Analysis of Modulation Format for NGPON2 Network for Long Reach using PIN Receiver

A Project Report

Submitted in partial fulfillment of the requirement for the award of the degree of

Bachelor of Technology

in

Electronics and Communication Engineering

by

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April 2018

DECLARATION

I hereby declare that the project work entitled "**Analysis of modulation formats of NGPON2 for long reach using PIN receiver**" submitted by me, for the award of the degree of *Bachelor of Technology in Electronics and Communication Engineering* to Vellore Institute of Technology is a record of bonafide work carried out by me under the supervision of

I further declare that the work reported in this report has not been submitted and will not be submitted, either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university.

Place : Vellore **Signature of the Candidate**

Date :

CERTIFICATE

This is to certify that the project work entitled “Analysis of modulation formats of NGPON2 for long reach using PIN receiver” submitted by School of Electronics Engineering, Vellore Institute of Technology, for the award of the degree of *Bachelor of Technology in Electronics and Communication Engineering*, is a record of bonafide work carried out by him/her under my supervision, as per the VIT code of academic and research ethics.

The contents of this report have not been submitted and will not be submitted either in part or in full, for the award of any other degree or diploma in this institute or any other institute or university. The report fulfills the requirements and regulations of the institute and in my opinion meets the necessary standards for submission.

Place : Vellore

Date :

Signature of the Guide

The project work is satisfactory / unsatisfactory

Internal Examiner **External Examiner**

Approved by

Head of the Department
Department of Communication Engineering

School of Electronics Engineering

ACKNOWLEDGEMENT

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Place : Vellore

Executive Summary

The diversity of different broadband services offered to internet users today, causes growing of individual user demands to internet traffic. Broadband applications, such as TV telephony, IP-TV, video conferencing, video on demand, interactive games and others, increases demands of internet users for internet traffic increase. Perspective solution widely applied today is the introduction of a broadband access network based on fiber-to-the-Office(FTTO) and fiber-to-the-home (FTTH). The most cost-effective way to deploy FTTH networks is passive optical networks (PON) technology.

PONs ensure higher reliability, simpler maintenance and reduced power consumption in comparison

with active optical networks (AONs). According to Gigabit-Capable PON (GPON) is currently dominating in the world market, but 10 gigabit Ethernet-PON (10G-EPON) and 10GPON (XG-PON) are currently in beginning phase of mass-market adaptation. The need to improve performance and decrease costs drives new standards. The next-generation PON (NGPON) with much higher bandwidth will feasibly be able to satisfy these demands. NG-PON1 considers the ODN to remain unchanged, whereas NG-PON2 means revolutionary change of ODN. TDM-PON and WDM PON has already been selected as the best candidate for NG-PON1 solutions, but one of proposed candidates for NG-PON2 is TWDM-PON. Requirements to NG-PON2 includes at least 10 Gb/s aggregate downstream capacity, more than 16 channels and 40km differential reach.

We have designed a TWDM-PON system which is simulated for transmission of 16 channels with 10 Gb/s data rate for both down stream and upstream. The right choice of modulation format can significantly influence system performance by increasing system reach and capacity. Here we investigate the simple modulation formats such as RZ, NRZ, RZ-DPSK, NRZ-DPSK, CSRZ-DPSK and DB, which are easier to

implement, and cost effective. We have analysed the various Q factors parameters for different receivers such as PIN receivers.

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List of Terms and Abbreviations

ASK	Amplitude shift keying
BW	Band width
CW	Continuous Wave
DPSK	Differential phase shift keying
DB	Duobinary
DWDM	Dense Wavelength Division Multiplexing
FDM	Frequency Division Multiplexing
FWM	Four wave mixing
FSK	Frequency shift keying
MZI	Mach-Zehnder Interferomter
MMF	Multimode fiber
NRZ	No return to zero
NLF	nonlinear fiber
OOK	On-off keying
OSNR	Optical noise to noise ratio
RZ	Return to zero
3R	Reamplifying, reshaping and retiming
Rx	Receiver
SMF	Single mode fiber
Tx	Transmitter

List of Symbols and Notations

λ	Wavelength
f	Frequency
α	Attenuation Constant

1. INTRODUCTION

1. MOTIVATION

Optical communication systems play's vital role in todays wired communication system. The demand of higher bandwidth requirement led to increase in the making of optical communication system. The various broadband services are provided to different internet users today, causes growing of individual user demands to internet traffic. Firstly, PON is a telecommunication technology which is used to provide Fiber to the end user for both the domestic and commercial purposes.

Asynchronous PON(APON) and Broadband PON (BPON) are first variants of the PON which were commercially bring into effective action. Asynchronous transfer mode(ATM) a protocol for transmitting data which was initially employed. To improve the efficiency of the previously deployed PON networks which uses ATM services were standardized and optimized for the packets based transmission at gigabit line rates.

Communication providers employed GPON technology to implement to provide FTTP services to fulfill the higher bandwidth requirement. The rapid increase in bandwidth demand of end users driven by the growth high data rates multimedia content and bandwidth intensive applications, GPON technology is outstripping the user demand. Flexible services towards the consumer is also provided by GPON. Low latency and quality of experience (QoE) will be guaranteed to the customers by GPON.

The conventional way to get high data rates at end users is NGPON2. Time Wavelength Division Multiplexing-Passive Optical Network (TWDM-PON) has been a key technique for Next Generation Passive Optical Network2 (NG-PON2). NG-PON2 is first multi wavelength access that provides data rate 40 Gbps, which is cost effective and has high efficiency.

2. BACKGROUND

A passive optical network (PON) is a point-to-multi-point (P2MP) architecture to provide broadband access. The point-to-multi-point architecture has become the most popular solution for FTTx formation among operators. PON-based FTTx has been widely deployed since 2004 when ITU-T Study Group 15 Q2 completed recommendations that defined GPON system [ITU-T series G.984].

ITU-T and Full-Service Access Network (FSAN) are the PON interest group and standard organization. In the view of above organizations, the next-generation PONs are divided into two phases: NG-PON1 and NG-PON2. Mid-term upgrades in PON networks are defined as NG-PON1, while NG-PON2 is a long-term solution in PON evolution. Major requirements of NG-PON1 are the coexistence with the formed GPON system.

The selection of NG-PON1 in FSAN is a trade off between the cost and technology. Operators require NG-PON1 systems that have higher capacity, bandwidth, more users and longer reach. NG-PON1 system is essentially an enhanced TDM PON from GPON. In NG-PON2 there are several types of prospective technologies that can be adopted. Among them, baseline is to improve the rate to 10Gbps to 40Gbps by TDM technology. The second method is wavelength division multiplexing(WDM) PON technology to achieve 40Gbps.

Optical distribution networks (ODNs) account for 70% of the total investments in deploying PONs. So, it is crucial for the NGPON evolution to be consistent with the formed networks. With the specification of system coexistence and ODN reuse, the only thing is of the migration from GPON to NG-PON1 is the maturity of the industry chain. In Fig 1.2 represent the evolution of NGPON2.

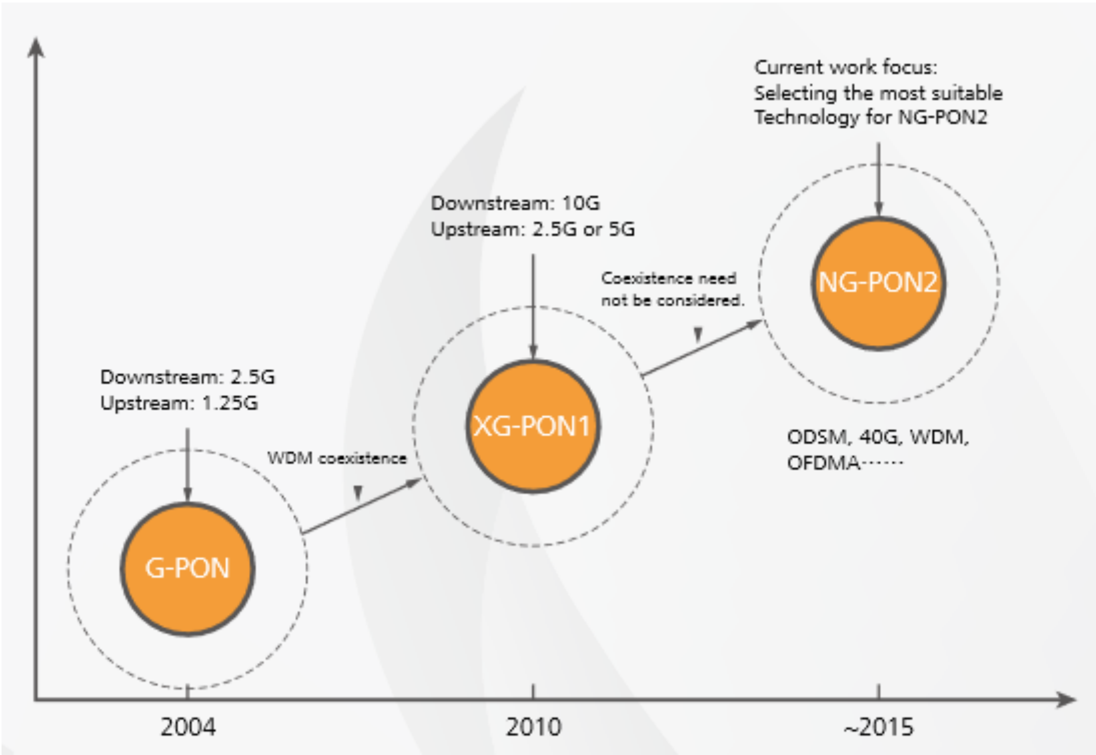

Fig 1.2 NG-PON roadmap by FSAN

3. OBJECTIVE

In our project we design and analyze the NG-PON2 architecture for upstream data rate of 10Gbps and downstream data rate of 40Gbps.

We first compare for different modulation formats such as NRZ, RZ, Duobinary, NRZ-DPSK, RZ-DPSK

We plot the graphs for different modulation formats varying distance and data rate using MATLAB and comparative analysis is shown at the end.

4. ORGANIZATION OF THE REPORT

In Chapter One we discuss about the basics of the PON Network and NGPON2.Then we discuss the development of the work, Motivation of our work.

In Chapter Two we discuss about NGPON2 working, Evolution of PON Network, Principle of Operation, about different Modulation Formats, about Transmitter(Tx), Receiver(Rx) and also about the PON Solution.

In chapter three the analysis method of our work is discussed. Here we discuss about the Opti System Software 15 and about the MATLAB R2017a.

In chapter four the design approach to our project has been discussed and the suitable codes and standards have been listed and certain trade offs have been mentioned.

In chapter five the duration of the project as well monthly progress milestones have been listed.

In chapter six we demonstrate the whole project with suitable diagrams and equations for a better understanding and certain graphs have been plotted for comparative analysis of different Modulation Formats.

In Chapter eight we discuss about results for different Modulation Formats.

2. PROJECT DESCRIPTION AND GOALS

2.1. THEORY OF PON

PON network avoids costly optic-electronic conversion, the minimum possible number of transceivers is N+1. Here uses passive splitters power loss is very minimum almost there will be no power needed and this avoid the costly optic-electronic conversion. A Passive Optical Network comprises of an Optical Line Terminal(OLT) in Central Office(CO). set of associated optical network units-ONUs, (or optical network terminals-ONTs) located at the customer's end, optical distribution network (ODN) consists of fibers and passive splitters or couplers for connectivity. In Fig 2.1 shows the information flow in the PON.

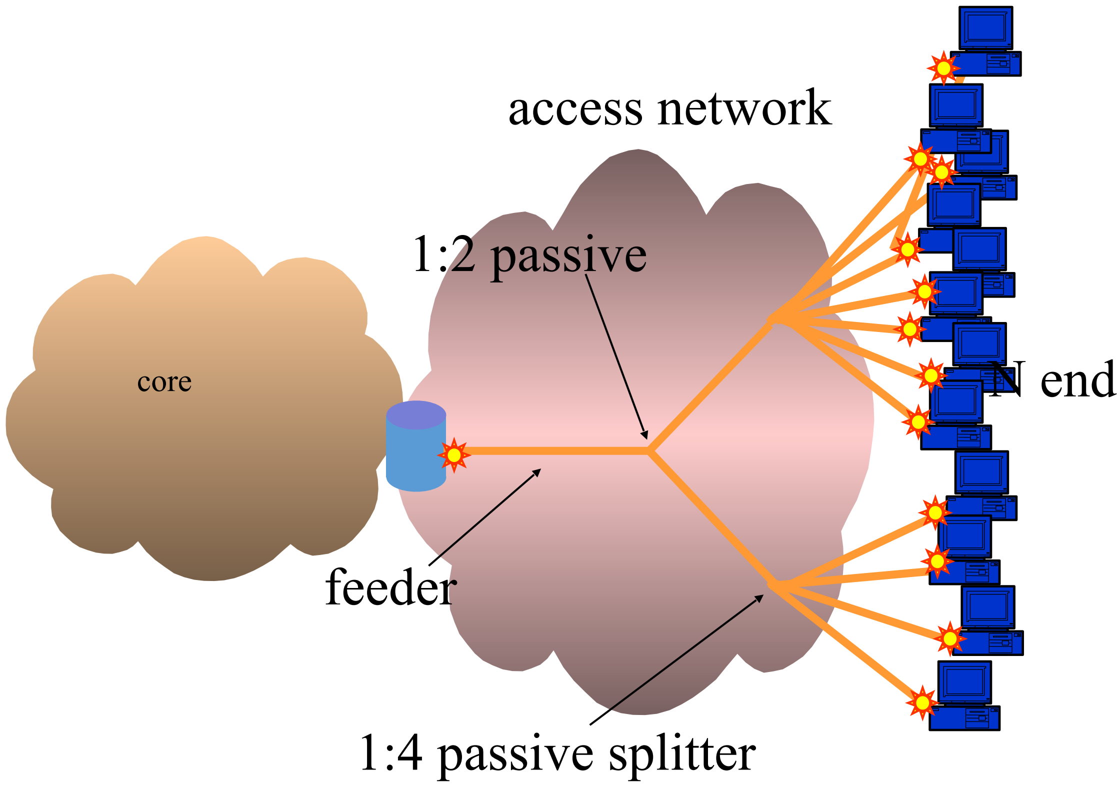

Fig 2.1 Structure of PON Network

2.2 EVOLUTION OF PON

- Optical line terminal(OLT) is located at central office which controls the bidirectional flow of data
- Optical network terminal(ONT) is present in the customer premises, The ONT provides an optical connection to the PON network on the upstream side, It interface electrically to the local customer equipment.
- Optical network unit(ONU) similar to an ONT, but it is located near the customer and is housed in an outdoor equipment shelter.

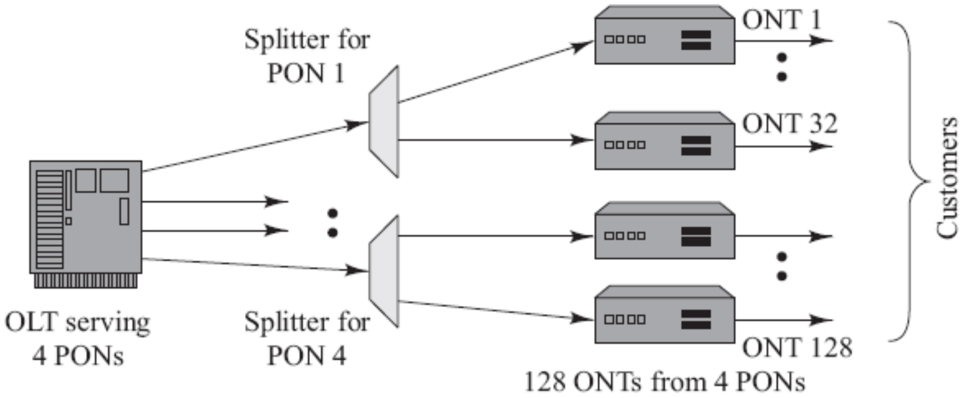

Fig 2.2 APON Architecture

- Early work on efficient Fiber to the home architectures was done in the 1990s
- The above Fig.2.2 represent the architecture of APON.
- There are two generalizations of PON
- The older one ITU-T G.983 standard is based on asynchronous transfer mode(ATM), and has therefore been referred to as APON (ATM PON)
- Gradual falling out of favor of ATM as a protocol led to the full, final version of ITU-T G.983
- It’s referred to more often as broadband PON, or BPON
- A typical APON/BPON provides 622 megabits per second (Mbit/s) of downstream bandwidth and 155 Mbit/s of upstream traffic
- The ITU-T G.984 (GPON) standard represents a boost in both the total bandwidth and bandwidth efficiency through the use of larger, variable-length packets

- GPON Encapsulation Method (GEM) allows very efficient packaging of user traffic, with frame segmentation to allow for higher Quality of Service (QoS) for delay-sensitive traffic such as voice and video communications.

- The IEEE 802.3 Ethernet PON (EPON or GEPON) standard was completed in 2004

- EPON uses standard 802.3 Ethernet frames with symmetric 1 gigabit per second upstream and downstream rates

- PON is applicable for data-centric networks, as well as full-service voice, data and video networks. Recently, starting in early 2006, work began on a very high-speed 10 Gbit/s EPON (XEPON or 10-GEPON) standard

2.2.1 Asynchronous Transfer Mode (ATM)

Asynchronous Transfer Mode(ATM) is a cell relay, packet switching network and data link layer protocol helps in encoding data traffic into small fixed size cells. It divides 53,48 bytes data and 5 bytes of header information. ATM provides data link layer services that runs over physical layer. ATM is based on connection oriented technology in which a logical connection is established between two end points before the actual data exchange begin.

3. Core architecture of FTTP network based on PON

The physical and logical reach of GPON is limited to 60Km and 20Km respectively due to the probability of increasing error occurrence and high data rates. Optimization is considered a key solution in maximizing the system capacity and minimizing the degradation caused in transmission impairment.

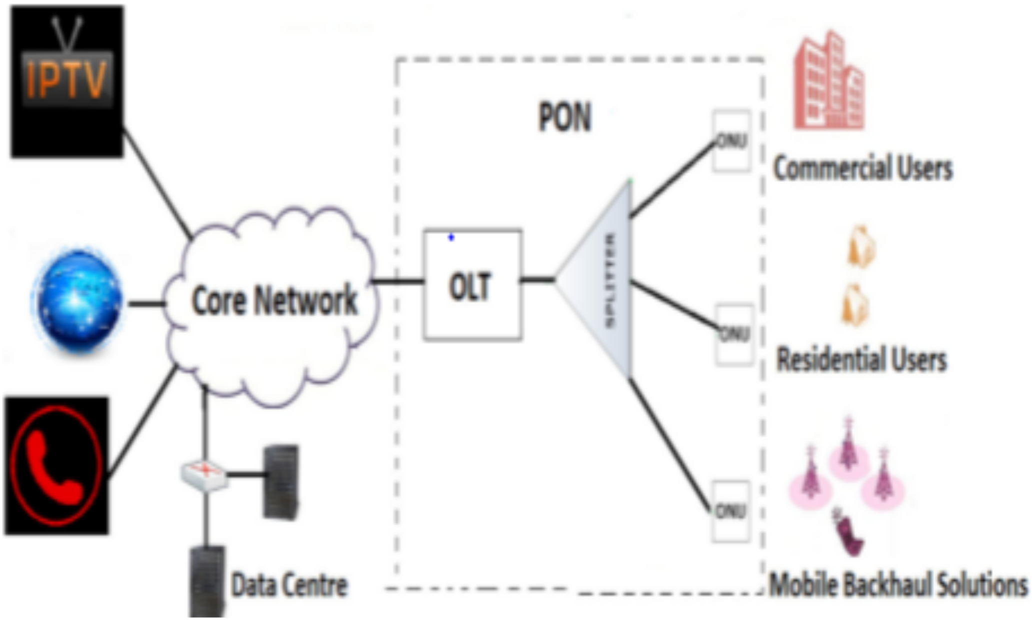

Fig.2.3 Core architecture of FTTP network based on PON

Asynchronous PON (APON) and the Broadband PON (BPON) are the first development of PON that were deployed commercially. Asynchronous Transfer Mode (ATM) protocol for data transmission was initially employs comprises downstream link rate of 622Mbps.

For improving the efficiency of deployed PON networks that used ATM services were standardized and optimized for the packet based transmission at gigabit line rates.GPON is an alternative to way for commercial deployed APON or BPON.

GPON provides asymmetrical data rates for downstream reach up to 2.488 Gbps while data rates for upstream reach up to 1.25 Gbps. Previously, vast research has been carried out for observing the effective way for the change in wavelengths of communication. The reduction in cost can be accomplished by increasing the data rates per channel. Fig.2.3 represent the core architecture of FTTP network based on PON

Higher bit rates necessary to meet the user requirements results in limitations and nonlinearities including signal degradation, dispersion, increased Bit Error Rate(BER) to become more exact. The physical and logical reach of GPON is limited to 60km and 20km respectively due to the probability of increasing error occurrence and high data rates.

4. PRINCIPLE OF OPERATION OF NGPON2

In past few years, There was intensive study on NG-PON2 for their intensive use in the optical communication, due to their high data rates and more bandwidth these networks can serve to many users with less traffic. Fiber-To-The-Premises (FTTP) network based on Gigabit PON has been considered as a viable solution for the growing demands of higher bandwidth.

The main difference is PON uses a Point to Multi-Point (P2MP) topology and Optical Networks uses Point to Point (P2P) topology. In P2MP single strand of fiber goes out to a passive optical splitter where its ,signal is multiplied to 32 different lines. WDM uses different wavelengths for upstream traffic and downstream traffic using Nonzero dispersion shifted fiber. This allows to transmit different wavelengths simultaneously. PON network uses WDM technique

The optical wave amplitude is controlled by MZM having ratio of extinction at 30dB. The signal is then modulated optically and fed into optical fiber through a circulator, which helps in separating the signals traveling in opposite directions. MUX is used in the operation of TWDM-PON and GPON both to multiplex the four and two signals respectively. In the case of TWDM-PON, the four multiplexed signals are further combined with the optical signals of GPON and RF Video Overlay. The 20 km Bi-directional optical fiber behaves as a channel for optical signal. Splitter is used for further splitting of the signal.

The same ODN is then reused for TWDM-PON in coexistence with GPON. 0.2 dB/km attenuation coefficient and 16.75ps/nm/km of dispersion is considered during experiment. Moreover, a 1 9 8 splitter is used to split the signal evenly for 8 ONU’s having an insertion loss of 1.5dB. The splitter's output is then received by an attenuator to attenuate the signal's power level for LPF (Optical Bessel Filter) for filtration process. PIN Diode is used to detect optical signal and perform O-E conversion. Subsequently, the converted electrical signals are sent at each ONU for eye diagrams through the BER analyser.

5. SIMULATION MODEL

2.5.1 BLOCK DIAGRAM

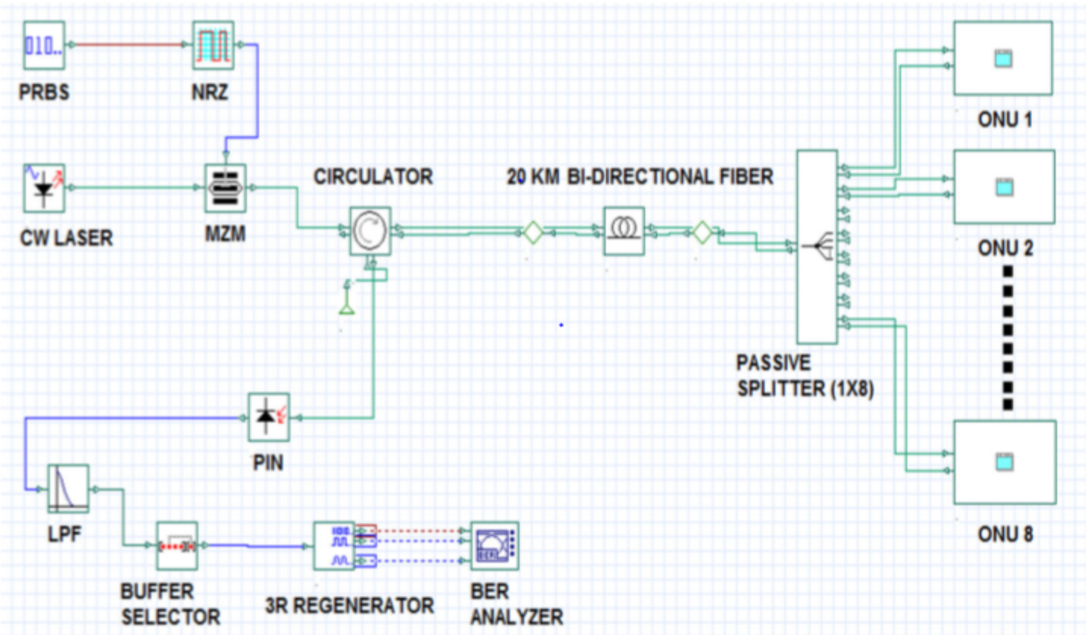

Fig.2.5.1 Experimental structure of Bi-directional NGPON2 comprising Central Office, Optical Network Unit and Optical Line Terminal

The architecture of our proposed model is illustrated in the above Fig.2.5.1. The setup considers two wavelengths of operations for this experiment, downstream direction uses 1490 and 1550 nm and 1310 nm in upstream. CW laser in the central office generates suitable wavelengths for downstream direction with suitable power as 3dBm optical power.

The signal is encoded using NRZ pulses separately using Mach-Zehnder modulator(MZM). The output of this becomes input to the circulator. Circulator helps in separating downstream and upstream transmission, After the circulator the output of the circulator is transmitted to Bi directional optical fibre, Output of fibre becomes input to passive splitter then the signal reaches to Optical Network Unit(ONU).

In Optical Network Unit(ONU) first it consists of De-mux toto separate the signals, to filter the unwanted signals Optical Bessel filter is used to filter the signal. The output of Bessel filter is sent to PIN receiver to convert the signal from optical to electrical conversion.

The output is fed to Low Pass Filter(LPF), this helps in removing any external noise in the received electrical signal, Buffer Selector is used to select required amount of power in the received signal, 3R Regenerator helps in multiplying the received signal with some factor to retain the power of the received signal, BER analyser is used to calculate the number of error bits. the upstream transmission is completely managed by the OLT placed inside Central Office. OLT allocates and assigns specific time slot and bandwidth to the ONUs placed at client premises to avoid frame collisions.

The upstream transmission of frames is carried out in TDMA manner to introduce a certain delay and collision avoidance. OLT is responsible for calculating the unique transmission delay on the basis of the distance at which each ONU is placed

2.6 OPTICAL NETWORK UNIT(ONU)

Each Optical Network Unit(ONU) consists of a De-Mux to separate downstream and upstream signal and transmitter for downstream and receiver to receive signal from Central Office(CO). Fig.2.6 is general block structure of ONU.

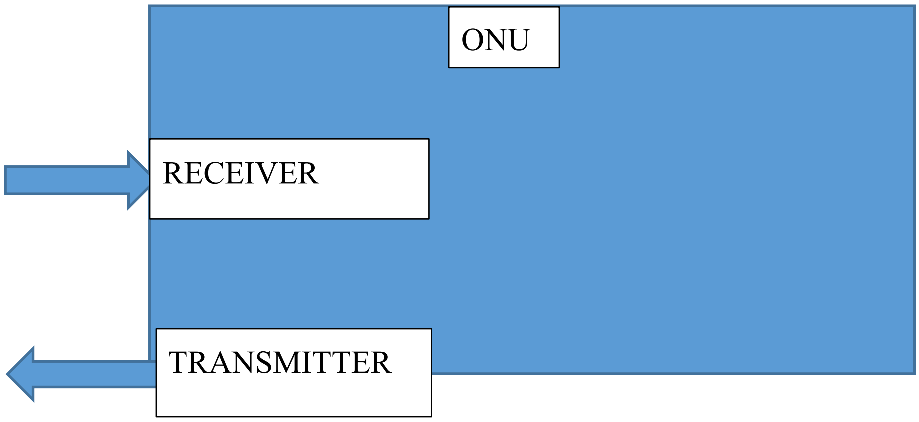

Fig.2.6 Optical Network Unit

2.6.1 TRANSMITTER

In this simulation we use six different modulation formats to encode the electrical signal to optical signal for transmission using the optical fiber, For each modulation format we use specific transmitter circuit.

1) Non-Return to-Zero(NRZ)
2) Return to Zero(RZ)
3) NRZ differential phase shift keying(NRZ-DPSK)
4) RZ differential phase shift keying(RZ-DPSK)
5) Carrier Suppressed RZ DPSK(CSRZ-DPSK)

6) Duobinary(DB)

2.6.2 Non-Return-to-Zero(NRZ) Transmitter

A non-return-to-zero (NRZ) line code is a binary code in which one is represented by one significant condition, usually a positive voltage, while zeros are represented by some other significant condition, usually a negative voltage, with no other neutral or rest condition. The pulse in NRZ have more energy than return-to-zero(RZ) code, which also has an additional rest state beside the conditions for ones and zeros. NRZ is not inherently a self-clocking signal. For a given bit rate the NRZ code requires only half the baseband bandwidth required by the manchester code(the passband bandwidth is the same). Fig 2.6.2 represents the general block diagram of NRZ modulation format.

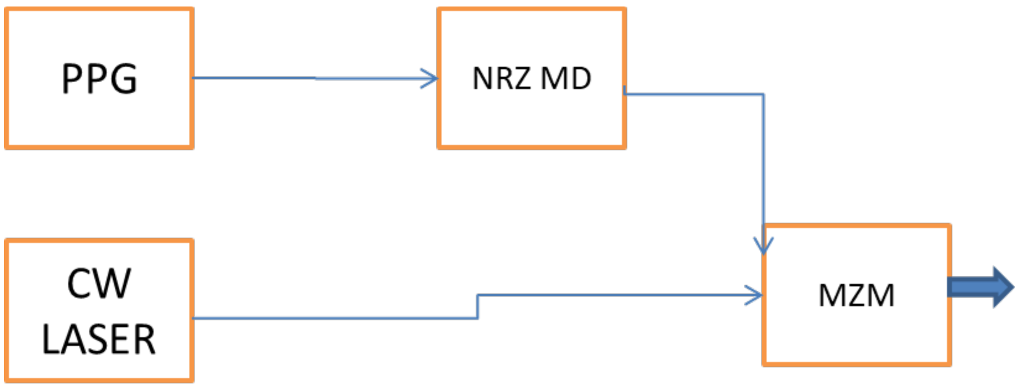

Fig.2.6.2 Non-Return to Zero

2.6.3 Return to-Zero(RZ) Transmitter

Return-to-zero (RZ) describes a line code used in telecommunication signal in which the signal drops (returns) to zero between each pulse. This takes place even if a number of consecutive 0's or 1's occurs in the signal. The signal is a self-clocking.

This means that a separate clock does not need to be sent alongside the signal, suffers from using twice the bandwidth to achieve the same data-rate as compared to non-return-to-zero format.

The "zero" between each bit is a neutral or rest condition, such as a zero amplitude in pulse amplitude modulation(PAM), zero phase shift in phase-shift keying(PSK), or mid-frequency in frequency-shift keying(FSK). That "zero" condition is typically halfway between the significant condition representing a 1 bit and the other significant condition representing a 0 bit. Fig 2.6.3 represents the block diagram of RZ transmitter.

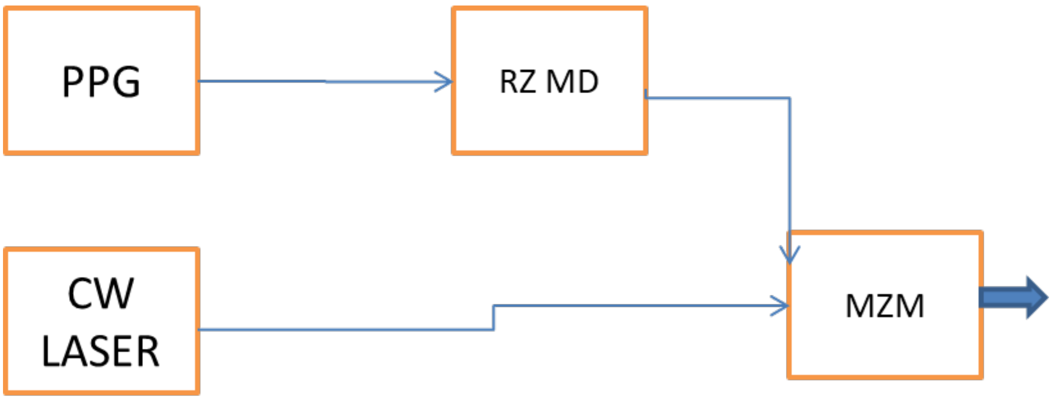

Fig.2.6.3 Return to Zero

2.6.4 NRZ differential phase shift keying(NRZ-DPSK) Transmitter

In the generation of NRZ-DPSK technique a MZI modulator is used for phase modulation, the modulator is biased at its transmission null in push-pull operation mode, and is driven at twice the switching voltage required for OOK modulation, thus generate NRZ-DPSK. Fig 2.6.4 represents the block diagram of NRZ-DPSK transmitter.

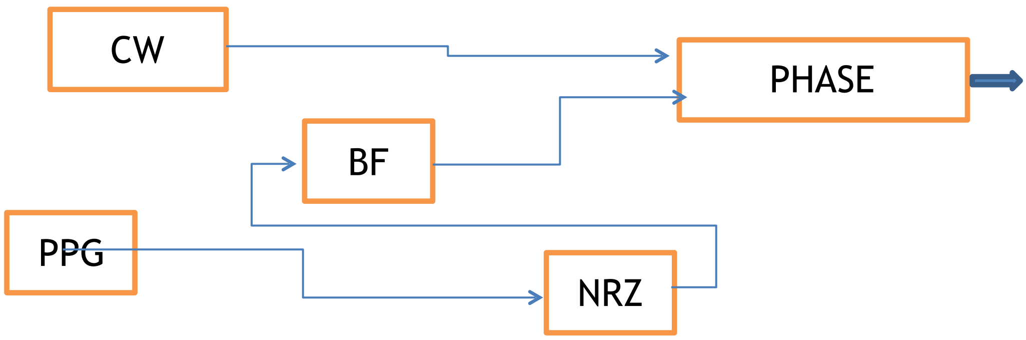

Fig.2.6.4 NRZ-DPSK

2.6.5 RZ differential phase shift keying(RZ-DPSK) Transmitter

For RZ-DPSK generation a continuously oscillating laser followed by one or two external modulators. A first modulator to encode phase-shift keying and a eventually a sinusoidal driven second modulator (pulse carver) to carve pulses out of the phase-modulated signal, thus generating RZ-DPSK. Fig 2.6.5 is the structure of RZ-DPSK transmitter

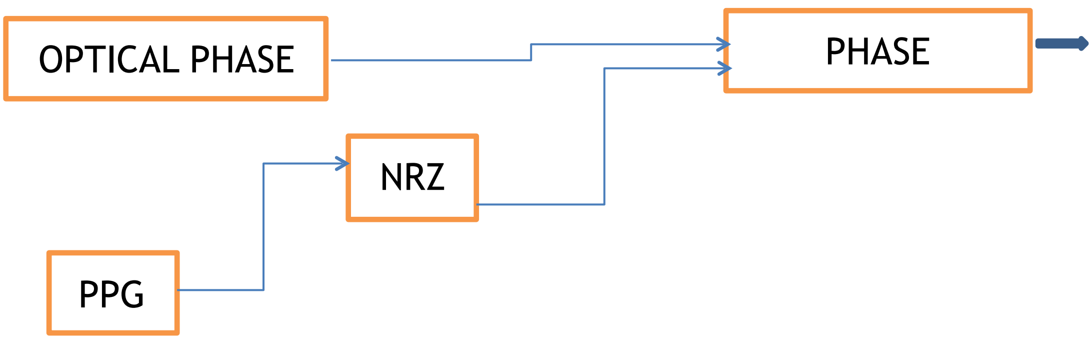

Fig.2.6.5 RZ-DPSK

2.6.6 Carrier Suppressed RZ DPSK(CSRZ-DPSK) Transmitter

This is the conventional RZ format with an additional phase modulation. If all even bit-slots have positive amplitude, then all odd bit slots have the negative amplitude (i.e. a π phase shift offset separates even and odd bit slots. . Fig 2.6.6 is the CSRZ-DPSK transmitter structure.

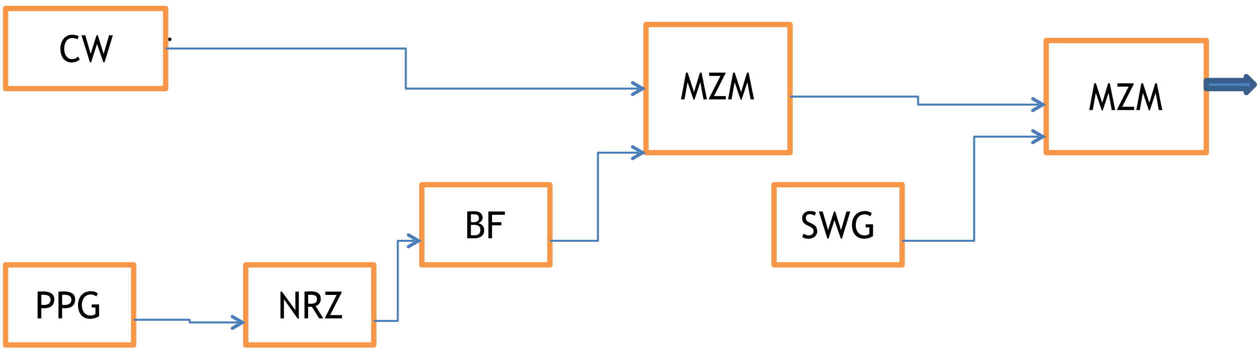

Fig.2.6.6 CSRZ DPSK

2.6.7 Duobinary(DB) Transmitter

“0”: low signal level

“1”: high signal level, without sign change if there is an even number of “0s” since last “1” bit, with sign change for odd quantity of “0s” since last “1.Fig 2.6.7 is the block diagram of Duobinary transmitter.

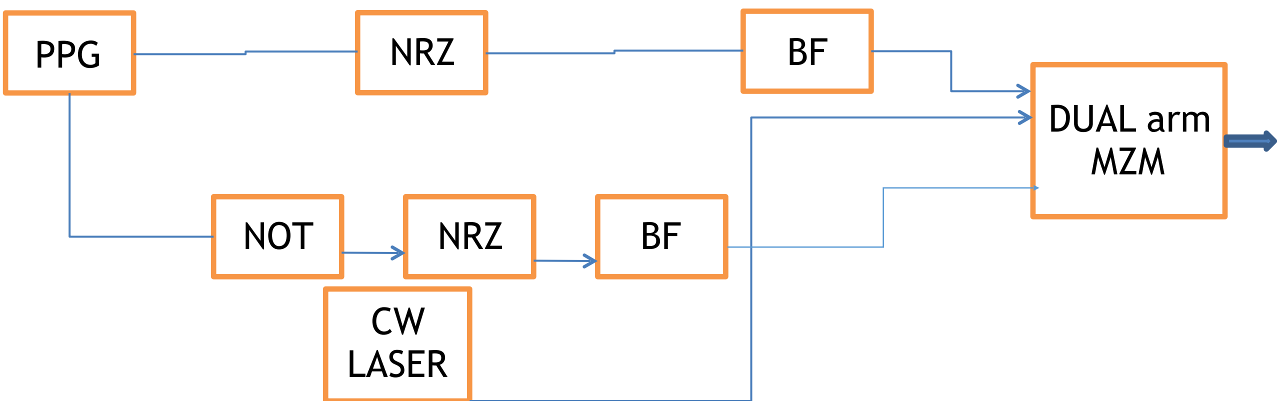

Fig.2.6.7 Duobinary

2.7 OPTICAL COMPONENTS

2.7.1 Mach-Zehnder modulator(MZM)

A Mach-Zehnder modulator is used for controlling the amplitude of an optical wave. The input waveguide is split up into two waveguide interferometer arms. If a voltage is applied across one of the arms, a phase shift is induced for the wave passing through that arm. When the two arms are recombined, the phase difference between the two waves is converted to an amplitude modulation.

2.7.2 Phase Pattern Generator(PPG)

Light pulse generators are the optical equivalent to electrical pulse generators with rep rate, delay, width and amplitude control. The output in this case is light typically from a LED or laser diode.

2.7.3 Sinusoidal wave generator(SWG)

A signal generator is an electronic device that generates repeating or non-repeating electronic signals in either the analog or the digital domain. It is generally used in designing, testing, troubleshooting, and repairing electronic or electroacoustic devices, though it often has artistic uses as well. Most commonly generated signal is a sine wave generator.

2.7.4 Bessel filter(BF)

In electronics and signal processing, a Bessel Filter(BF) is a type of analog linear filter with a maximally flat group/phase delay (maximally linear phase response), which preserves the wave shape of filtered signals in the passband. Bessel Filter are often used in audio crossover systems.

2.7.5 Continuous Wave laser (CW laser)

Continuous wave operation of a laser means that the laser is continuously pumped and continuously emits light. The emission can occur in a single resonator mode (→ single-frequency operation) or on multiple modes. The first CW laser was a helium–neon laser operating at 1153 nm

2.8 RECEIVER

We use ONE types of receivers in the above simulation model to convert the optical signal to electrical signal

1)PIN photo diode or On-Off-keying(OOK)

2.8.1 PIN photo diode Receiver

Fig.2.8.1 Pin Photo Diode

The above Fig.2.8.1 represent PIN photo diode is a type of photo detector, it can convert optical signals into electrical signals. This was invented in the latest of 1950's. There are three regions in this type of diode. The three regions are p-region, intrinsic region and n-region. The p-region and n-region are comparatively heavily doped than the p-region and n-region of usual p-n diodes. The width of the intrinsic region should be larger than the space charge width of a normal p-n junction.

The PIN photo diode operates with an applied reverse bias voltage and when the reverse bias is applied, the space charge region must cover the intrinsic region completely. Electron hole pairs are generated in the space charge region by photon absorption. The switching speed of frequency response of photo diode is inversely proportional to the life time.

3. TECHNICAL SPECIFICATIONS

We have worked with **OPTI SYSTEM 15** software to compare different modulation formats in NGPON2. We have got our desired numerical answers & graph for different modulation formats such as RZ, NRZ, RZ-DPSK, NRZ-DPSK, DUOBINARY for both Pin photo diode(PIN) and Avalanche photo diode(APD) receivers.

We executed the circuit in the software and obtain different Bit Error Rate(BER) at each ONU for different distances and we plotted these results by comparing different modulation formats.

In the same way we noted the readings of Q-Factor and plotted for different distances. We varied the data rate and noted the readings of BER and Q-Factor and this is done using both PIN receiver and APD receiver.

1. **MATLAB R2017a**

It is used to plot graphs according to above readings measured in Opti System.The MATLAB application is built around the MATLAB scripting language. Common usage of the MATLAB application involves using the Command Window as an interactive mathematical shell or executing text files containing MATLAB code.

MATLAB supports developing applications with Graphical User Interface (GUI) features. MATLAB includes GUIDE (GUI development environment) for graphically designing GUIs. It also has tightly integrated graph-plotting features. For example, the function plot can be used to produce a graph from two vectors *x* and *y*. The code

MATLAB (matrix laboratory) is a multi-paradigm numerical computing environment. A proprietary programming language developed by MathWorks, MATLAB allows matrix manipulations, plotting of functions and data, implementation of algorithms, creation of user interfaces, and interfacing with programs written in other languages, including C, C++, C#, Java, Fortran and Python.

2. OPTI SYSTEM 15

Optical communication systems are increasing in complexity on an almost daily basis. The design and analysis of these systems, which normally include nonlinear devices and non-Gaussian noise sources, are highly complex and extremely time-intensive. As a result, these tasks can now only be performed efficiently and effectively with the help of advanced new software tools.

OptiSystem is an innovative optical communication system simulation package that designs, tests, and optimizes virtually any type of optical link in the physical layer of a broad spectrum of optical networks, from analog video broadcasting systems to intercontinental backbones. Opti System is a stand-alone product that does not rely on other simulation frameworks.

It is a system level simulator based on the realistic modeling of fiber-optic communication systems. It possesses a powerful new simulation environment and an hierarchical definition of components and systems. Its capabilities can be extended easily with the addition of user components, and can be seamlessly interfaced to a wide range of tools.

4. DESIGN APPROACH AND DETAILS

4.1. DESIGN APPROACH

OPTI SYSTEM 15

Open software OPTI SYSTEM 15 and select a new layout page

- After selecting the new layout page then we select the components in the component library.
- Then after selecting the components we drag the components on to the layout page
- Then we adjust the distance and data rate in the properties of the components.
- The power and the frequency can also be adjusted in the properties of the components.
- The power can be adjusted in the CW laser and the Data rate can be adjusted in PRBS generator.
- By adjusting all the power, frequency, distance and data rate then there will be a run option so that the results can be obtained for the different modulation formats

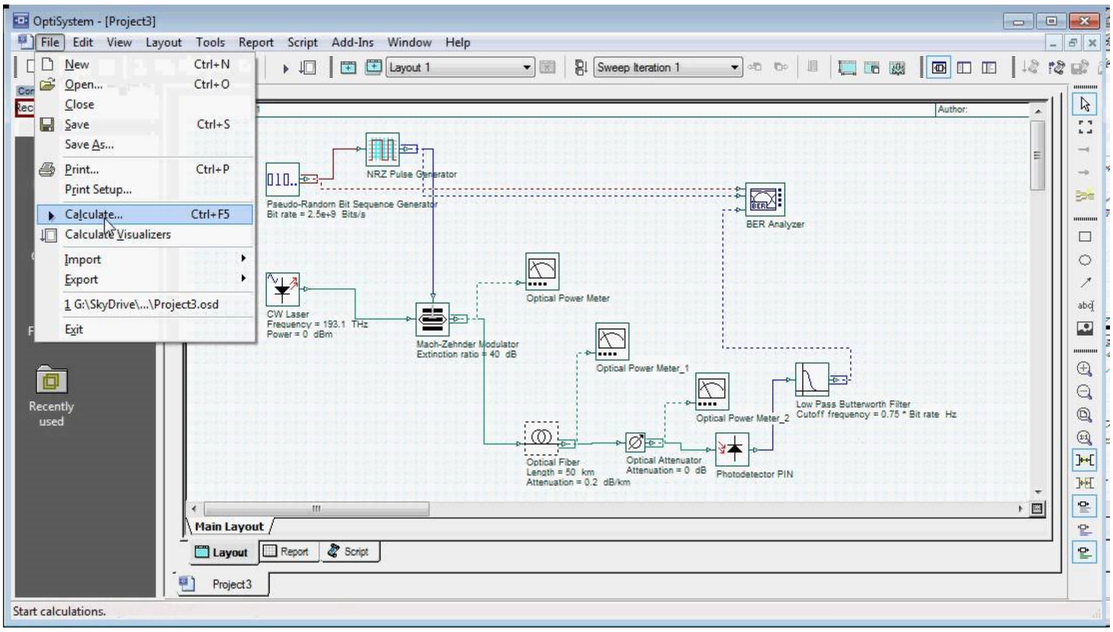

Fig.4.1 Example of Opti System Soft ware

- We need to adjust the specifications of every block to get best possible BER values.
- The above Fig.4.1 represent the basic structure of OPTI SYSTEM 15
- Then go to file > calculate to observe results.
- Open each BER analyzer to view eye diagram and Bit Error rate.

4.2. CONSTRAINTS, AND TRADE-OFFS:

4.2.1 CONSTRAINTS

In the existing optical networks, new enhanced NGPON2 network have the limitations and constrains of coexisting with the old GPON network. The data rate and distance is also limited to 100 Km.

Externally Modulated Laser (EML) introduced the dispersion. Semiconductor Optical Amplifier (SOA) is used to boost to transmit the power of EML. We can also use DML by having higher transmit power, Low ER DML is applied for reduced dispersion penalty.

Transmitter Tuning, Thermal or Current Injection (DBR), Receiver Tuning, Thermal or MEMS.

4.2.2 TRADE OFFS

Here the trade off, if distance is increased and data rate is increased optical amplifier must be used, there fore trade off must be done between data rate and distance, because both does not go hand on hand. Next trade off is power budget increase or decrease depending on network size and number of ONUs. Trade off must be done between bandwidth and data rate. As the network size increases trade off must be done between Amplifier gain and distance.

5. SCHEDULE, TASKS AND MILESTONES

Schedule of the given project timeline

Sl.no	**Month**	**Task completed**
1	December	First Review
2	January	25% of project implementation
3	February	50% of project implementation
4	March	90% of project implementation
5	April	Poster presentation and viva-voce

Table No 5.1 Schedule Of the Given Project Timeline

5.1 MILESTONES

I started this project in December, I have gone through the reference paper and tried to execute basic circuit that comprises of four channels at OLT, during my first execution struck with the connection problem and some parameters in each block. I tried changing each parameter in transmitter block then I got some values to get proper results I worked by changing the parameters by some proper methods, after getting proper values of BER and Q-factor, increases the number of channels to sixteen. When executed for the first time some BER values has end up with zero results I tried many ways to get this problem out by changing the power and extinction ratio, In the end the results are observed and tabulated.

6. PROJECT DEMONSTRATION FOR PIN RECEIVER

In our analysis we find Bit Error Rate(BER) and Q-Factor for different modulation formats such as RZ, NRZ, NRZ-DPSK, RZ-DPSK, Duobinary(DB) in Opti System15 software.

6.1 SPECIFICATION TABLE

Data Rate	1Gbps-10Gbps
Power	3dBm-25dBm
Fibre length	10Km-70Km

Extinction ratio	30dB-40dB
Attenuation coefficient	0.2dB/Km
Central frequency(f)	193.1GHz
Channel spacing(f0)	100THz
Receiver responsivity	0.7A/W-1A/W

Table.6.1 Specification Table

6.2 RETURN TO ZERO(RZ)

In RZ format we compare Distance vs BER, Data Rate vs BER, Distance vs Q-Factor and Data Rate vs Q-Factor by using Pin Photo Diode receiver.

6.2.1 DATA RATE VS BER USING PIN RECEIVER

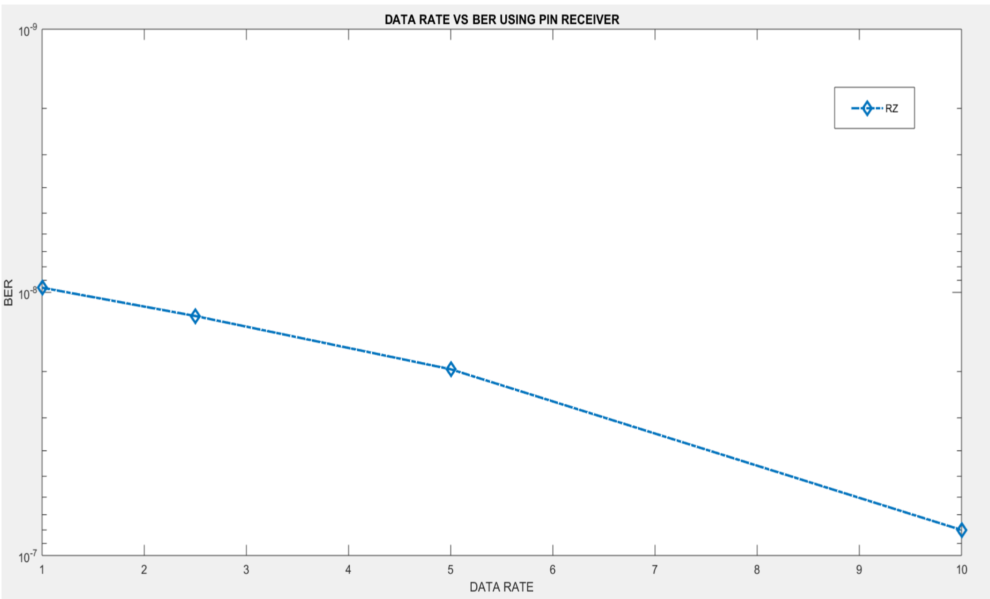

Fig.6.2.1 DATA RATE VS BER PIN RECEIVER

In the above Fig.6.2.1 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.2.2 DISTANCE VS BER USING PIN RECEIVER

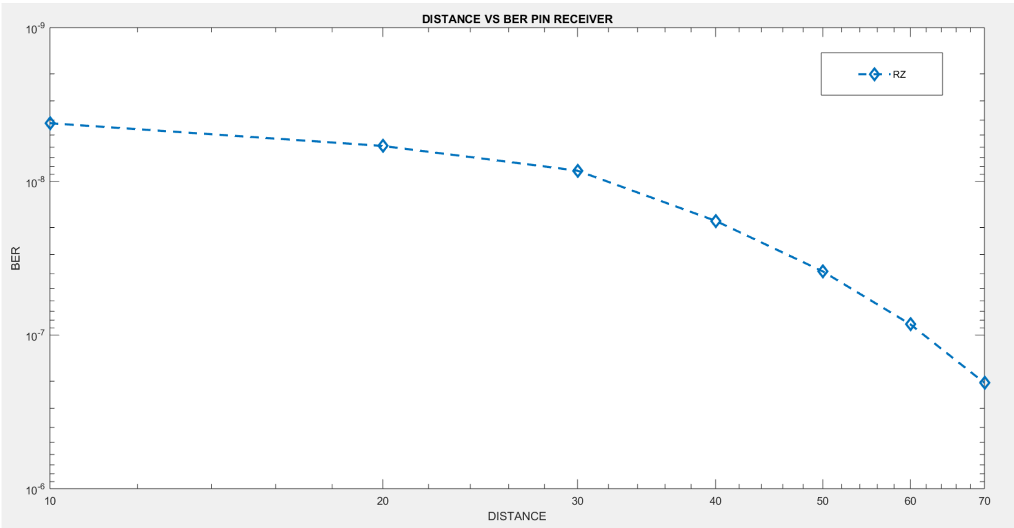

Fig.6.2.2 DISTANCE VS BER PIN RECEIVER

In the above Fig.6.2.2 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.2.3 DISTANCE VS Q-FACTOR USING PIN RECEIVER

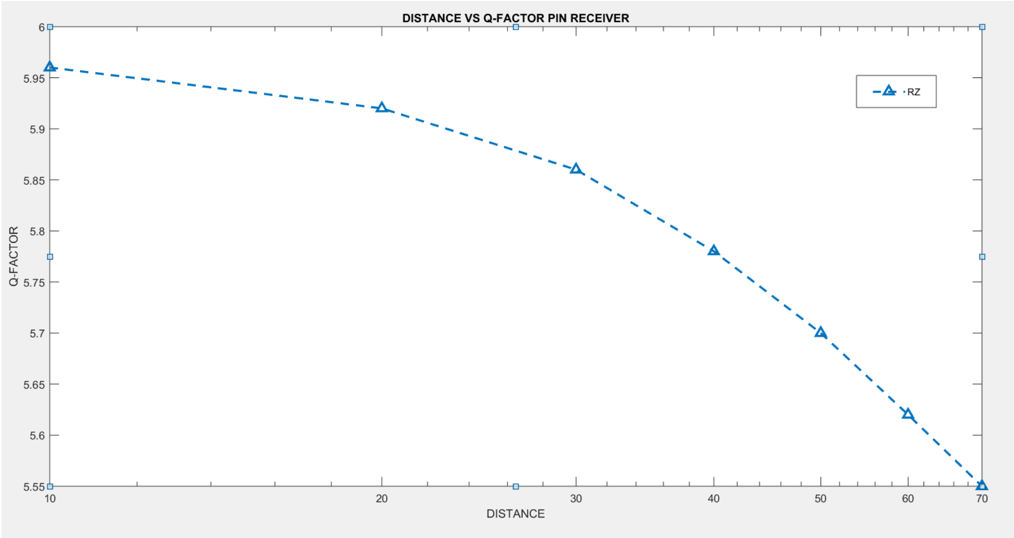

Fig.6.2.3 DISTANCE VS Q-FACTOR PIN

In the above Fig.6.2.3 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.2.4 DATA RATE VS Q-FACTOR USING PIN RECEIVER

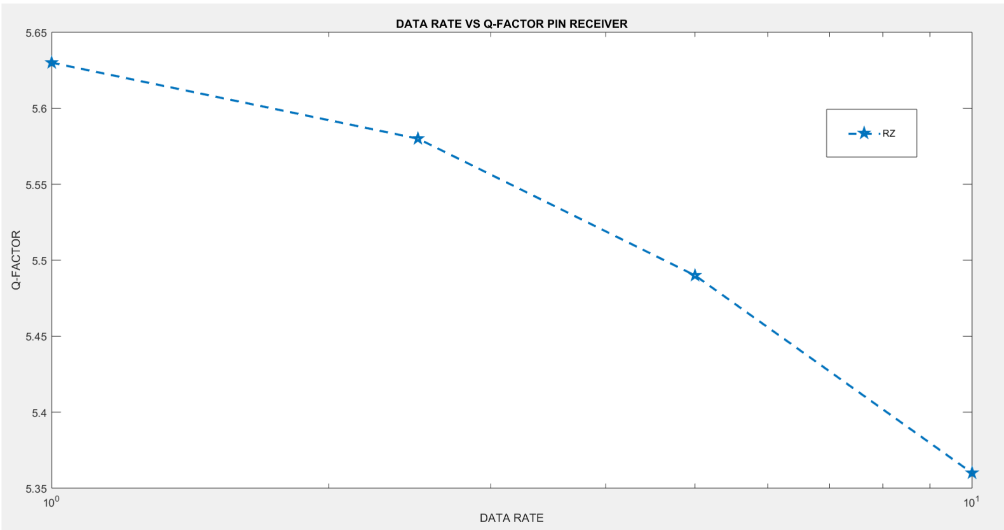

Fig.6.2.4 DATA RATE VS Q-FACTOR PIN

In the above Fig.6.2.4 Data Rate vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for Data Rates 1,2.5,5,10 Gbps Respectively.

6.3 NON-RETURN TO ZERO

6.3.1 DATA RATE VS BER USING PIN RECEIVER

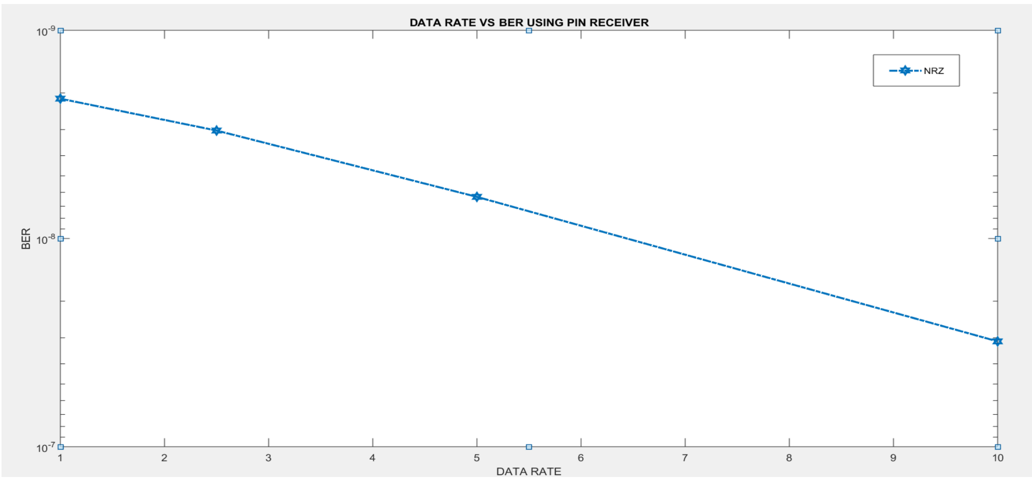

Fig.6.3.1 Data Rate vs BER pin

In the above Fig.6.3.1 Data rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.3.2 DISTANCE VS BER USING PIN RECEIVER

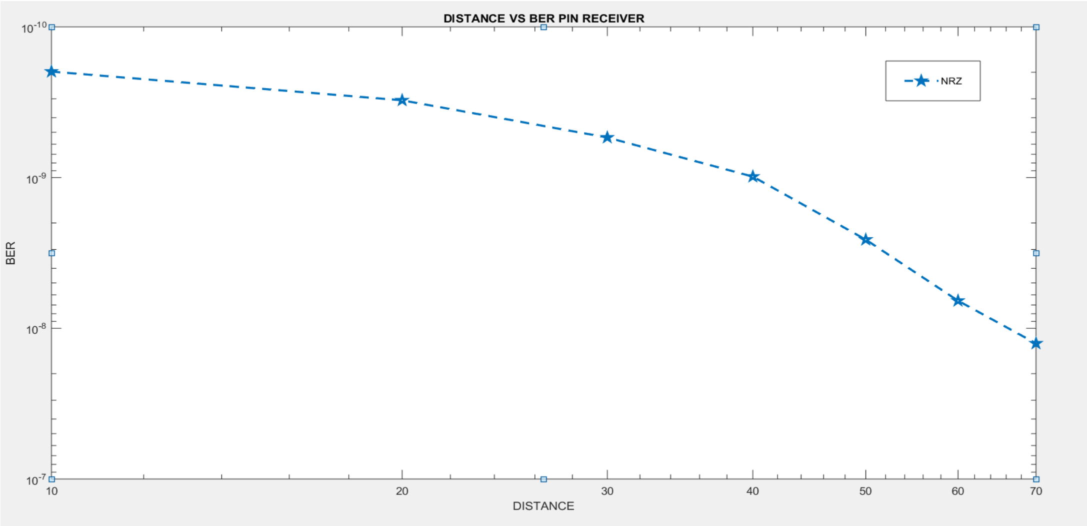

Fig.6.3.2 Distance vs BER Pin

In the above Fig.6.3.2 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.3.3 DISTANCE VS Q-FACTOR PIN RECEIVER

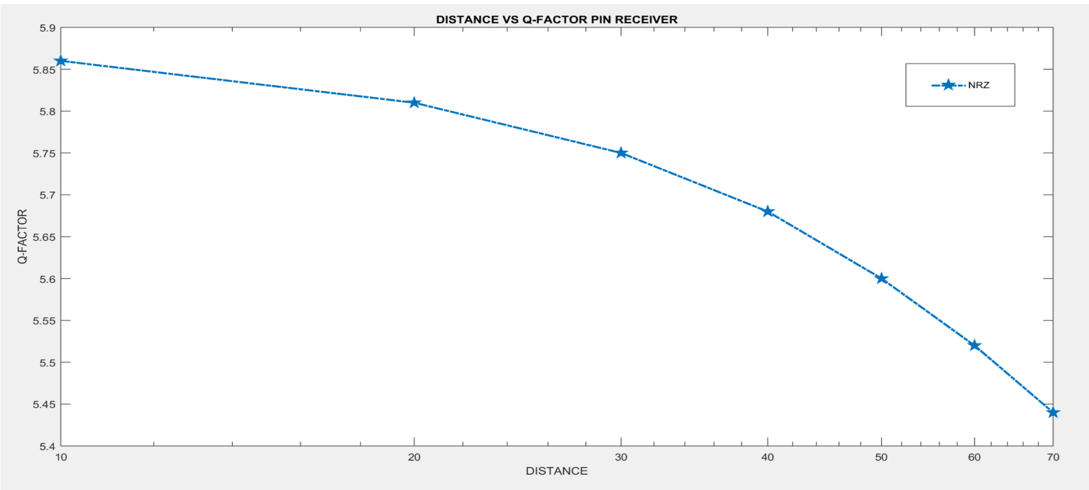

Fig.6.3.3 Distance vs Q-Factor Pin

In the above Fig.6.3.3 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.3.4 DATA RATE VS Q-FACTOR USING PIN RECEIVER

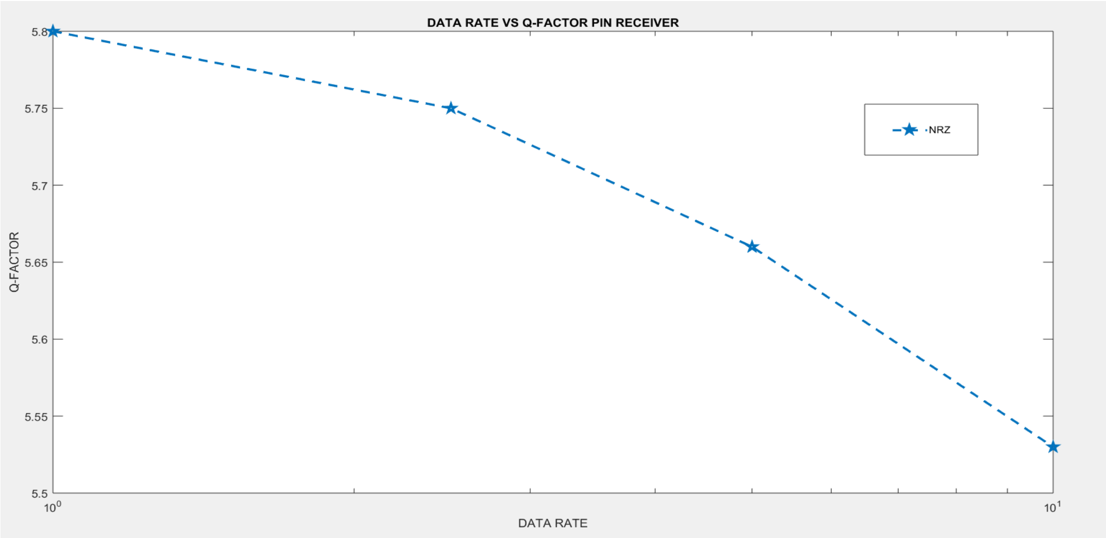

Fig.6.3.4 Data Rate vs Q-Factor Pin

In the above Fig.6.3.4 Data Rate vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for Data Rates 1,2.5,5,10 Gbps Respectively.

6.4 RZ-DPSK

6.4.1 DISTANCE VS BER USING PIN RECEIVER

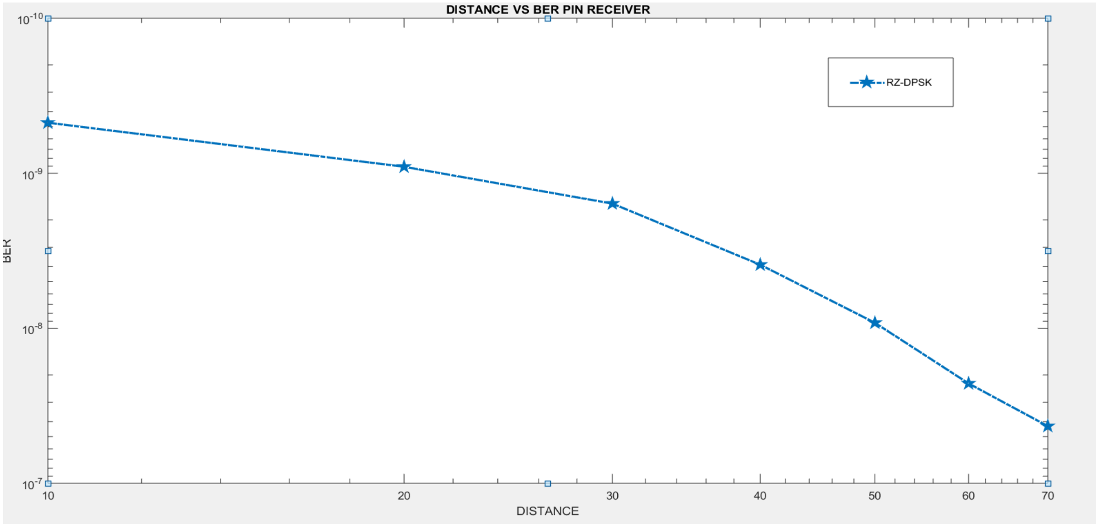

Fig.6.4.1 Distance vs BER PIN

In the above Fig.6.4.1 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.4.2 DATA RATE VS BER USING PIN RECEIVER

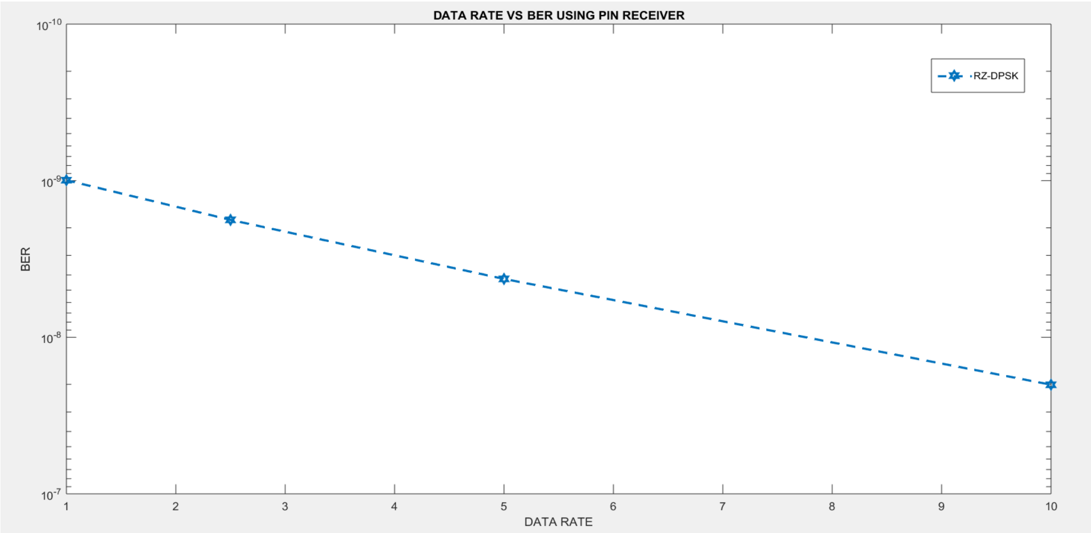

Fig.6.4.2 Data Rate vs BER Pin

In the above Fig.6.4.2 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.4.3 DISTANCE VS Q-FACTOR USING PIN RECEIVER

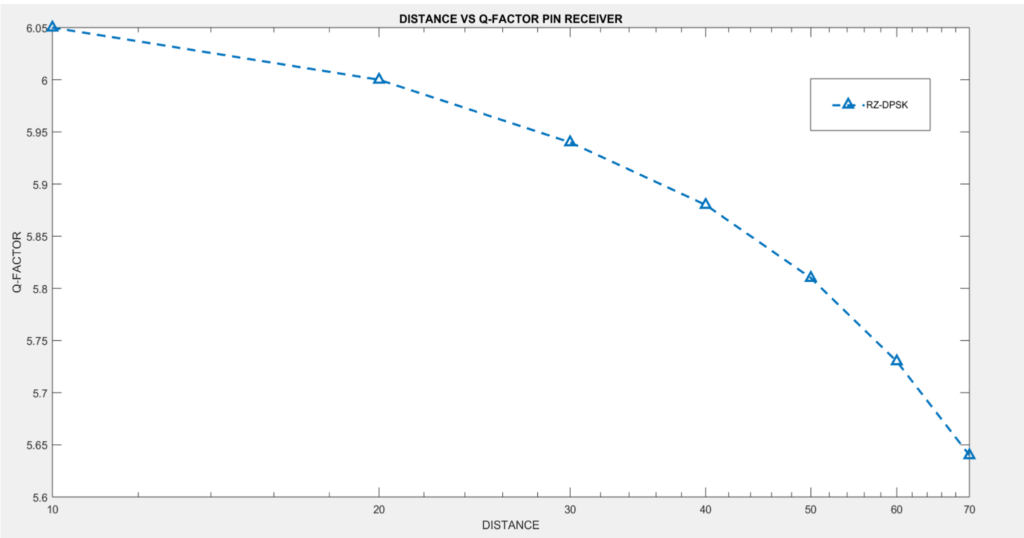

Fig.6.4.3 Distance vs Q-Factor PIN

In the above Fig.6.4.3 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.4.4 DATA RATE VS Q-FACTOR USING PIN RECEIVER

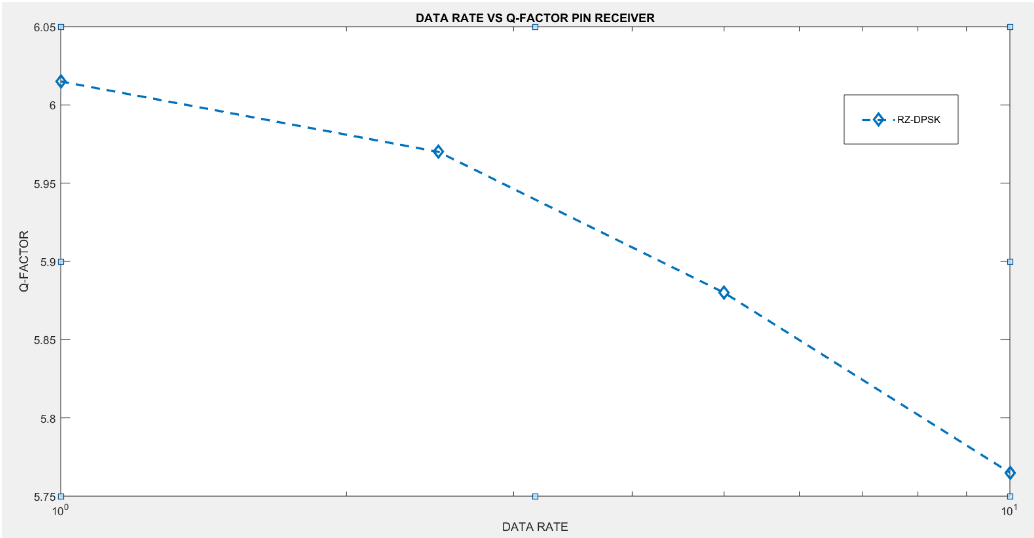

Fig.6.4.4 Data Rate VS Q-factor PIN

In the above Fig.6.4.4 Data Rate vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for Data Rates 1,2.5,5,10 Gbps Respectively.

6.5 NRZ-DPSK

6.5.1 DISTANCE VS BER USING PIN RECEIVER

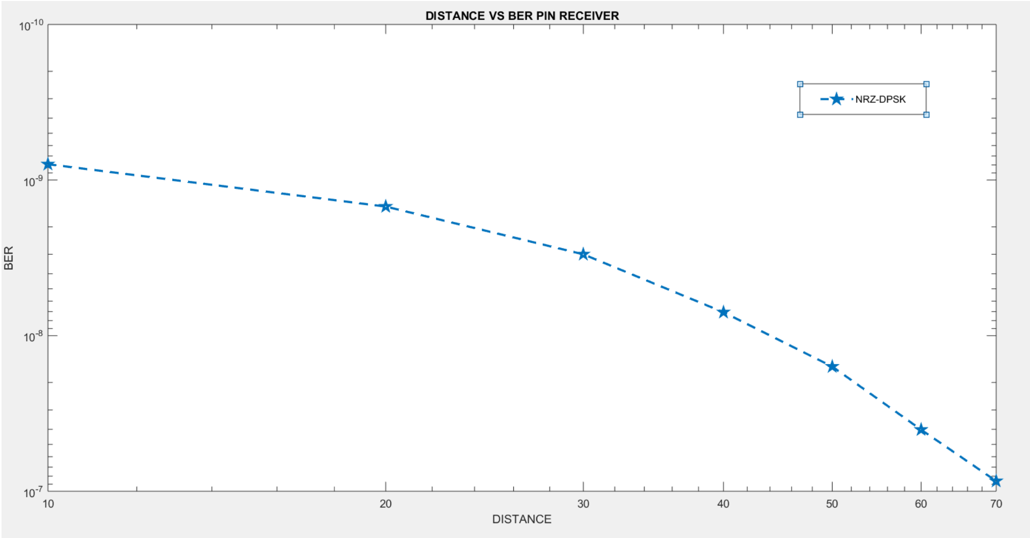

Fig.6.5.1 Distance vs BER PIN

In the above Fig.6.5.1 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.5.2 DATA RATE VS BER USING PIN RECEIVER

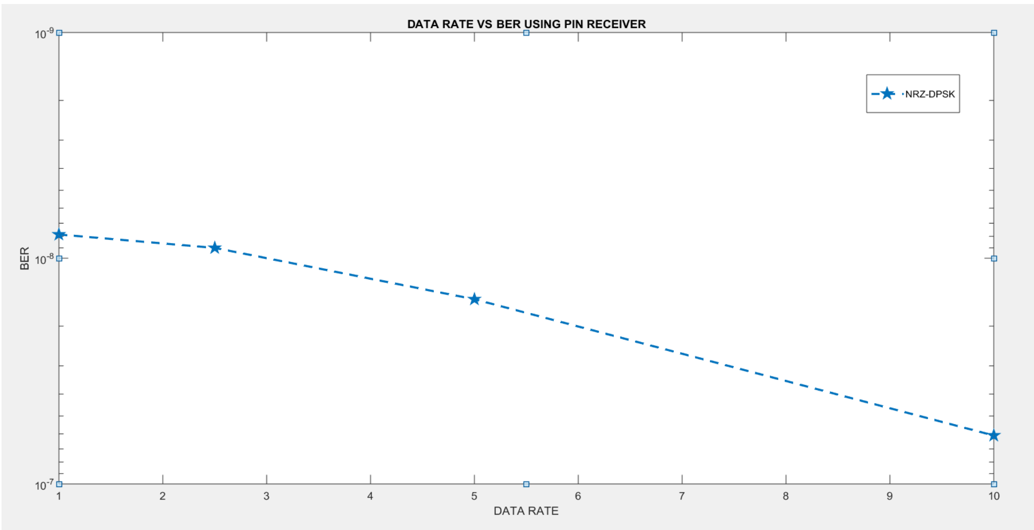

Fig.6.5.2 Data Rate vs BER PIN

In the above Fig.6.5.2 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.5.3 DISTANCE VS Q-FACTOR USING PIN RECEIVER

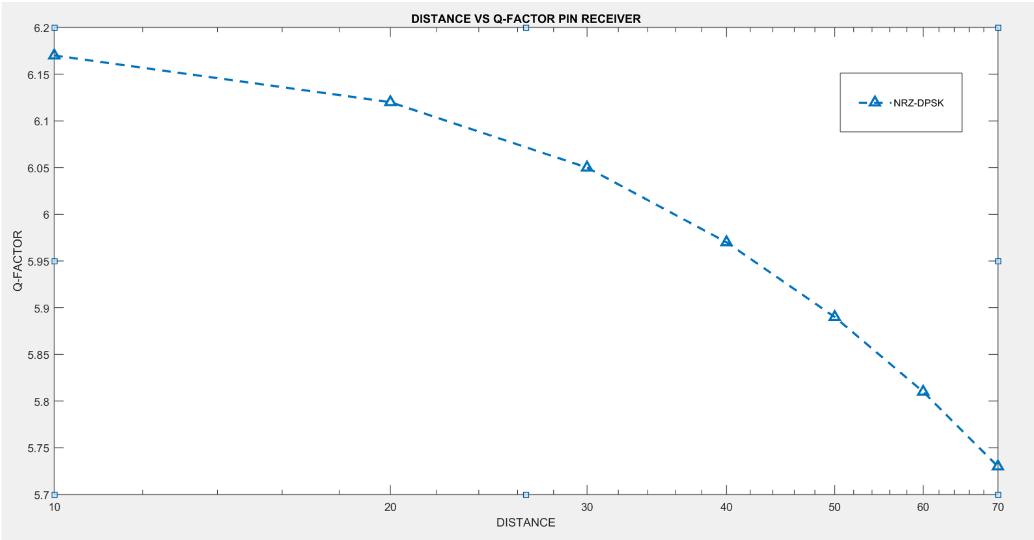

Fig.6.5.3 Distance vs Q-Factor PIN

In the above Fig.6.5.3 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.5.4 DATA RATE VS Q-FACTOR USING PIN

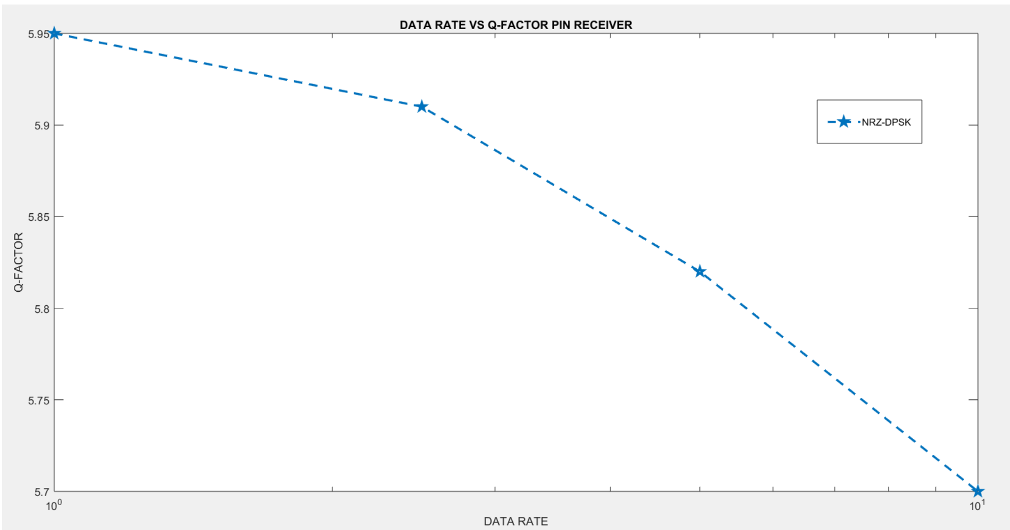

Fig.6.5.4 Data Rate Vs Q-factor PIN

In the above Fig.6.5.4 Data Rate vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for Data Rates 1,2.5,5,10 Gbps Respectively.

6.6 DUO BINARY

6.6.1 DISTANCE VS BER USING PIN RECEIVER

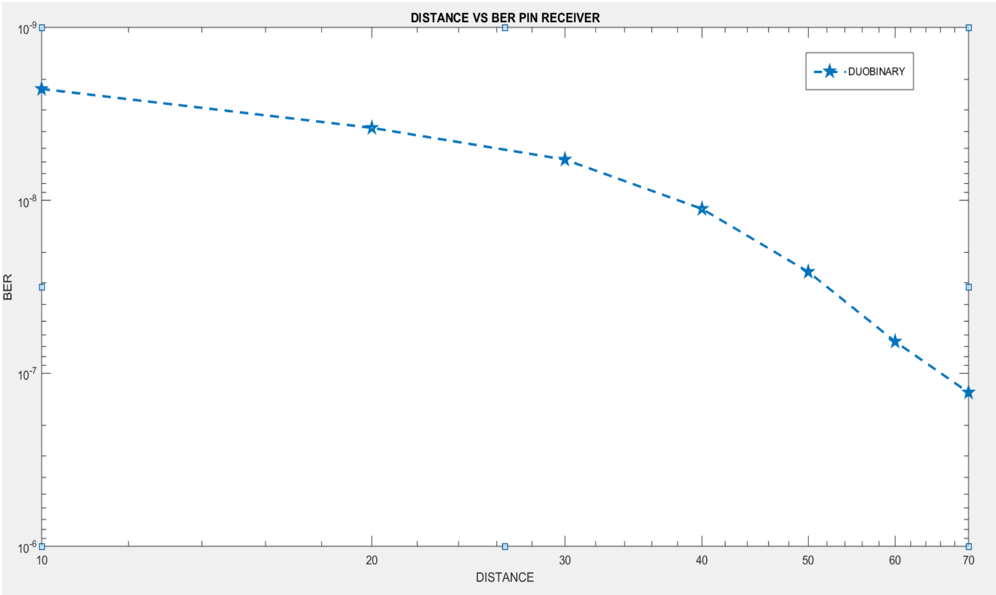

Fig.6.6.1 Distance vs BER PIN

In the above Fig.6.6.1 Data rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.6.2 DATA RATE VS BER USING PIN RECEIVER

In the Fig.6.6.2 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively

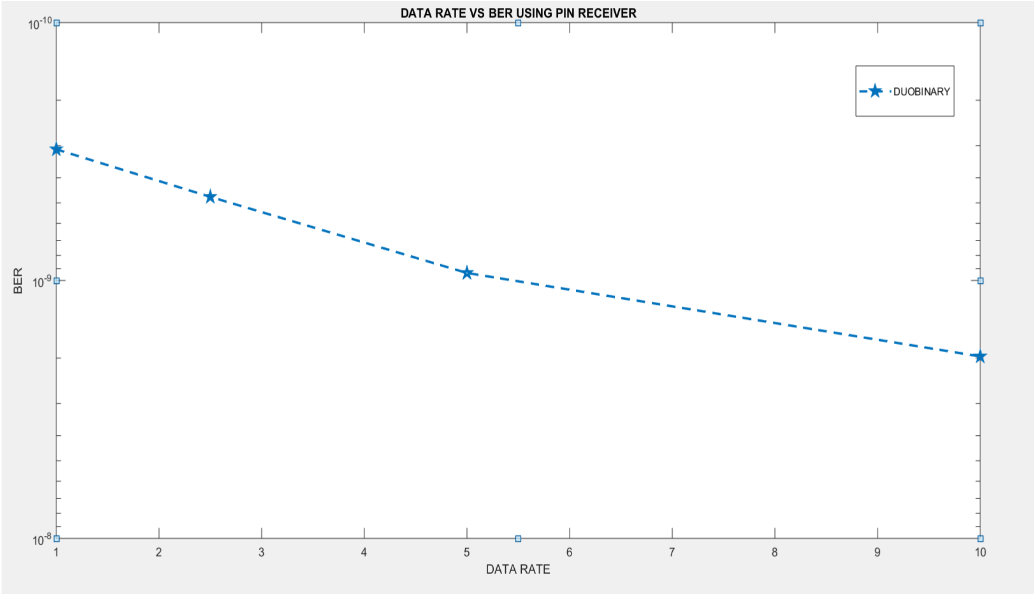

Fig.6.6.2 Data Rate vs BER PIN

6.6.3 DISTANCE VS Q-FACTOR USING PIN RECEIVER

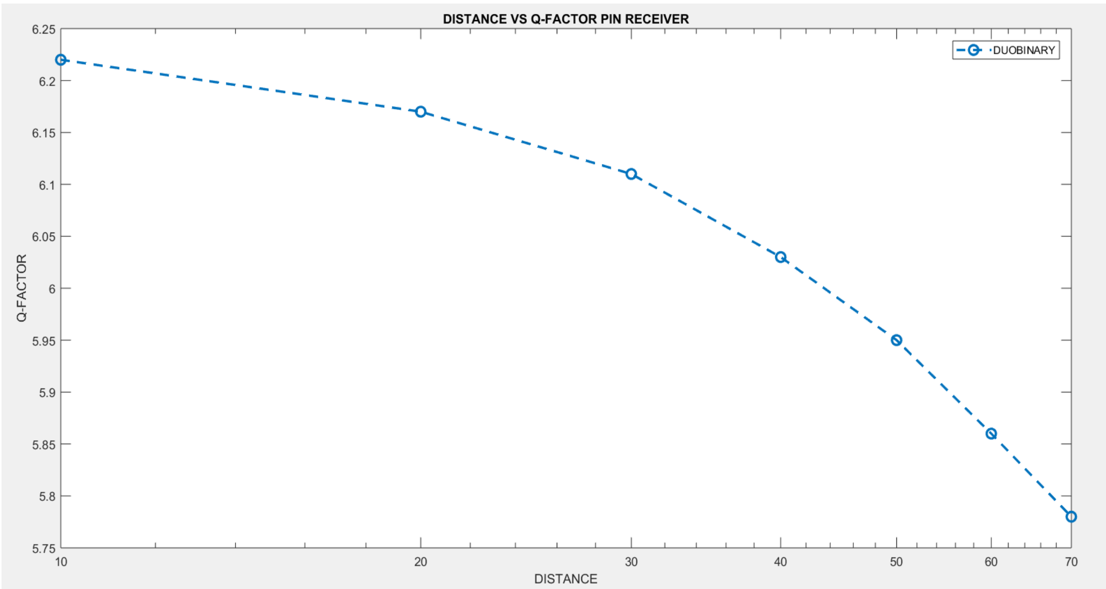

Fig.6.6.3 Distance vs Q-Factor PIN

In the above Fig.6.6.3 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.6.4 DATA RATE VS Q-FACTOR USING PIN RECEIVER

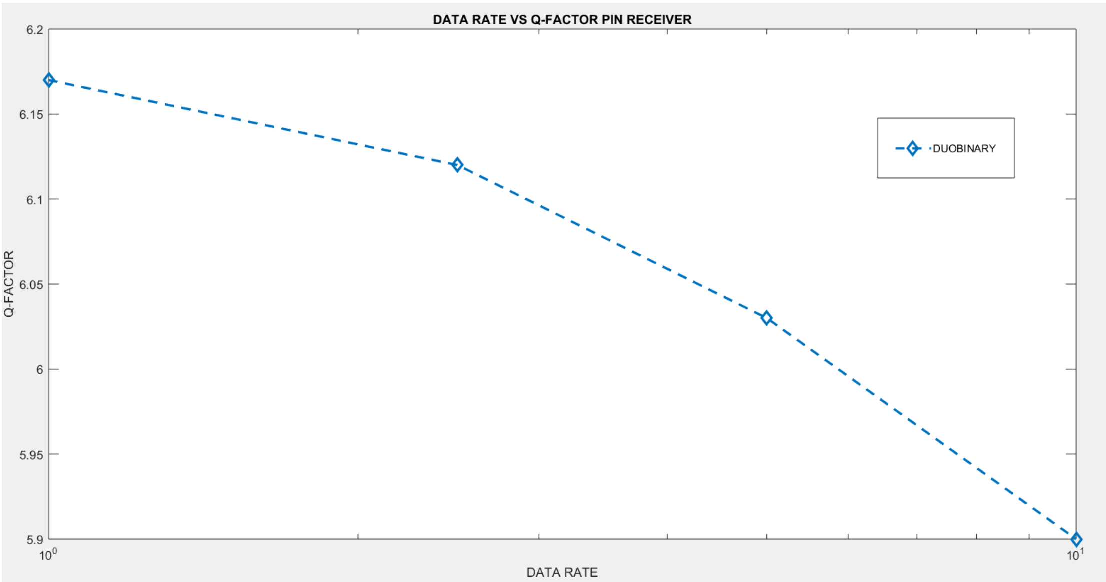

Fig.6.6.4 Data Rate Vs Q-factor Using PIN Receiver

In the above Fig.6.6.4 Data Rate vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for Data Rates 1,2.5,5,10 Gbps Respectively.

6.7 CSRZ

6.7.1 DISTANCE VS BER USING PIN RECEIVER

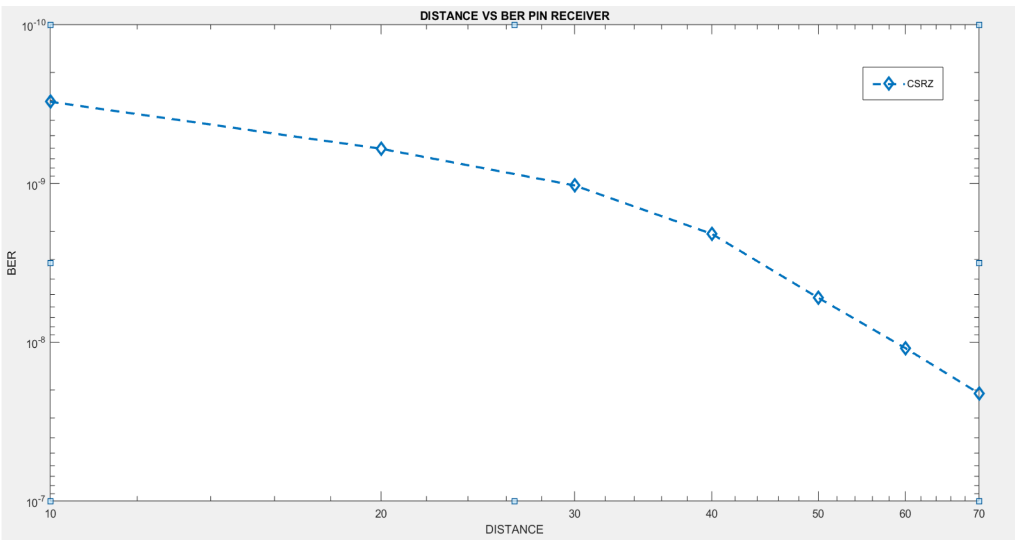

Fig.6.7.1 Distance vs BER PIN

In the above Fig.6.7.1 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.7.2 DATA RATE VS BER USING PIN RECEIVER

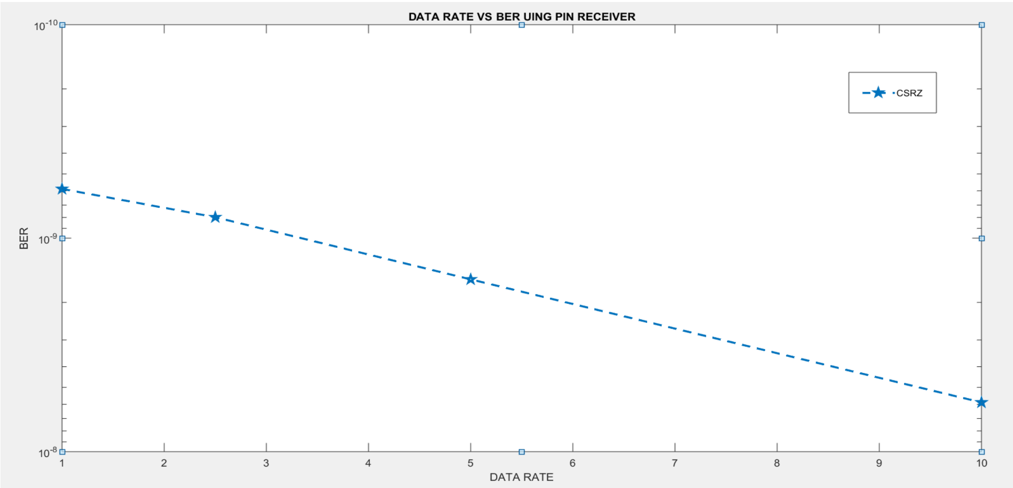

Fig.6.7.2 Data Rate vs BER PIN

In the above Fig.6.7.2 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.7.3 DATA RATE VS Q-FACTOR USING PIN RECEIVER

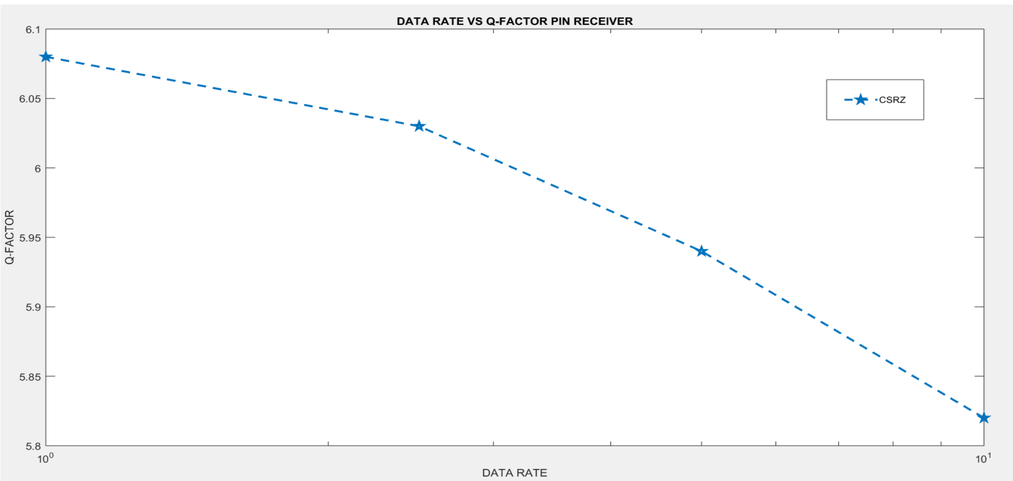

Fig.6.7.3 Data Rate vs Q-Factor PIN

In the above Fig.6.7.3 Data Rate vs Q-FACTOR Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.7.4 DISTANCE VS Q-FACTOR USING PIN RECEIVER

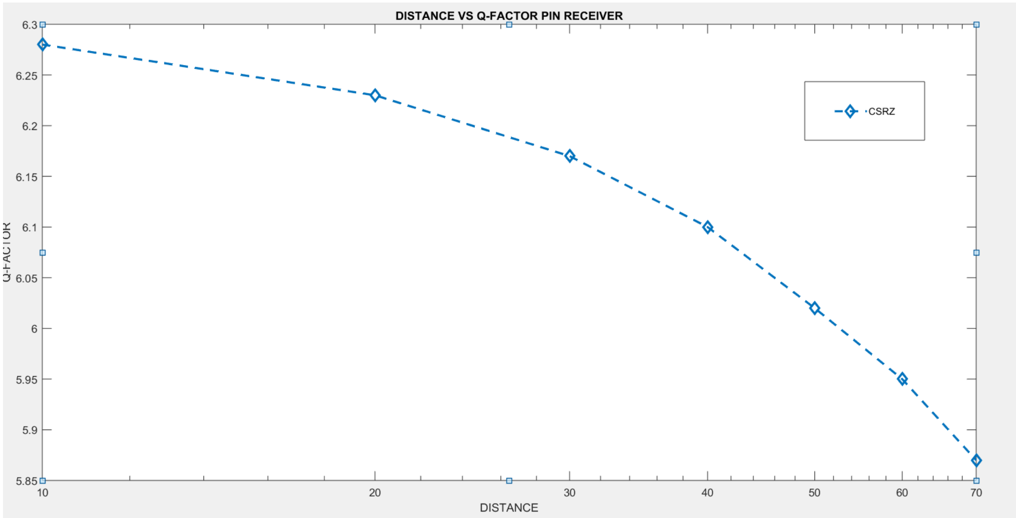

Fig.6.7.4 Distance vs Q-Factor PIN

In the above Fig.6.7.4 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.8 RETURN TO ZERO(RZ)

6.8.1 DATA RATE VS BER USING PIN RECEIVER

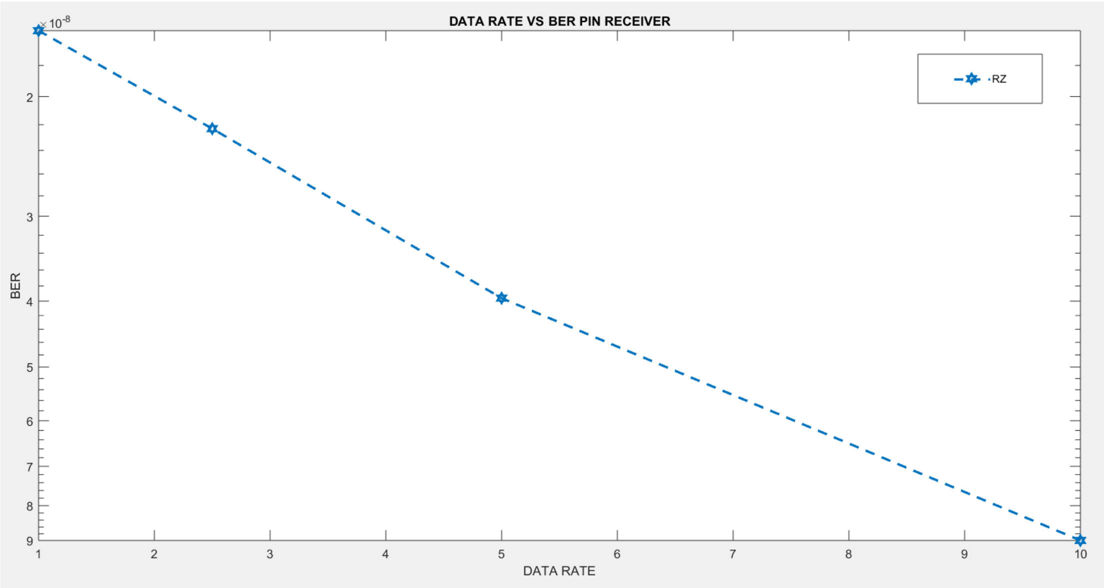

Fig.6.8.1 Data Rate vs BER PIN

In the above Fig.6.8.1 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.8.2 DATA RATE VS Q-FACTOR USING PIN RECEIVER

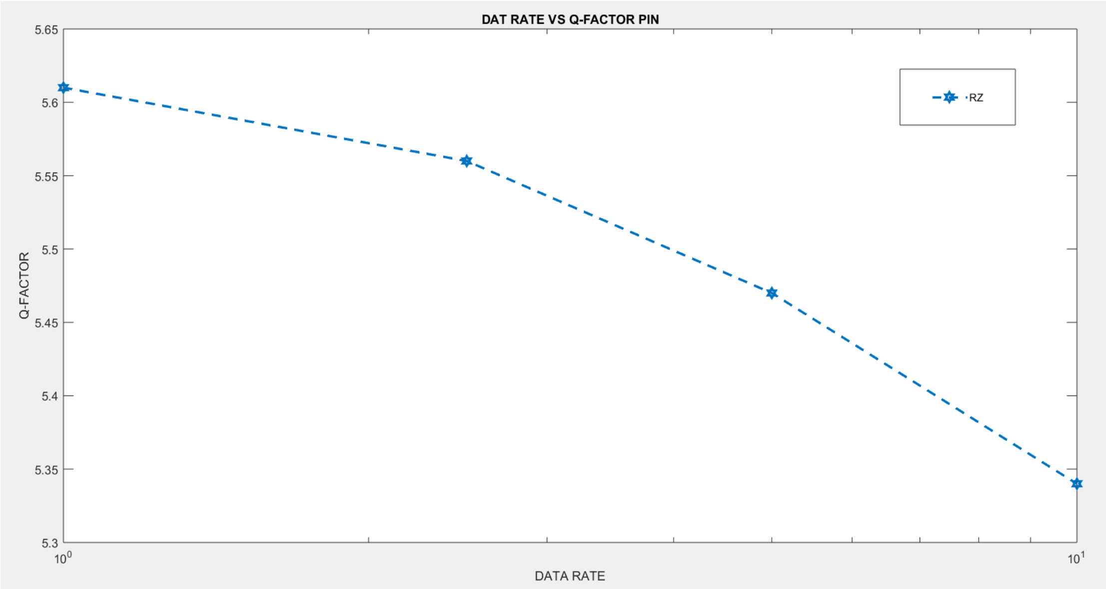

Fig.6.8.2 Data Rate vs Q-Factor PIN

In the above Fig.6.8.2 Data Rate vs Q-Factor Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.8.3 DISTANCE VS BER USING PIN RECEIVER

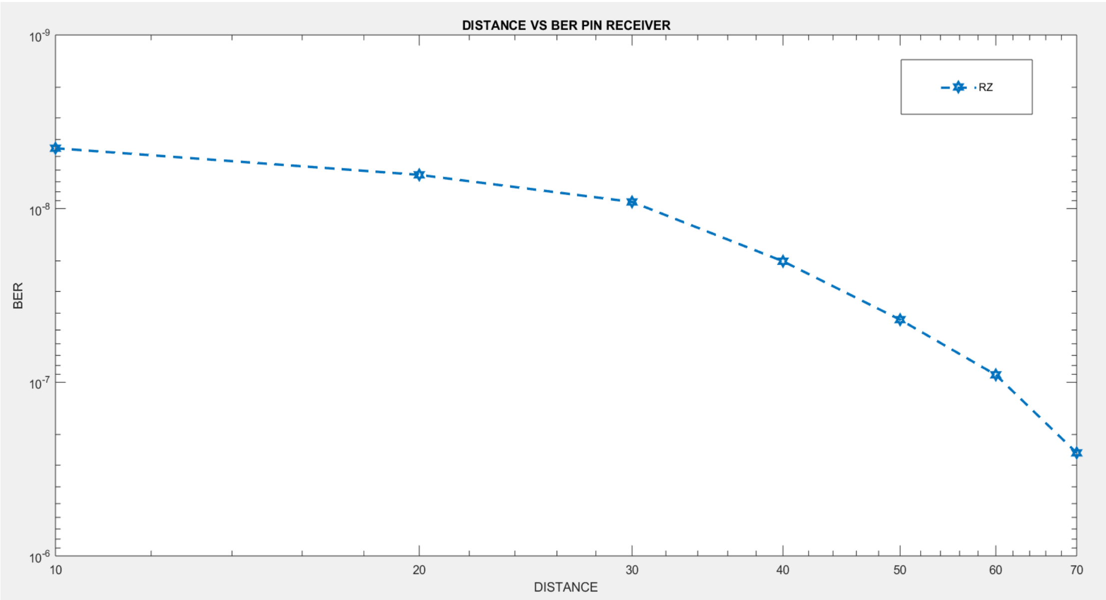

Fig.6.8.3 Distance Vs BER Using PIN Receiver

In the above Fig.6.8.3 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.8.4 DISTANCE VS Q-FACTOR USING PIN RECEIVER

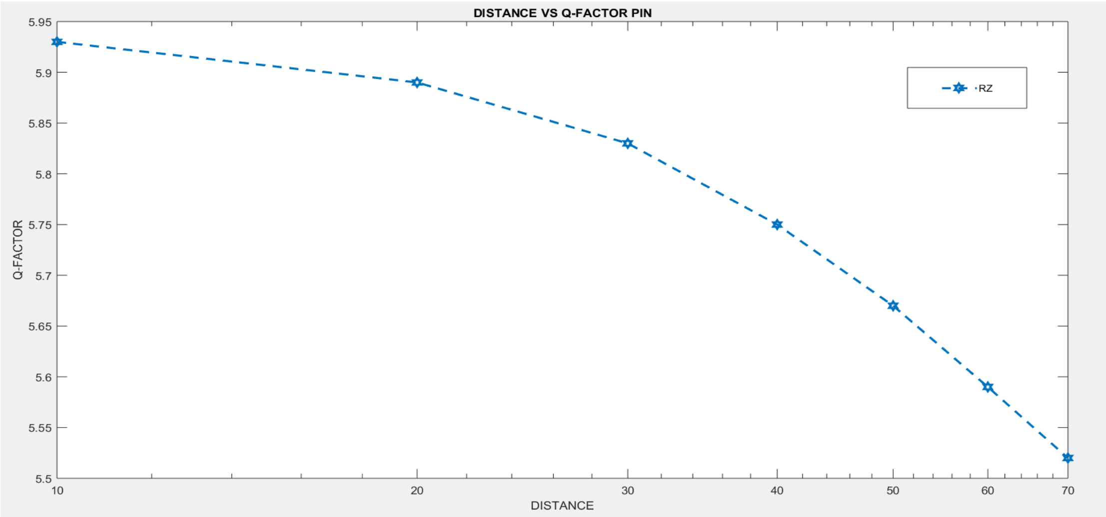

Fig.6.8.4 Distance vs Q-Factor PIN

In the above Fig.6.8.4 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.9 NON RETUEN TO ZERO(NRZ)

6.9.1 DISTANCE VS Q-FACTOR PIN

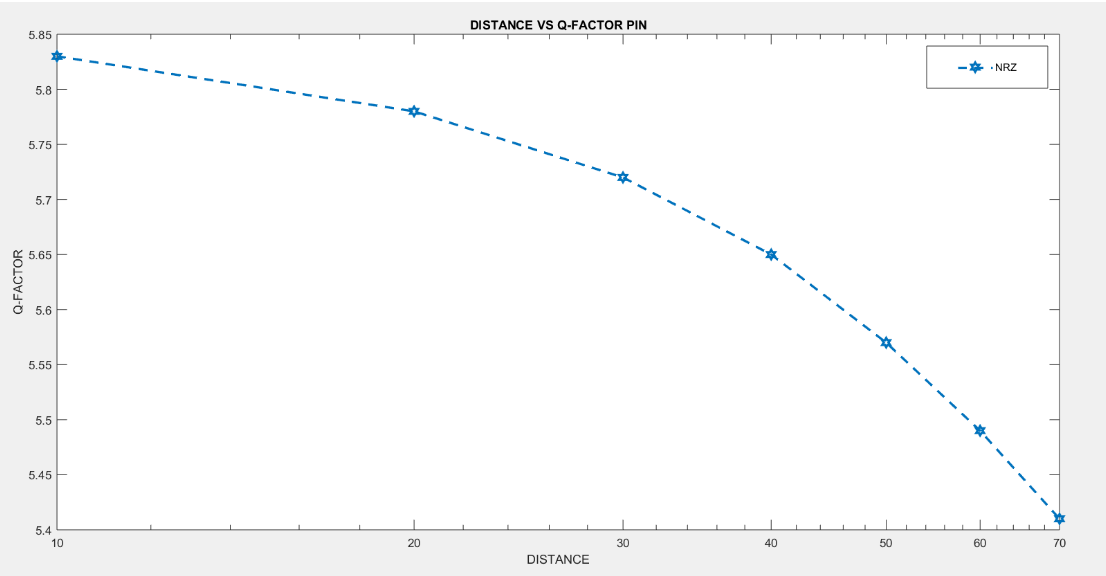

Fig.6.9.1 Distance vs Q-Factor PIN

In the above Fig.6.9.1 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.9.2 DATA RATE VS Q-FACTOR USING PIN RECEIVER

In the Fig.6.9.2 Data Rate vs Q-Factor Using PIN receiver Graph has been Plotted and Q-Factor values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

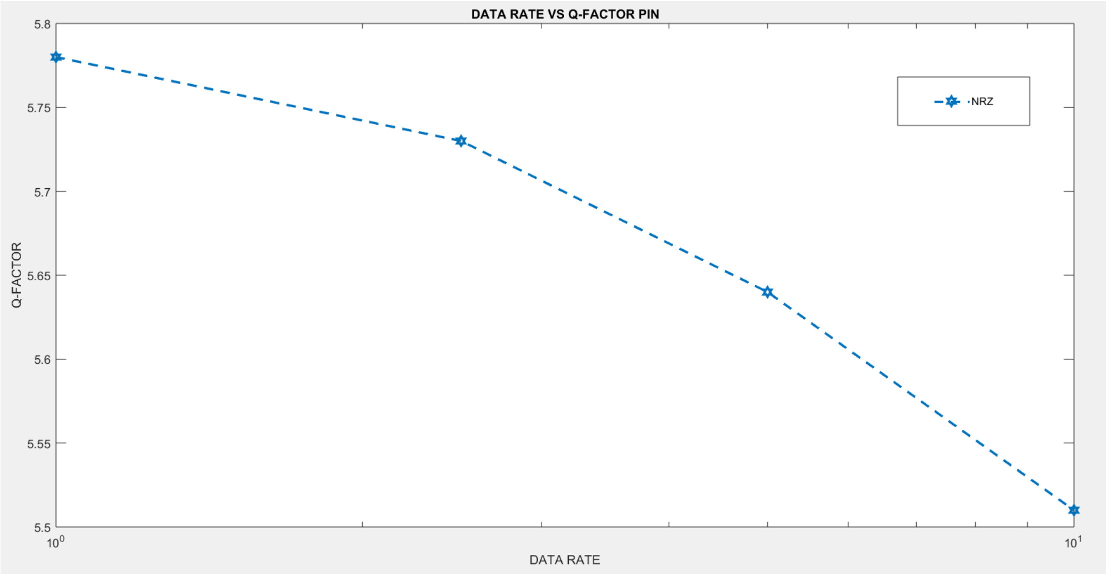

Fig.6.9.2 Data Rate vs Q-Factor PIN

6.9.3 DATA RATE VS BER USING PIN RECEIVER

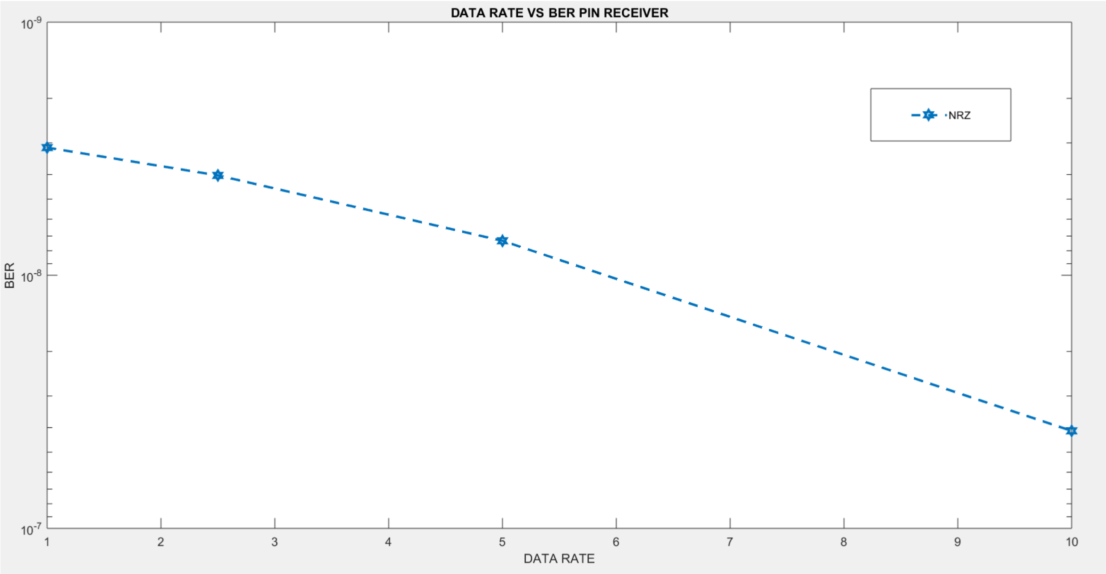

Fig.6.9.3 Data Rate vs BER PIN

In the above Fig.6.9.3 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.9.4 DISTANCE VS BER USING PIN RECEIVER(NRZ)

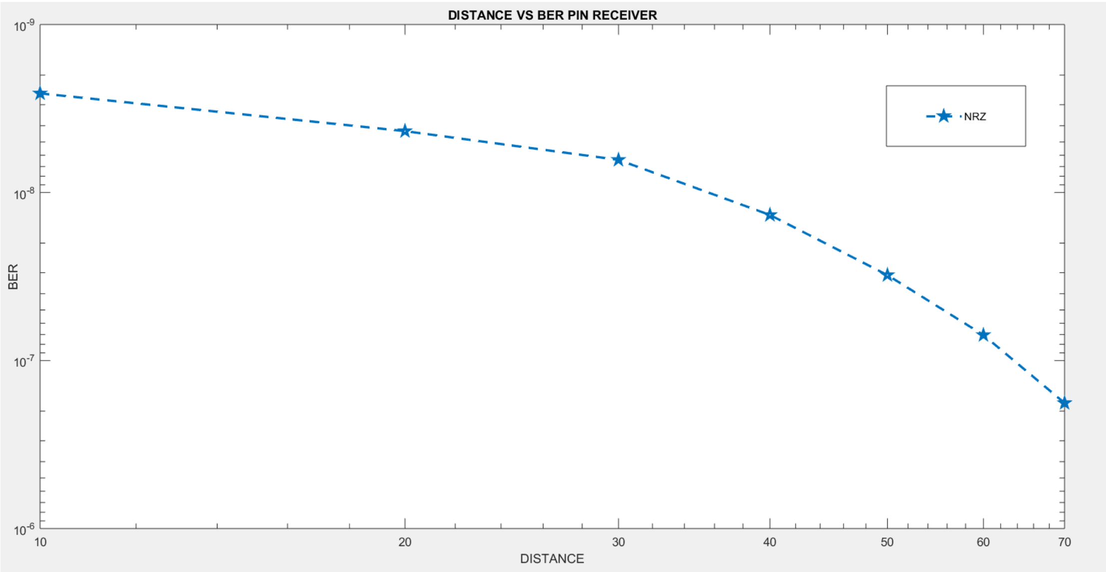

Fig.6.9.4 Distance vs BER PIN

In the above Fig.6.9.4 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.10 RZ-DPSK

6.10.1 DATA RATE VS BER USING PIN RECEIVER(RZ-DPSK)

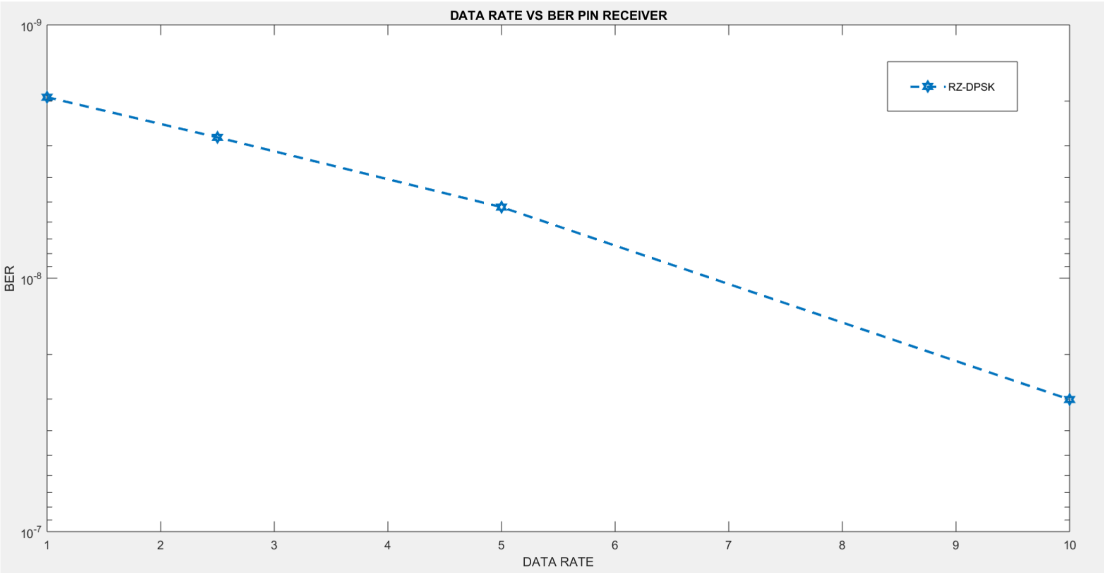

Fig.6.10.1 Data Rate vs BER PIN

In the above Fig.6.10.1 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.10.2 DATA RATE VS Q-FACTOR USING PIN RECEIVER

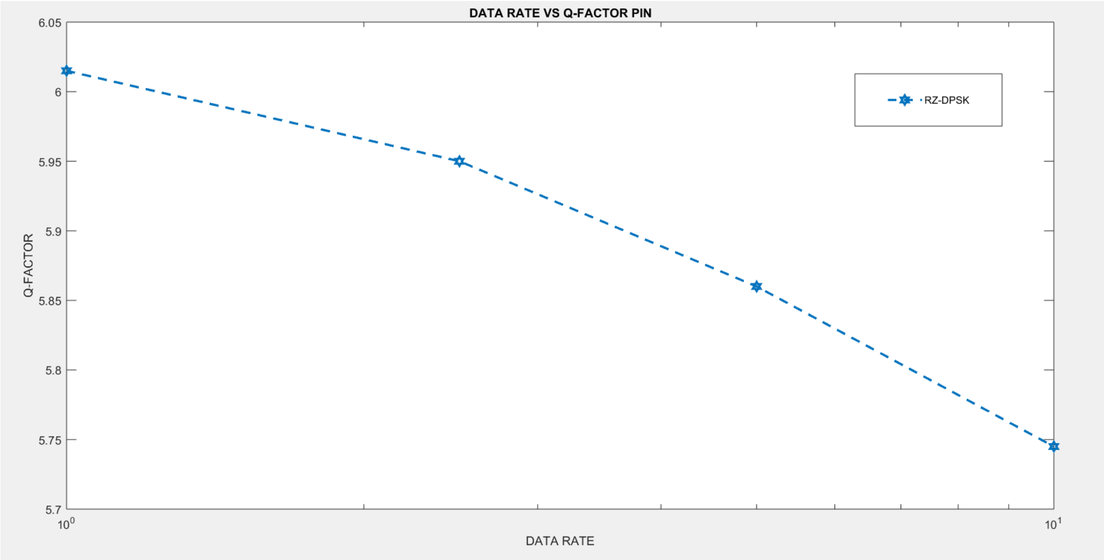

Fig.6.10.2 Data Rate vs Q-Factor PIN

In the above Fig.6.10.2 Data Rate vs Q-Factor Using PIN receiver Graph has been Plotted and Q-Factor values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.10.3 DISTANCE VS BER USING PIN RECEIVER

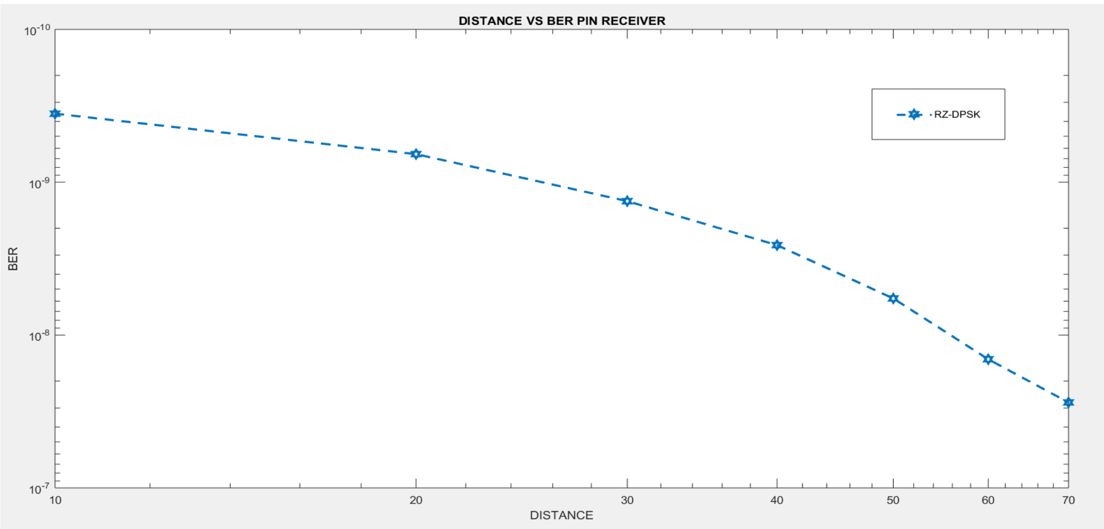

Fig.6.10.3 Distance vs BER PIN

In the above Fig.6.10.3 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.10.4 DISTANCE VS Q-FACTOR USING PIN RECEIVER

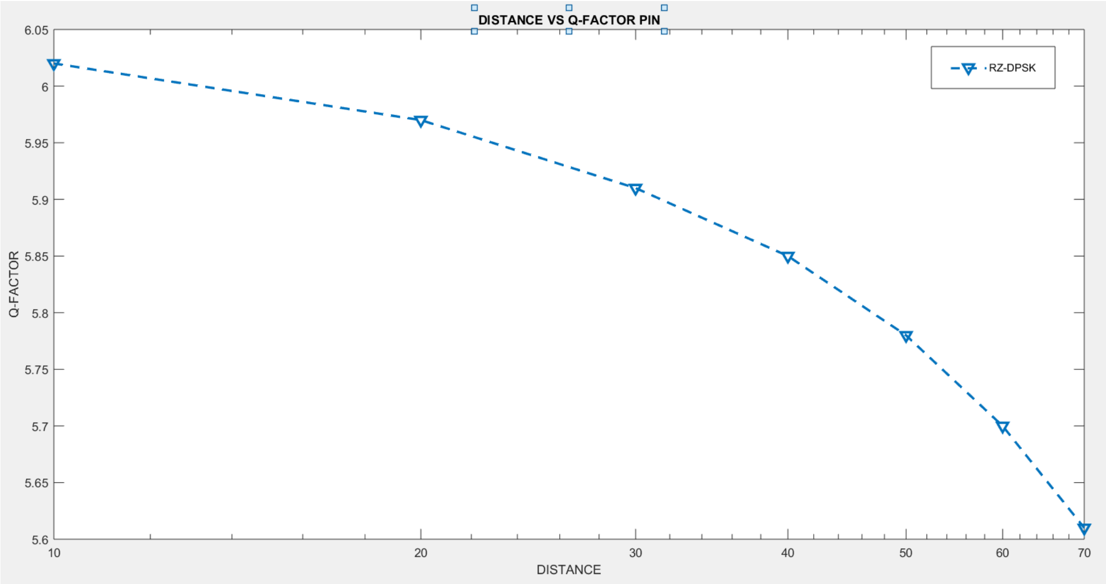

Fig.6.10.4 Distance vs Q-Factor PIN

In the above Fig.6.10.4 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.11 NRZ-DPSK

6.11.1 DATA RATE VS BER USING PIN RECEIVER(NRZ-DPSK)

In the Fig.6.11.1 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

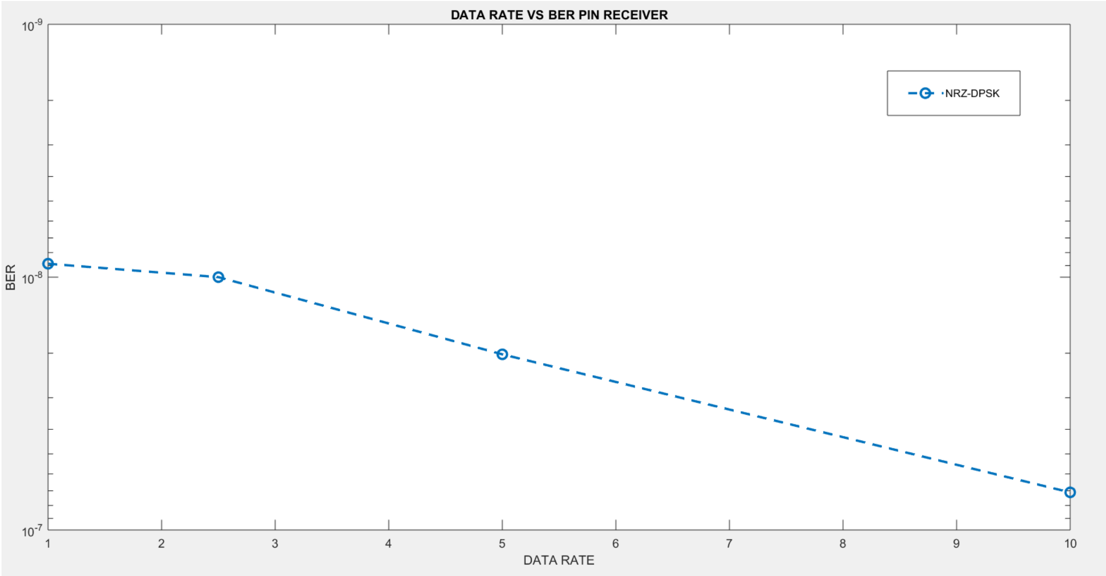

Fig.6.11.1 Data Rate vs BER PIN

6.11.2 DATA RATE VS Q-FACTOR USING PIN RECEIVER

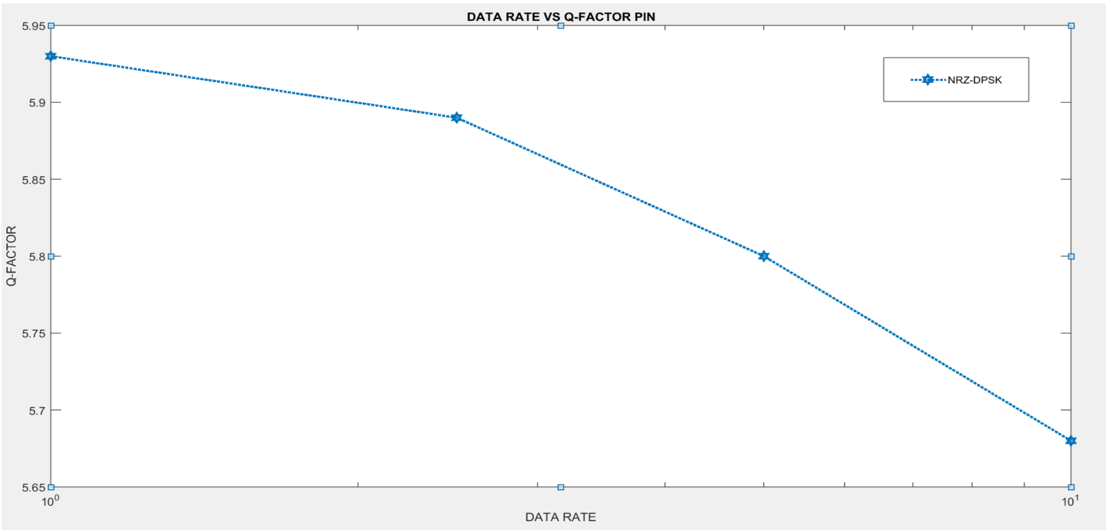

Fig.6.11.2 Data Rate vs Q-Factor PIN

In the above Fig.6.11.2 Data Rate vs Q-Factor Using PIN receiver Graph has been Plotted and Q-Factor values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.11.3 DISTANCE VS BER USING PIN RECEIVER

In the Fig.6.11.3 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

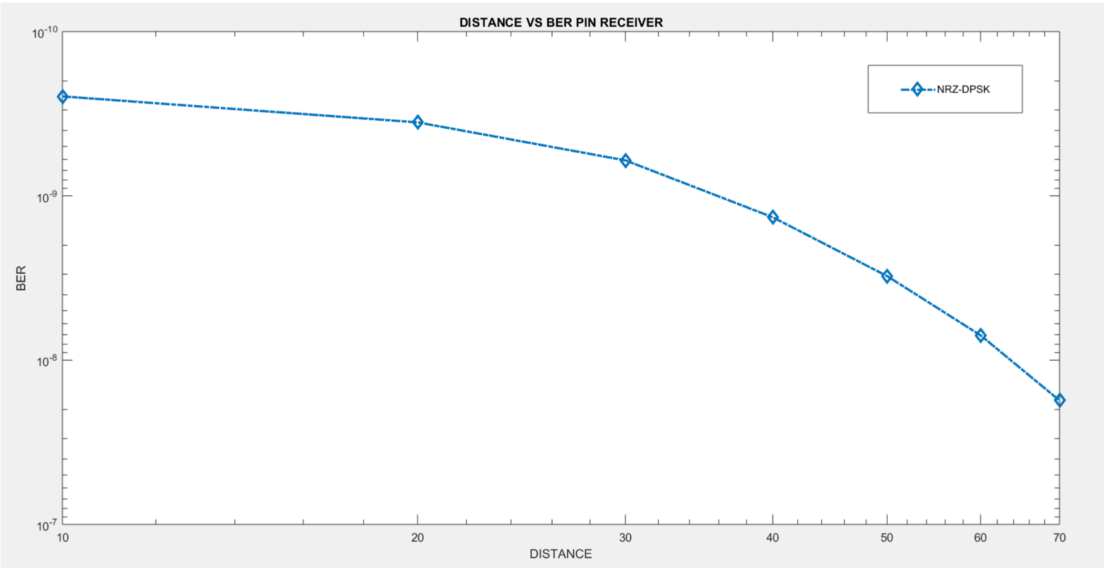

Fig.6.11.3 Distance vs BER PIN

6.11.4 DISTANCE VS Q-FACTOR USING PIN RECEIVER

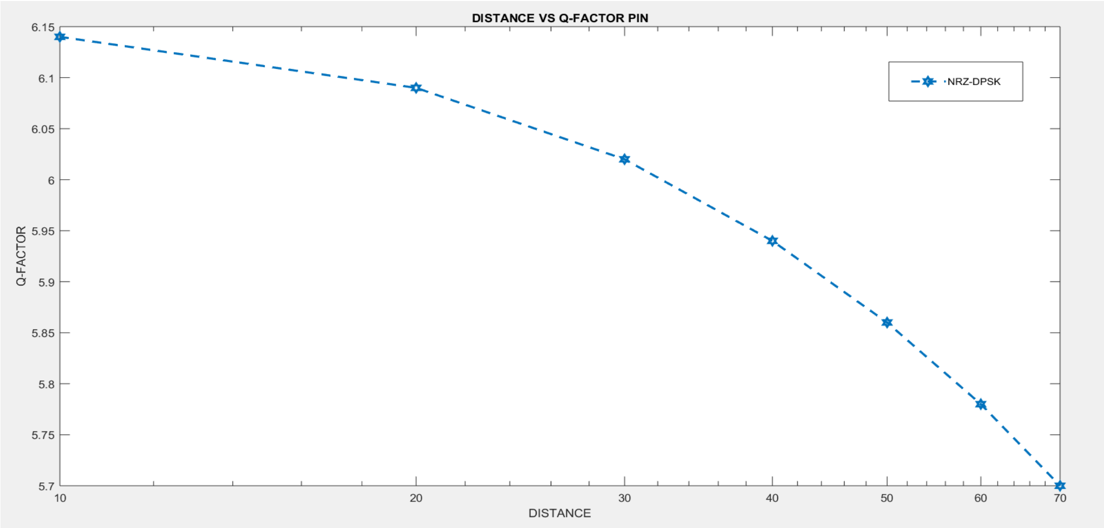

Fig.6.11.4 Distance vs Q-Factor PIN

In the above Fig.6.11.4 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.12 DUOBINARY

6.12.1 DATA RATE VS BER USING PIN RECEIVER

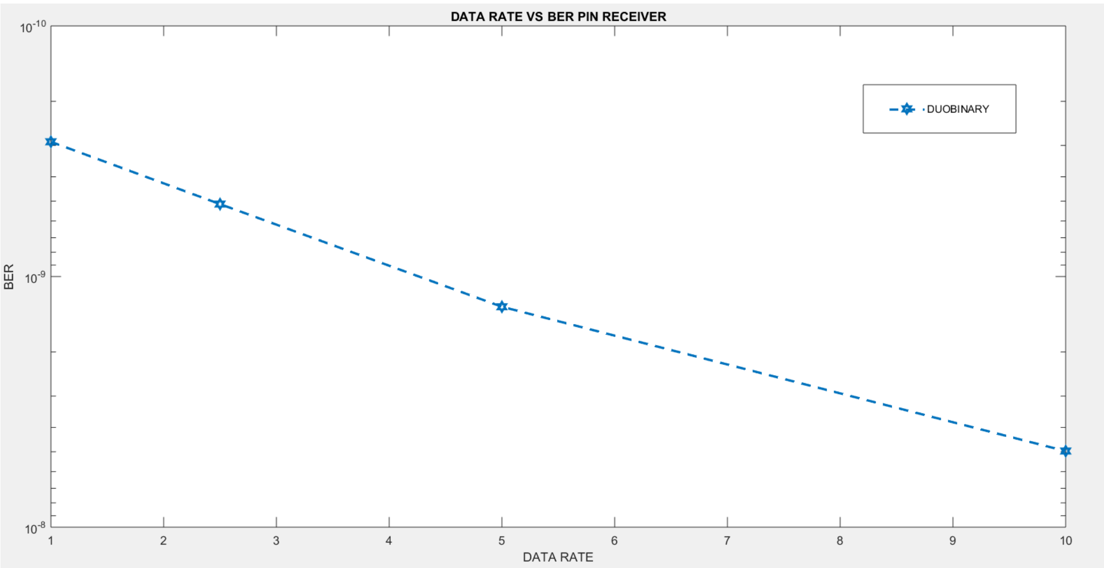

Fig.6.12.1 Data Rate vs BER PIN

In the above Fig.6.12.1 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.12.2 DATA RATE VS Q-FACTOR USING PIN RECEIVER

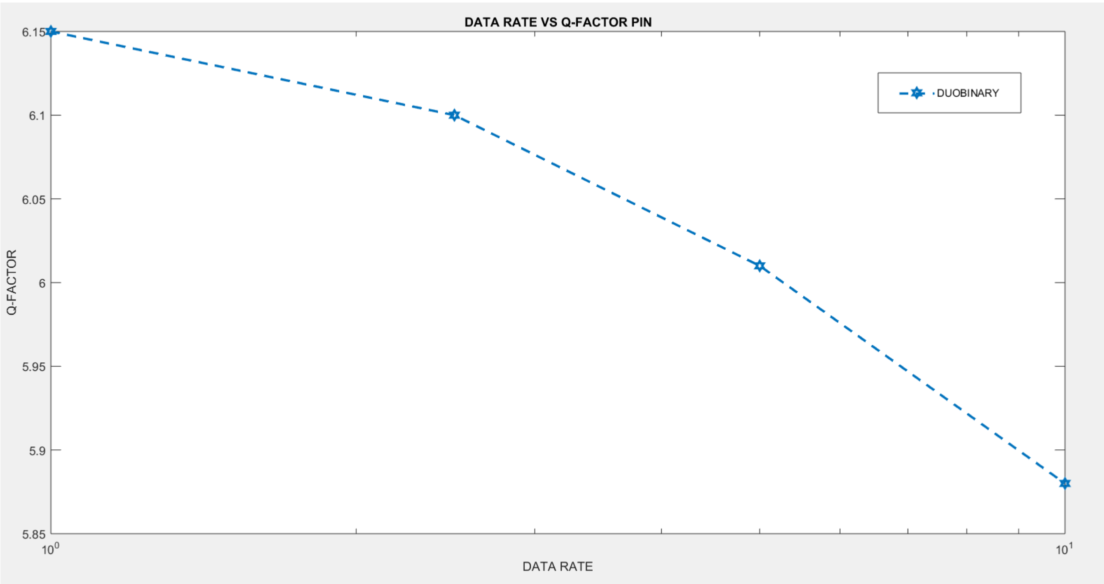

Fig.6.12.2 Data Rate vs Q-Factor PIN

In the above Fig.6.12.2 Data Rate vs Q-Factor Using PIN receiver Graph has been Plotted and Q-Factor values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.12.3 DISTANCE VS BER USING PIN RECEIVER

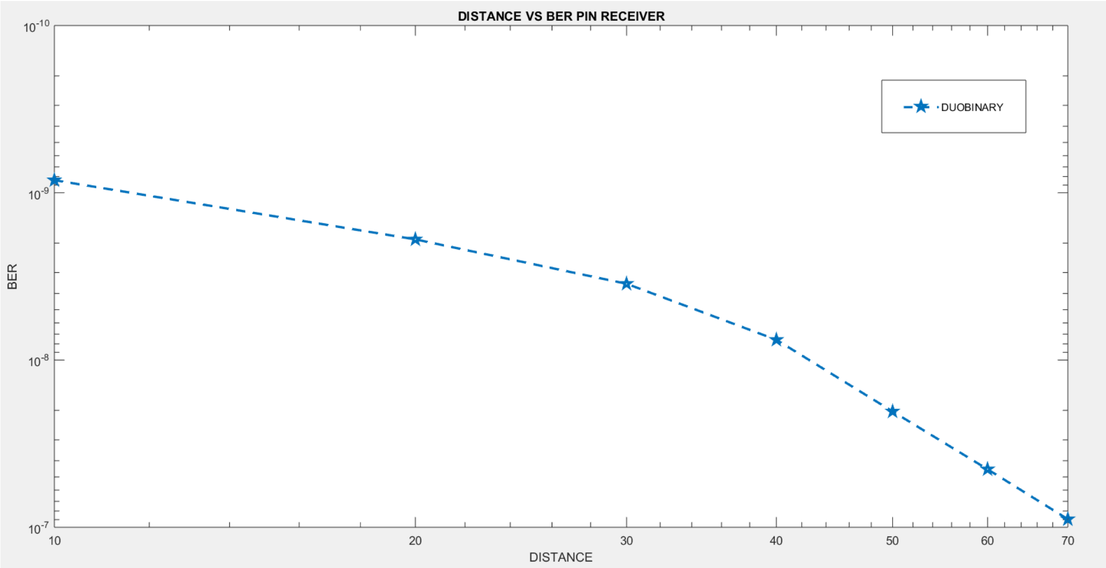

Fig.6.12.3 Distance vs BER PIN

In the above Fig.6.12.3 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.12.4 DISTANCE VS Q-FACTOR USING PIN RECEIVER

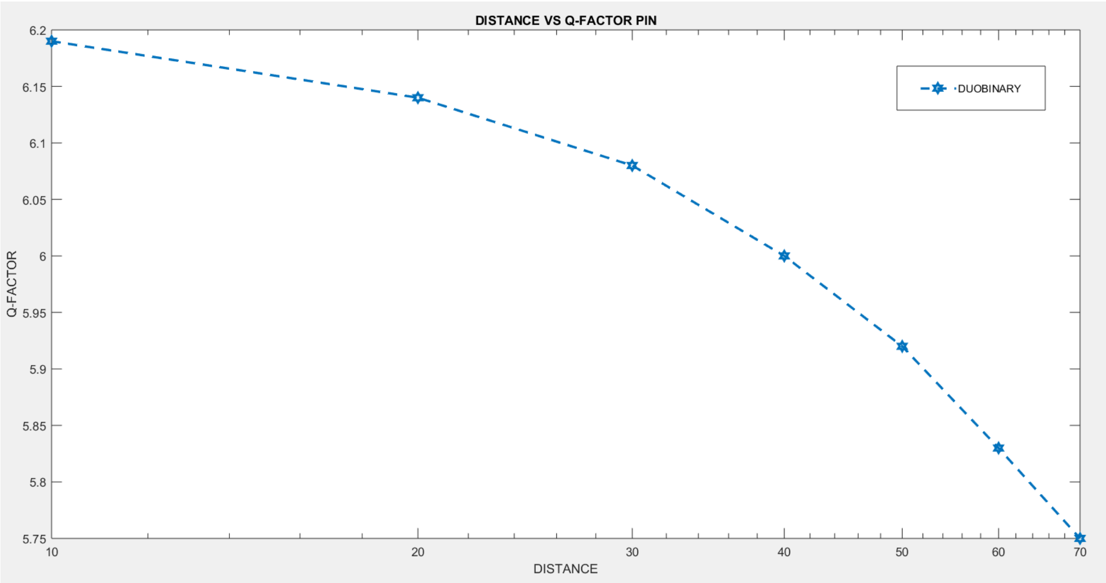

Fig.6.12.4 Distance vs Q-Factor PIN

In the above Fig.6.12.4 Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.13 CSRZ

6.13.1 DATA RATE VS BER USING PIN RECEIVER

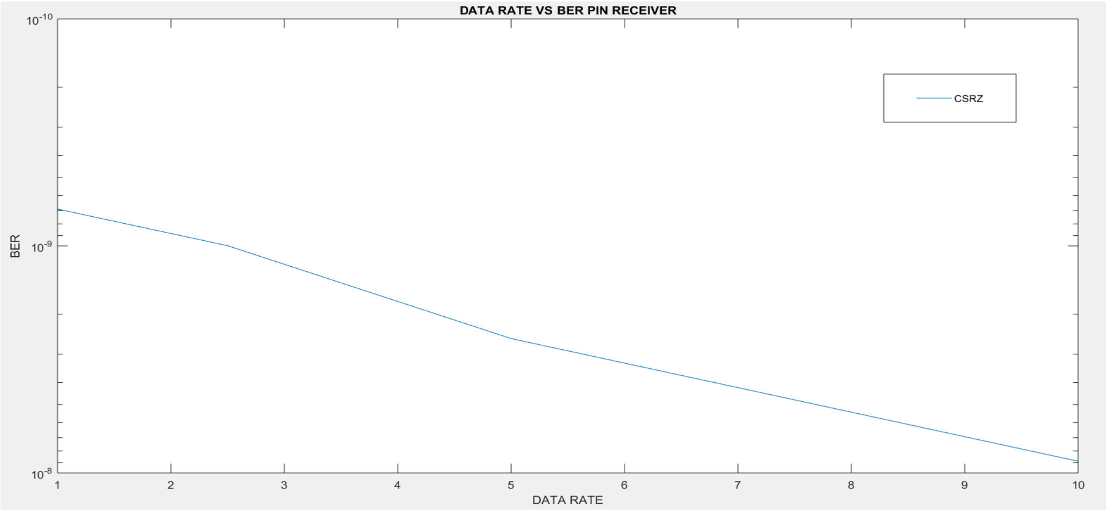

Fig.6.13.1 Data Rate vs BER PIN

In the above Fig.6.13.1 Data Rate vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.13.2 DATA RATE VS Q-FACTOR USING PIN RECEIVER

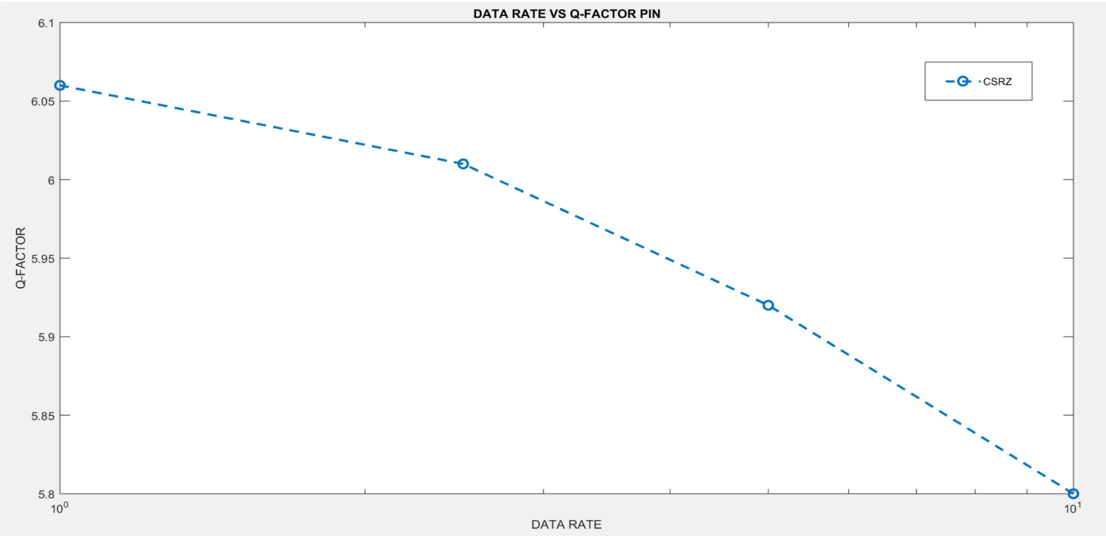

Fig.6.13.2 Data Rate vs Q-Factor PIN

In the above Fig.6.13.2 Data Rate vs Q-Factor Using PIN receiver Graph has been Plotted and Q-Factor values are Plotted for Data Rate 1GBPS, 2.5 GBPS, 5GBPS, 10GBPS Respectively.

6.13.3 DISTANCE VS BER USING PIN RECEIVER

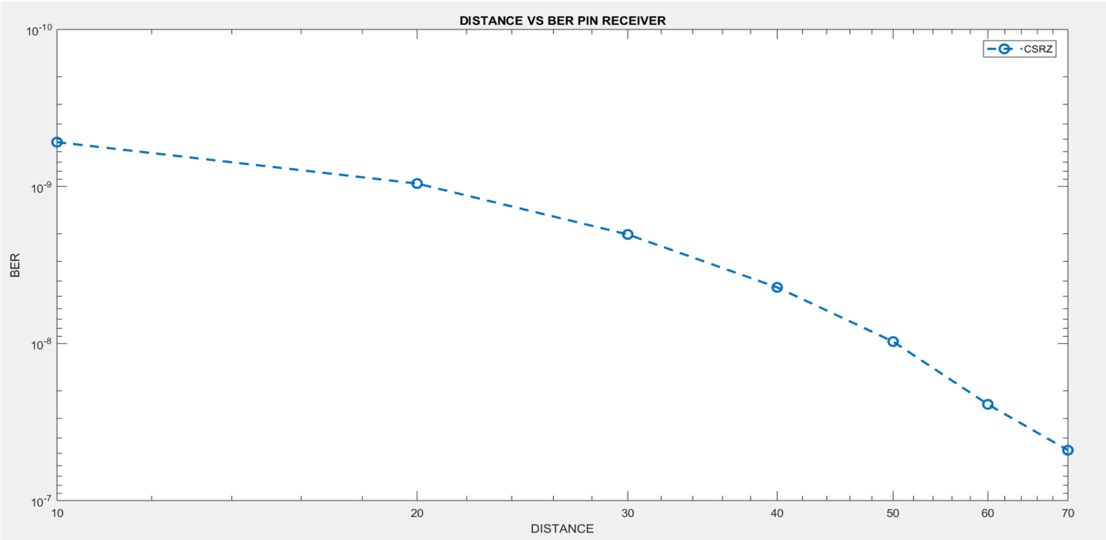

Fig.6.13.3 Distance vs BER PIN

In the above Fig.6.13.3 Distance vs BER Using PIN receiver Graph has been Plotted and BER values are Plotted for distances from 10-70 km Respectively.

6.13.4 DISTANCE VS Q-FACTOR USING PIN RECEIVER

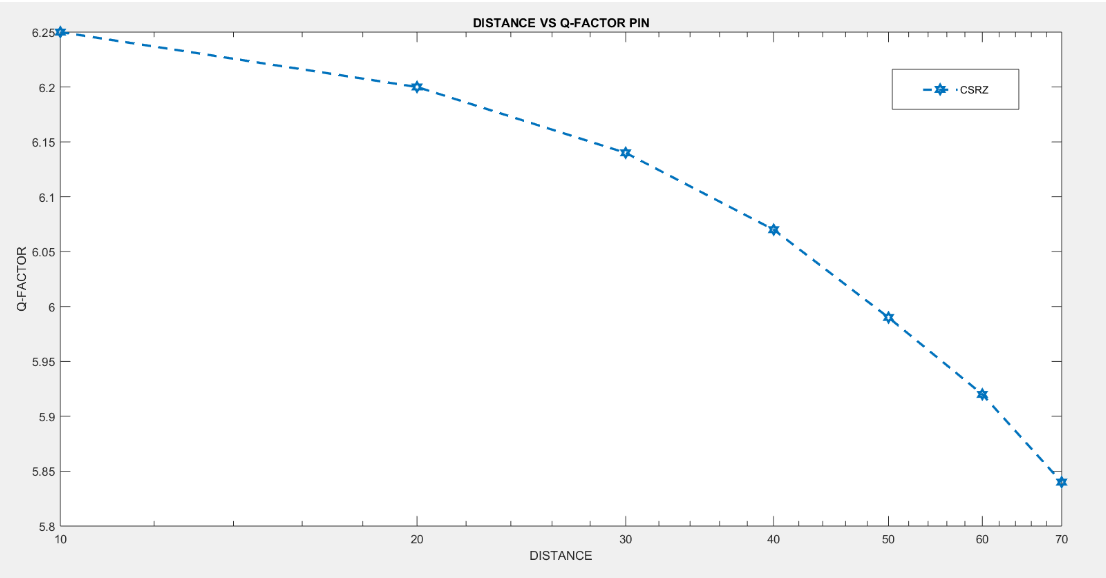

Fig.6.13.4 Distance vs Q-Factor PIN

In the above **Fig.6.13.4** Distance vs Q-FACTOR Using PIN receiver Graph has been Plotted and Q-FACTOR values are Plotted for distances from 10-70 km Respectively.

6.14 COMPARISION OF DIFFERENT MODULATION FORMATS FOR DOWN STREAM

6.14.1 DISTANCE VS BER USING PIN RECEIVER

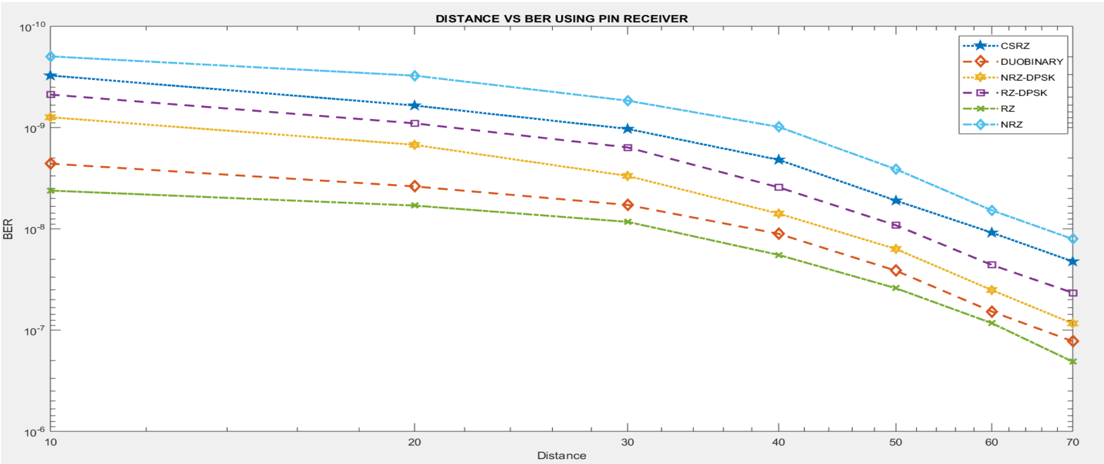

Fig.6.14.1 Distance vs BER PIN

In the above **Fig.6.14.1** Distance vs BER Using PIN Receiver is compared for all the Six types of Modulation Formats.

6.14.2 DISTANCE VS Q-FACTOR USING PIN RECEIVER

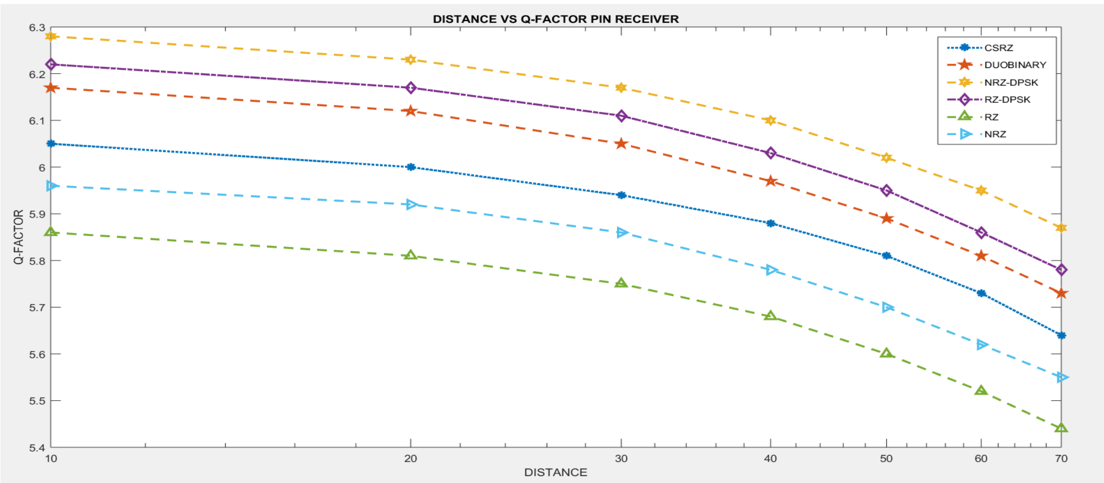

Fig.6.14.2 Distance VS Q-Factor Using PIN

In the above **Fig.6.14.2** Distance vs Q-Factor Using PIN Receiver is compared for all the Six types of Modulation Formats. From the above Fig 6.14.2 NRZ-DPSK modulation format gives the best performance with Q-factor value 6.25 and the least performance is NRZ format and for the communication purpose we go with the optimum results, CSRZ, RZ-DPSK, DB, RZ can be used for optimum distance for optimum transmission.

6.14.3 DATA RATE VS Q-FACTOR USING PIN RECEIVER

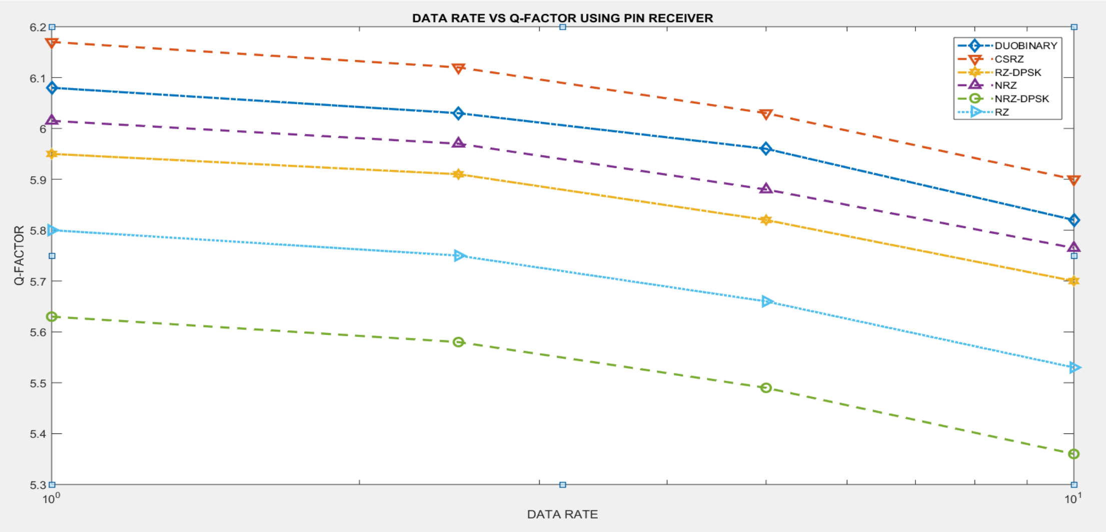

Fig.6.14.3 Data Rate vs Q-Factor pin

In the above **Fig.6.14.3** Data Rate vs Q-Factor Using PIN Receiver is compared for all the Six types of Modulation Formats. From the above Fig 6.14.3 CSRZ modulation format gives the best performance with Q-factor value 6.18 and the least performance is NRZ-DPSK format and for the communication purpose we go with the optimum results, NRZ, RZ-DPSK, DB, RZ can be used for optimum data rate.

6.14.4 DATA RATE VS BER USING PIN RECEIVER

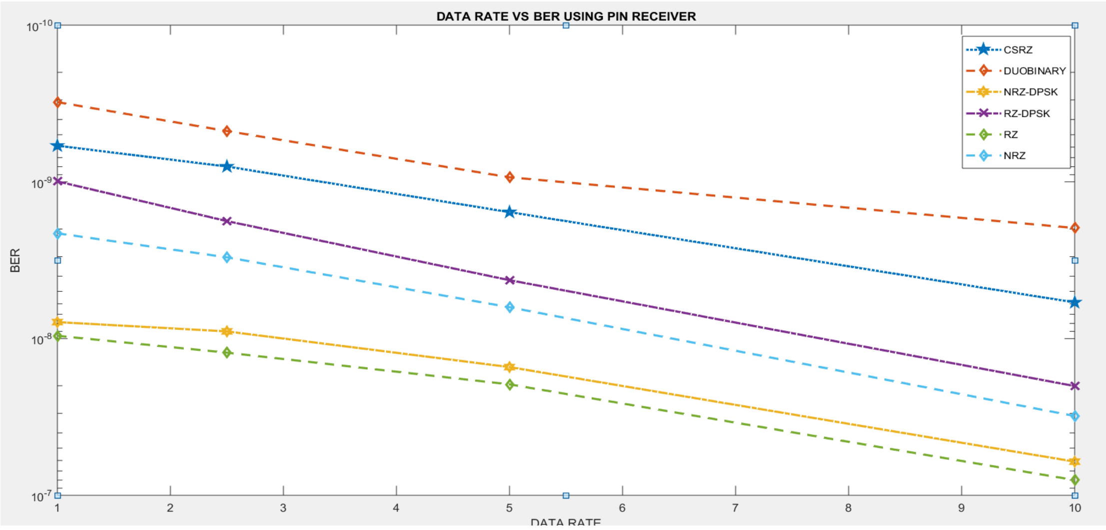

Fig.6.14.4 Data Rate vs BER PIN

In the above **Fig.6.14.4** Data Rate vs BER Using PIN Receiver is compared for all the Six types of Modulation Formats. From the above Fig 6.14.4 DB modulation format gives the best performance with BER value 4.2*10^-10 and the least performance is RZ format and for the communication purpose we go with the optimum results, CSRZ, NRZ-DPSK,NRZ-DPSK, NRZ can be used for optimum data rate

6.15 COMPARISION OF DIFFERENT MODULATION FORMATS FOR UPSTREAM

6.15.1 DISTANCE VS BER USING PIN RECEIVER

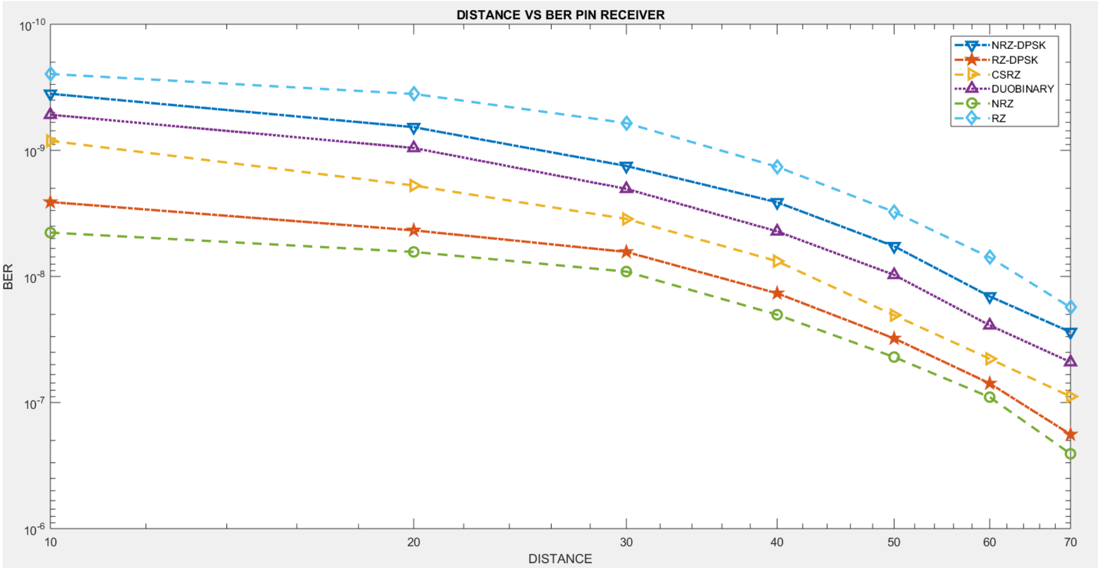

Fig.6.15.1 Distance vs BER PIN

In the above **Fig.6.15.1** Distance vs BER Using PIN Receiver is compared for all the Six types of Modulation Formats. From the above Fig 6.15.1 RZ modulation format gives the best performance with BER value 3.2*10^-10 and the least performance is NRZ format and for the communication purpose we go with the optimum results, CSRZ, NRZ-DPSK, DB, RZ-DPSK can be used for optimum distance.

6.15.2 DISTANCE VS Q-FACTOR USING PIN RECEIVER

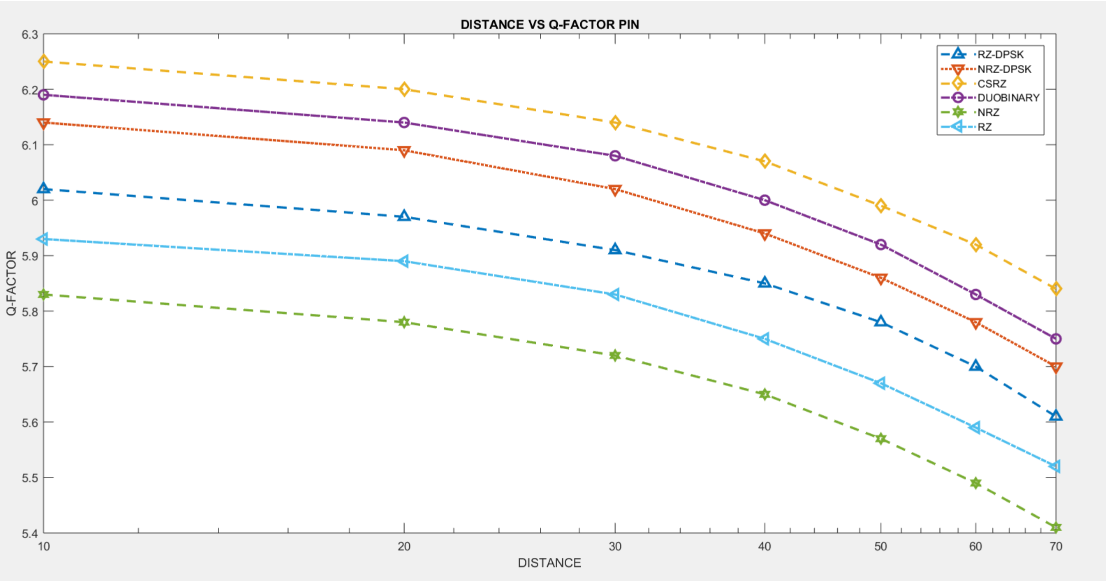

Fig.6.15.2 Distance vs Q-Factor PIN

In the above **Fig.6.15.2** Distance vs Q-Factor Using PIN Receiver is compared for all the Six types of Modulation Formats. From the above Fig 6.15.2 CSRZ modulation format gives the best performance with Q-factor value 6.28 and the least performance is NRZ format and for the communication purpose we go with the optimum results, NRZ-dpsk, RZ-DPSK, DB, RZ can be used for optimum distance.

6.15.3 DATA RATE VS Q-FACTOR USING PIN RECEIVER

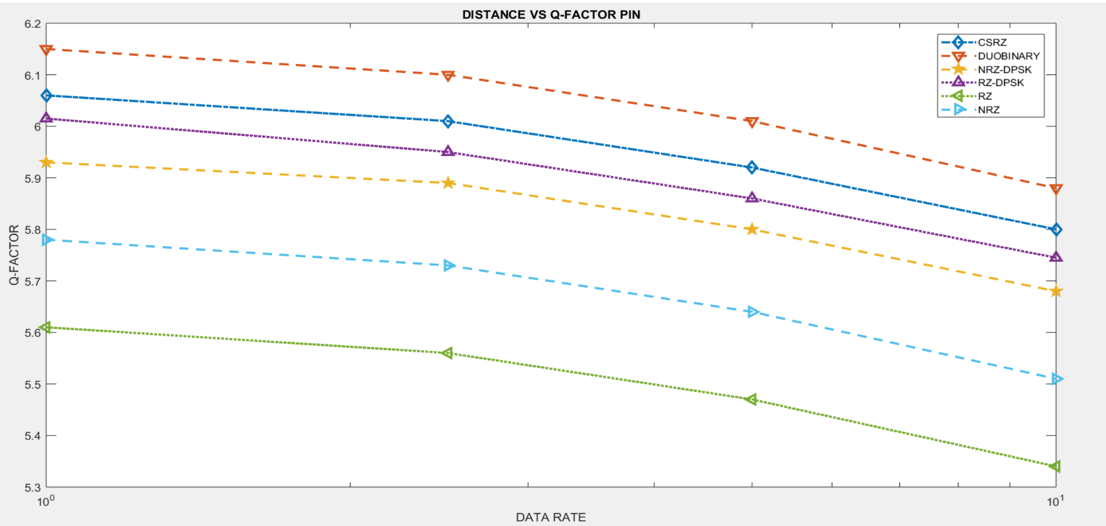

Fig.6.15.3 Data Rate vs Q-Factor PIN

In the above **Fig.6.15.3** Data Rate vs Q-Factor Using PIN Receiver is compared for all the Six types of Modulation Formats. From the above Fig 6.15.3 DB modulation format gives the best performance with Q-factor value 6.18 and the least performance is RZ format and for the communication purpose we go with the optimum results, NRZ, RZ-DPSK,NRZ-DPSK, DB, RZ can be used for optimum Data rate

6.15.4 DATA RATE VS BER USING PIN RECEIVER

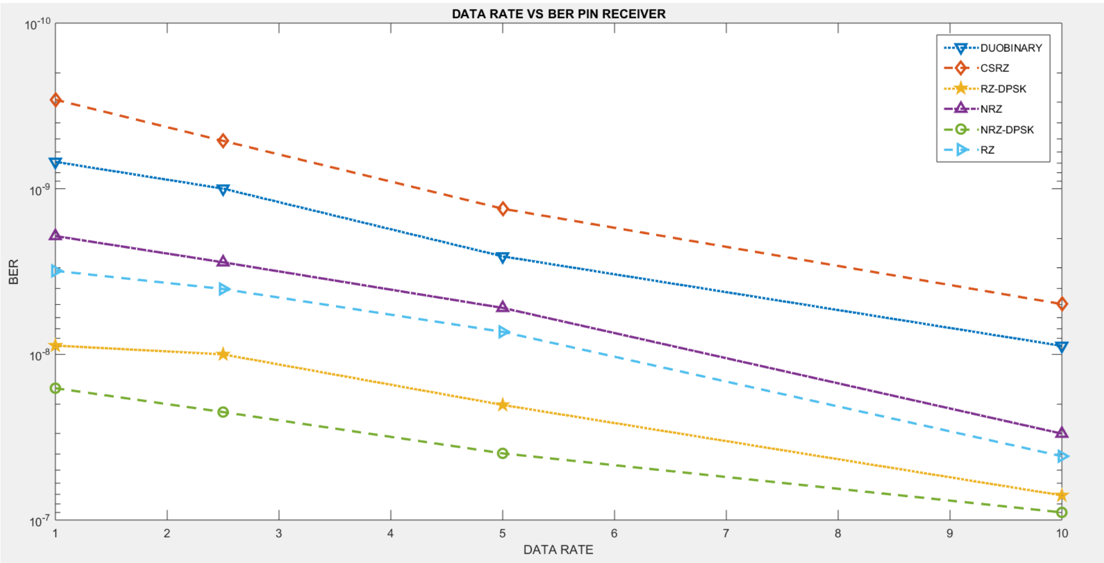

Fig.6.15.4 Data Rate vs BER PIN

In the above **Fig.6.15.4** Data Rate vs BER Using PIN Receiver is compared for all the Six types of Modulation Formats. From the above Fig 6.15.4 CSRZ modulation format gives the best performance with BER value 5.2*10^-10 and the least performance is NRZ-DPSK format and for the communication purpose we go with the optimum results RZ, RZ-DPSK, DB, NRZ can be used for optimum data rate.

7. **COST ANALYSIS**

The project is done by downloading Opti system software.

So the project was done without any expenditure. This project is was very economical.

I have spent daily four hours working on project for the past six months, cost does not means only physical expenditure but the time spent working on this project also a mental cost

8. **CONCLUSION**

We have designed and simulated a NGPON2 network for 16 number of ONU for both upstream and downstream transmission of data. Here we have analysed for varying data rate from 1Gpbs to 10 Gbps and also analysed for varying the distance from 10 Km to 70 Km.

Here we conclude that CSRZ gives better BER of $9 * 10^{-10}$ performance and Q factor than all other codes in downstream data transmission when we are transmitting the data rate from 1 to 10Gbps for PIN receivers where as NRZ DPSK gives least performance.

CSRZ gives better BER of $6* 10^{-10}$ performance and Q factor than all other codes in downstream data transmission when we are transmitting the data rate from 1 to 10Gbps for PIN receivers, where as NRZ DPSK gives least performance.

When we are analysis with respect to distance by varying it from 10Km to 70 Km CSRZ gives better BER of $6* 10^{-10}$ performance and Q factor than all other codes in downstream data transmission for PIN receivers where as NRZ gives least performance.

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