ULTRA HIGH BIT RATES HYBRID OPTICAL COMMUNICATION SYSTEM DESIGN

(OPTICAL FIBRE)

A Dissertation report submitted
In partial fulfilment of the Requirement for the
Award of the Degree of

Master of Technology in Electronics and Communication

By

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DECLARATION

I hereby declare that the dissertation proposal entitled Ultra high bit rates hybrid optical communication system design and implementation submitted for the M.Tech Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date:

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CERTIFICATE

This is to certify that ASHISH KUMAR RATHI has completed M.Tech dissertation proposal titled ULTRA HIGH BIT RATES HYBRID OPTICAL COMMUNICATION SYSTEM DESIGN under my guidance and supervision. To the best of my knowledge, the present work is the result of his original investigation and study. No part of the dissertation proposal has ever been submitted for any other degree or diploma. The dissertation proposal is fit for the submission and the partial fulfilment of the conditions for the award of M.Tech in Electronics & Communication Engineering.

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Signature of Advisor:
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ASHISH KUMAR RATHI

ABSTRACT

In optical communication system with increase in the length of fibre the dispersion of the optical signal also increases. Due to dispersion it becomes very difficult to implement a long distance transmission system. In this research work to overcome dispersion such as chromatic dispersion, material dispersion and various nonlinear effects such as scattering effects and Kerr effect, dispersion compensating fibre (DCF) has been used with single mode fibre (SMF). As a communication engineer I have keep compression between the DCF and FBG for reduce the pulse width. Now today not only increasing demand is sufficient but security, better quality is necessary for a vendor. Optical Communication can be provide the <100 Gbps data rate for long haul. The probability of errors is minimum as compare to the wireless communication and provide fastest services as compare to wireless communication.

In My Thesis work the main achievement of high data rate for long haul communication with minimum probability of errors. In this the hybrid technique is used for WOBAN. That means both wired and free space communication is used. Wired link is used for long haul and free space for short haul communication. Differential phase shift keying(DPSK) is used for both communication system means Hybrid system design. DPSK keep more power and low BER for long and short both optical communication. In pre, post and symmetric compensation scheme symmetric gives the best results as compare to these compensation scheme. My work done is on symmetric compensation scheme. As the data rate would be increase the Q factor, BER and signal power should be reduce. FBG (Fibre Bragg Grating) is technique which is usefull for many application of optical communication. In my thesis I used it for pulse width reduction when the pulse width should be minimum then data rate should be high and it is a better technique as compare to DCF.

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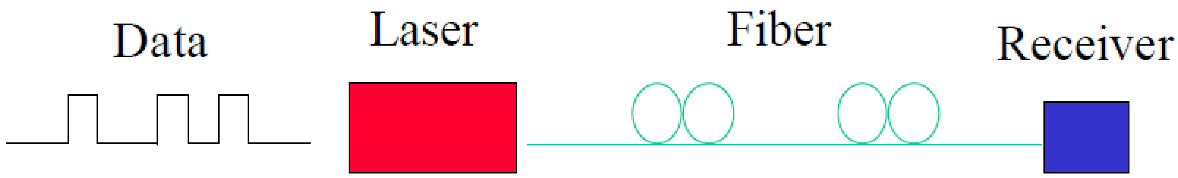
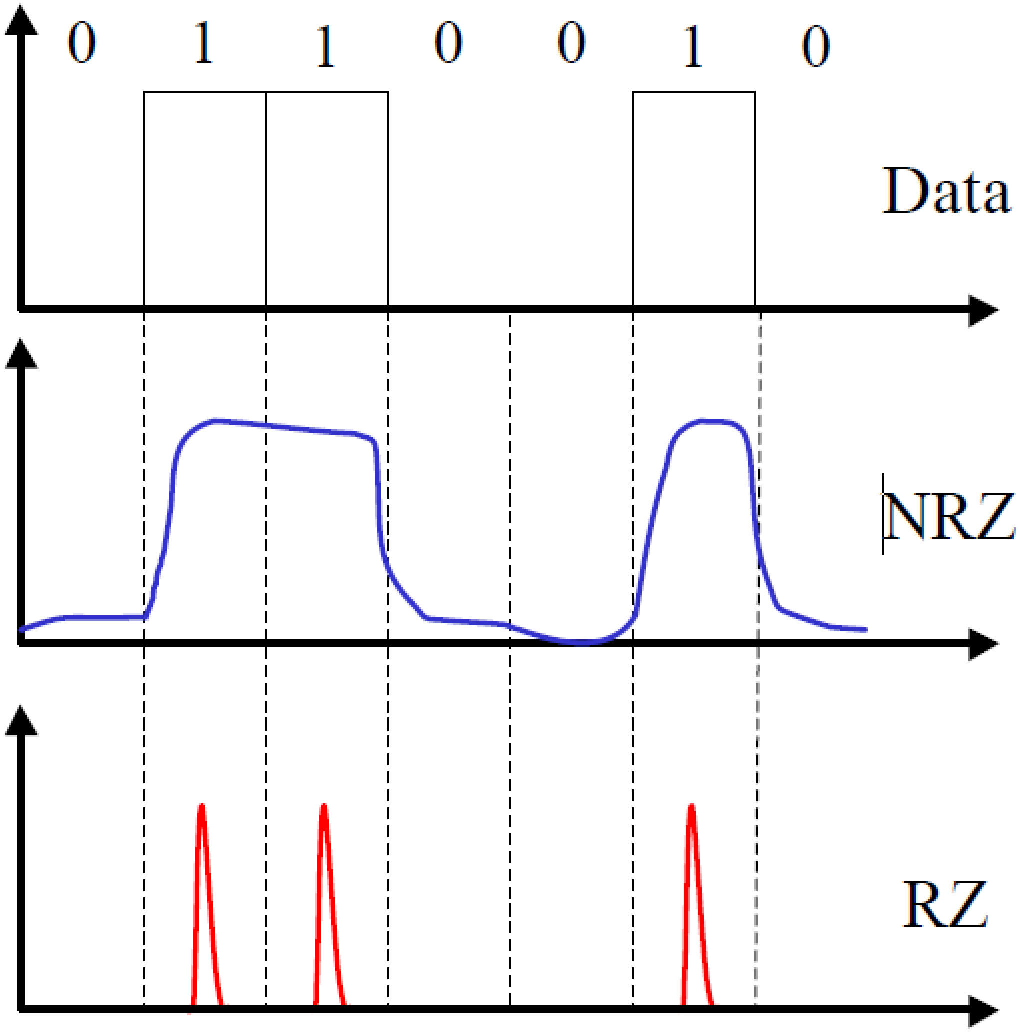
INTRODUCTION

The development of lasers was in the 1960s and low loss fibres in the early 1970s made possible the first fibre optical communication system in 1978. These systems were able to transmit signals at 100 Mb/s using multimode fibre's operating near about 0.85 µm. Although the repeater spacing was less than the 10 km, it was sufficiently large than the repeater spacing of the former coaxial system. This feature made fibre optical communication system an attractive alternative for the future, thus the first generation of fibre optic systems was born. The desiring to reduce the number of regeneration units by increasing the repeater spacing, the first generation systems quickly reach to the second generation system in the early 1980s. The second generation system allowed for increasing repeater spacing by operating the system at the lower loss near about 1.3 µm. Some additional improvements were also made in optical fibre technology by the introduction of the single-mode fibre, this earlier propelled the system capacity to Gb/s with repeater spacing in excess of 50 km. The operation of wavelength in system was further moved to 1.55 µm to take advantages of the lowest fibre losses for the third generation system, those was introduced in the 1980s. The increased in propagation distance allowed by lower fibre losses and the larger fibre dispersion at 1.55 µm, which is introduced fibre dispersion as the next generation to tackle. The dispersion problem was eventually solved by the using of dispersion-shifted fibre's and single longitudinal mode lasers is able to reduce the spreading of the transmitted pulse. Such systems may operate in excess of 10 Gb/s with repeater spacing is as large as 100 km. The early generations of fibre-optical systems relied on repeaters to compensate fibre losses through electrical amplification. These re-generation stations consisted of decoders, that transform the information from an optical domain to an electrical domain, electronic amplifiers to re-boost the signal, and transmitters to re-transform the information, from a electrical domain back to the optical signal. This process was an expensive process. The development of Erbium Doped fibre Amplifier (EDFAs) during the 1990s it's provided a breakthrough which allowed the pulses to be optically amplified thus reducing the need of many's regeneration stations. This technology reduced the cost while provided a very dynamic and transparent solution. Optical amplifiers have paved the way to another ground-breaking technology, that is WDM. This technique offered the ability to scale the system capacity via the same fibre by simply adding data in the same channels using slightly different wavelengths. The fourth generation systems boasted capacity of upwards of terabits per second (Tb/s).Because of, the demand is still increasing with time. The simplest model of a light wave system consists of a transmitter, a transmission medium such as an optical fibre, and a detector or estimator. Information is transmitted in digitized form as such as 1's or 0's (it's also referred to as bits) and the optical pulses representing this information and it is then send using a laser and a modulator. Semiconductor laser's are capable of emitting sufficient powers upto 10 mW and have a relatively high coupling efficiency (50%) for single mode fibre. Frequently, semiconductor lasers are the choice for long-haul communication systems.



Figure[1]: Diagram of basic optical communication

Currently, there are two format's for encoding optical bit streams, one is non-return-to-zero (NRZ) and another is return-to-zero (RZ) (shown in Figure 2). An optical pulse representing the RZ encoding is shorter than the NRZ pulse, and its amplitude become zero before the bit duration is over. For a NRZ pulse, the Amplitude of a "1" bit does not return to zero during the bit duration. Therefore, two successive 1's are merged into a pulse that is twice are making long. We have smaller signal bandwidth that why NRZ format is used currently, however, for systems those based on soliton principles, the RZ format must be used.



Figure[2]: Transmitting Data Format in Optics

The optical bit stream is transported through optical fibre link from one location to another. The capacity of a fibre optical communication system is evaluate by the number of bits it can send per second, or alternatively, by the inversing of the bit slot. Thus, a system transmitting 100-ps pulses using NRZ or 25-ps pulses using RZ (with pulse separation equal to the 4 times the pulse width) will be carry a single channel capacity of 10 Gb/s.

The basic receiver's role is to be convert the optical signal received from the optical fibre link back to the original electrical signal. Modern systems are used the direct-detection scheme, 3 which is consists of A semiconductor detector, A clock recovery circuit, and A decision-making circuit to identify bits as 1 or 0. The performance of fibre-optical communication systems will depend on the number of error's made per second as counted by the receiver circuit, or the bit-error rate (BER). Typically, a system is specified as having error-free transmission when it has BER is less than 10 db. With novel coding algorithm's, systems can be gain several dB in performance using forward error correction (FEC).

The design of a fibre optical communication system requires an understanding the nonlinear propagation of optical pulses, with emphasis on fibre loss and fibre dispersion.

1.1 THE OPTICAL FIBERS

The Optical fibre is basically thin glass fibre from which we can transmit the light. The optical fibre is thicker than human hair, flexible and transparent fibre which are made up of silica glass. According to the length the optical fibre will carry the light. The data transmission system of the optical fibre is done by turning the electrical signals into light. The Transmission For the optical fibre cable need repeaters at some distance intervals. Long-distance lines for most of the telephone company are basically made up of optical fibre. The Optical fibre used in optical fibre communications which are used for transmit data over long distance along with data rate needed to be high. According to the copper wire optical fibre carry more information.

1.1.1 Types of optical fibre:-

The basic 3 types of optical fibre cable are:

1] Step-index multimode.

2] Step-index single mode.

3] Graded-index.

The fibres which have many propagation modes are called to be Multi-mode fibres. While the fibres which has one or single mode of propagation are called to be Single-mode. So, generally the two types of fibres which are used for longer distances are called Single-mode fibre and which are used for the shorter distance are called Multi-mode fibres.

Step – index multimode

1.Easy coupling

2. Lower data rates

3. Modal dispersion

4. Shorter distance

Step-index single mode

1. Difficult coupling

2. Higher data rates

3. No modal dispersion

4. Longer distance

1.1.2 OPTICAL FIBRE COMMUNICATION SYSTEM:

The optical fibre communication system block diagram made up of various blocks:

1] Transmitter.

2] Information channel.

3] Receiver.

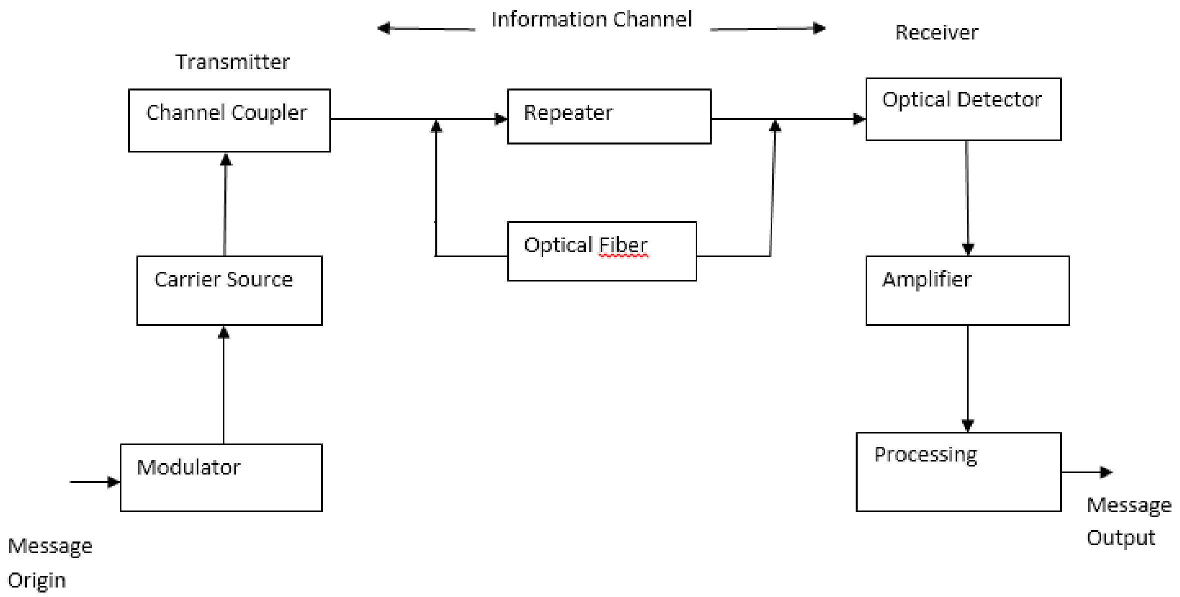


FIG. [3]: BLOCK DIAGRAM OF OFC SYSTEM

Message origin: Transducer is a device convert the non-electrical message into an electrical signal.

1] Modulator: main two function of modulator are - 1] electrical message is converted into the proper format. 2] The wave is generated by the carrier source get impresses by the signal.

2] Carrier source: The information is transmitted by the wave generated by carrier source. That wave to be called as the carrier. In optical fibre system we use optic oscillators which are light emitting diode (LED) and a laser diode (LD). They are very helpful in providing stable and single frequency waves mainly for long distance propagation with sufficient power.

3] Channel coupler: In the information channel the power is feed by the coupler. In the optical fibre system the channel coupler is a lens which is used for directing the light toward the receiver by collimating the light emitted by the source. From the source to the optic fibre channel coupler help in efficiently transfer the modulated light beam.

4] Information channel: The basic path between the transmitter and receiver is information channel. Glass or plastic fibre is the main channel in optical fibre. The main characteristic of the information channel is that it has low attenuation. Optical amplifiers boost the power levels of weak signals. The optical Amplifiers are required to provide sufficient power to the receiver for long links which will boost the power levels of weak signals.

5] Optical detector: In the optical fibre system the photo detector convert the optic wave into an electric current which contain the transmitted information. The power in the incident optic wave is proportional to the current developed by the detector. The properties of photo detectors are economy, low power consumption, high sensitivity, size is small and life is long.

6] Signal processing: Filtering and amplification is done in signal processing. In which to maximize the ratio of signal to unwanted power proper filtering is used. Decision circuit is an additional block in digital system. There should be very small bit error rate (BER) for good quality of communications.

7] Message output: The messages which are in electrical form are converted into visual image or sound wave. Whenever the computers or other machines are mainly connected through optical fibre system we can use these signals directly.

So, these are the various blocks of the optical fibre Communication system in three main blocks that is transmitter, information channel and receiver. If we compare the general communication system and the general optical fibre communication system general communication system provide the information source which will pass through the transmitter (modulator).Proceed the information and the data to the transmission medium which is the centre hub of the general communication system. Then transmission medium will transmit the information and data to the receiver (demodulator). Receiver will receive the information and further transmit that information source to the destination. And in the case of general optical fibre communication system information source will transmit through the electrical transmitter and that will further transmit the information to the optical source. Then the optical source will be transmitted through the optical fibre cable to the optical detector which will detect the signal and transmit further. Then electrical receiver will receive the signal and send that to the destination. Generally the fibre optical communication is a method by sending pulses of light transmission of the information from one place to another. To carry the information electromagnetic carrier wave is modulated. The optical fibres are used for the fibre optic communication which is helpful for the transmission at higher BW for the long distance.

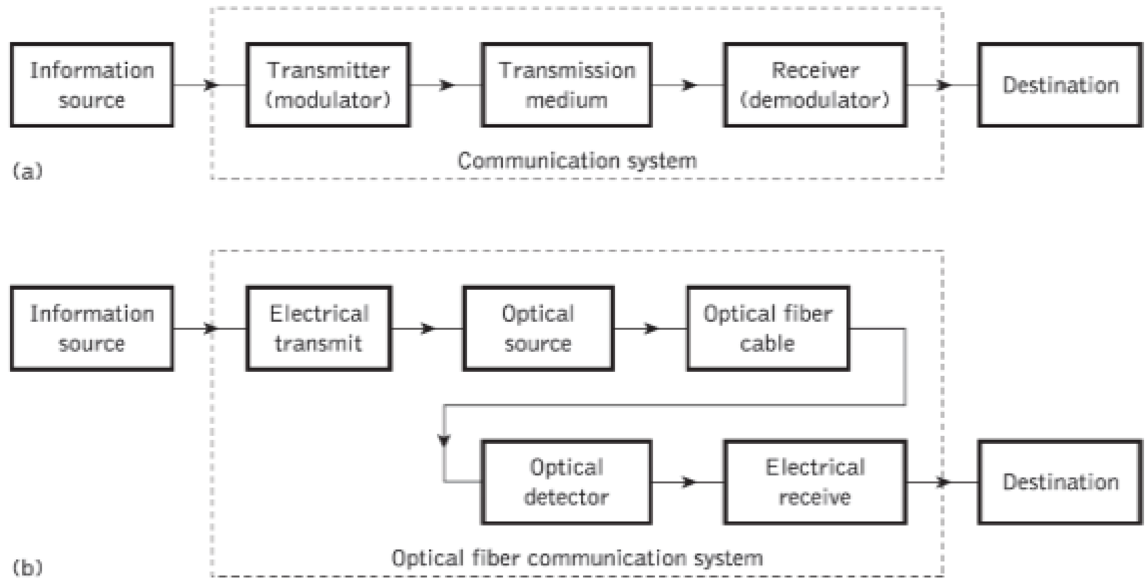


FIG [4]: A) GENERAL COMMUNICATION SYSTEM &

B) GENERAL OPTICAL FIBRE COMMUNICATION

1.1.3 ADVANTAGES / BENEFITS OF OPTICAL FIBRE COMMUNICATION:

1] Low cost: optical fibre is less expensive than copper and we know that optical cable prices are low as compare to others. As comparison to other system optical fibre cost is very less so the services of telecommunications with the smaller cost provide a good quality formation. With the less cost optical fibre cables last longer than copper cables.

2] High bandwidth: Today every communication requires a large amount of bandwidth. The optical fibre communication has hundreds times more BW that of other cables. With the high BW transmission of data is done with the high speed which offers immediately transmission of data under the very high speed. Optical fibres have very small diameters near about a human hair.

3] Long-distance signal transmission: Due to low attenuation of signal while transmit the weak signals can be strengthened very easily by amplifier. There is very less signal attenuation for longer distance offer by the optical fibre causes less loss.

4] Light weight: The optical fibre cables are lighter than copper cables, aluminium cables or any other cables which are made of silica glass or plastic.

5] Security: The optical fibres provide a high degree of signal security as the light does not radiate significantly. It is impossible to detect the signals which are being transmitted within the cable because of the dielectric nature of optical fibre this can be done by accessing the optical fibre. With the major security format optical fibre is used in governmental bodies, banks and many other areas.

6] Environment immune: The optical Fibre cables are not affected by gases or corrosive liquids: The optical Fibre cables can handle the extremes temperature variations.

7] Easy installation: The optical Fibre cables are easy to maintain and install. The small size and light weight of optical fibre make installation easier.

8] Non conductivity: Dielectric nature is the one of the major advantage the optical fibre. The optical fibre can be installed in the areas or region with electromagnetic interference (EMI) and radio frequency interference (RFI). In the electrical and magnetic field the optic fibre cables are having high immunity.

9] Less requirements of signal power/energy for transmit: In the way of transmission of data less consumption of energy and concerning the electric signal required.

1.1.4 APPLICATION OF THE OPTICAL FIBRE COMMUNICATION:

1. The optical fibre is used in telephone network because they have high transmission bandwidth and low attenuation as compared to other cables.

2. Broadband application.

3. Medical application.

4. Military application.

5. Industrial application

6. Mining application

7. Railways and aircraft

8. Telecommunication, data communications, video control and protection switching.

9. SONAR application

10. Used as light guide in medical and other buildings.

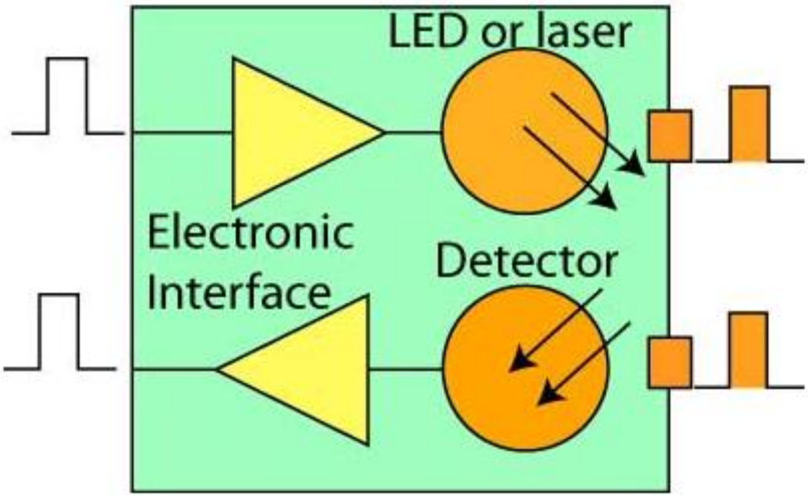
11. Optical fibre sensors

12 CCTV

1.2: OPTICAL TRANSMITTERS AND OPTICAL RECEIVERS

1.2.1 OPTICAL TRANMITTERS

LASER is an transmitter in optical communication. It is acronym for “Light Amplification by the Stimulated Emission of Radiation”. Laser produce far and away the better kind of light for optical communication. Ideal laser light is produced a single-wavelength only. This is also related to the characteristics of the material which used in the laser manufacturing. It is also formed in parallel beams and in a single phase. That why, it is “coherent”. This is not extremly true for communication lasers. Lasers can be modulated (controlled) the light wave very precisely. Lasers can only produce relatively high power. Indeed some types of laser can produces Kilowatts of power. In optical communication applications, semiconductor lasers of power up to about 20 mille watts are available now. This is so much times greater power than LEDs can generate. Other semiconductor lasers (Those used in “pumps” for optics amplifiers) have produced output up to 250 mille watts. As we know, laser light is produced in some parallel beams, a high percentage of light (50% to 80%) can be transferred into the fibre. Above <1Gbps LED is replaced with Laser(VCSEL).the output of broad but laser is limited.

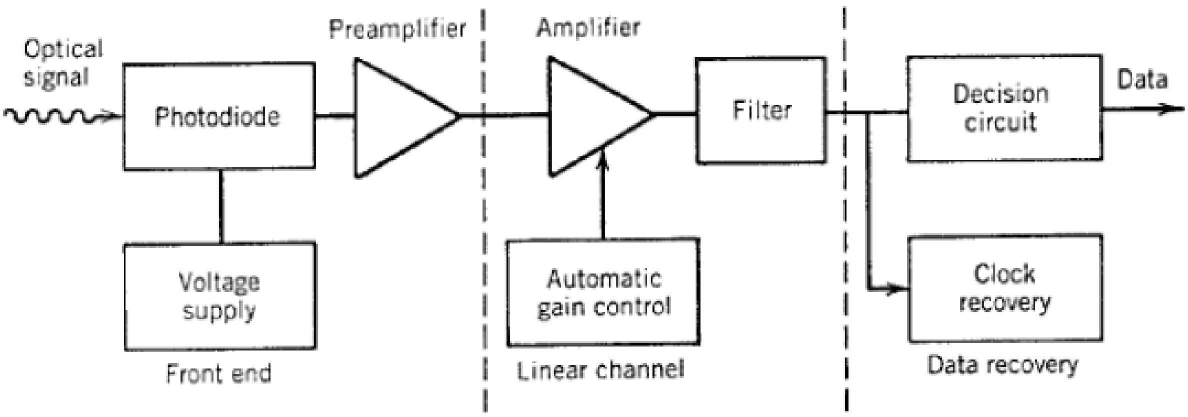


Figure[4]: Trans Receivers of Optics Communication

1.2.2 OPTICAL RECEIVERS

For the optical receiver or optical detectors we have to take in our mind some important parameter/characteristic like:

1. The range of wavelength on which the device is operate.
2. The efficiency should be of the device.
3. The faculty of the device which understand the suddenly and quickly changes of light.
4. The noise which there is at the devise and how it influences the signal in low level of signal.



FIGURE[5]:- Receiver Process Used In Optics Communication

There are some photoconductors which are the simplest type of an optical detector. This device have a piece of material (semiconductor) with two contacts of electricity, where there is voltage. When a photon is on the semiconductor. So, we have a pair electron/hole. Because of the voltage is in two contacts. So, the electron goes to the positive contact side and the hole to the negative contact side. As we can understand there is a different value of resistance of device is proportionally to the light. There is the gain, because electron drift is much faster moved than hole drift. Electrons tend to arrive at the positive contact side before a hole arrives at the negative side. Also there are photodiodes which convert the light into electricity. Because of that a diode will make the electron again from a photon as we may understand the current from the device is very small, we need an amplifier that amplifying the current level before the signal goes to the receiver. Also there are the PIN diodes, the Schottky-Barrier photo-diodes, APDs avalanche photodiodes, Hetero-interface photo-detectors, Travelling-Wave photo-detectors, and Resonant-Cavity photo-detectors.

1.3 TRANSMISSION IMPAIRMENTS IN OPTICAL FIBRE:

The two main transmission impairments are: 1] Dispersion 2] Non linear effect.

1.3.1 DISPERSION:

Pulse spreading in an optical fibre is basically called as dispersion. Dispersion is expressed in term of the symbol Δt. The fibre elements such as core diameter, refractive index profile, wavelength, and numerical aperture propagates the pulse of light which make the pulse to be broaden. The dispersion will be as more as longer the fibre will be. Data rate-distance product is governed by the dispersion not the data rate.

We can determine Dispersion Δt: $\Delta t = (\Delta t\text{out} - \Delta t\text{in})1/2$ and,

Total dispersion per unit length: $\Delta t\text{total} = L \times (\text{Dispersion/km})$

The overall effect of dispersion on the performance of a fibre optic system is known as Inter symbol interference. Dispersion is divided into different categories: chromatic dispersion, modal dispersion, polarization mode dispersion.

1.3.1.1 CHROMATIC DISPERSION:

Among the degrading effects of fibre chromatic dispersion plays a very important role. Chromatic dispersion exists due to finite bandwidth of the signal. Chromatic dispersion is also known to be intra-modal dispersion which is present in single mode or in multimode. Different velocities through the fibre different wavelengths of light propagate which make chromatic dispersion as pulse spreading. The unit of chromatic dispersion is nanoseconds or picoseconds per (km-nm). Different wavelengths propagate at different velocities as the refraction index of glass fibre is a wavelength-dependent quantity.

1.3.1.1.1 MATERIAL DISPERSION:

Material dispersion exists due to intrinsic properties of the material, glass. The change in index of refraction for different wavelengths causes material dispersion. Pulse broadening is done from the different spectral component of different velocities launch from the optical fibre source due to material dispersion. Material dispersion causes the effect of pulse travel at different velocities comprising at different wavelength. The factor contributing to chromatic dispersion material dispersion is basically synonymous with spectral dispersion and intra-modal dispersion.

Material dispersion for unit length [L=1]:

$$D_{mat} = \frac{-\lambda}{c} \; X \; \frac{d_n^2}{d\lambda^2}$$

Where,

c = Light velocity

λ = wavelength

$\frac{d_n^2}{d\lambda^2}$ = Second derivative of index of refraction w.r.t wavelength

The upper sideband signal (lowest wavelength) indicates the negative sign which arrives before the lower sideband (highest wavelength).

1.3.1.1.2 WAVE GUIDE DISPERSION:

Waveguide dispersion exists due dispersive nature of the bound medium. The velocity is a function of frequency in the optical fibre bound medium. Physical structure of the waveguide causes the waveguide dispersion. Only fibres which are carrying fewer than 5-10 modes make use of waveguide dispersion. The multimode optical fibres will not have waveguide dispersion as it carry hundreds of modes. Due to waveguide dispersion it arise the group delay (τwg). As we know that the combination of waveguide dispersion and material dispersion is known to be chromatic dispersion. These losses primarily concern with the correct choice of wavelength.
The waveguide dispersion is significant as the effect of the different dispersion mechanisms are not easy to separate within single mode fibre. Waveguide dispersion fully depends on the ratio of a/λ.
Fig [7] compares the material chromatic and fibre dispersion-shifted fibre and wavelength dispersions for single-mode:

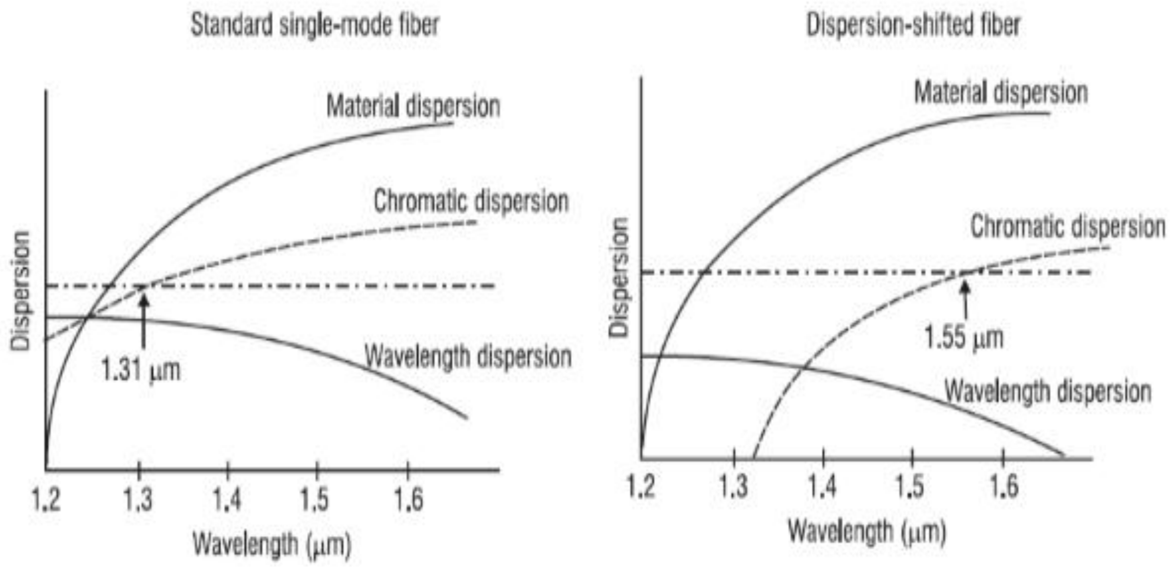


FIG [7]: Single-mode versus dispersion-mode versus dispersion-shifted fibre

The modal dispersion and polarization mode dispersion are another dispersion which are to be discussed further after the chromatic dispersion.

1.3.1.1.3 MODAL DISPERSION:

The main thing about modal dispersion is that it takes place in multi mode fibres. The modal dispersions are almost eliminated in single mode index fibre. Mostly in the graded Index fibres modal dispersion is present. Other names for this can be multimode dispersion, modal distortion or multimode distortion. Even with monochromatic light source modal dispersion is present. Modal dispersion has a very special case as polarization mode dispersion which associated with single mode fibres. The bandwidth of multimode fibre is limited by the modal dispersion.

Modal dispersion is given by:

$$\Delta t_{modal} = \frac{n_1 z}{c}\left(\frac{\Delta}{1-\Delta}\right)$$

Where,

Δt modal -Dispersion

n1 - Core refractive index

Z - Total fibre length

c - Velocity of light in air

Δ - Fractional refractive index

1.3.1.1.4 POLARIZATION MODE DISPERSION:

The limiting factor for optical communication system at high data rates is PMD [polarization mode dispersion] so that the effect of polarization mode dispersion must be compensated. The different polarization state [such as linear polarization and circular polarization] acquires by the different frequency component. Among all the different dispersion polarization mode dispersion is the most complex. Polarization mode dispersion very much attached to single mode fibres. Different velocities having different polarization mode travel with different propagation time between the two modes.

1.3.1.1.5 DISPERSION COMPENSATION SCHEME:

For the long distance transmission single mode fibre is upgraded to compensate the dispersion format. For that dispersion compensation scheme is applied to the system where we are using dispersion compensating fibre (DCF), single mode fibre (SMF) and EDFA. So the three dispersion compensation schemes are: pre, post and symmetric configuration.

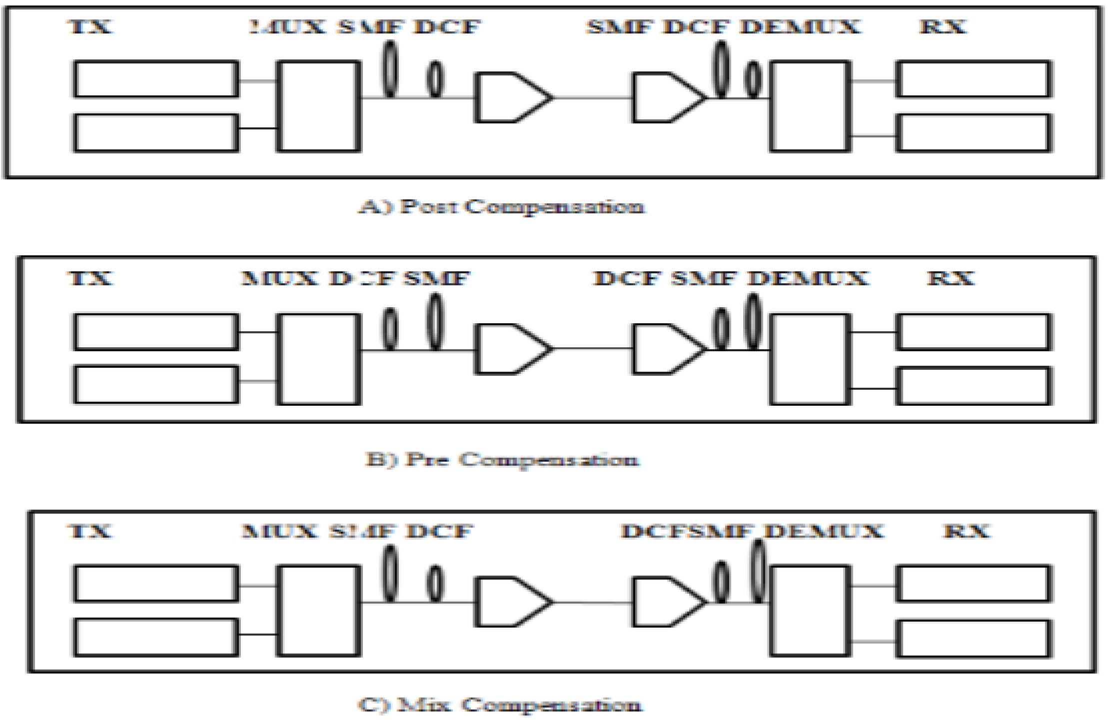


FIG [8]: DISPERSION COMPENSATION SCEMES [4]

1.3.2 NONLINEAR EFFECTS:

The fibre refractive index will be modified when the optical intensity inside the optical fibre increases. Non linearity may occur due to the optical power of few tens of Mw in single mode optical fibre. The pulse propagation gets significantly modified when the optical fibre becomes non-linear which generates some new frequencies inside the optical fibre. The spectrum of the output signal is not similar to the input signal. Large optical power is required to observe the non-linearity in the bulk medium. Where as optical non-linearity can be easily observed with low optical power. The nonlinear effects are weak at low powers which can become stronger at high optical intensities.

To handle the signal propagation affected by non- linearity there is two approaches:

- By keeping low optical power levels we can avoid nonlinearity: Since the optical power has to be increased for long distance communication then the first option does not seem very feasible. Also in a multi-channel system like WDM, the total power of all channels together is large enough to drive the optical fibre into non-linear regime even if each channel has low power so this point to be considered.

- By Understanding the non-linear signal propagation and making the use of it for increasing the transmission capability of the fibre: The second option is more desirable. This option is challenging because the non-linear pulse propagation is a very complex phenomenon.

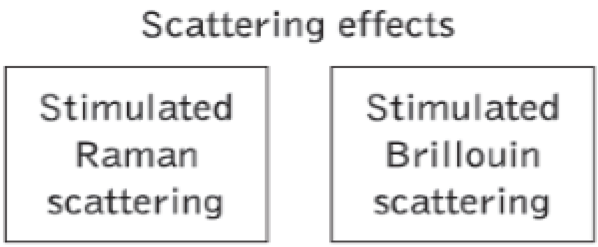
The main two categories of nonlinear effects are:

1] Scattering effects.

2] Kerr effects.

1.3.2.1] SCATTERING EFFECTS:

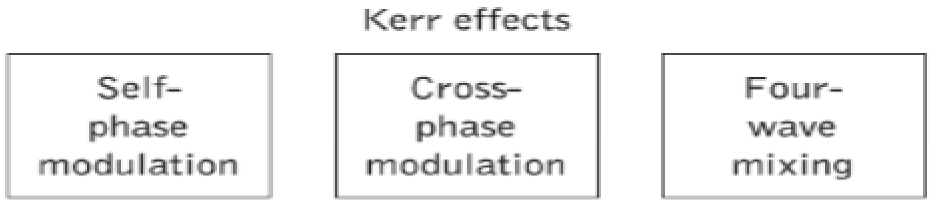
Scattering take place when a single signal or wave strike the rough surface which leads to scattering of multiple signal. Optical wave in a fibre scattered the medium incident photons by producing a phonon emitted at various shifted frequencies. The energy difference with the scattered photon emerges at a frequency shifted below or above the incident photon frequency between the two photons being deposited or extracted from the scattering medium. Only if the material gives up quantum energy equal to the energy difference between the incident and scattered photon then only up shifted photon frequency is possible.



FIGURE[9]:- Scattering Effect

1.3.2.2] KERR EFFECT:

Kerr nonlinearities are the effects described by the intensity-dependent refractive index of the fibre. Kerr effect is also name as quadratic electro optic effect. Kerr effect causes a variation which is fully proportional to the local irradiance of light. To avoid the chromatic scattering at the time of transmission of light Kerr effect is used. Kerr nonlinear effects may be observed at higher optical intensities applied to field. Kerr effect is basically the production of double refraction by an electric field in a substance.



FIGURE[10]: Kerr Effect

The three process through which Kerr effect is produced are: self-phase modulation (SPM), cross-phase modulation (XPM) and four-wave mixing (FWM). The effect self-phase modulation (SPM) causes the modification to the pulse spectrum when the light pulse propagating in the fibre the leading and trailing pulse edges compared with different transmission phase for the peak. Depending on the fibre type and its chromatic dispersion the spectral broadening that is caused by SPM produces the dispersion effects which can limit the transmission rates for the long-haul optical communication systems. Cross-phase modulation (XPM) is very much similar effect to self-phase modulation (SPM) other than the overlapping of pulses possessing example as different wavelengths or polarizations involved in this. XPM is crosstalk mechanism between channels when either the intensity modulation is used in dispersive optical fibre transmission or, when the phase encoding is employed. Where as four-wave mixing (FWM) is termed as the generation of modulation sidebands at the new frequencies where the beating between the light at different frequencies or wavelengths in multichannel fibre transmission causes phase modulation of the channels.

1.4: WAVELENGTH DIVISION MULTIPLEXING AND FIBRE GRATING SCATTERING

1.4.1 WAVELENGTH DIVISION MULTIPLEXING

Wavelength Division Multiplexing (WDM) is a technique in which we can multiplex many signals and transmit into fibre optical cable. WDM, work like FDM which use the radio frequency (RF), here we have infared (IR) wavelength from the electromagnetic spectrum.

Each channel carries IR and combined data which transmit by one only fiber. But instead of taking place in radio frequency (RF), WDM under the IR section of the electromagnetic (EM) spectrum. We have each wavelength IR which bears many RF signals in conjunction with the assistance of the FDM or time-division multiplexing (TDM). Each multiplexed wavelength can be separated, or demultiplexer, the initial signals to the destination. If you use FDM or TDM IR in each channel, along with many IR WDM channels of data in different forms at different speeds and can be transmitted simultaneously on a single fiber. In early WDM systems, there are two wavelengths per fiber. At destination, the wavelengths were demultiplexer by two wavelength filter cut-off wavelength approximately midway between the wavelengths of the two channels. Soon it became clear that more than two multiplexed IR channels could be demultiplexer using cascaded filters, leading to coarse-wavelength division multiplexing (CWDM) and dense-wavelength division multiplexing (DWDM). In CWDM, there are usually eight different IR channels, but can be up to 18. In DWDM, there may be dozens. Because each IR channel has its own set of signals multiplexed RF, it is theoretically possible to transmit data combined on a single fiber at a total effective rate of several hundred gigabits per second (Gbps). DWDM provide the 32 channels now a day. The demand f increasing data rate is growing day by day And we have limited bandwidth.

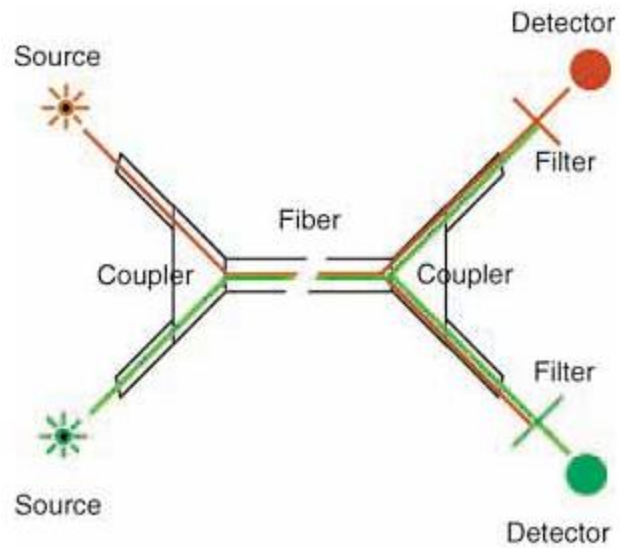


Figure [11]: WDM System with Filters And Detectors

1.4.2 FIBRE BRAGG GRATING(FBG)

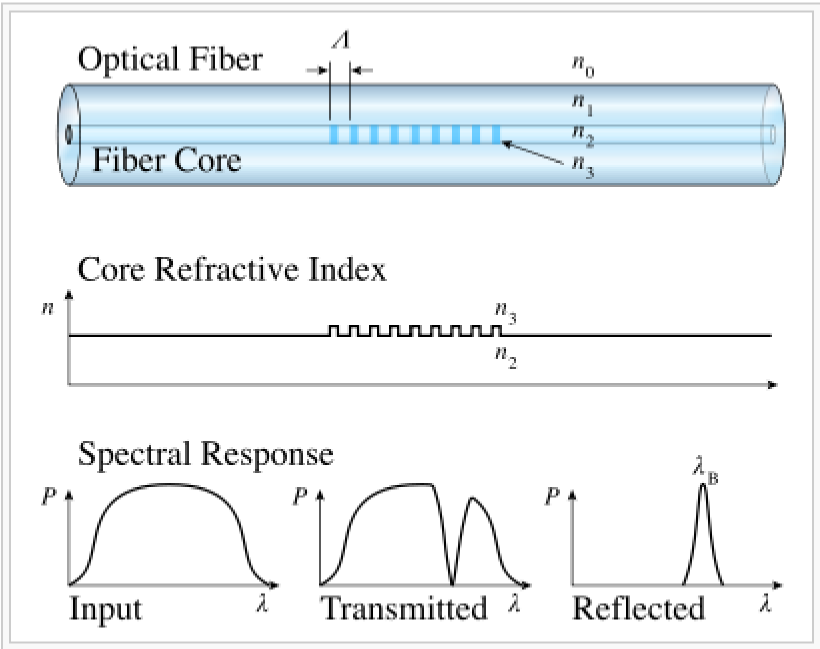
A fiber Bragg grating (FBG) is a type of distributed Bragg reflector constructed in a short segment of optical fiber that reflects particular wavelengths of light and transmits all others.

This is achieved by creating a periodic variation in the refractive index of the fiber core, which generates a wavelength-specific dielectric mirror. A fiber Bragg grating can therefore be used as an inline optical filter to block certain wavelengths, or as a wavelength-specific reflector.

The fundamental principle behind the operation of a FBG is Fresnel reflection,where light traveling between media of different refractive indices may both reflect and refract at the interface.

The refractive index will typically alternate over a defined length. The reflected wavelength (λ_B), called the Bragg wavelength, is defined by the relationship,

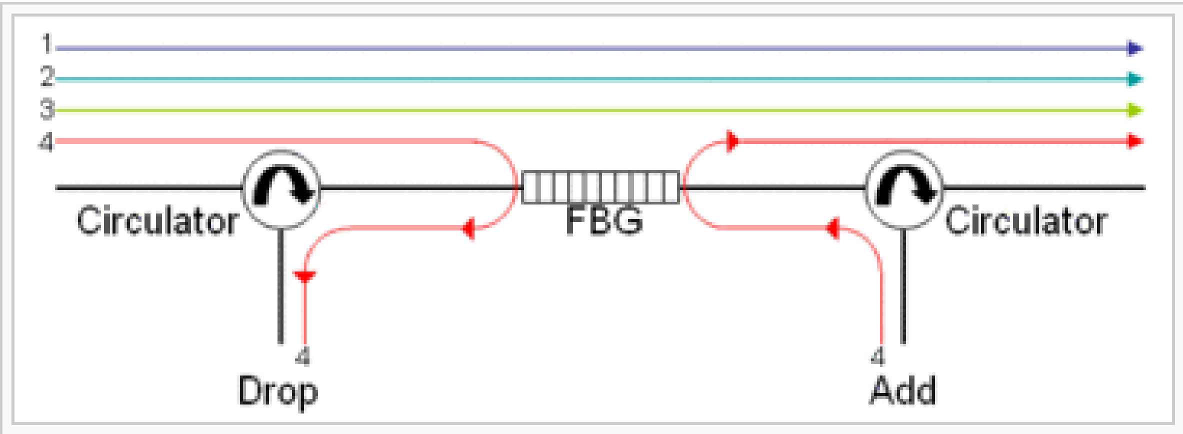
$$\lambda_B = 2n_e\Lambda$$



FIGURE[12]: A Fiber Bragg Grating structure, with refractive index profile and spectral Response

The primary application of fiber Bragg gratings is in optical communications systems. They are specifically used as notch filters. They are also used in optical multiplexers and demultiplexers with an optical circulator, or optical add-drop multiplexer (OADM). Figure 5 shows 4 channels, depicted as 4 colours, impinging onto a FBG via an optical circulator. The FBG is set to reflect one of the channels, here channel 4. The signal is reflected back to the circulator where it is directed down and dropped out of the system. Since the channel has been dropped, another signal on that channel can be added at the same point in the network.

A demultiplexer can be achieved by cascading multiple drop sections of the OADM, where each drop element uses an FBG set to the wavelength to be demultiplexed. Conversely, a multiplexer can be achieved by cascading multiple add sections of the OADM. FBG demultiplexers and OADMs can also be tunable. In a tunable demultiplexer or OADM, the Bragg wavelength of the FBG can be tuned by strain applied by a piezoelectric transducer. The sensitivity of a FBG to strain is discussed below in fiber Bragg grating sensors.



FIGURE[13]:- Optical add-drop multiplexer.

1.5: FREE SPACE OPTICAL COMMUNICATION

Free-space optical communication (FSO) is an optical communication technology that use for light propagating in free space median using light rays to wirelessly transmit data for computer networking or telecommunications. "Free space" means air, vacuum, outer space or something similar to free space. This contrasts with using solids such as optical transmission line or optical fibre cable. The technology is useful where the physical connections are impractical due to high costs, hiking or other considerations.

Free space optical (FSO) communications is an alternative means of providing high data rate over a short to medium range. it has seen a growing increase in research and development activities over the past few recently years. Increasing commercial demand of FSO could be said to be partly responsible for this surge new development in research activities. FSO is used in many numbers of applications including the cellular communication background, back-up link in optical fibre communications, exhibition halls, and disaster recovery among other emerging needed applications. However, the major concern in FSO for out-door environment is also dependence of its channel on unpredictable weather conditions likes rain, sun heat and air wind. Effects of rain, atmospheric gases, fog and aerosols or others result in beam attenuation due to photon absorption from electron and scattering process. Other factors that caused effect on FSO performance include turbulence, building sway, strong wind and background radiations and emission.

In dense climate conditions like fog, laser radiations suffers from high attenuation. it's up to ~270dB/km, thus resulting in deteriorated quality of service and reduced link span. To ensure that communication in this kind will depend on weather condition, a new hybrid scheme FSO/RF could be deployed. The advantage of hybrid FSO/RF is fact that electromagnetic waves within the radio frequency(RF) spectrum does not suffer a great deal of attenuation likes ~270dB/km in foggy weather unlike infrared radiations(IR). In clear and clean weather conditions when attenuation is minimal, FSO link is able to perform over a longer haul. But when distance greater than 1 km, the turbulence effect needs to be taken into consideration. The turbulence results from the random variation in the account of refraction of the atmosphere which is directly propontial to the atmospheric temperature fluctuations, wind speed and altitude. In FSO communication turbulence will result or caused effect in laser irradiance fluctuation also known as scintillation as well as the phase fluctuation. The Techniques those reported in literature to mitigated the effect of irradiance fluctuations include forward error control, temporal diversity and spatial effect, aperture is averaging and adaptive optics. In FSO using BPSK modulation scheme with subcarrier modulation was investigated in clear atmospheric turbulence with have no diversity and this was extended in with the inclusion of spatial diversity.

1.6: FREE SPACE OPTICAL LINK

Technologically, very less challenging are established the data links between metropolitan buildings (LAN-to-LAN connections), where a free-space laser makes data link over 100 meters of distances or even over a few kilo meters of distances can be very much simpler and more cost-effective to install the any kind of cable networks, particularly if a road in between coverage range or some other kind of barrier has to be crossed, or if a connection is required within a limited time. It is possible e.g. to obtain fast Internet access for all buildings and offices, even if only one of them has direct access to a fibre network.

The laser powers required are very moderate, as a significant factor of the sent the power can hit the receiver by the help of a photodiode. Therefore, there are usually no significant laser safety issues, if eye-safe lasers those don't put the effect on human which will be emitting in the 1.5-μm spectral region . However, the availability of services is very smaller than a cable cover-aging area, because the link between source to destination may be disturbed by some atmospheric influences (e.g.by heavy deeped fog, by heavy rain, by snow falls, or by strong wind) or by flying some objects such as airlines and birds. In this proposed, free-space transmission(FSO) is less robust from other wireless technologies such as radio links, but it also have a higher potential for transmission capacity, it is more immune against the electromagnetic interference(EMI/EMC), and does not raise concerns in the context of electro-magnetic interference. And also does not lead to interference between different data links, so that it does not need of a license to be giving service, and in terms of data security it is superior, since it is very difficult to intercept a tightly collimated laser beam than a radio link. Finally, the reliability of it's can be enhanced in various ways, (e.g. with multibeam architectures of laser light) larger power margins as compare to Rf link, and backup systems, and the security can be extremely very high with certain schemes of quantum cryptography.

For not too long haul distances (e.g., up to few kilometers) and moderate data rates, one does not required a laser transmitter, because the use of light-emitting diodes (LEDs).

It is even possible to establish short-range optical link in which the data connections without a direct line of sight(LOS). When ultraviolet light(UV) is used, this is strongly scattered in the atmosphere region, and it is possible to receive some part of that light. That technology has become more popular with the advent of light-emitting diodes (LEDs) emitting in the deep UV (UV-C), and also suitable for semiconductor photodetectors.

Essential advantages of laser data links over satellite,radio frequency or microwave links are the promise to high data rate, , compact size, low power requirements and lower probability of signal interception by another parties. And one more advantage is, there is no need for governmental frequency assignment and no risk of different laser data links of mutual interference.

1.7: FREE SPACE OPTICAL NETWORK

Fibre optical uses light signals to transmit data. As this data moves across a fibre, needs to be a way those will separate it so that finally, it gets to the proper point of destination. There are basically two important types of systems that make the fibre-to-the-home broadband connections possible. These are called active optical networks and passive optical networks. Each of them offers the ways to separate data and route it into the proper place or destination, and each one have advantages and disadvantages as compared to the other.

On the other hand, A passive optical network, does not include any electrically powered switching equipment and it uses the optical splitters to separate the power signal and collect all the optical signals as those move through a network. A passive optical network shares the fibre optical strands for portions of the network. Powered equipment is only required at the source side and receiving ends side of the signal.

In some cases, To form a hybrid system sometimes a FTTH systems may combine elements of both active and passive architectures.

Passive optical networks, or also called PONs have some advantages. They're efficient, in which each fibre optical strand can serve up to 32 users. PONs have a low building cost relative to active optical networks along with the lower maintenance costs. Because there are few moving particles likes as electrical parts, they simply less that can go wrong in a passive ptical network.

Passive optical networks(POS) also have some disadvantages. They have less range as compare to an active optical network, that’s mean subscribers must be geographically closer the central source of the data. Passive optical networks also make it difficult to calculate a failure when they occur. Also, due to the bandwidth in a Passive optical network is not dedicated to individual subscribers, data transmission speed may be down slow during the peak usage times

in an effect which is known as latency. Latency will quickly degrades services such as audio and video, which need a smooth data rate to maintain quality.
Fibre optical uses light signals to transmit data. As this data moves across a fibre cable, needs to be a way to separate it so the optical signal can get to the proper destination.

An active optical system uses electrically powered switching equipment, such as a router or a switch aggregator, to manage signal distribution and direct signals to specific customers. This switch opens and closes in various ways to direct the incoming and outgoing signals to the proper place. In such a system, a customer may have a dedicated fiber running to his or her house.
Active optical networks(AOS), however, also have some weaknesses. They require at least one switch to be aggregator for every 48 subscribers. Because it requires power, inherently an active optical network is less reliable than a passive optical network.

1.9: MODULATION TECHNIQUES

Modulation is a process in which the properties of a sinusoidal signal (like Frequency, Amplitude And Phase) also called the carrier signal is linearly varied accordance with massage signal. Massage signal is called the base signal and modulated signal is called the band pass signal. Base band signal will be inside the pass band signal and carrying the massage information. Modulation is used for reduce the height of the antenna, to reduce noise factors and transmitting the high power at the receiver end. Modulation basically are two types Analog and Digital. In Analog modulation the signal is varied continuesly but in digital modulation scheme data should be in form of binary sequence and transmitted over an analog signal. Analog modulation scheme is used in transmitted the broadcast signal for TV and Radio transmission.
Now these days we used the very advanced modulation techniques because data demand is increased day by day and we have limited spectrum. And provide the minimum probability of error to an user. More than one bits transmitted at a time. There are some techniques are following below:

1.9.1 ON-OFF Keying:- It is a digital modulation technique. The simplest basic form of Digital Modulation represents a series of logical '1's and '0's by simply switching the on and off the carrier. By this reason it is called *On-Off Keying* (OOK).In which massage signal is converted into binary bits and transmitted over the channel in analogue form. The simple binary scheme can be carrying one bit at a time. The bandwidth requirement and probability of error is more in simple binary modulation scheme. In the figure '1' is represent by the amplitude is high or ON process and '0' is represent the no informatin is present in signal and keying is Off. We can represent into algebraic form also that is

$$S\{t\} \equiv a \text{ Sin}\{2\pi f t + \varphi\}$$

Where a is represent the amplitude of carrier signal And q represent the phase of carrier signal. The on/off keying modulation is to have a capability of burst the carrier power during every symbol period, but to change the phase of the carrier to during a '1' from a '0'. This method is called the *Binary Phase Shift Keying* (BPSK) modulation, and it's generally preferred to the simple on/off keying(OOK) method.

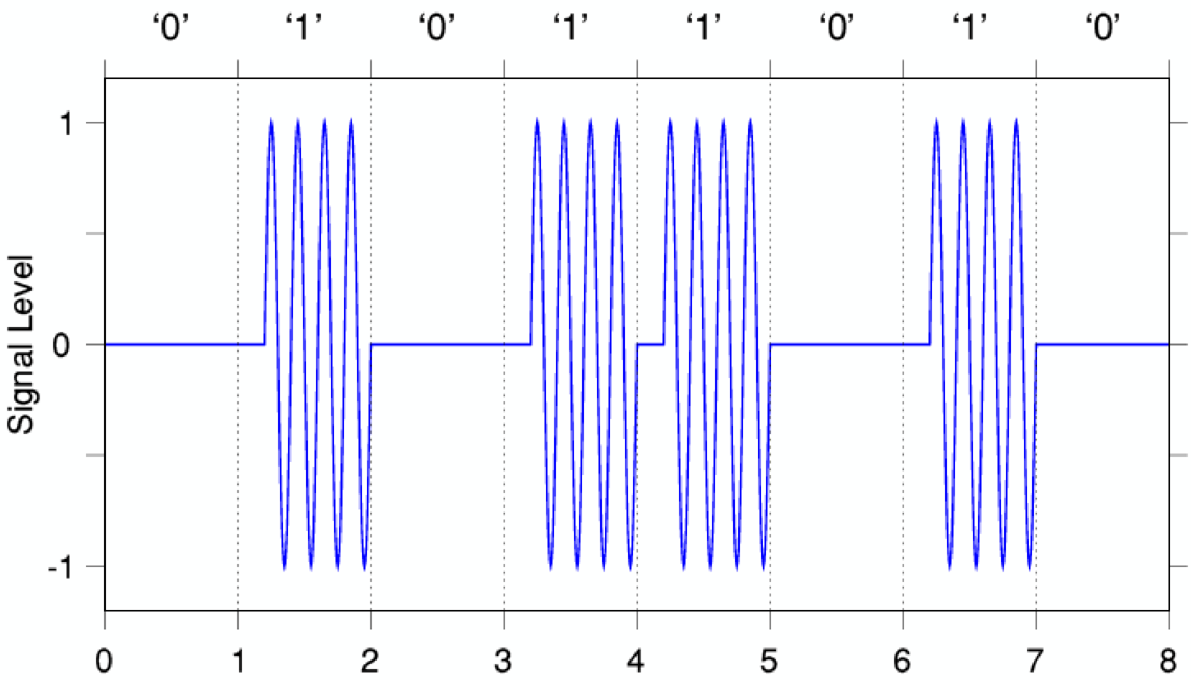


Figure [14]: Simplest On-Off binary Keying

1.9.2: Quadrature Phase Shift keying (QPSK):

Quadrature Phase Shift Keying(QPSK) is type of phase shift keying(PSK) modulation scheme.

In this technique two bits of information can be transmitted at a time. In QPSK the bandwidth requirement is half then the BPSK. And probability of error is twice the BPSK. Which is a DSBSC modulation scheme with digital bits for the base band. QPSK is also the DSBCS scheme but it is capable for sending two bits at a time of information signal in same carrier. At the input side of the modulator, data's even bits (i.e., bits 0,2,4,6 and so on) are stripped from the data bit stream by using a "bit-splitter" and are multiplied with a carrier signal that generate a BPSK signal. On another hand,the data's of odd bits (i.e., bits 1,3,5,7,9and so on) are stripped from the data bit stream and also multiplied with the same carrier signal at the same time and also generate a second BPSK signal .However, these carrier signal's is phase shifted by 90^o before being modulated.

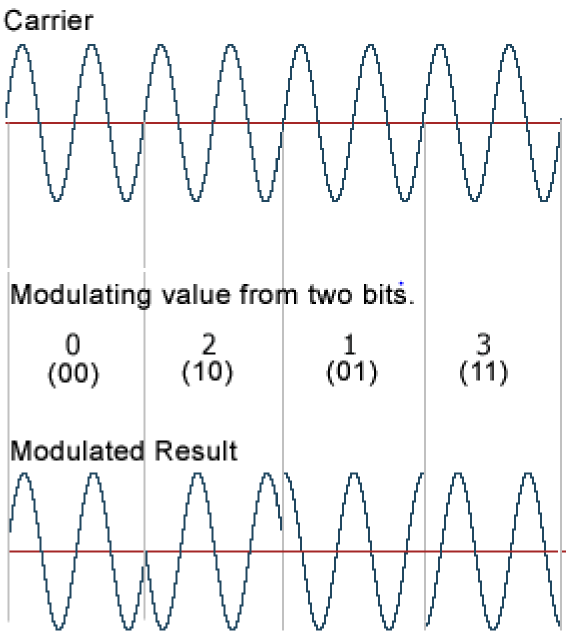


Figure [15]: QPSK Modulated Waveform

The two BPSK signals are added together for transmission and they have the same carrier signal, they will on the same portion of the radio frequency spectrum. While the two sets of signals would be irretrievably mixed together and they required the 90° of phase difference between the carriers.The constellation diagram of QPSK is as shown below:

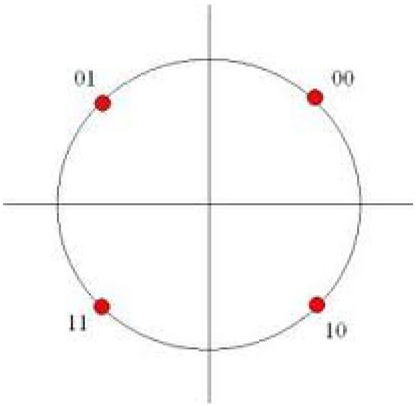


Figure [16]: QPSK Conselation Diagram

With four different phases, QPSK can able to encode the two bits per symbol that to minimize the BER that is the twice from BPSK. this is used for sending the double data rate compared to a BPSK. To maintain the data rate of BPSK but half bandwidth is needed. The implementation of QPSK is more simple than the BPSK. Symbols writing in the constellation diagram in terms of sine and cosine waves. This have the four phases $\pi/4$, $3\pi/4$, $5\pi/4$ and $7\pi/4$ as shown. This is a two dimensional signal space with own unit basis functions. The first basis function is used for the in-phase component and the second basic function used as the quadrature component of the signal. Hence the signal constellation diagram consists of the four signal space points.

1.9.3 Differential Phase shift keying

For the DPSK signal generation, we will use two concatenated modulators. In DPSK format the phase modulation was generated by using a duo-binary the NRZ signal is firstly encoded that will drive the first MZM and modulates the phase of the CW signal. Then concatenate the first modulator with second modulator driven by a sinusoidal electrical signal with the frequency of 20 GHz. And then the encoding in the initial bit sequence will allow the demodulation of the transmitted signal at the receiver by using a Mach-Zehnder interferometer and balanced photodiodes. The various phases of the optical carrier are also used to represent the digital signal, which is OPSK (Optical Phase Shift Keying). The improvement of mono frequency laser sources with the active optical phase locking application makes the PSK very use full in all the formats. The DPSK modulation format is the most widely used among others. It will be recognized as "1" When there is a phase change between consecutive data bits in the carrier, and it will be considered as digital "0" when there is no phase change. The optical power remains always constant is the main aspect of NRZ DPSK signal. Here the DPSK modulation format comes to be the best format among MDRZ and CSRZ.

CHAPTER 2

LITERATURE REVIEW

[1] Bijenanda Patnaik∗,and P.K. Sahu "**Optimized ultra-high bit rate hybrid optical communication system design and simulation" 2011 Elsevier.**

In this proposed paper, The Authors is work done on the hybrid optical communication. The system uses 1550 nm wavelength and applicable for boths. wired optical communication is used for long haul communication and free space communication for short haul communication. Firstly, the wired optical link is coming in an office, home or a building throw the optical cable for long haul communication and in office it's provide the WOBAN service through the laser beam prvide the connectivity between transmitter and receiver. Which is also capable for high data rate and minimization the atmospheric turbulence but this technology for short distance(<1KM). this technology is very good in term of security. Because no other user can not be access the service. 1550 nm wavelength is selected here for ultra-high bit rate FSO system. Modified duo-binary return-to-zero (MDRZ) is the best modulation technique for tolerating dispersion and non-linearity present in the optical fiber. This also proved that among several dispersion compensation techniques, symmetric dispersion compensation technique is the best for long haul communication. For free space optical communication, the QPSK is used because Sometimes there is no line of site between the transmitter is present due to the atmospheric turbulence. Qpsk having low probability of error and coverage distance is high. And modulation technique with an atmospheric attenuation of 200 dB/km is considered.

[2] W.O. Popoola and Z. Ghassemlooy,"**Free-Space Optical Communication in Atmospheric Turbulence using DPSK Subcarrier Modulation",** IEEE 2009.

The performance of free-space optical communication link and the bit error rate (BER) expression in clear atmosphere but in turbulent atmosphere using subcarrier intensity modulation (SIM) with differential phase shift keying (DPSK) is presented. The practical linear combining of boths technique suitable for differentially modulated data (selection combining) is to be considered and its performance evaluated under clear or atmospheric turbulence. The theoretical link margin obtainable from using selection combining of boths under clear or weak turbulence modeled is also discuss the log normal distribution .

[3] Simranjit Singh, R.S. Kaler∗,"**Performance evaluation of 64×10 Gbps and 96×10 Gbps DWDM system with hybrid optical amplifier for different modulation formats,** Elsevier 2011.

In this paper, The Authors investigated the performance of multi terabits DWDM system consisting of hybrid optical amplifiers RAMAN-EDFA for differents data format such as return to zero (RZ), non-return to zero (NRZ) and differential phase shift keying (DPSK). they find the in 64×10 Gbps and 96×10 Gbps system, RZ is more advenced affected by nonlinearities, and NRZ and DPSK is more affected by effect of dispersion . Then they further show that RZ format provide good quality factor (13.88 dB for 64 channels and 15.93 dB for 96 channels), less eye closure (2.609 dB for 64 channels and 3.191 dB for 96 channels) and bit error rate is acceptable (3.89×108 for 64 chanels and 1.24×109 for 96 channels) at the respective distance as compare to someother existing modulation format. They further investigated the maximum single span distance covered by using suitable existing data formats.

[4] Simranjit Singh, R.S. Kaler," **Hybrid optical amplifiers for 64×10 Gb ps dense wavelength division multiplexed system." in Elsevier 2012.**

In this paper, The performance of the optical amplifier for 64×10 Gbps dense wavelength division multiplexed (DWDM) system has been compared between optical/hybrid system. It is consered that hybrid optical amplifier (RAMAN–EDFA) provide us better results as compared to others conventional amplifiers. The impact of modulation scheme (RZ,NRZ and DPSK) on hybrid optical amplifier has been furthering investigated and found that 64×10,means 64Gbps for 10 channels. Adversely affected by nonlinearities on RZ is more, where the NRZ and DPSK is more affected by dispersion.

[5] 1Chirag Saini, 2Gaurav Agarwal, 3Vikash Patnaik,4Jabeena A," **Performance Analysis of Different Hybrid-Optical Amplifiers".** ***SSRG-IJECE April 2014.***

This paper analyses the optical fibre amplifiers Such as Raman amplifiers (RAs), Erbium doped fiber amplifiers (EDFAs), semiconductor optical amplifiers (SOAs), and Hybrid configurations of these, namely EDFA-EDFA, Raman-EDFA, EDFA-SOA, and Raman-SOA. The hybrid optical amplifiers configuration at 10*96. Means 10Gb/s for 96 channels. Calculating their configuration such as Qfactor, bit error rate, eye opening, eye closure and output power are compared by varying distances from 60 to 180 km and also keeping the fixed dispersion at 2 ps/nm/km both terms in the presence and absence of non-linearities. Furthermore, then go through the some of the main characteristics of these amplifiers and applicibility of Hybrid optical amplifiers over the basic single optical amplifiers. Every amplifier is suitable for certain applications and performance depending on there characteristics and the transmission distance.

[6] Ankit V. Patel, R.B Patel and Kinjal, A Mehta **"Comparative Analysis of Single Span High Speed 40 Gbps Long Haul Optical Link Using Different Modulation Formats in the Presence of Kerr Nonlinearity" in IEEE 2014**.

This paper proposes to examine long distance optical link by using various modulation format by using three dispersion compensation schemes in the presence of nonlinear effect. Here in this paper modulation formats like carrier-suppressed return to zero (CSRZ), modified duo binary return to zero (MDRZ), and differential phase shift keying (DPSK) are used. For this modulation format effect of change in the input power and transmission distance is observed in terms of Q value, BER and eye opening. For all three modulation formats the pre, post and symmetrical analysis is also carried out. We are simulating the single span optical link for long transmission distance. In all the three Pre, Post and Symmetrical Compensation schemes performance analysis is done for the three different modulation schemes used CSRZ, MDRZ and DPSK. Among the modulation formats DPSK with Symmetrical DCF compensation performance in terms of Q value, BER and eye opening is better than all.

[7] Jyoti Choudhary; Lalit Singh Garia and Rajendra Singh Shahi **"Comparative analysis of DWDM system using different modulation and dispersion compensation techniques at different bit rates" in IJARCSE 2014.**

In this paper 16 channels DWDM system using different modulation techniques like NRZ, CSRZ, MDRZ and DRZ is used . here we are using different dispersion compensation schemes like pre, post and symmetric at various bit rates 10Gbps, 20Gbps and 40Gbps are used to find the difference in terms of BER and Q factor among them and we concluded that symmetric compensation gives the better result among pre and post compensation techniques at 40Gbps data rate with MDRZ (modified duo binary return to zero) modulation technique.

[8] Sandeep Singh and V.B Tyagi ***"Performance Analysis of WDM Link Using Different DCF Techniques"*** **in IJARCSE 2012.**

In this paper the most commonly used technique is dispersion compensation fibre (DCF). Here we are studying the three compensation schemes pre-compensation, post compensation, symmetric –compensation which shows the symmetric is the best. Symmetric compensation generally reduces the influences of the fibre nonlinearity and also help full in increasing the transmission distance. Symmetric-compensation scheme reduce the fibre nonlinear effects better than other two.

[9] **Saurabh Kumar, M Kumar and A.K Jaiswal** ***"Performance Analysis of Dispersion Compensation in Long Haul Optical Fiber with DCF"*** **in IJOR 2013.**

This paper proposed to investigate post, pre and symmetrical/mix dispersion compensation methods for 40 Gb/s for non-return to zero link using dispersion compensated fibre to optimize high data rate optical transmission. By increases the power of CW laser evaluation is done for the performance of optical communication systems. The simulation is done for finding the Q factor and bit error rate (BER). Here we are using fibre brag gratings (FBG) are implemented instead of using dispersion compensated fibre (DCF) for dispersion compensation schemes. It is found that compensation schemes reduced the dispersion but the post compensation scheme reduced the chromatic dispersion to the maximum possible value. Bigger value of laser average power is favourable to the performance of the transmission system. So dispersion and loss are the major factor that that plays a role in affecting the fibre-optical communication. So here we are studying how to reduce the loss and dispersion by affecting the long haul optical fibre.

[10] Anandita joy Agarwal 1, Mukesh kumar 2 , Rohini Saxena 3" **Comparison of different techniques of dispersion compensation" in ijecse 2013.**

This paper proposed we will study the various types method of dispersion compensation scheme in single mode fibre created because of dependence of group index to wavelength known as chromatic dispersion. Various methods of dispersion compensation are Dispersion compensation fiber (DCF) which compensates dispersion at 1310nm and 1550 nm and Fiber Bragg gratings (FBG) which compensate dispersion at wavelength around 1550nm. Also we will study the comparison between the two. DCF techniques increases the total losses non-linear effects and costs of optical transmission system. FBG helps in decreasing the cost of the system and also have low insertion loss.

[11] Kishore Bhowmik1, Md.Maruf Ahamed2 And Md.Abdul Momin3.” **Reduction of Dispersion in Optical Fiber Communication by Fiber Bragg Grating and Optical Phase Conjugation Techniques”,** in IJMNCT june 2012.

In the modern day industries, Fiber optic transmission and communication are technologies that are constantly growing and support more challenges. Three properties of optical fibers are dispersion, absorption and scattering which cause attenuation and also decreased in transmitted power. To combat these losses and improve the reliability of fibers introduced many advanced technologies. Here two compensation techniques such as Fiber Bragg Grating and Optical Phase Conjugation are discussed with the help of simulation software “**OPTSIM”** to compensate dispersion**.** We have also analyzed the time delay of the received signal with variation of frequency by using **B4530 trainer** in the “Telecommunication Lab, Rajshahi University of Engineering & Technology, Bangladesh” and proved that when frequency of the transmitted signal increases then time delay i.e. dispersion of the received signal decreases.

[12] Xiaoming Zhu and Joseph M. Kahn, “**Free-Space Optical Communication Through Atmospheric Turbulence Channels”** in IEEE transaction 2002**.**

In free-space optical communication links, atmospheric turbulence causes fluctuations in both the intensity and the phase of the received light signal, impairing link performance.
In this paper, we describe several communication techniques to mitigate turbulence-induced intensity fluctuations, i.e., signal fading. These techniques are applicable in the regime in which the receiver aperture is smaller than the correlation length of fading and the observation interval is shorter than the correlation time of fading. We assume that the receiver has no knowledge of the instantaneous fading state. When the receiver knows only the marginal statistics of the fading, a symbol-by-symbol ML detector can be used to improve detection performance. If the receiver has knowledge of the joint temporal statistics of the fading, maximum- likelihood

sequence detection (MLSD) can be employed, yielding a further performance improvement, but at the cost of very high complexity. Spatial diversity reception with multiple receivers can also be used to overcome turbulence-induced fading. We describe the use of ML detection in spatial diversity reception to reduce the diversity gain penalty caused by correlation between the fading at different receivers. In a companion paper, we describe two reduced-complexity implementations of the MLSD, which make use of a single-step Markov chain model for the fading correlation in conjunction with per-survivor processing.

[13] Hennes HENNIGER1, Otakar WILFERT2," **An Introduction to Free-space Optical Communications",** RADIOENGINEERING, VOL. 19, NO. 2, JUNE 2010.

In this paper proposed, Free-space optical communication (FSO) systems (in space and inside the atmosphere) have developed in response to a growing need for high-speed and tap-proof communication systems. Links involving satellites, deep-space probes, ground stations, unmanned aerial vehicles (UAVs), high altitude platforms (HAPs), aircraft, and other nomadic communication partners are of practical interest. Moreover, all links can be used in both military and civilian contexts. FSO is the next frontier for net-centric connectivity, as bandwidth, spectrum and security issues favor its adoption as an adjunct to radio frequency (RF) communications.

CHAPATER-3

PROBLEM FORMULATION

A number of techniques are being found to increase speed and the length of fibre optic link. The research proved that the major issue which comes across while attaining high speed and long haul optical links for hybrid optical communication means wired and wireless communication. When the data rate should be high on the another hand is various types of noise like chromatic dispersion, PMD and non -linear effect like kerr effect. Out of these noises, Chromatic dispersion significantly affects the system quality.

From literature survey, we concluded number of suggested ways but the issues is with implementation of these ways inspires us to look forward for solution which in itself should not be a problem to the high data rate and long distances optical network issue.

Discussion of various problems identified:

1. In analysis of MDRZ modulation format we getting the waek signal for hybrid configuration to remove that problem we again put the modulation scheme QPSK for short haul communication.

2. Signal power: when the distance should be more then the power level should be low. But in long haul link high power is required so high power in long haul high speed link create problem.

3. Increasing the cost: When we used two modulators for provide the hybrid communication then the cost of the link should be more and set up problem for the link.

So, by analysing the various issues in solutions of various reports in literature survey motivates us to find a promising way out to decrease the cost, chromatic dispersion noise issue which can help us to enhance the high speed long haul systems in future and also to increase the speed of already existing systems by making minor possible changes into them.

CHAPATER 4

OBJECTIVES AND RESEARCH METHODOLOGY

4.1 <u>Objectives:-</u> In our thesis work the basic objective is to provide the high data rate at long haul communication and also keep the probability of error minimum as possible. In base paper[1] work done on hybrid wireless optical broadband accesses network. In this wired communication is used for long haul and free space link for short haul. The aim of this paper is to high data rate at longer distance.in this paper the modified due to return to zero modulation technique is used for long distance communication and quadrature phase shift keying is used for free space communication. Which is provide the minimum error probability and best LOS between transmitter and receiver. To setup the perfect line of site and diffusion link between transmitters and receiver and also effect of atmospheric turbulence. We have also notice the effect of dispersion on system and Also analysis the effect of pre, post and symmetric configuration of DCF on chromatic dispersion. We will analysis the effect of bit error rate, power received at the receiver side and signal to power ratio. The main objectives is followings:-

1. Analysis simulative investigation of CSRZ at the place of MDRZ modulation scheme on long wired link and QPSK short distance FSO link.
2. Comparative Analysis of Pulse Width Reduction Techniques in DPSK system Using DCF and FBG.
3. Design of 160G Hybrid Communication System in Passive Optical Network Using Wired and Wireless Channel.
4. To compare and analyse parameters of DPSK in terms of Q-factor, Bit Error Rate, Received Power and Signal to Noise Ratio at output.

4.2 <u>Research Methodology</u>:-

The first step will be designing and simulation of the Ultra-High Bit Rate Hybrid optical communication system design Using MDRZ for long haul communication and QPSK modulation schemes in Presence of Atmospheric Turbulences as shown in base paper but design passive optical network using only DPSK modulation format. This will be done by using Optiwave's Optisystem software. Firstly the study about software will be done. The optisystem software is easy to use, flexible, powerful and fast. The optisystem enables users to plan, test and simulate the following:

1. Optical Fiber network design.
2. SONET/SDH ring design.
3. Transmitter, channel, amplifier and receiver design.
4. Dispersion map design.
5. Estimation of BER and system penalties with different receiver models.
6. Amplified system BER and link budget calculations.

The optisystem components library includes one to hundreds of components that enable to enter parameters that can be measured from real devices value. We can incorporate new components based on subsystems and user-defined libraries, or utilize co-simulation with a third party tool such as MATLAB or SPICE.

In order to predict the system performance, optisystem calculates parameters such as BER and Q factor using numerical analysis or semi-analytical techniques for systems limited by Intersymbol Interference and noise. Optisystem allow us to incorporate dispersion compensation technique by using different configurations. This allows to process data after simulation without recalculating. An arbitrary number of visualizers can be attached to the monitor at the same time.

By using model design in optisystem software, the parameters such as Data rate, modulation schemes, signal power etc are varied and used to study system performance. The BER analyzer visualizer will be used for analysis, where the system BER, Q-factor, and eye diagrams will be obtained. And the graphs between Q-factor,power ,BER plot will be plotted.

4.3 Problem Formulation:-

A number of techniques are being found to increase data rate and the length of fiber optic link. The research proved that the major issue which comes across while attaining high speed and long haul optical link is various types of noise like chromatic dispersion, attenuation significantly affects the system quality .Also there is major issue that to connect every user with the fiber for data access ,number of fibers are needed which increase the deployment cost.

From literature survey, we come across a number of suggested ways come but the issues with implementation of these ways inspires us to look forward for solution which in itself should not be a problem to the chromatic dispersion and deployment of least fiber to home by using hybrid network.

Discussion of these solutions include:

1. **Deployement cost:** Optical high speed links are used using different modulation schemes ,but for end user to avail the data speed fiber should be reach at user's home.It increase the fiber deployment and cost.
2. **Conventional FSO systems:** conventional FSO systems operate at 800nm which covers small distance and carry only the 2 Gbps data or less than.so for high data rate conventional FSo is not compatible.
3. **OOK modulation**:On off keying is conventional modulation scheme simplest and widely in use.But ook scheme is not immune to atmospheric turbulences.
4. **Non symmetric DCF:** single configuration DCF are used in system to get best results. a novel fiber introduction to non-symmetric place reduce the dispersion but not give best results.

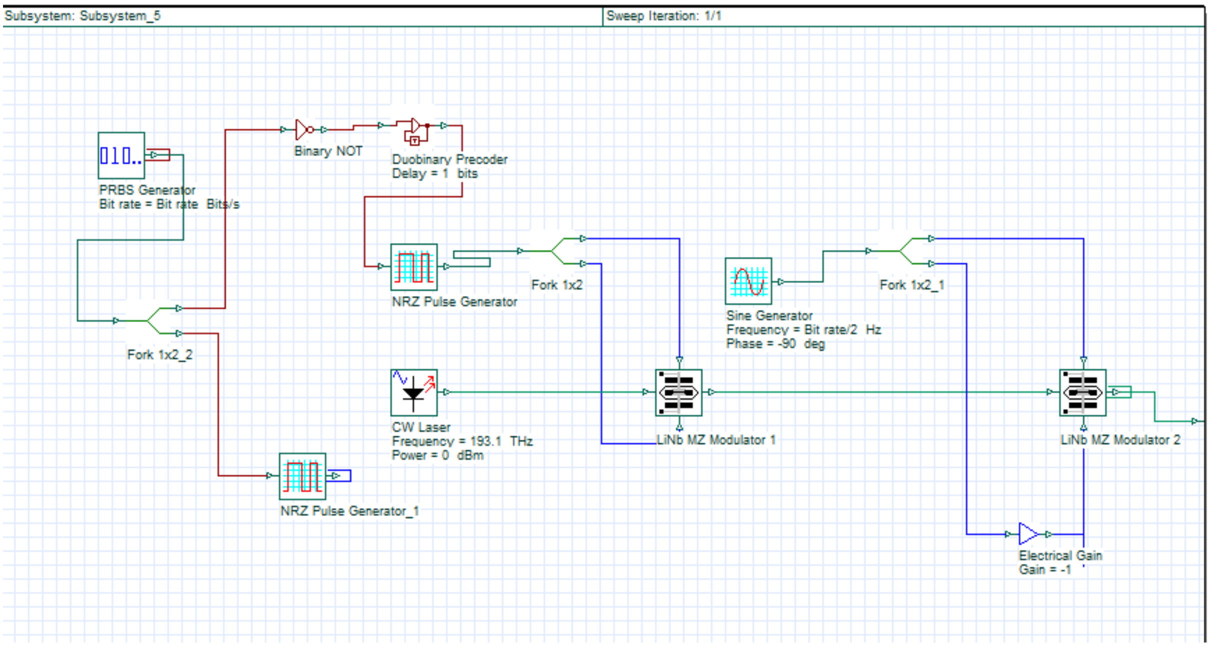
So, analyzing the various issues in solutions of various reports in literature survey motivates us to find a promising way out to provide wireless access to users and to solve chromatic dispersion noise issue which can help us to enhance the hybrid high speed network systems in future and also to increase the speed of already existing systems by making possible changes into them.

CHAPATER 5

SIMULATION SETUP & RESULTS & CONCLUSION

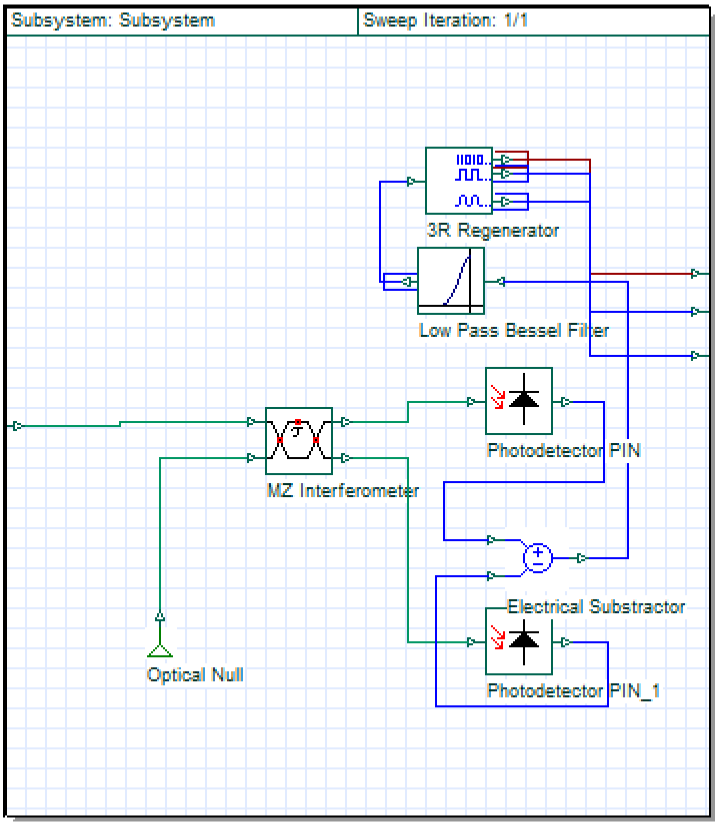
5.1 SIMULATION SETUP:-

In my research DPSK transmitter is used and it also used 8 different channels for providing the connectivity to different-different users. Basically, in my work done 4 channels is used for wired communication and 4 channels is used for wireless communication these 4 wireless channels can provide access to different building, office and homes. In my workdone we basically reduce the cost of the system and provide the accessibility to many users.



SIM FIG 1: DPSK transmitter model inside look

And now DPSK (Differential phase shift key) receiver model subsystem inside look in FIG 2:



SIM FIG 2: DPSK RECIEVER model inside look

So we came to know about the DPSK (Differential phase shift key) transmitter and receiver model inside look for the simulation setup for dispersion compensation schemes. Now TABLE 1 and TABLE 2 are used for showing the simulation parameters and the fibre parameters used in DWDM system are as follows:

Table 1: Simulation parameters

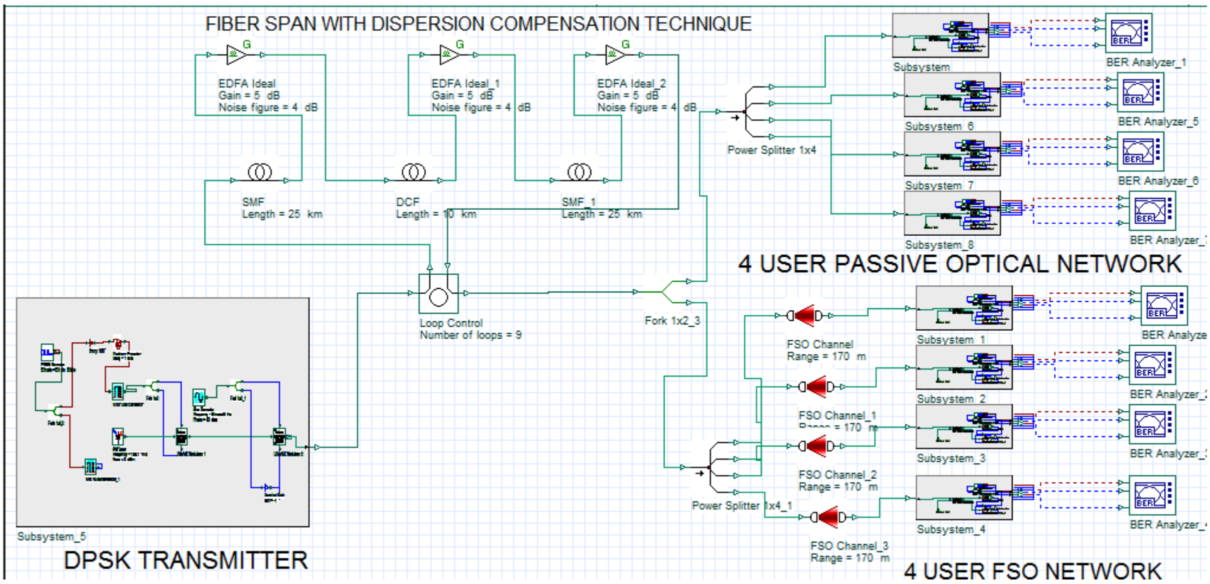
BIT RATE	160 GBPS
SEQUENCE LENGTH	128
SAMPLES PER BIT	64
BANDWIDTH	20
SPACING BETWEEN CHANNELS	1550nm
CAPACITY	160Gbps*8

Table 2: Fibre parameters

PARAMETER	SMF	DCF
ATTENUATION (dB/Km)	0.2	0.5

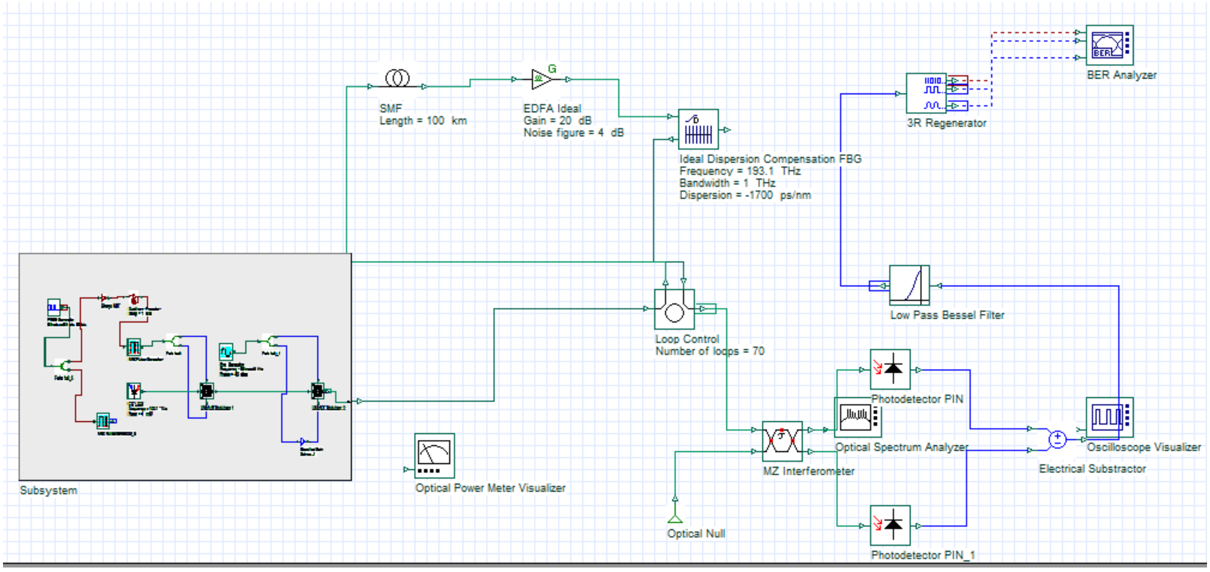
DISPERSION (ps/nm/Km)	17	85
DISPERSION SLOP (ps/Km- nm2)	0.075	-3
DIFFENTIAL GROUP DELAY (ps/km)	0.2	0.2
EFFECTIVE AREA	70	22

The simulation set up for DPSK (Differential phase shift key) PON (Passive Optical Network) system using Symmetric dispersion compensation technique in FIG 3:



SIM FIG 3: DPSK DWDM SETUP FOR SYMMETRIC DISPERSION SCHEMES

Now by FBG pulse reduction technique which is usefull to compress the pulse width which is directly propontial to spacing and bandwidth should be high. FBG is technique which is usefull in many area of fibre like reduce the spacing, sensoning, long term stability, minituire size, multiplexing and easy or cost of installation.



SIM FIGURE 4- FBG Compensation Technique

5.2 RESULTS AND ANALYSIS

The DPSK (Differential phase shift key) modulation format for different dispersion compensation schemes ie: pre, post and symmetric compensation schemes for 8 channels but symmetric is given best result as compare to all others techniques as we used symmetric technique as soon in base paper.

DWDM (Dense wavelength division multiplexing) system results are obtained in terms of Quality (Q) factor and BER (Bit error rate) by using eye diagram formation. To analyse the DPSK - DWDM system the results of first channel has been taken as it is a worst case format and the worst Q factor comes in 1st and 8th channel as they experience the most dispersion and nonlinear effects. The performance of pre, post and symmetric compensation has been analysed for various distance. The narrow channel spacing is done for 25 GHz form the central frequency of 1st channel 193 THz to 193.2 THz of 8th channel by using polarization interleaving technique.

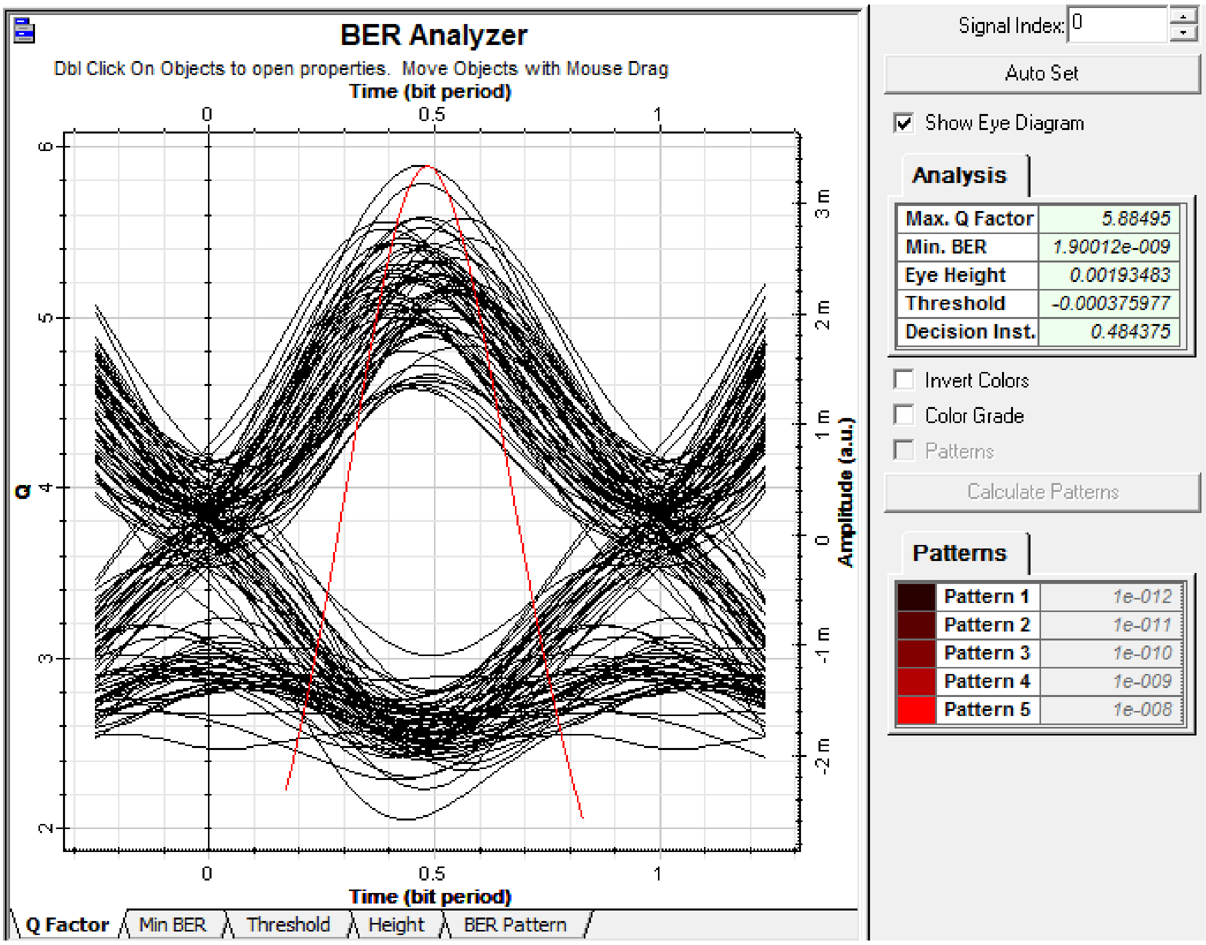


Fig A) FBG Compensation Scheme

In Fig B Shows that the DCF Compensation Scheme Which is shown the less BER as shown in diagram and less Q factor So concluded that FBG is Better than DCF For Pulse Width Reduction Technique.

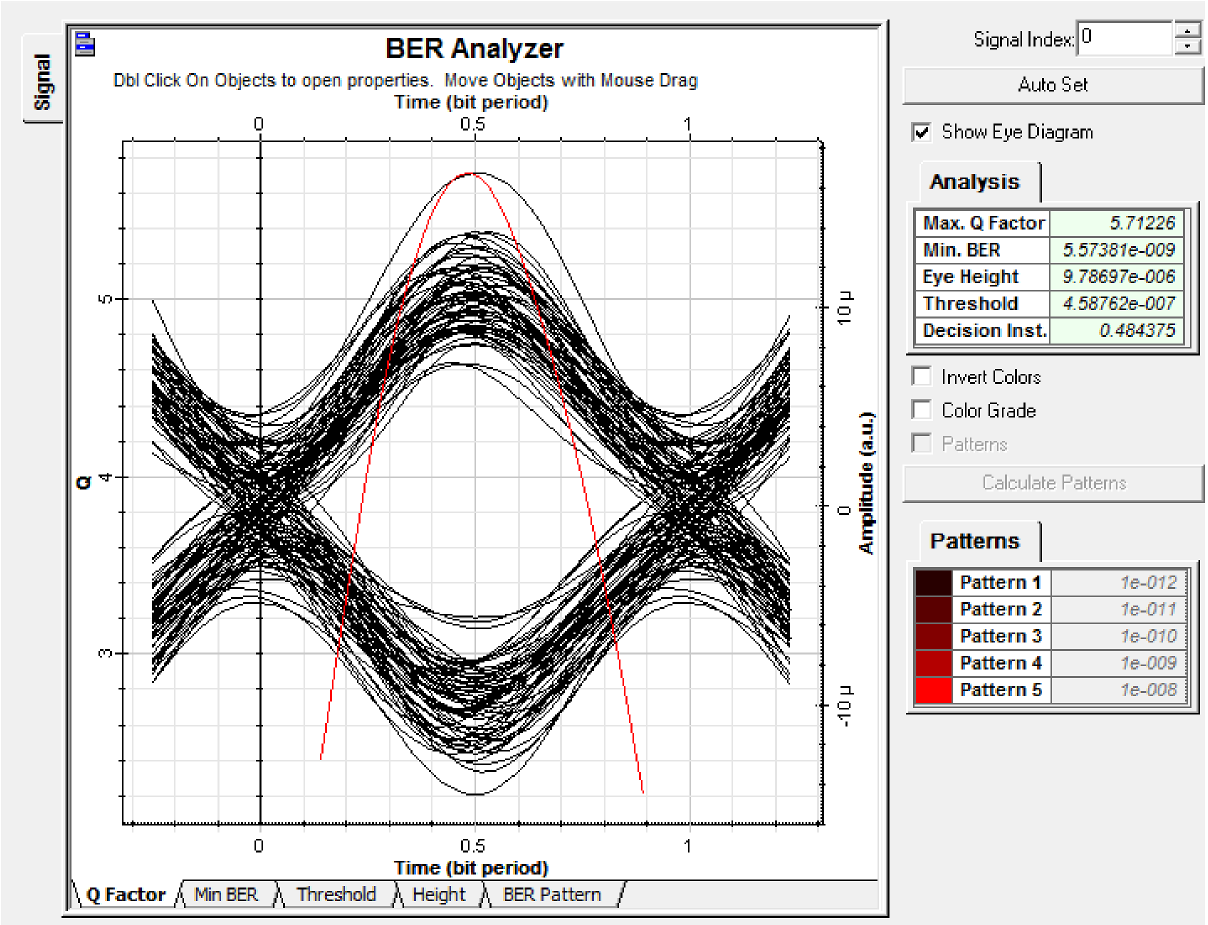
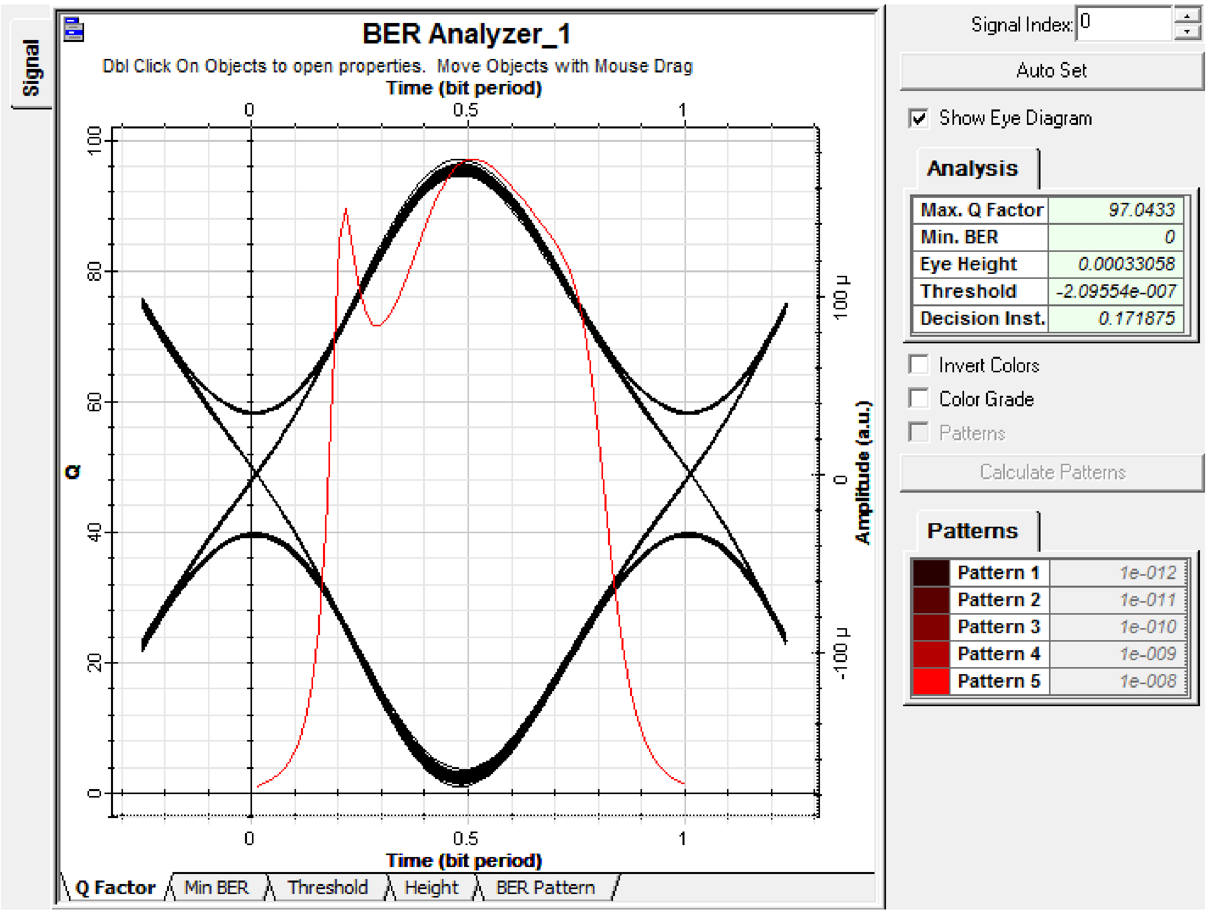


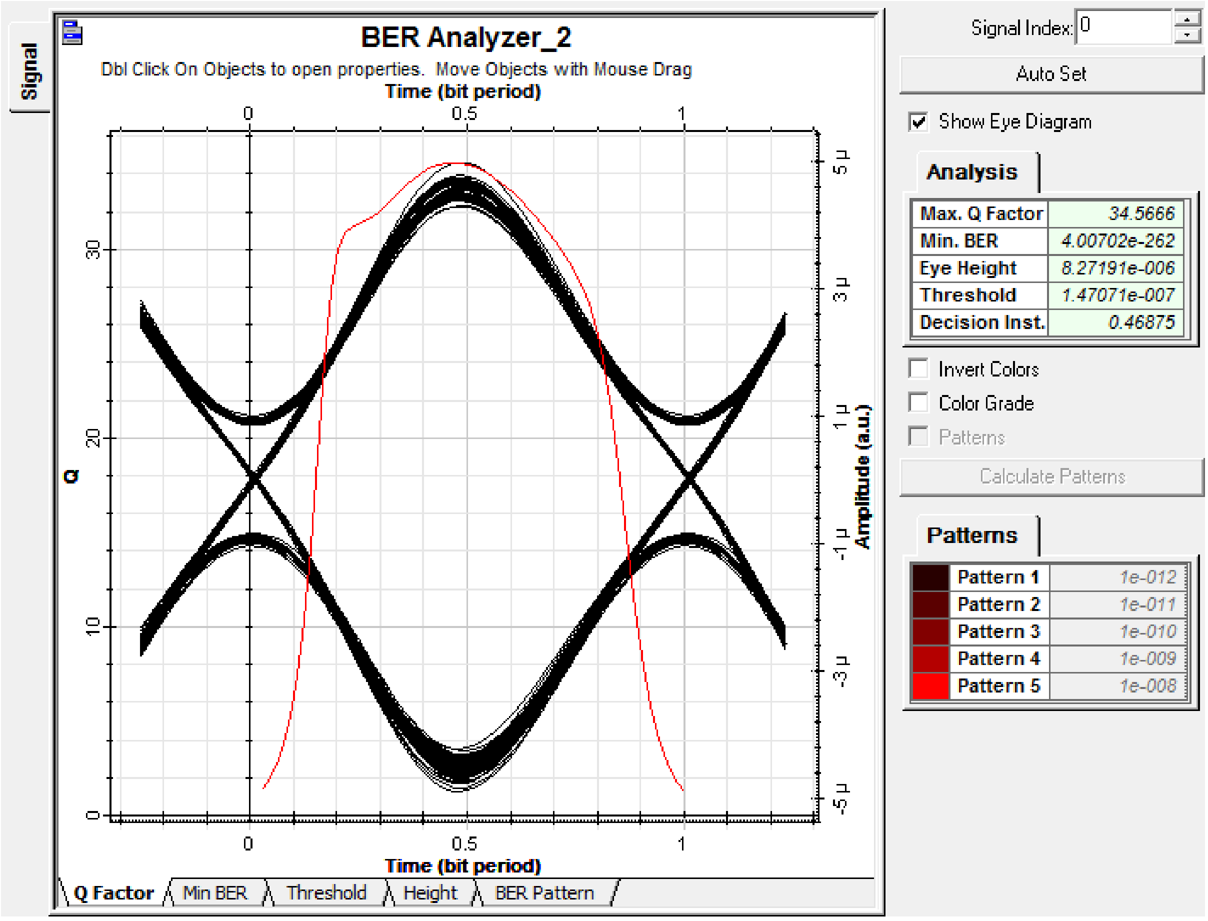
Fig B- DCF Compensation Scheme

From Second work done we have the PON in which eight different users using the splitter four user is compensated with wired optics and four user are compensated with wireless optics comm. So the result would be eight because each user have different- different accessibility. I am starting from wired comm. Channels first user will be come in first and second will comes in second picture like as third would be third picture and fourth would would in fourth picture. Like as for wireless channel first user will be come in first and second will comes in second picture like as third would be third picture and fourth would would in fourth picture. Let see in result quality of each users. At 10 Gbps, 80 Gbps and 160 Gbps.

AT 10 Gbps The PON Results

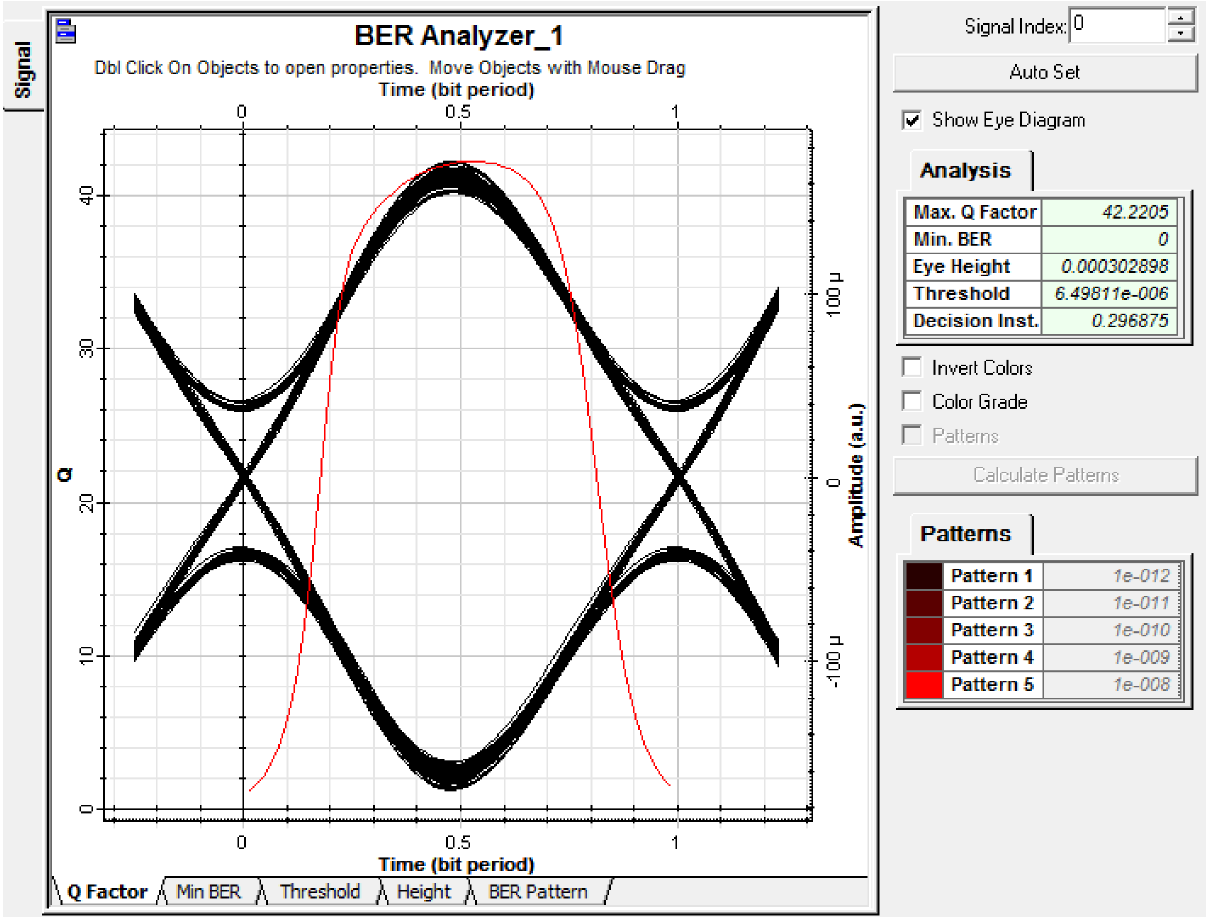


Figure[c]:- At 10 Gbps DCF Compensation scheme

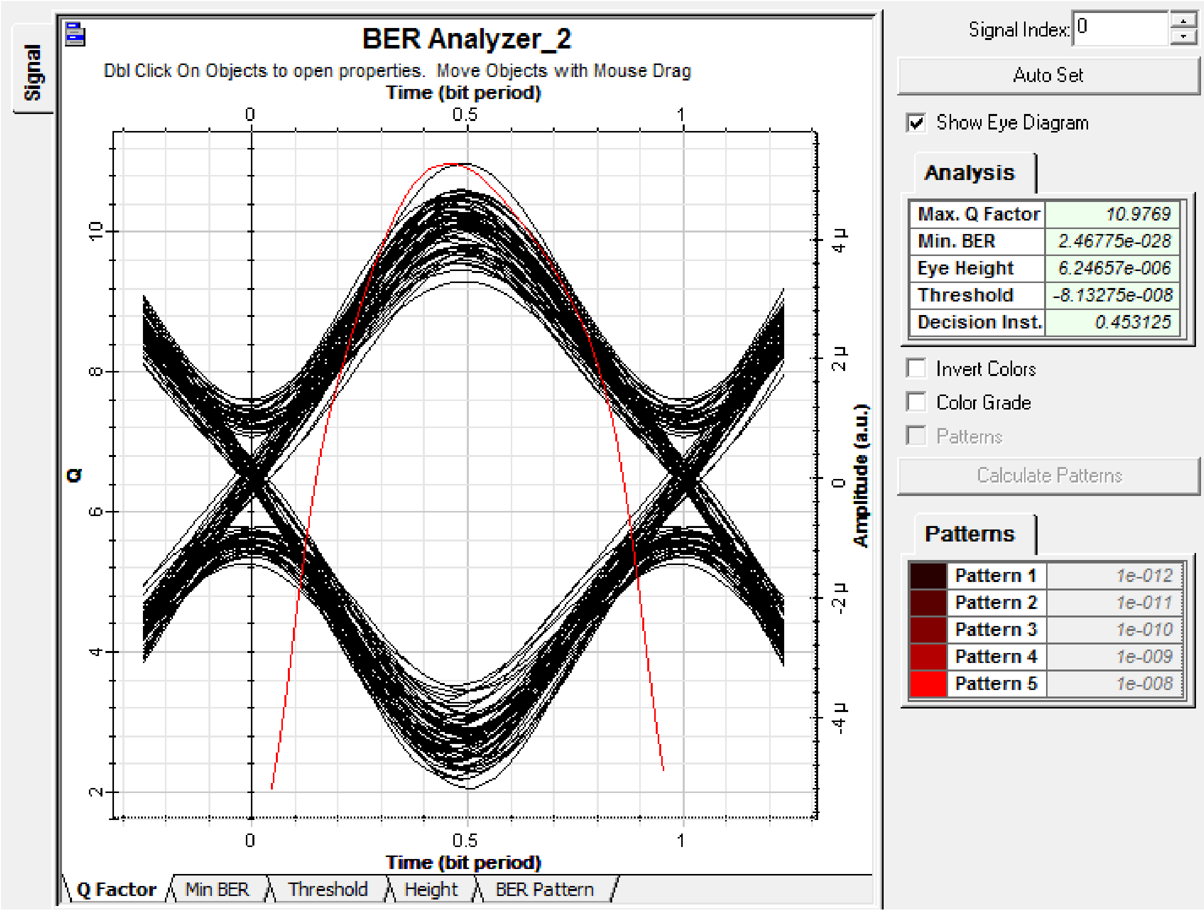


Figure[d]:- At 10 Gbps DCF Compensation scheme For FSO

AT 80 Gbps The PON Results



Fig[e]:- At 80 Gbps Wired Users



Figure[f]:- At 80 Gbps DCF Compensation scheme for FSO user

At 160 GBPS:-

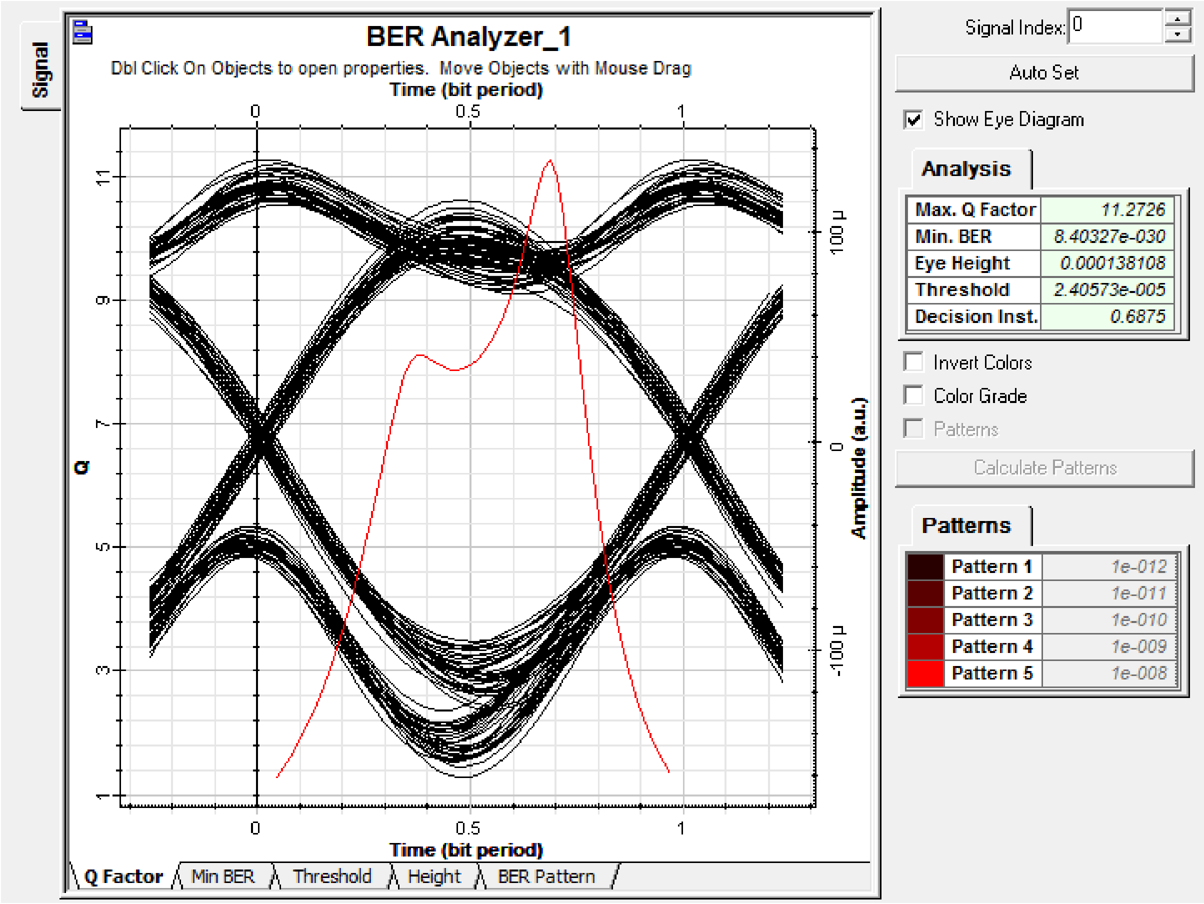


Fig [g]:- At 160 Gbps For wired user

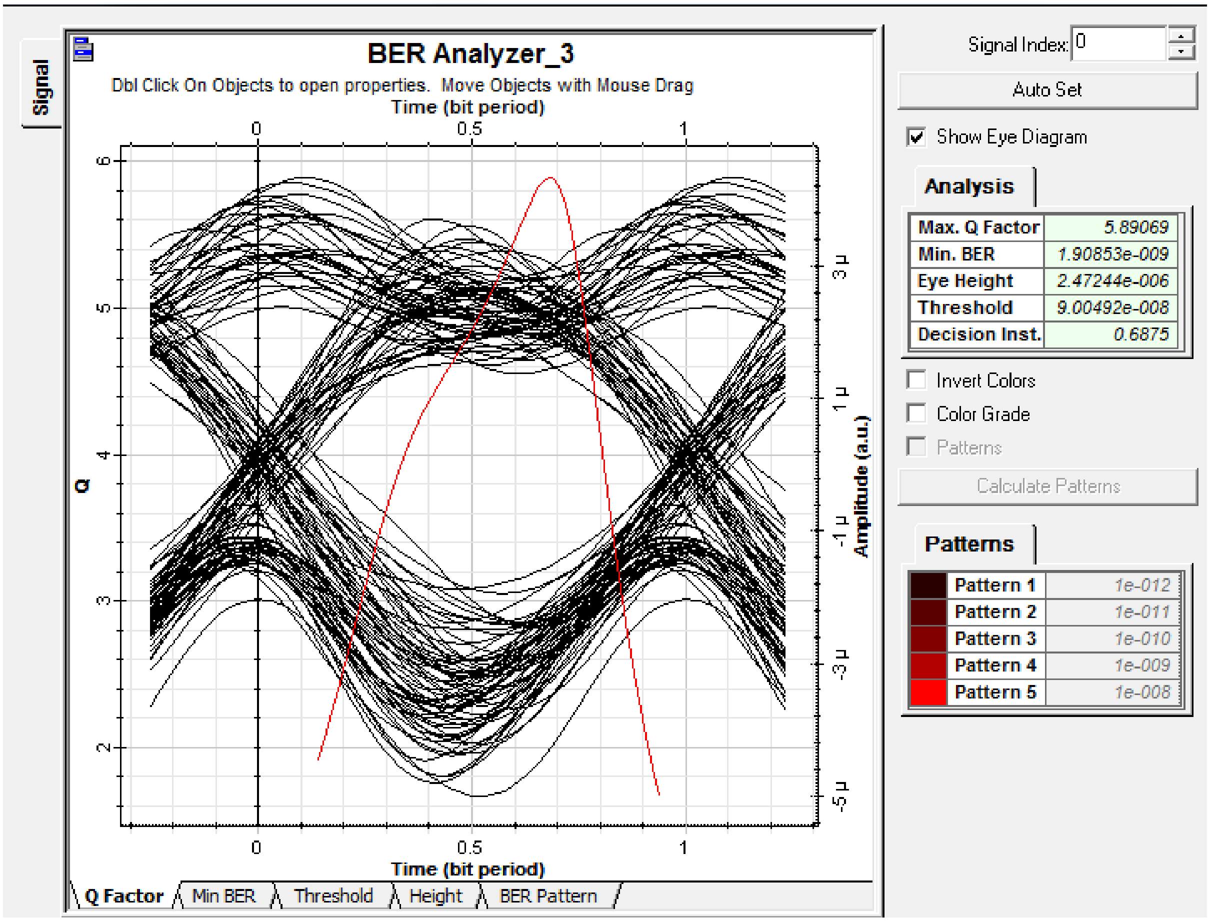


Figure [h]:- At 160 Gbps wireless user

We See at different- different data rate Q factor, Min BER and Signal power level. In which the 10 Gbps provide the best result as we know that enhanced data demand increase day by day So that 160 Gbps provide a acceptance result to us and data rate is more high so keep in mind the 160 Gbps data rate system.

5.3 CONCLUSION AND FUTURE SCOPE

This dissertation report gives a background of fundamental of optical fibre theory. Then in it I have discussed about the basic theory of optical fibre communication system, what are the problem arises in long haul single mode optical fibre which are dispersion and nonlinear effects and to analyse the effect of symmetric dispersion compensation scheme by using modulation formats DPSK (Differential phase shift key) . Here we compare the FBG and DCF compensation scheme for pulse width reduction. When the pulse width should be reduce then we will getting the high data rate. In my work FBG is better than DCF Scheme.

In next step I have investigated DPSK symmetric configuration to design a hybrid system with PON In which the eight different-different users which split in two parts one is wired comm. And another is wireless optical comm. part whose performance is better in terms of Q value and BER. And we find that the DPSK modulation format with symmetrical DCF compensation shows the best performance with the 10 Gbps System but as the data rate demand increasing per day so 160 Gbps is given good performance and for wireless channel it is also give best results as shown in chapter no.5.

So by simulating these models in Optisystem software we will find the best transmission format for long haul and short haul optical communication for hybrid system design.. The optisystem software is easy to use and faster than others which help in testing and simulating the transmitter, channel, amplifier and receiver design and estimation of BER. Lot of Future work is based on my work as we can increase the distance more by decreasing the dispersion and nonlinear effect. We can increase the no of channels to provide data to various users. In general if we say optical fibre is the future for whole world as it is the best wireless and wired communication format.

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