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# DESIGN STUDY AND SIMULATION OF A DIGITAL FIBER COMMUNICATION SYSTEM USING (OPTISYSTEM.10)

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## ABSTRACT

Recent digital fiber optic communication systems address modulation and detection techniques for high spectral efficiency and robustness against transmission impairments. The proposed objective of this project is to design studies and analyze the simulation model of a Digital Fiber Communication System using (optisystem.10), as well as the front-end components and units used to implement them. Using the most suitable settings of the system which include laser transmitter with (1310nm) and (1550nm) wavelengths as input power (dBm), optical fiber with both (SM and MM) cable types as channel length (km),(RZ and NRZ) modulationand demodulation schemes to maximize spectral efficiency and power efficiency by encoding information are analyzed in order to evaluate their penalization over the signal qualityat the receiver.There are three different parameters will be investigated which are output power (dBm), noise figure (dB), and transmittance for the two types of fibers .

**KEYWORDS**:Digital Fiber Communication,Optisystem.10,(RZ and NRZ) modulation, BER and Q-Factor.

## INTRODUCTION

Optical fiber communication technology stood out from the optical communication and has become one of the main pillars of modern communications [1]. Optical communication systems use high carrier frequencies (~100 THz) in the visible or near-infrared region of the electromagnetic spectrum. They are sometimes called Lightwave systems to distinguish them from microwave systems, whose carrier frequency is typically smaller by five orders of magnitude (~1 GHz). Fiber-optic communication systems are Lightwave systems that employ optical fibers for information transmission. Indeed, the Lightwave technology, together with microelectronics, is believed to be a major factor in the advent of the "information age"[2]. Optical fiber systems have many advantages over metallic-based communication systems. These advantages include: long-distance signal transmission, large bandwidth, light weight, and small diameter, non conductivity, security.[3]

## BACKGROUND THEORY

A basic fiber optic system consists of three elements, as shown in figure (1), a transmitting device that converts an electrical signal into a light signal [3]. The majority of light sources used in fiber optics emits light at one of three different wavelengths: 850nm, 1300nm and 1550nm , these wavelengths are desired because they exhibit the least amount of attenuation in the glass fiber. Of the light sources, there are mainly two types used today: the light emitting diode (LED) and the laser diode (LD). The actual choice of one source over another depends on the type of application, cost, desired output as well as temperature considerations, . LDs have a non linear output, usually measured in milliwatts (mW) ,as well as the output of an LD is very narrow, with a spectral spread on the order or 1 to 10 nm, compared to an LED that may have a spread as high as 100nm. Because LDs have a higher output potential and coupling efficiency, they are well suited for long distance transmissions[4,5].Normally, the output of an optical source such as a semiconductor laser is modulated by applying the electrical signal either directly to the optical source or to an external modulator. There are two choices for the modulation format of the resulting optical bit stream. These are known as the return-to-zero(RZ) and nonreturn-to-zero(NRZ) formats[2]. The second part of fiber optic system is Optical fibers which are the actual media that guides the light, they can be made of glass or plastic. A typical fiber is made up of a core, cladding and a jacket, there are basically two types of fibers: stepped index and graded index.The stepped index fibers can be broken down into two types: single-mode and multi-mode. The multi-mode stepped index fiber has, as one might guess, multiple paths for the light to travel while the Singlemodefiber only allows a single light ray to propagate and because the core diameter is so small, LDs are usually used to couple light to the fiber [6]. The third part is Optical detectors Like optical sources, the optical detectors used in fiber optics are almost exclusively semiconductor devices in the form of PIN diodes and avalanche photo diode (APD) detectors[5,7].

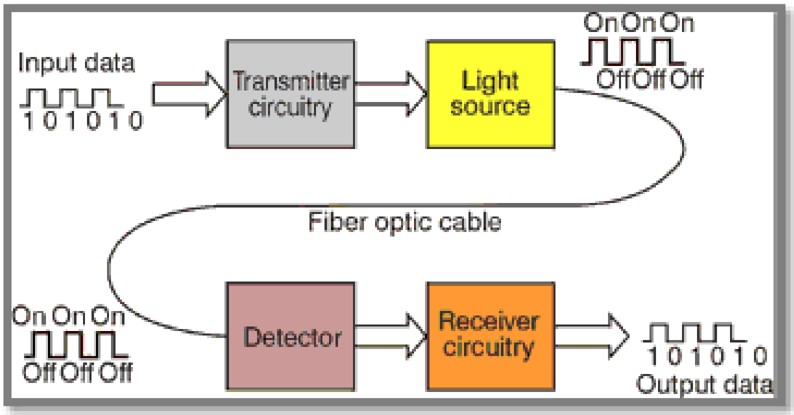


***Figure (1): The basic fiber communication system***

## OPTISYSTEM SOFTWARE

Now, optical communication systems are becoming increasingly more complex[1] . These systems often include multiple signal channels, different topology structure, nonlinear devices and non-Gaussian noise sources, which make their design and analysis quite complex and require high-intensity work. Optisystem will allow the design and analysis of these systems become quickly and efficiently [8] . OptiSystem is an innovative optical communication system simulation package which was explored by an Optiwave company in order to meet the academic requirement of the system designers, optical communications engineers, researchers. It integrates design, test and optimize all types of broadband optical network physical layer functions such as virtual optical connection . It has a huge database of active and passive components, including power, wavelength, loss and other related parameters. Parameters allow the user to scan and optimization of device-specific technical parameters on the system performance. Optisystem has powerful simulation environment and real components and systems of classification definitions. A fiber optic communication system model is based on the actual system-level simulator. Its performance can be attached to the device user interface library and can be completely expanded to become a widely used tool [9].

## DESIGN CONSIDERATIONS

The system transmits information using optical carrier wave from transmitter to receiver via optical fiber. The input signal contains electrical data that is represented by 0's and 1's has been generated by pseudo-Random Bit Sequence Generator with non-return-zero (NRZ) once and again to return-zero (RZ) . Then the input signal is modulated with semiconductor laser that is represented by Continuous Wave (CW) laser through Mach- Zehnder modulator. CW laser supplies input signal with 1550nm and 1310 nm wavelengths and input power which is externally modulated at( 2.5e+9) Bits/s with a non-return-zero (NRZ) and return-zero (RZ) pseudorandom binary sequence in a Mach-Zehnder modulator with 10 dB of extinction ratio. The optical fiber used is single mode fiber, because single mode fiber can yield higher data rate, less dispersion and also can operate in a long haul distance, so it is suitable to be used as transmission link ,finally the signal received by PIN detector. The layout of the network is given as the following Figure (2):

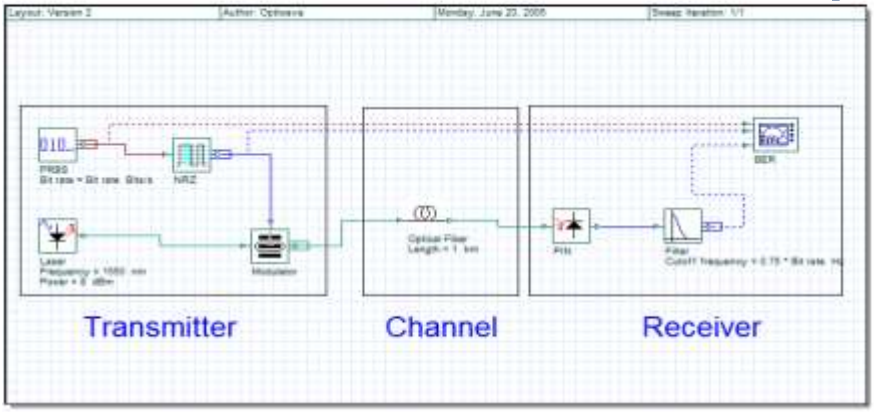


***Figure (2): The layout of fiber optic communication design***

## RESULTS AND DISCUSSIONS

Digital fiber optic communication system basic design was modeled and simulated for performance characterization by using OptiSystem.10 which is a powerful software design tool that enables to plan, test and simulate almost every type of optical links .The input signal contained digital data instead of analog because it needs power very small to transmit the format ,it considered negligent in relation to analog data ,as shown in figure (3), in digital signal, at power of CW laser equal to (-10dBm) , and link range was (1km), the signal after the filter is shown in the figure (3.a) ,but when you transmit analog signal at this power we will not get the data sent , as shown in (3.b),it has been obtained on a signal bonus to of the transmitted digital signal at (-10dBm), at a transmission analog signal with power of CW laser equal to (30 dBm),as (3.c).

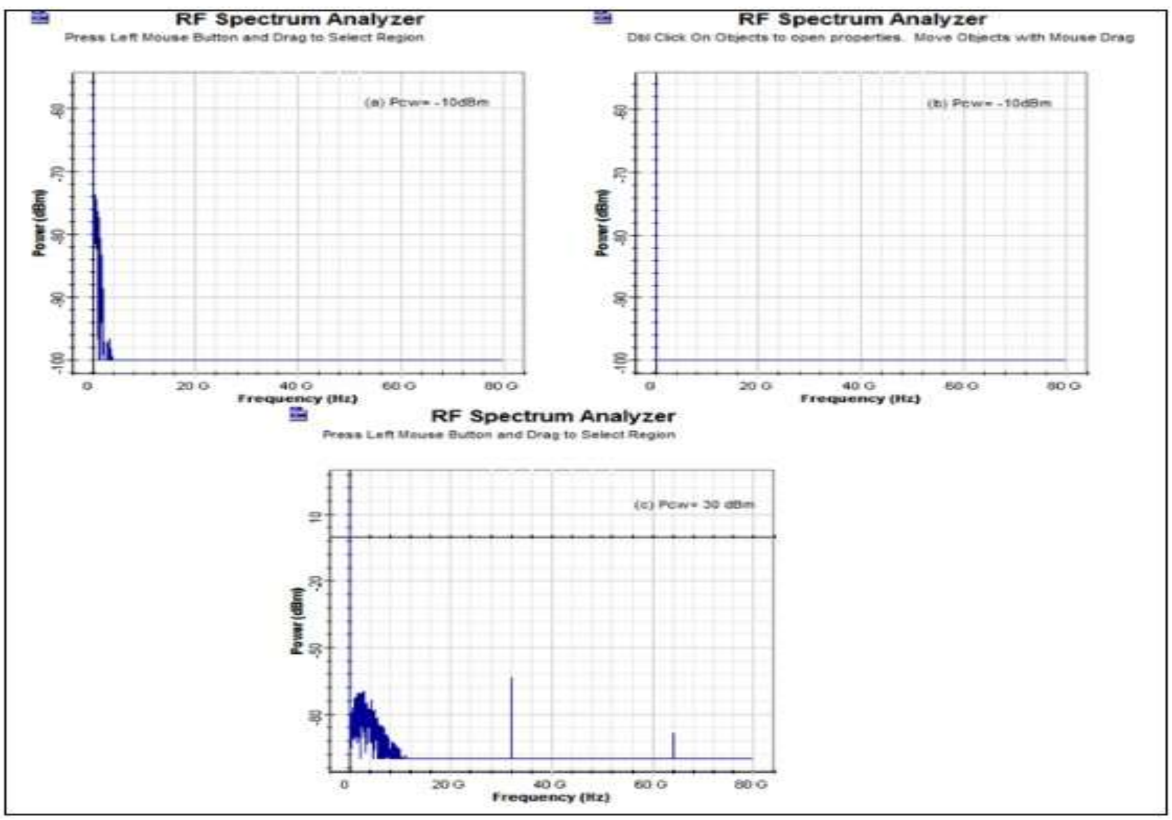


***Figure (3):The comparison between digital and analog signals***

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But in power of CW laser equal to (15 dBm ), we will get a signal shown in figure (4), (a) Digital signal and (b) Analog signal, As well as the noise in digital signal was slightly lower from analog signal but transmit analog data needs to power much larger .

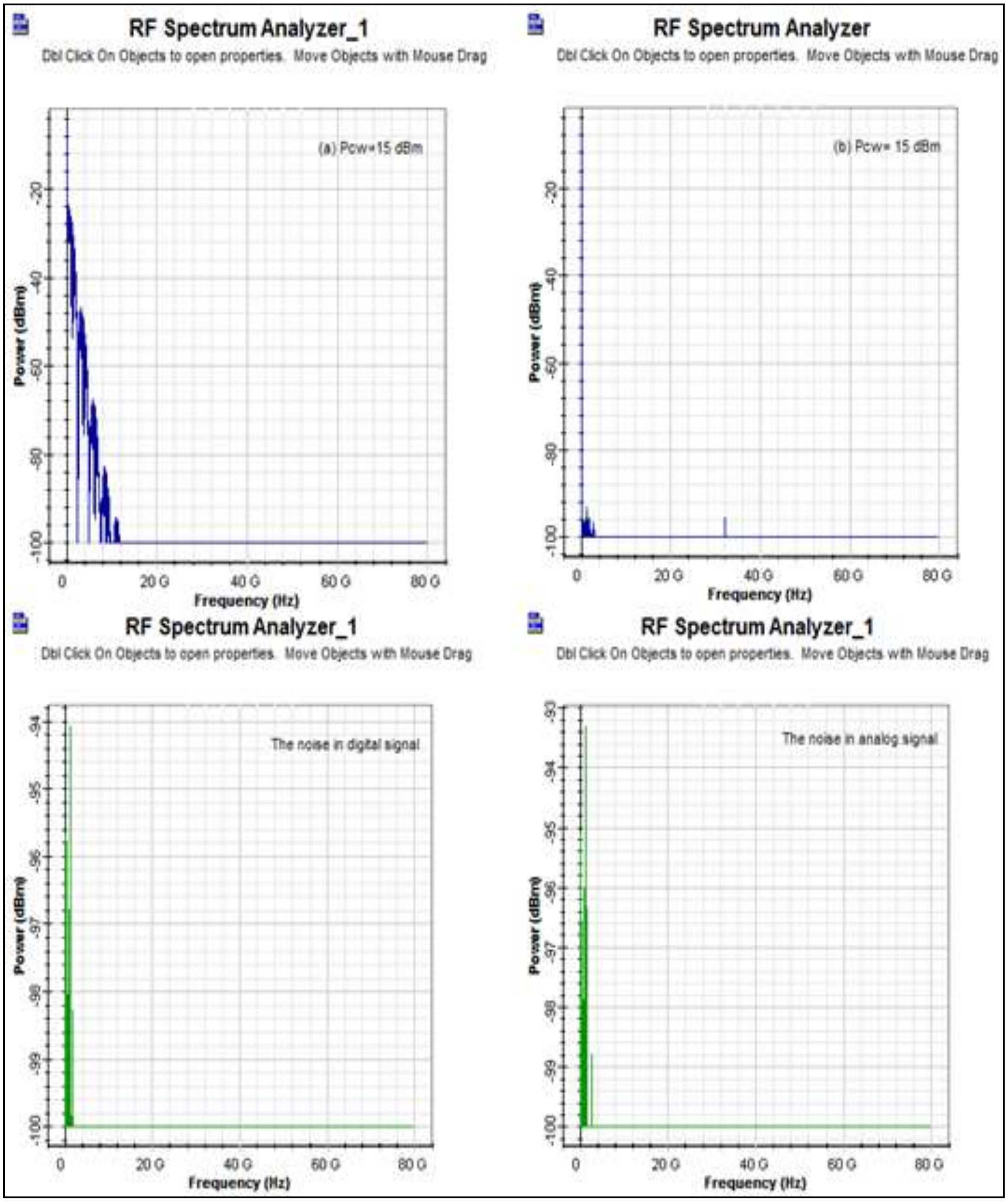
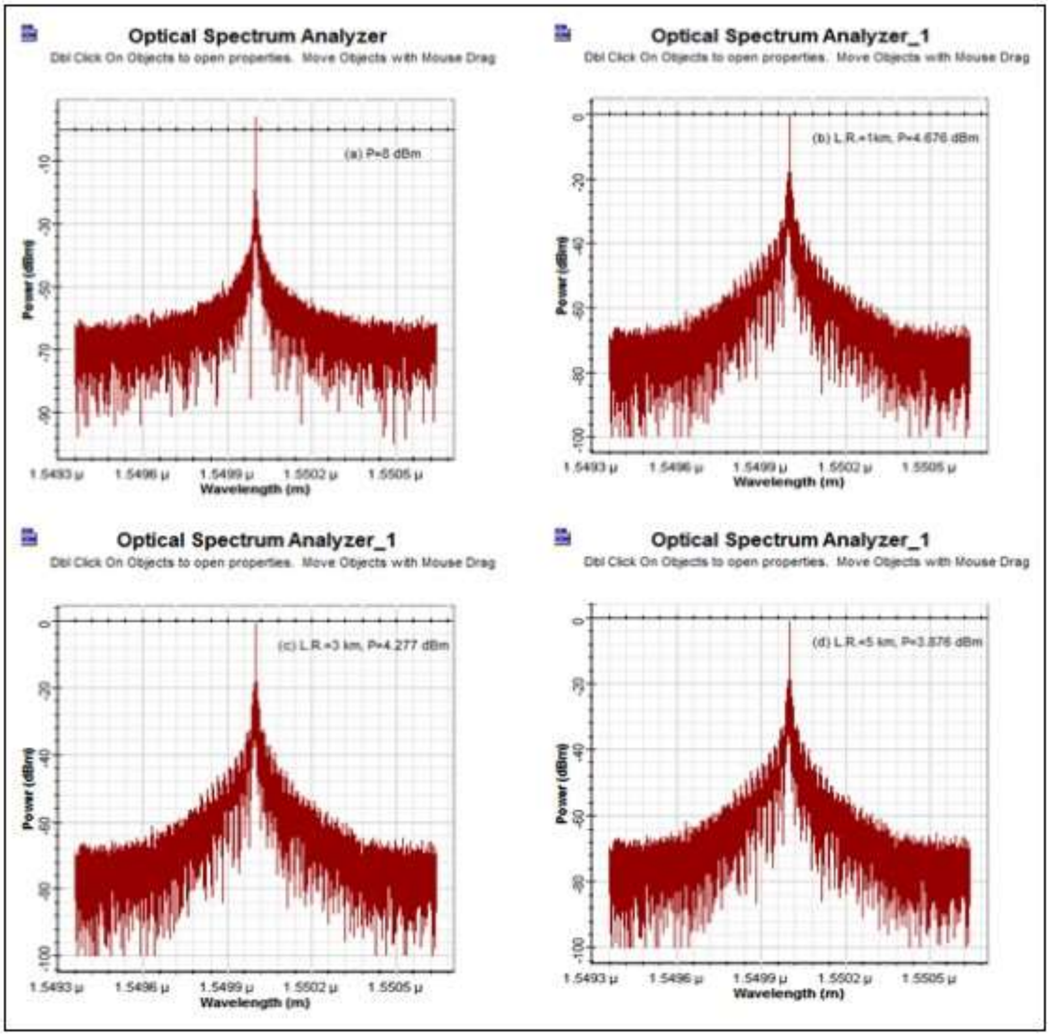



***Figure (4) The comparison between digital and analog signals at (Pcw=15 dBm) and the result noise from them used a small power of CW Laser equal to (8 dBm=6.31mW ) in order to achieve a communication between two points without use any amplify and transmit digital signals, as showing in the figure (a.5), then the digital signal after link ranges (L.R.) between (1-5) km.***




*.Figure (5):The transmitted signal and the signals after link ranges (1-5)km*

Then we used the wavelength (1550nm) and (1310nm) to transfer the signal, the losses in the two wavelengths were very convergent therefore we choose the wavelength (1550nm), as showing in figure (6).

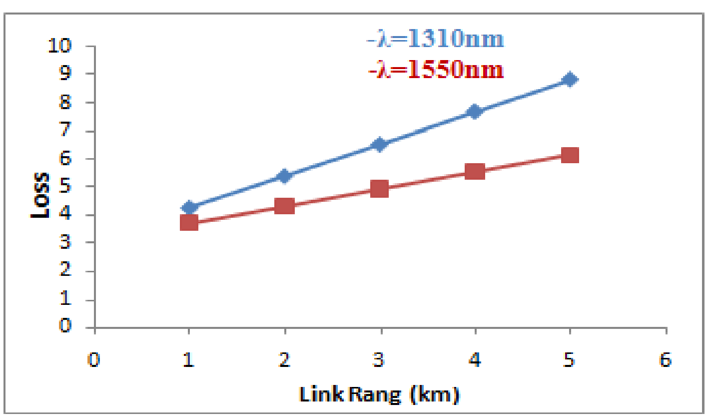



*Figure (6): Shows the losses between the two wavelengths*

The input signal is modulated with CW laser that is through Mach- Zehnder modulator, with NRZ and RZ :

***Table (1) The comparison between NRZ and RZ at(Pcw=8dBm, λ=1550nm***

| The type of modulation | Power after MZ(dBm) | Loss |
|---|---|---|
| **NRZ** | **4.876** | **3.12325** |
| **RZ** | **2.61** | **5.39** |

To show the difference between NRZ and RZ ,we take the signals after link range (5km) as shown in figure (7).

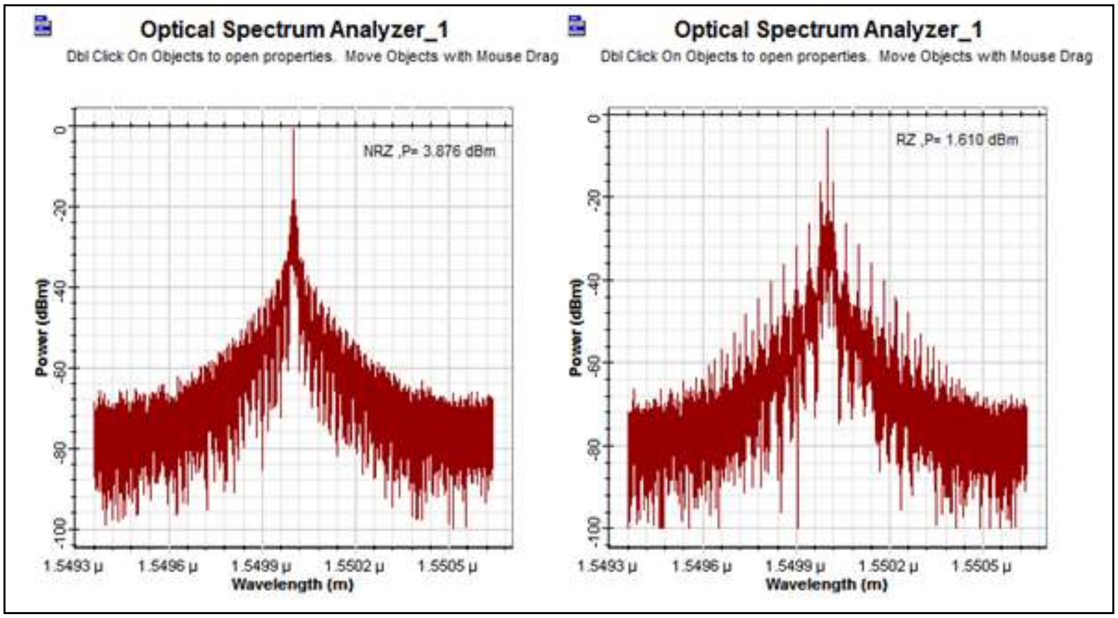



***Figure (7): The comparison between NRZ and RZ***

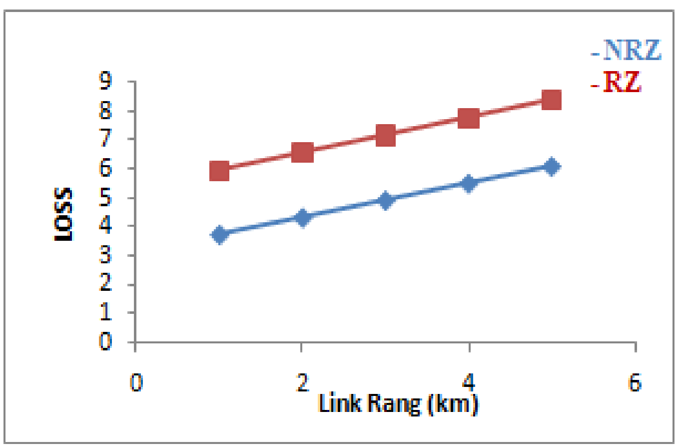



***Figure (8):The losses in each NRZ and RZ***

The losses in NRZ and RZ for link ranges between (1-5) km, demonstrated that the modulation NRZ best from modulation RZ , as shown in figure (8). We employed two types of fiber single mode and multimode to transmit the signals ,the losses in single mode fiber were very less than multimode fiber and transmittance in single mode larger than multimode fiber for transmitter links rang (1-5) km, as shown in figure (9).

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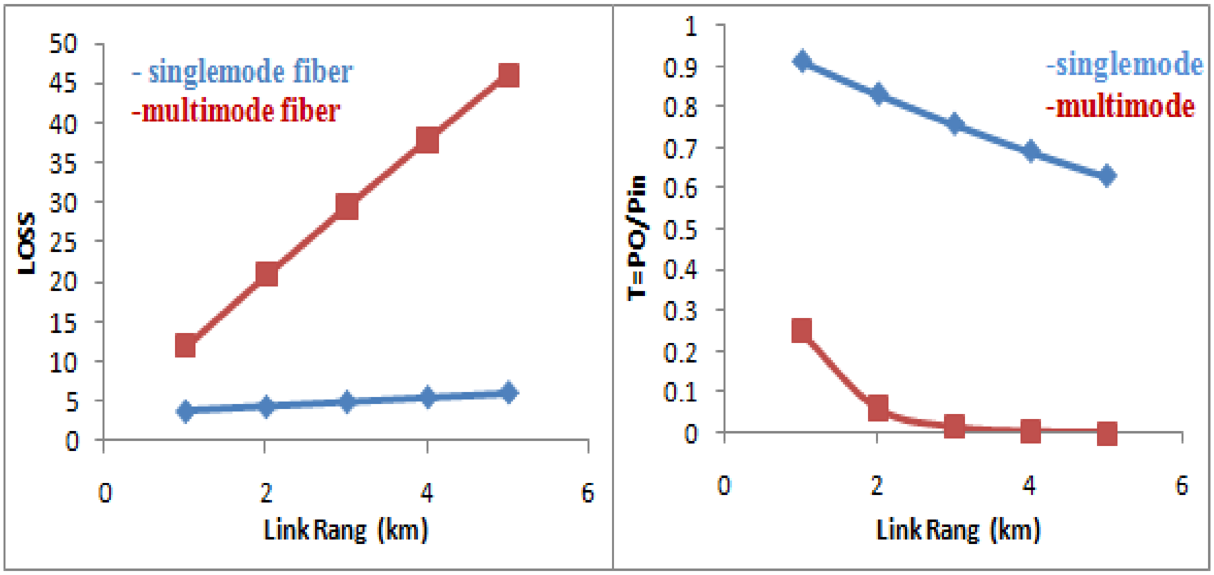


***Figure (9):The loss and transmittance in single mode and multimode fibers***

But after ranging equal to (5)km the signals in single mode and multimode fibers explained in the following figure (10) :

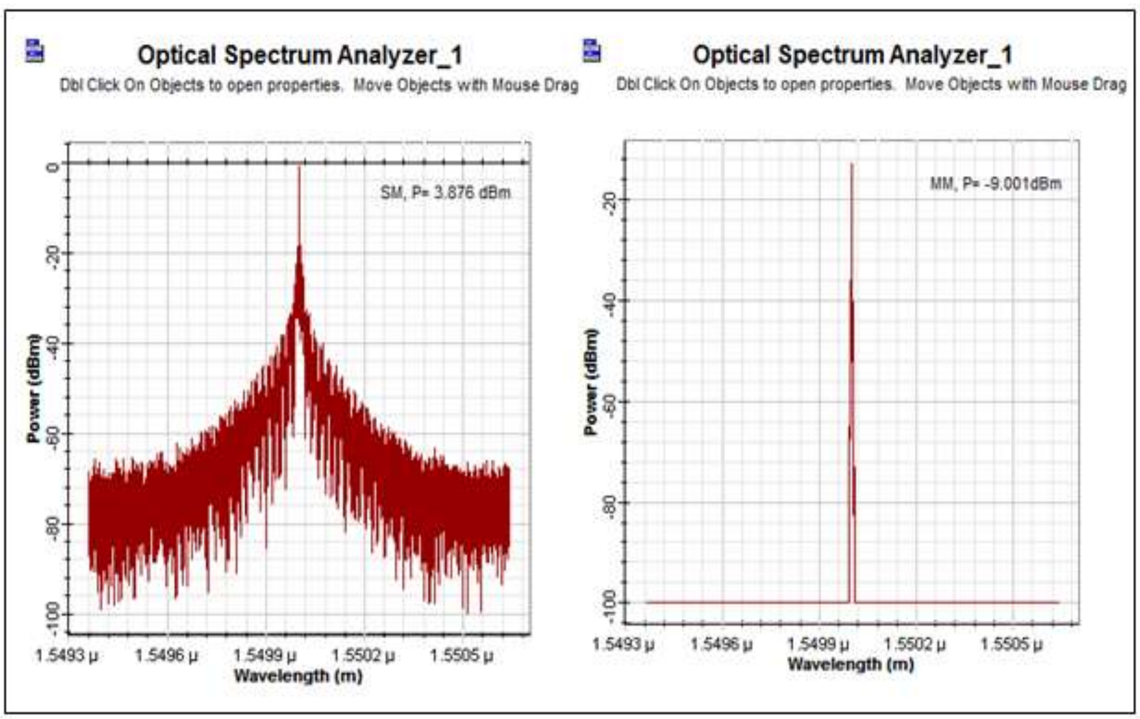


***Figure (10): The signals in singlemode and multimode after link***

In the layout of the fiber optic communication design, the signal was received by PIN detector, because the noise during PIN be less than the resulting noise from using APD detector, although the output power for APD be larger than output power for PIN after link range equal to (5 km) ,as shown in figure (10).

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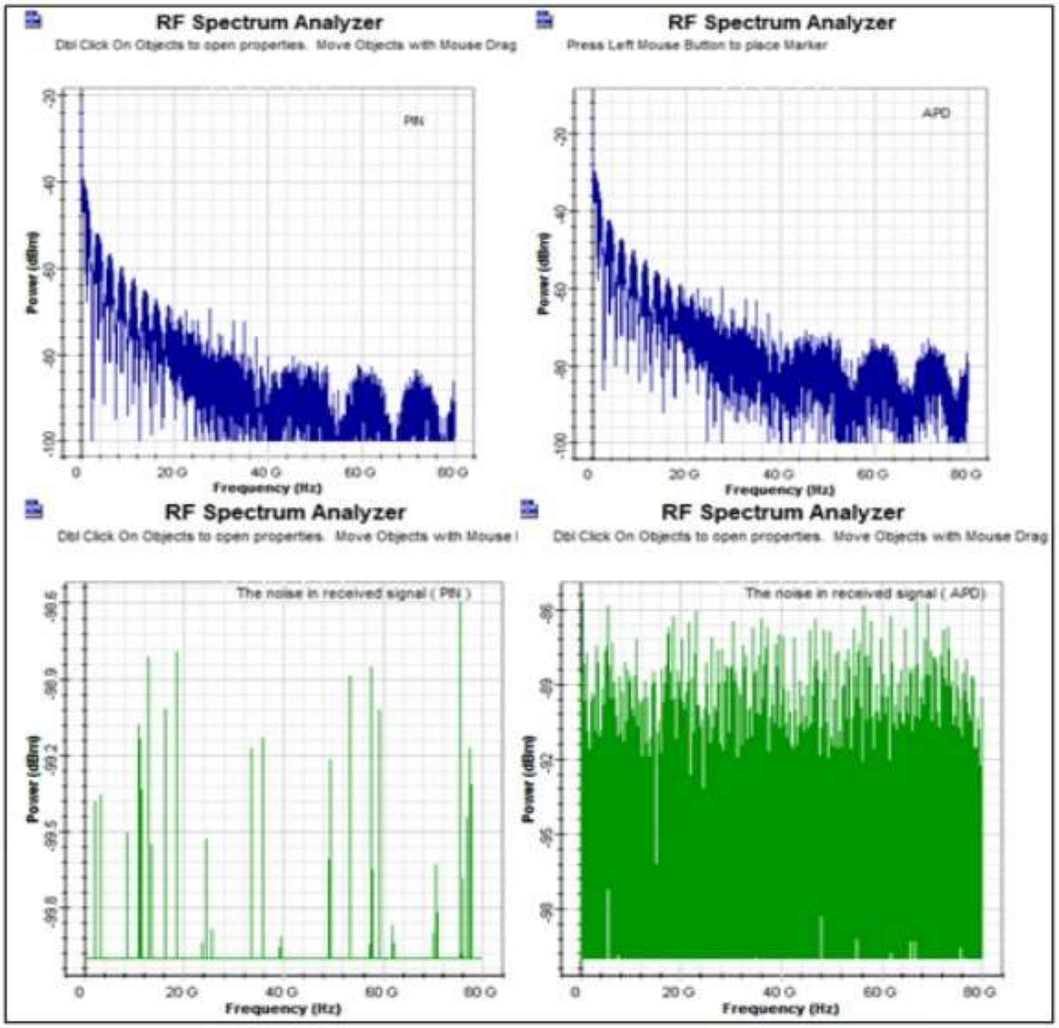


***Figure (10):Shows the signals and losses after PIN and APD***

## REFERENCE

[1] Sun Qiang, Zhou Xu."Optical fiber communication system and its applications " Beijing: The Press of Tsinghua University, 2004.
[2] John Wiley & Sons, Inc." Fiber-Optic Communications Systems", Third Edition ,2002.
[3] Nick Massa," FUNDAMENTALS OF PHOTONICS ", 2000.
[4] Gerd Keiser, "OPTICAL COMMUNICATIONS ESSENTIONS " , 2004.
[5] Mohammad Azadeh, "Fiber Optic Engineering ", 2009.
[6] Emmett Ientilucci," Fundamentals of Fiber Optics ",1993.
[7] Jim Hayes, "Fiber Optics Technician's Manual ", 2nd Edition, 1994.
[8] Shi Shunxiang, Chen Guo Fu, Zhao Wei et al.. “Nonlinear optics,” Xi’an: The Press of Xidian University, 2003
[9] Automation net “OptiSystem software for the design of optical communication system ,” http://www.zidonghua.net.cn.
[10] Cisco ," Calculating the Maximum Attenuation for Optical Fiber Links ", Page 1 of 5, 2006.