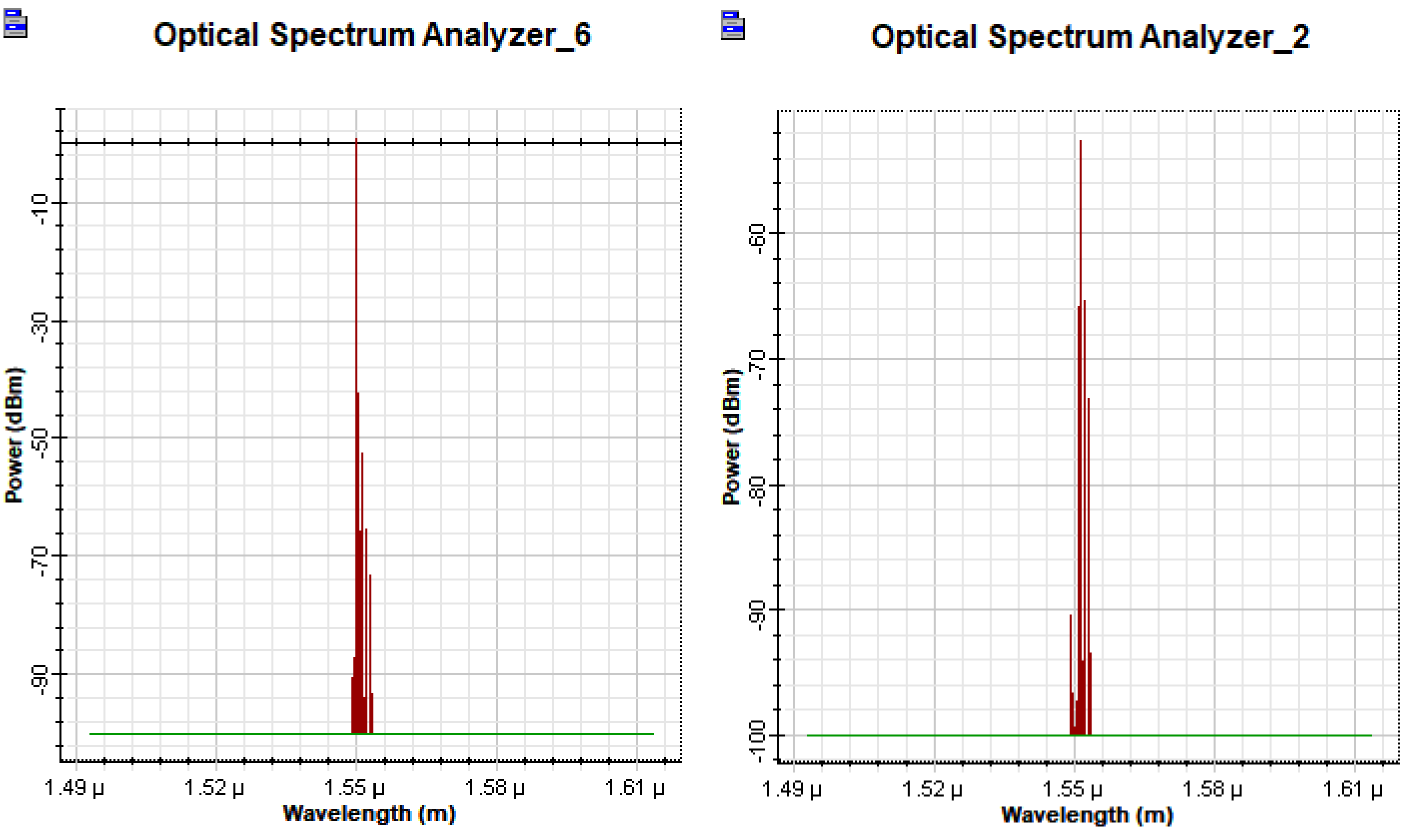

Figure (4-9) Effect nonlinear at spectrum receiver 1nd channel DPSK (a) without FBG (b) with FBG

- **Amplifier Optical (SOA)**

Performs lumped amplification with traveling wave semiconductor optical amplifiers (SOA). The rate-equation approximation has been used in which the electrical field is described by the wave equation and the carrier density by means of the rate equation. Such model is applicable to describe the amplification of CW and optical pulsed signals.

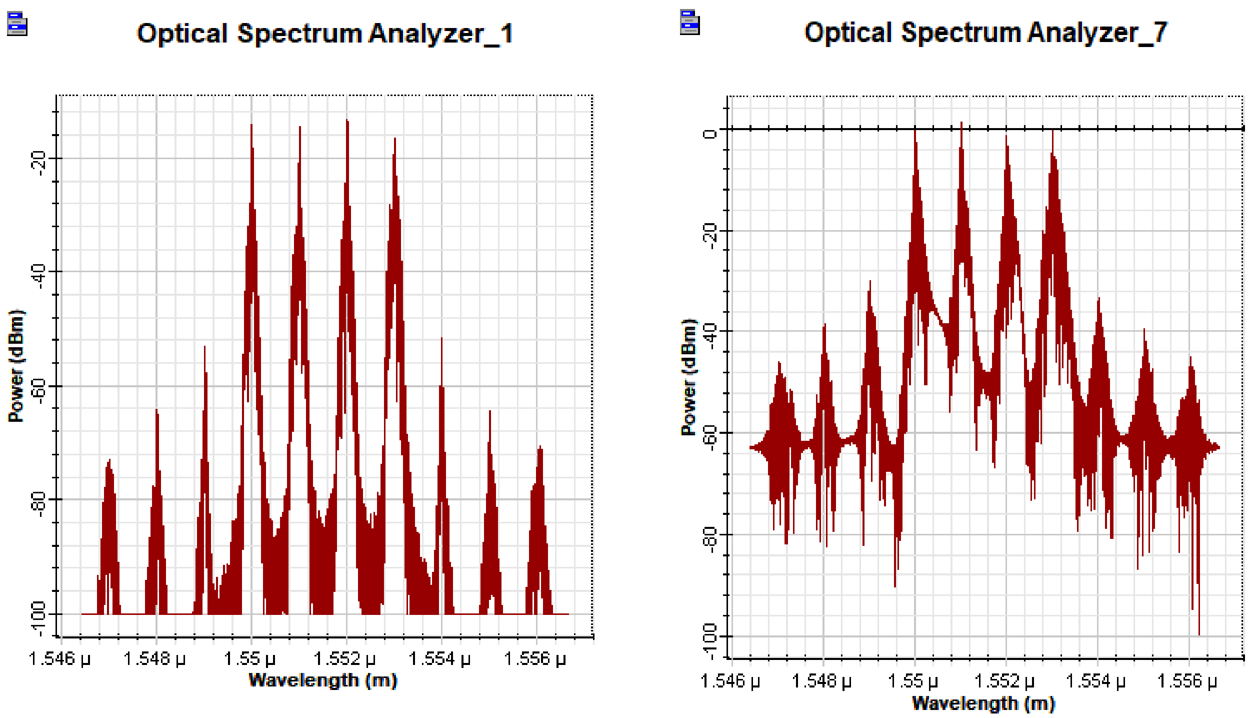

Figure (4-10) Effect amplifier optical (a) before SOA (b) After SOA

Conclusions and Future Works

5.1 Conclusion

The discussion on the design and implementation of the proposed work is summarized as follows:

1) For the (RoF)system we've designed, we've calculated the transmission distance of 5Ghz RF signals over 1550nm standard fiber at 100 km. Different modulation schemes and data rates were tested, with the results showing how well the(RoF) system performed.

2) Simulation results showed how much can sending signal in WDM that cancellation, effect of laser on output power ,effect type of amplifier on transmission power , effective dispersion of fiber optical.

3) Comparison between DPSK and QAM modulation have been made based on the performance metrics.

4) The DPSK modulation achieved better performance than QAM modulation at the same conditions

5.2 Future Work

Proposals for this work can be summarized as follows:

1) Study and evaluation the Performance of WDM Radio over Fiber using Differential Quadrature Phase Shift Keying (DQPSK) Modulation

2) To investigate the WDM Radio over Fiber based on Orthogonal frequency division multiplexing

3) To investigate the WDM Radio over Fiber based on Orthogonal frequency division multiplexing and adaptive signal processing

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الخلاصة

من أجل تحسين أداء أنظمة اتصالات الألياف الضوئية ، تقدم هذه الدراسة تقنيات تعديل لأنظمة الاتصالات الراديوية عبر الألياف. معظم تقنيات التعديل المقترحة لتحقيق هذا الهدف هي مزيج من طرق التعديل التقليدية. يتم تطبيق تقنيات التعديل التي تجمع بين تقنيات مثل اتساع النبضة وتعديل سعة التربيع وتعديل QAM DPSK على نماذج أنظمة الاتصالات البصرية المختلفة. باستخدام نتائج المحاكاة ، توضح دراسة جديدة وتميز بين أنواع مختلفة من تقنيات التعديل. تتضمن النتائج معلومات عن الطاقة المستلمة. لدراسة النماذج المقترحة ، تقدم هذه الورقة تحليلاً شاملاً لنظام الإرسال البصري بتقسيم الطول الموجي (WDM) باستخدام تقنية الراديو عبر الألياف (RoF). استخدم البحث في الشبكات الضوئية لمكافحة آثار اللاخطية والتشتت اللوني وفقدان الإشارة. تم تنفيذ Fiber Bragg Grating (FBG) في شبكة نظام نقل WDM ذات 4 قنوات بسرعة 10 جيجابت / ثانية للتعويض عن التشتت والتشويه غير الخطي. كما أن استخدام مضخمات الألياف المشبعة بالإربيوم (EDFA) من أجل تحسين جودة خدمة نظام النقل. في Digital RoF ، تمت أيضًا مناقشة أنواع التعديل مثل DPSK و QAM. قارنا نتائجنا بنتائج الدراسات السابقة من خلال النظر في مخططات الكوكبات ، والطاقة الضوئية المستلمة ، وأنواع التعديل ، وتشتت الألياف ، وتباين تباعد القنوات ، وقوة الليزر. وجاءت أبرز النتائج للحصول على قياسات جيدة وتقليل الضوضاء غير الخطية والحفاظ على قوة الإشارة باستخدام مكبر الصوت.

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الطالبة

سهير امه خان يحيى

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