CHAPTER 1
INTRODUCTION

1.0 Introduction

This first chapter will give an overview of this project. The purpose of this project will be discussed in this chapter. Start with the problem that has been facing today that going to be translated into the problem statement. By focusing the problem statement, the objective of the project was created to overcome the listed problem statement. Then the scope and limitation for this project were defined in the project scope and limitation section.

1.1 Background

Presently day's Internet data streams transverse over proceed as effectively as it streams over the workplace. With such a variety of "point and snap" powerful associations, it is anything but difficult to overlook that the world's interchanges needs are made conceivable by open framework in view of fiber optic links. The world's zones are associated with a web of undersea fiber optic links that join the world's significant populace focuses. Any individual who makes the universal telephone calls, sends global faxes or just surfs the web at locales in different places are utilized undersea fiber optic links.

The first undersea fiber optic systems were installed across the Atlantics and Pacific Oceans in 1988 – 1989 and had capacity of 280 Megabit/sec on each of three fiber pairs. These system actually hybrid optical system in the sense that the repeaters converted the incoming signals from optical to electrical, regenerated the data with high speed integrated circuits and retransmitted the data with a local semiconductor laser. In addition, long haul systems usually carry high speed, high bandwidth and large capacity data that demand very high reliability. As system speed and capacity increase to provide the fast traffic growth, it is important to incorporate effective optical performance monitoring (OPM) into the system in order to simplify system design, facilitate operations, enhance system performance, and reduce overall operational cost.

Today's undersea system use erbium doped fiber amplifiers (EDFA) to compensate the attenuation in the optical fiber cable. These optical amplifiers are in repeaters that are typically spaced every 50 km along the cable and have an optical bandwidth that is wide enough to support many optical channels using WDM techniques. Data signals coming from the land based system as terrestrial system are converted to an optical format that is more for transmission.

1.2 Problem Statement

Typical fiber loss around 1.5 µm is ~0.2 dB/km. While the low loss of optical fiber permits signs to travel several kilometers, to a great degree whole deal lines and submarine links require regenerators or repeater to increase the amplifier occasionally. They need to be amplified or signal-to-noise (SNR) of detected signals is too low and bit error rate (BER) becomes too high where typically want BER$< 10^{-9}$ for the long haul transmission. From the problem state above, cord protector are important which will prevent water high pressure in undersea. Fiber optic submarine cable was used to very long period either 15 or 20 years. So, the cable must be stable and working properly.

1.3 Objective

The objective has been define according to the problem that going to be solve when this project done. These objectives going to be achieved are:

i. To study the concept of Optical Amplifier in submarine cable.
ii. To analyze and design of EDFA Amplifier in Optical Amplifier.
iii. To improve the performance submarine optical amplifier.

1.4 Scope

For this project only involves in study literature, design, animation and simulates. This project will only focus on the parameters that can effects such as power loss, power amplifier, signal-to-noise ratio (SNR) and others. For this project a MATLAB Software and Geographic User Interface (GUI) is the software that can be used to describe the function of the simulation at last is the thesis report writing.

1.5 Thesis Outline

The structure and layout of the thesis is as follows:

Chapter 1 – Introduction: This chapter gives a short introduction on the project. It focused on the overview of the project, covers the problem statement, objectives and scope of the project.

Chapter 2 – Literature Review: This chapter explains more about the method concept, theory and some characteristic that used in this project.

Chapter 3 – Methodology: This chapter discusses the methods and approach taken to complete the project which consists of schedule or steps and detailed reports of studies done to achieve the aim objective.

Chapter 4 – Results and analysis / discussion: This chapter shows the result and findings of the analysis also discusses about all the problems arise when design the optical amplifier.

Chapter 5 – Conclusion and Recommendations: This chapter concludes the project and discuss about enhancement that can be made for future project.

CHAPTER 2
LITERATURE REVIEW

2.0 Introduction

This chapter was briefly described what a literature is and will review on some studies and reference has been done as guideline. The guidelines are gathered from various sources such as books, articles, journals and internet. All of these sources play as important role in making this project successful.

2.1 Fiber Optic

Fiber optic communication is a way of transmitting information from one place to another by sending pulse of light through an optical fiber. The system of fiber optic can be used in three locations which are at transmitter, at receiver or in the middle of the line. Most frameworks work by transmitting in one bearing on one fiber and in the turnaround heading on another fiber for full duplex operation. The advantage of optical fibers compared to copper wires are long distance transmission, large information capacity, small size and low weight, immunity to electrical interference, enhanced safety and increased signal security. An amplifier is one of simply electronic device that increase the power and amplitude of a signal which makes it stronger than the given input. (M. Romeiser,2006)

2.2 Class Optical Amplifier

There are three classes of optical amplifiers which are in-line optical amplifier, preamplifier and power amplifier. In-line optical amplifier, the effect of fibers dispersion may be small so the limitation to repeater spacing is fiber attenuation. In a single mode link does not require to complete regeneration of signal, simple amplification of the optical signal already enough. Preamplifier is being use as a front-end preamplifier for an optical receiver. Compared to another front-end device such as avalanche photodiodes or optical heterodyne detectors, an optical preamplifier provides a larger gain factor and a wider bandwidth. For power amplifier is placing the device immediately after an optical transmitter to boost the transmitted power. This power amplifier is used to increase the transmission distance by 10 – 100 km depending on the amplifier gain and fiber loss. (G. Keiser,2011)

2.2.1 In- line Optical Amplifier

In-line optical amplifier is used as repeaters to boost the signal power and extend the transmission distance between digital regenerators. Because of it is use to extend the transmission distance, high output power is required. However, the signal that entering into it must be both a good preamplifier and a good power amplifier. Dynamic range is important for in-line amplifier because of the span losses can be different and the number of channels can be change from none to the design maximum. Thus dynamic range is important for in-line amplifiers. In-line amplifier must be designed with high gain, high output power, and a low noise figure for a wide dynamic range of input signals. Thus an in-line optical amplifier can be used to compensate for transmission loss and increase the distance between regenerative repeaters, as Figure 2.1 illustrate. (G. Keiser,2011)

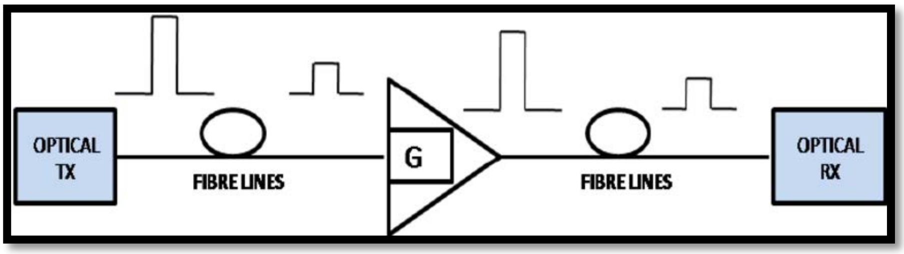

Figure 2.1: In-line amplifier
<Source: fiberopticshare.com>

2.2.1 Preamplifier

The optical amplifier as Figure 2.2 shows being used as a front-end preamplifier for an optical receiver. An optical preamplifier is set quickly before a recipient to enhance its affectability. Since the information signal level is typically very low a low noise characteristic is necessary. Be that as it may, just a moderate increase figure is required following the sign is being encouraged straightforwardly into a recipient. Ordinarily a preamplifier won't have input control as it can be run well less absorption. (G. Keiser,2011)

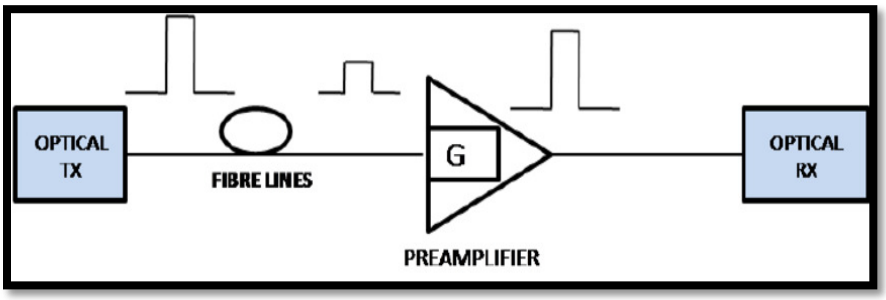

Figure 2.2: Pre-amplifier
<Sources: fiberopticshare.com>

2.2.2 Power Amplifier

Power or booster amplifier application includes putting the device quickly after an optical transmitter to help the transmitted power, as Figure 2.3. This serves to build the transmission separation by 10 – 100 km relying upon the amplifier gain and fiber loss. As a case, utilizing this system together with an optical preamplifier at the less than desirable end can empower repeaterless undersea transmission separations of 200 – 250 km. Moreover, most of distributed feedback (DFB) amplifier lasers have an output only around 2mW but a fiber can combined power levels of up to 100 to 200 mW before nonlinear effects start to occur. A power amplifier may be working to boost the signal directly following the transmitter. Usual EDFA power amplifiers have an output of around 100mW. (G. Keiser,2011)

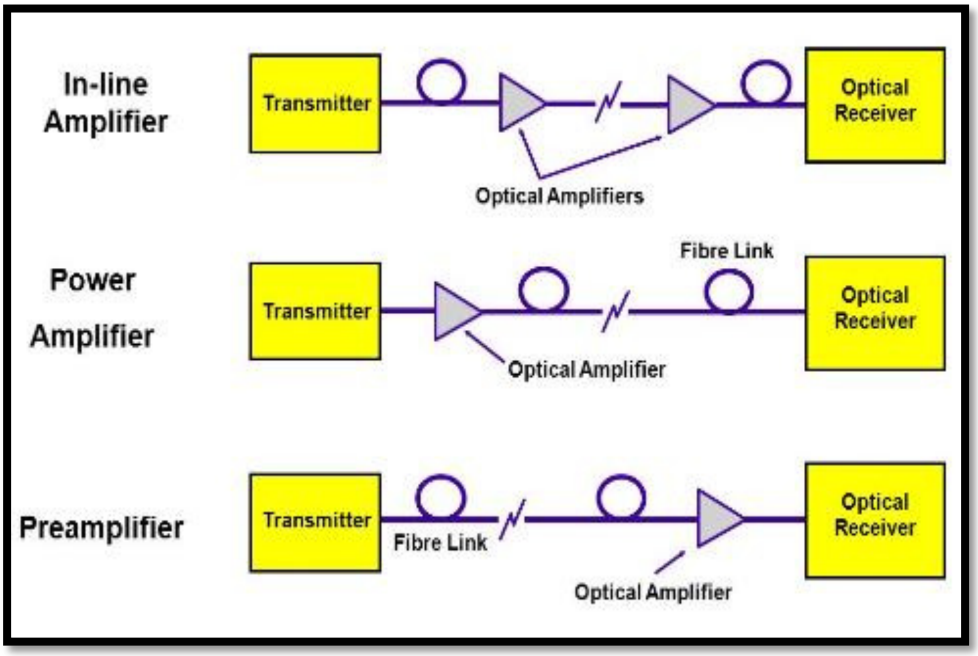

Figure 2.3: Application of optical amplifiers

<Source: Applied Optoelectronics Centre>

2.3 Type Amplifier

There are three types of optical amplifier that can be classified as semiconductor optical amplifiers (SOAs) active fiber or doped fiber amplifiers (DFAs) and Raman amplifiers. According to Gerd Keiser (2011), to get more characteristic risks identified with evolving atmosphere. Environmental change will influence the other marine exercises, for example, angling, with potential effect on links. In SOAs and DFAs the device for creating the population inversion that is needed for stimulated emission to occur is the same as is used in laser diodes. Although the organization of such an optical amplifier is similar to that of a laser, it does not have the optical feedback device that is necessary for lasing to take place. Therefore, an optical amplifier can boost inward signal levels, but it cannot generate a coherent optical output by itself. The basic operation is shown in Figure 2.4 as below. The device absorbs energy supplied from an external source called the pump. The pump supplied energy to electrons in an active medium, which increases them to higher energy levels to produce a population inversion. An incoming signal photon will trigger these energized electrons to drop to lower levels through a stimulated-emission process.

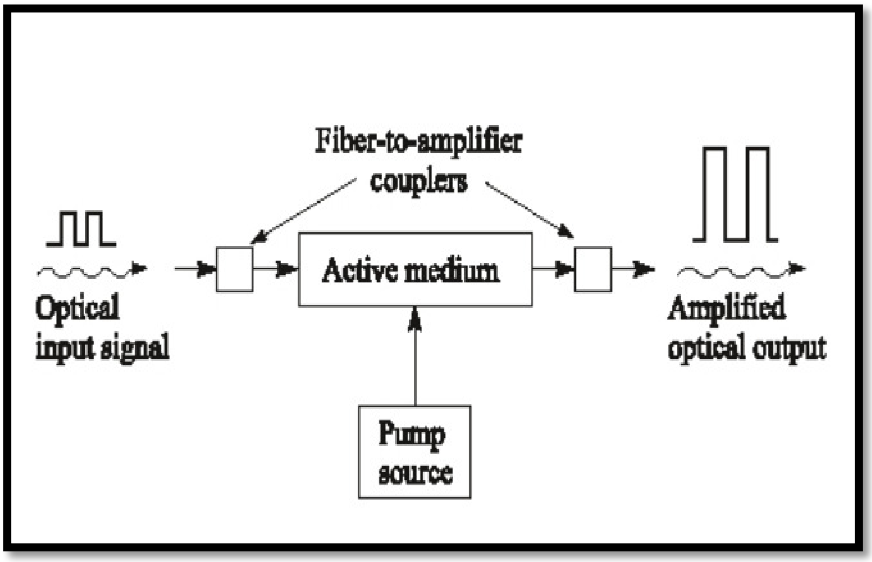

Figure 2.4: Basic operation of a generic optical amplifier
(Sources: G.Keiser book)

2.3.1 Active Fiber

As the interest of high information speed systems is expanding, a response to long separation correspondence framework is optical correspondence frameworks which utilize optical fiber that can be utilized as a medium for telecom and systems administration. The light spreads through the optical fiber with little constriction contrasted with electrical links. An optical intensifier is a gadget that increases an optical flag specifically without the need to first change over it to an electrical sign in optical fiber correspondences. EDFAs are for the most part utilized as preamplifiers with multichannel enhancement without crosstalk furthermore multigigabit transmission rates by low bit errors. (M. N. Zervas, R. I. Laming, and D. N. Payne, 1995).

Most critical component of EDFA innovation is the Erbium-Doped Fiber (EDF), which is a routine silica fiber doped with Erbium. Erbium-doped fiber intensifiers have pulled in the most consideration since they work in the wavelength area almost 1.55 µm. The sending of EDFA in WDM frameworks has reformed the field of optical fiber interchanges and prompted light wave frameworks with limits surpassing 1 Tb/s. Active fiber also known as doped fiber amplifier. Amplification in an Erbium-doped fiber amplifier happens through the instrument of stimulated release. At the point when the Erbium is lit up with light energy at a reasonable wavelength (either 980 nm or 1480 nm), it is excited to a long lifetime middle state level 2 taking after which it rots back to the ground state by discharging light inside the 1500–1600 nm groups. (J. Hecht, 2002).

2.3.2 Raman Amplifier

A fiber Raman enhancer is shown in Figure 2.5. The increase medium is undoped fiber. Force is exchanged to the optical sign by a nonlinear optical procedure known as the Raman impact. Energy to supply the optical addition is offered by an optical pump. The wavelengths that experience optical addition are chosen by the wavelength of the optical pump, so the Raman enhancer can be custom-made to open up a given optical wavelength by real determination of the pump wavelength. The optical increase in a Raman amplifier is carried over a long pass through of optical fiber. Normally, the optical pump is presented toward the end of a length of fiber keeping in mind the end goal to give optical gain that expansion towards the end of the fiber.

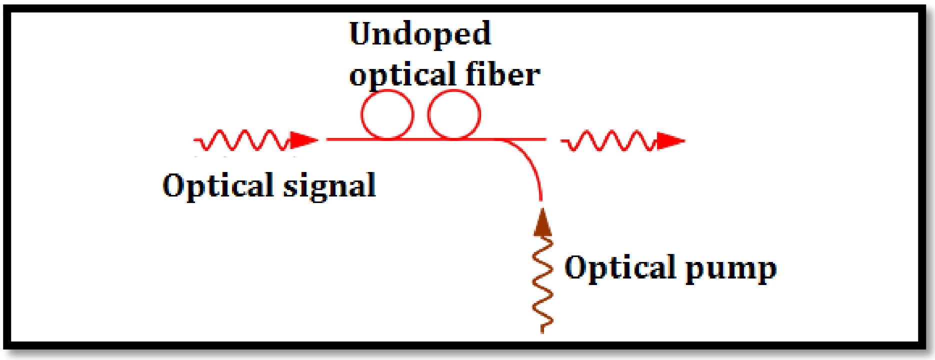

Figure 2.5: A fiber Raman amplifier

<Source: www.fiber-optical-networking.com>

In a Raman amplifier, the signal is opened up because of animated Raman scattering (SRS). Raman scattering is a procedure in which light is scattered by atoms from a lower wavelength to a higher wavelength. SRS is a nonlinear cooperation between the signal and the pump and can happen inside any optical fiber. In many aspects however the productivity of the SRS procedure is low, high pump power (commonly more than 1 W) is required to acquire valuable sign addition. In this way, by and large Raman speakers can't contend effectively with EDFAs. Then again, Raman intensification gives two exceptional points of interest over other enhancement advancements. The primary point of interest is that the intensification wavelength band of the Raman enhancer can be customized by changing the pump wavelengths, and afterward intensification can be accomplished at wavelengths without being upheld by competing advances. The second, more critical, favorable position is that intensification can be accomplished inside the transmission fiber itself, empowering what is known as Distributed Raman Amplification (DRA). In this procedure high pump force is propelled into the transmission fiber with a specific end goal to give enhancement to the sign as it goes along the fiber. Since increase happens along the transmission fiber, DRA keeps the sign from being weakened to low powers. Raman enhancers are regularly utilized together with EDFAs to offer ultra-low NF joined speakers, which are valuable in applications, for example, long connections without inline intensifiers, ultra-long connections extending a large number of kilometers, or high piece rate joins. (G. Keiser,2011)

2.3.3 Semiconductor Optical Amplifier

According to A Selvarajan, S Kar, & T Srinivas (2002), Semiconductor optical amplifier or known as SOA are basically laser diodes without end mirrors which have fiber attached to both. SOA amplify any optical signal that comes from either fiber and transmit an amplified version of the signal out of the second fiber. In other word, SOA transmit bidirectionally which is making the reduced size of the device an advantage over regenerator of EDFA. SOA also have a wide range of amplification wavelengths. The electrical gain switching is possible allowing modulation to be integrated within the amplifier.

The amplification is characteristically polarization-delicate, however speaker plans have been produced which give almost polarization self-sufficient attributes. For instance, one may utilize two identical intensifiers in arrangement, where the second one is turned against the first by 90°. There are additionally arrangements with two parallel enhancers for the two polarization bearings, with polarizing shaft splitters previously, then after the fact these speakers. Another possibility is to utilize a double go through a self-contained enhancer, where there is a Faraday rotator between the device and the reflecting mirror.

The SOAs setup is much compact, containing only a small semiconductor chip with electrical and fiber connections. The output powers are significantly smaller, particularly when comparing with high-power fiber amplifiers. Furthermore, the necessary operation power is also smaller which is typical drive currents a few hundred milliamperes. For the gain bandwidth can be similar in different wavelength regions can be made and the noise figure is typically higher. The figure 2.6 shows the SOAs structure.

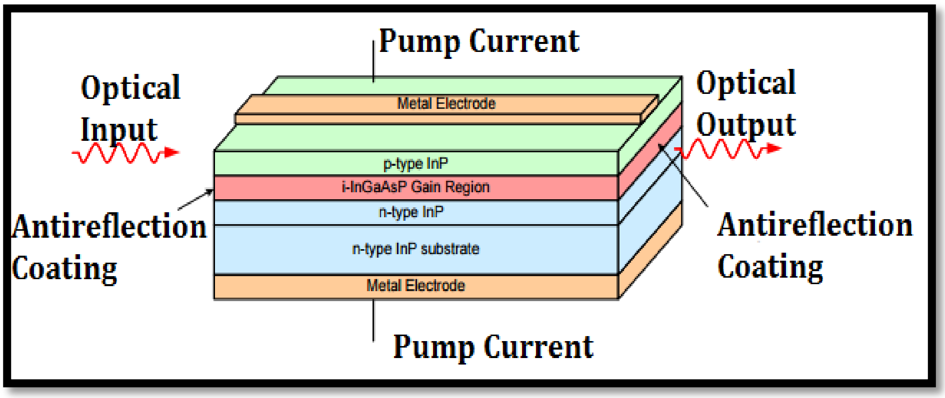

Figure 2.6: A semiconductor optical amplifier

<Source: www.fiber-optical-networking.com>

SOAs work correspondingly to standard semiconductor lasers (without optical criticism which causes lasing), and are bundled in little semiconductor "butterfly" bundles. Not at all like other optical enhancers, they are pumped electronically and a different pump laser is not required. SOAs are less costly and along these lines appropriate for utilizing as a part of nearby systems where best execution is not required but rather cost is a vital factor. Despite their little size and conceivably ease because of large scale manufacturing, SOAs experience the ill effects of various disadvantages which make them unacceptable for generally applications. Specifically, they give generally low pick up, have a low immersed yield power and moderately high clamor component (NF). These disadvantages makes SOAs inadmissible for multichannel application yet fit for some single channel which don't require high pick up and high yield power.

2.4 Erbium Doped Fiber Amplifier (EDFA)

An erbium-doped fiber amplifier (EDFA) is a device that opens up an optical fiber signal. It is utilized as a part of the information transfers field and in different sorts of analysis fields. An EDFA is "doped" with a material called erbium. The expression "doping" refers to the procedure of utilizing mixture components to encourage results through the control of electrons. (Ivan Kaminow & Tingye Li , 2002).

Overall, EDFA works away at the standard of stimulating the outflow of photons. With EDFA, an erbium-doped optical fiber at the center is pumped with light from laser diodes. This sort of setup in telecom frameworks can help with fiber correspondences, for illustration, boosting the force of an information transmitter. An EDFA may likewise be utilized to keep up long crosses of a distant fiber organize and may similarly be utilized for some transcribes of apparatus testing. Pump lasers, known as pumping groups, embed dopants into the silica fiber, bringing about an addition, or intensification. EDFA enhancement happens as the pump laser energizes the erbium particles, which then achieve a higher energy level. Photons are transmitted as erbium particle levels decline, or rot. This decaying procedure makes an association between the phonons and the glass framework, which are vibrating atomic flexible structures as the figure 2.7 illustrate.

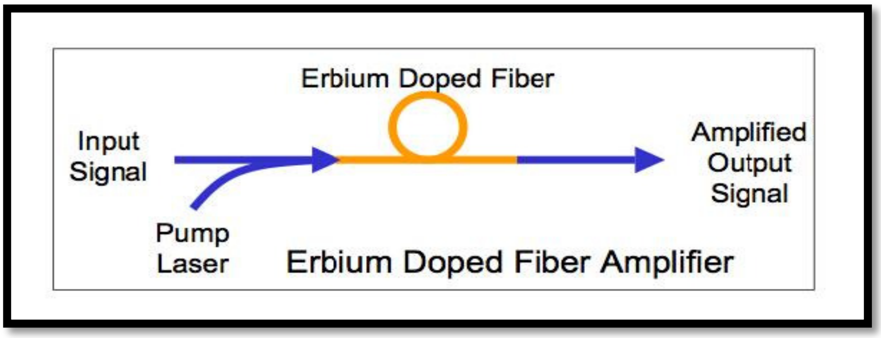

Figure 2.7: Erbium doped fiber amplifier
<Source: fiber-optic tutorial.com>

The EDFA rate, or enhancement window, depends on the optical wavelength scope of amplification and is controlled by the dopant particles' spectroscopic properties, the optical fiber glass structure and the pump laser wavelength and force.

As particles are sent into the optical fiber glass, energy levels widen, which results in amplification window expanding and a light range with a wide pick up data transmission of fiber optic enhancers utilized for wavelength division multiplex correspondences. This single intensifier might be utilized with all optic fiber channel signals when signal wavelengths are in the intensification window. Optical isolator devices are set on either side of the EDFA and serve as diodes, which keep signals from going in more than one bearing. (Ivan Kaminow & Tingye Li, 2002).

2.4.1 Amplification Mechanism

Though semiconductor optical enhancers use outside current infusion to energize electrons to higher vitality levels, optical fiber intensifiers use optical pumping. In this procedure, one uses photons to straightforwardly raise electrons into energized states. The top vitality level to which the electron is lifted must lie vigorously over the wanted lasing level. In the wake of achieving its energized state, the electron must discharge some of its vitality and drop to the required lasing level. From this level, a sign photon can then trigger it into fortified discharge, whereby it discharges its remaining vitality as another photon with a wavelength indistinguishable to that of the sign photon. Since the pump photon must have a higher vitality than the sign photon, the pump wavelength is shorter than the sign wavelength. (G. Keiser,2011).

To get a phenomenological comprehension of how an EDFA functions, the energy–level structure of erbium had taken a look. The erbium iotas in silica are genuine Er3+ions, which are erbium molecules that have lost three of their external electrons. In depicting the moves of the external electrons in these particles to higher energy states, it is regular to allude to the procedure as "raising the particles to higher energy levels". Figure 2.8 shows a simplified energy- level diagram and various energy level transition processes of these Er3+ ions in silica glass.

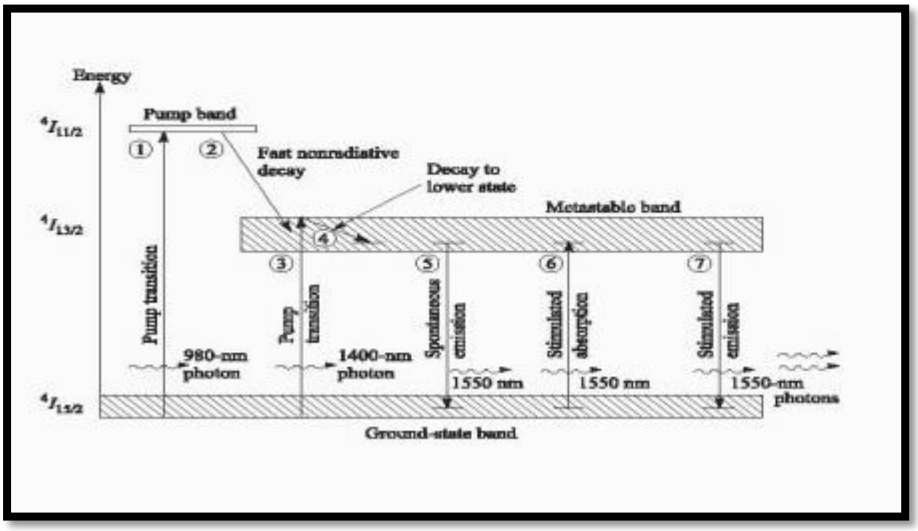

Figure 2.8: Erbium energy-level diagram and amplification mechanism
(Source: G.Keiser book)

2.4.2 EDFA Architecture

An optical fiber comprises of a doped fiber, one or more pump lasers, an uninvolved wavelength coupler, optical isolators, and tap couplers, as shown in figure 2.9. The wavelength specific coupler couples both the pump and flag optical power effectively into the fiber enhancer. The tap couplers are wavelength unfeeling and are for the most part utilized on both sides of the enhancer to think about the approaching sign with the enhancer yield. The dichroic (two-wavelength) coupler levers either 980 / 1550-nm or 1480 / 1550-nm wavelength combinations to couple together the pump and signal optical powers capably into the fiber amplifier. The tap couplers are wavelength-insensitive with typical ratios ranging from 99:1 to 95:5. (G. Keiser,2011)

They are by and large utilized on both sides of the intensifier to contrast the approaching sign and the enhanced yield. The optical isolators keep the intensified sign from reflecting once again into the device, where it could expand the amplifier noise and lessening its productivity.

The pump light is generally infused from the same course as the sign stream. This is known as co-directional pumping. It is additionally possible to infuse the pump power the other way to the sign stream, which is known as counter-directional pumping. One can utilize either a solitary pump source or utilize double pump source plans, with the resultant picks up regularly being +17 dB and+35 dB, respectively.

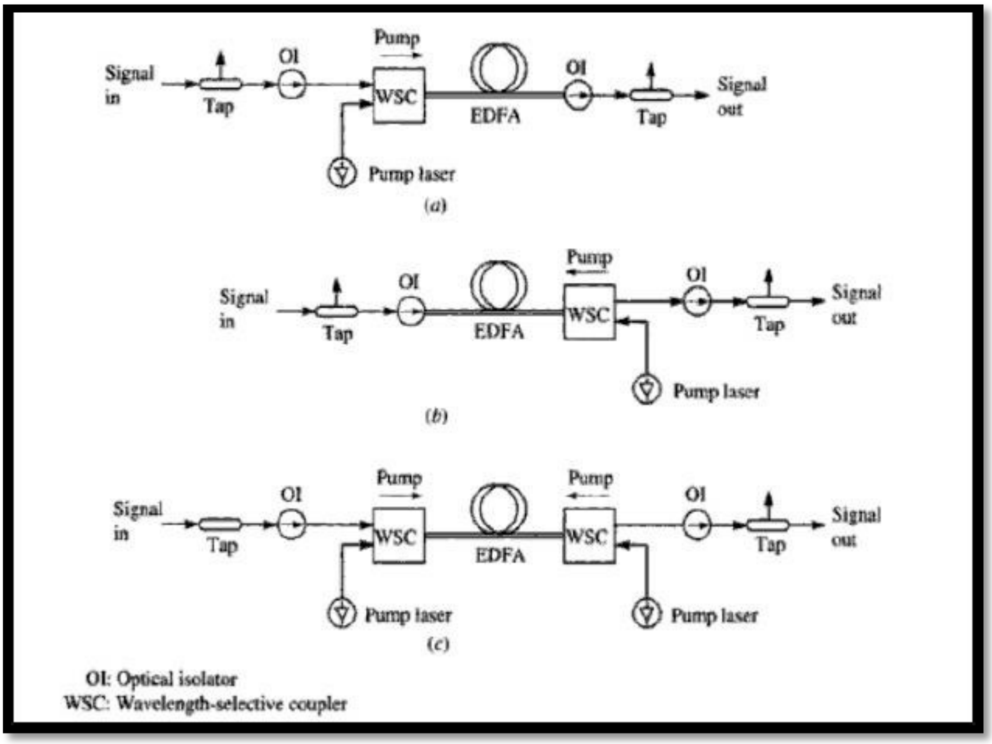

Figure 2.9: Three possible configuration of an EDFA (a) co-directional pumping (b) counter -directional pumping (c) dual pumping
(Source: G.Keiser book)

Counter-directional pumping permits higher increases, yet co-directional pumping gives better commotion execution. Likewise, pumping at 980-nm is favored, since it creates less clamor and accomplishes bigger populace reversals than pumping at 1480-nm

2.4.3 Properties of the EDFA

The properties of an EDFA is complete as several parameters such as pump power, erbium concentration, fiber length, pumping mechanism, noise sources, input signal power and etc. Main performance parameters are amplifier gain, output power, noise and crosstalk. (G. Keiser,2011)

The increase of an optical intensifier ought to be free of the information polarization. This is possible in EDFA as a result of the round symmetry of the fiber and the arbitrary introduction of Erbium ions in the host. Further, a more extended metastable state renders EDFA moderately safe to pick up changes. This is especially valid on account of rapid frameworks, where beat periods are little. A set up to gauge framework increase is appeared in figure 2.10

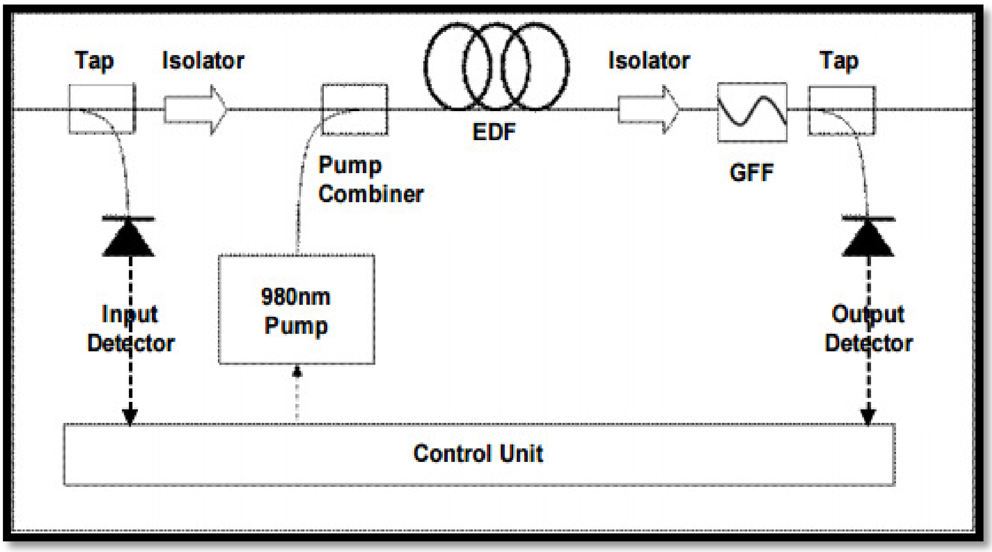

Figure 2.10: Typical single stage EDFA, showing the three basic components (EDF, pump and WDM combiner).
<Source: finisar.com>

The most important element of the EDFA is addition as it decides the intensification of individual channels when a WDM sign is increased. The amplified output signal power is measured from the yield line and is taken after the channel. Furthermore, the information signal force is altered as 0.001 mw. This opened up yield signal force is corrupted because of the Amplified Stimulated Emission (ASE) commotion, and the yield signal force increments because of the fortified emanation, and this is because of populace reversal and populace reversal is because of pumping force. (S.Semmalar & S. Malarkkan, 2013)

Optical amplifiers let one to cover link distance between a transmitter and receiver. Amplifier can recompense for attenuation. It also cannot recompense for dispersion and crosstalk in DWDM systems. Amplifier also presented noise, as each amplifier reduces the optical SNR by a small amount known as noise figure 2.11.

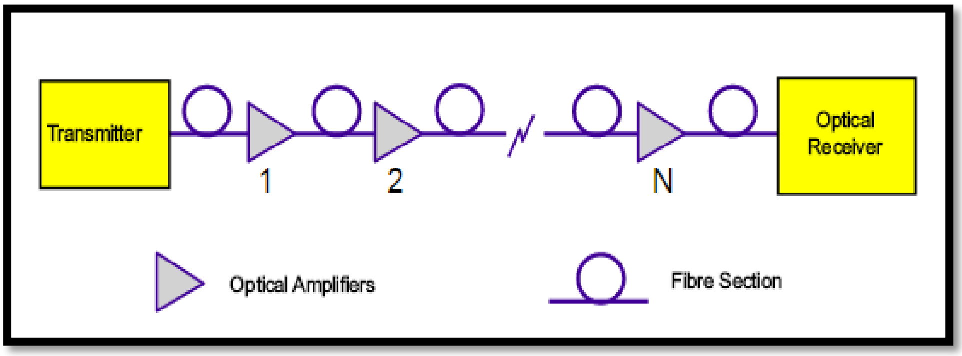

Figure 2.11: Noise of amplifier

<Source: Optoelectronic centre>

Optical Signal to Noise Ratio (OSNR) in dB is the measure of the ratio of signal power to noise power in an optical channel. OSNR is significant because it submits a degree of loss when the optical signal is passed by an optical transmission system that includes optical amplifiers. Optical signal suffers more than only reduction. In amplitude, spectrally, temporally signal collaboration with light-matter, light-light, light-matter-light indications to other signal troubles such as power reduction, dispersion, polarization, and unbalanced amplification. Thus, the primary to random noise, which cause disturbances resulting in erroneous bits which known as bit-error-rate. The figure 2.12 is show the OSNR. (Dr.D.Kripp,2005)

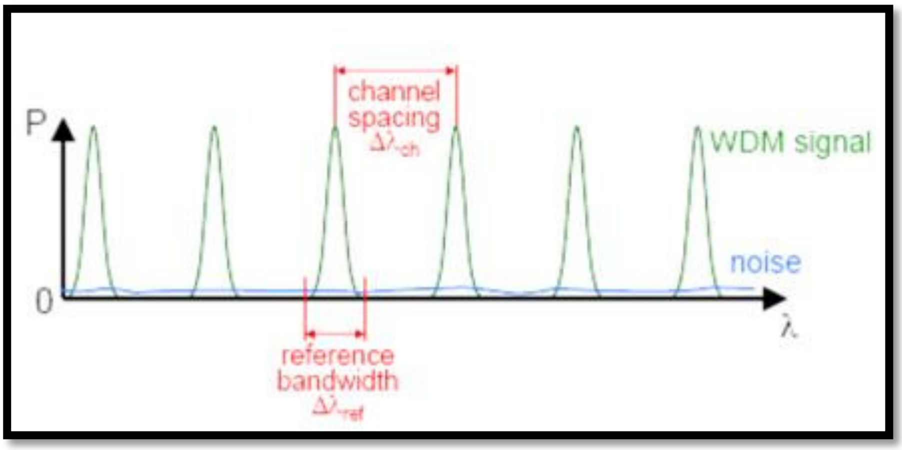

Figure 2.12: Optical Signal to Noise Ratio (OSNR)
<Source: Dr.D.Kripp, www.opticwave.com>

Wavelength division multiplexing (WDM) is known as an approach to enhance the limit of high piece rate transmission frameworks. In any case, there are a few constraints emerging from request collection in course EDFA frameworks, chromatic and polarization scattering and in addition degradation because of crosstalk produced from nonlinear impacts, for example, four wave blending (FWM). In WDM systems EDFAs fill in as sponsor enhancers to adjust the misfortunes created by the insertion of various segments in the optical cross connect hub. Besides the sign level conveyed by every channel can expect diverse qualities because of ways in the system which is not very much evened out. This jumble can be directed by method for optical attenuators which figure out how to hold the channels at comparative conditions. With attention on the only utilization of the optical transporter this phenomenon can be categorized pick up crosstalk. (F.Meli, M. Angellieri and G. Grasso, 1992)

2.4.4 Passive Optical Network (PON)

As optical signals go through an optical fiber, they are weakened. In whole deal applications, the signal is pointed to the point where re-enhancement is required. Generally, a device ordinarily referred to as a repeater finished this re-enhancement.

A repeater is fundamentally a recipient and transmitter joined in one bundle. The beneficiary changes over the approaching optical energy into electrical energy. The electrical yield of the recipient drives the electrical contribution of the transmitter. The optical yield of the transmitter speaks to an increased adaptation of the optical information signal in addition to noise.

The innovation accessible today wipes out the requirement for repeaters. Inactive optical enhancers are currently utilized rather than repeaters. An uninvolved optical speaker enhances the sign specifically without the requirement for optical-to-electric and electric-to-optical transformation. There are a few diverse optical speakers with which to inactively increase an optical sign: Erbium Doped Fiber Amplifier (EDFA), Semiconductor Optical Amplifier (SOA), and Raman Fiber Amplifier (RFA), all of which utilize a procedure called laser pumping. (Lionel Carter, 2009).

2.5 Submarine Cable

Submarine cable are use the Erbium- doped fiber amplifier (EDFA) to boost the intensity of optical signal being carried through a fiber optic communication system. There are many failure cable that have been appears because of human activity, natural hazard, environment, and animal. For human activity include of fishing, shipping and illegal fishing at the cable protector area. Besides that, for the natural hazard basically from the submarine earthquakes, density currents, current and waves, tsunami, storm surge and sea level rise. Moreover, the environment happens when almost 3 m of rain fell in the central mountains. This caused rivers to flood and carry vast amounts of sediment to the ocean. Furthermore, the animal that have been causes of cable failure not only fish, it also include the shark where in 1985-1987, a domestic fiber optic cable installed in the Canary Islands was damaged by shark in 1-2 km water depth. Figure 2.13 and 2.14 shows the statistic of the cable failure. (Doug Burnett, 2011).

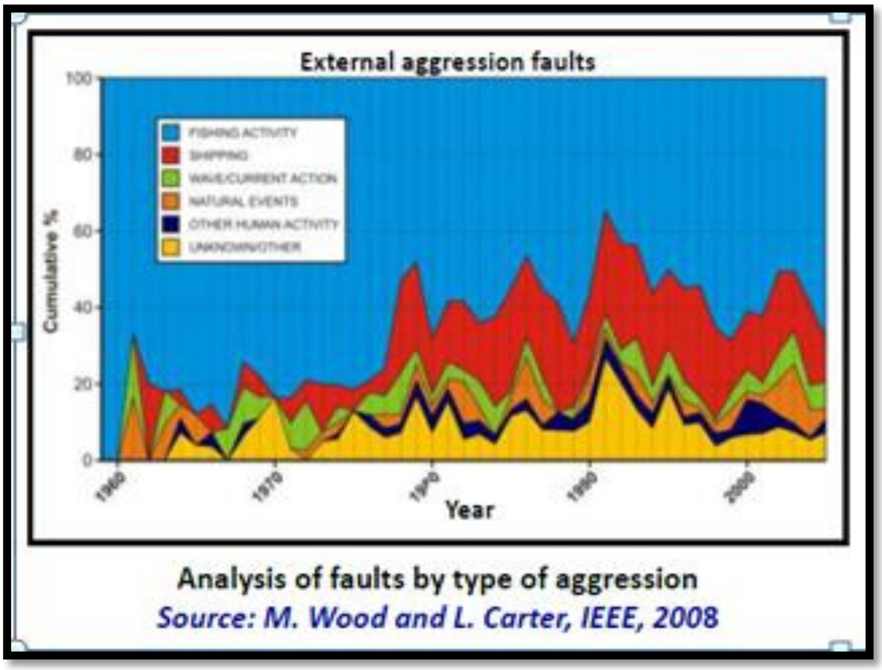

Figure 2.13: Causes of cable failure

<Source: www.iscpc.org>

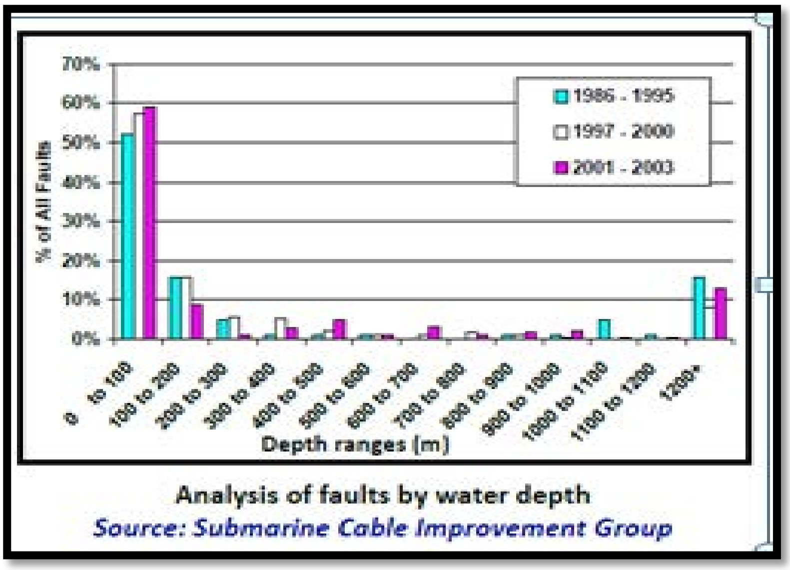

Figure 2.14: Causes of cable failure

<Source: www.iscpc.org>

2.5.1 Long haul

Long-haul optical transmission framework is based on a few center revolutions: advanced low-loss fibers, high-speed opto-electronic devices, fiber amplifiers, and WDM advances. Figure 2.15 show a run of the mill point-to-point whole deal transmission join. It comprises of a couple of unidirectional fiber joins and the terminal types of equipment on two finishes. The fiber connections are made of a progression of fiber ranges and fiber enhancers. The eastward and westward fiber enhancers are colocated in the moderate hubs. Locality channels can be included or dropped at the moderate hubs. For effortlessness, the moderate include drop capacity is not appeared in the figure. The terminal hardware is made of optical transmitters and receivers, and in addition multiplexers and demultiplexers. (Chan, Calvin C. K. ,2010)

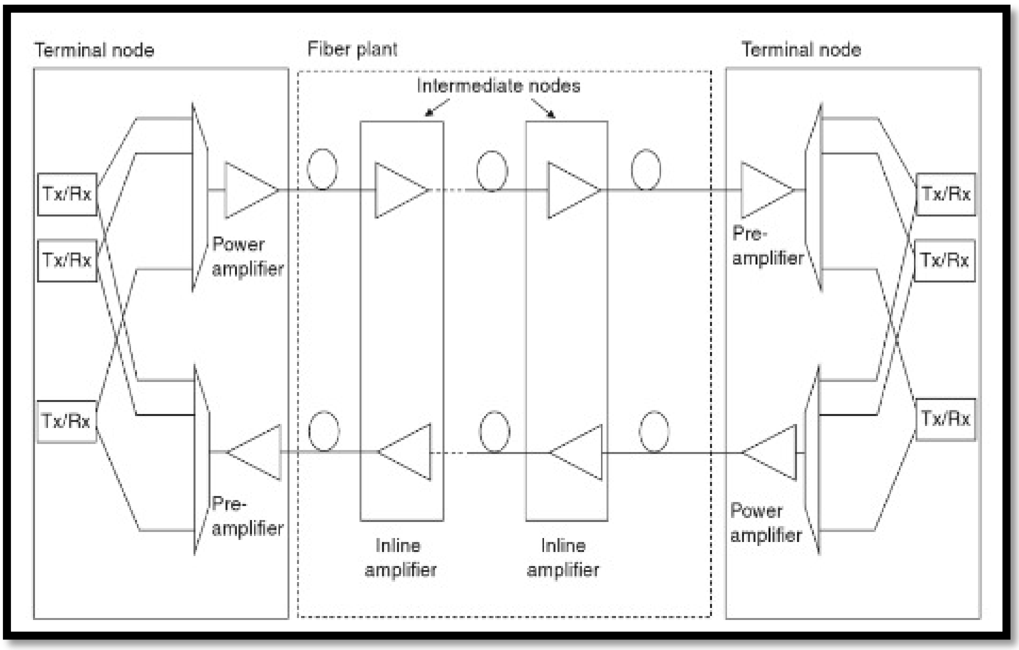

Figure 2.15: Typical bidirectional long-haul optical transmission link
(Source: Calvin C.K. Chan book)

2.5.2 Type of cable

The low loss of optical fiber allows signals to travel hundreds of kilometers, extremely long haul lines and submarine cables require regenerators or repeaters to amplify the signal periodically. Cable and fiber, repeaters, equalizers, branching units and marine installation are very important in undersea plant. Cable and fiber usually specified for each span of each system. Typically 1 to 4 types of cable depends on the type of environmental protection needed. Furthermore, one or three types of fiber also depend on management of optical transmission properties and or the network costs differ commonly depending on type of cable. There are fundamentally two sorts of optical submarine links. One is a light weight link, and is utilized as a part of remote ocean regions of around 1,000 m to 8,500 m depth. The other is a protected link being connected a steel wire to the light weight link, and is utilized as a part of a shallower region than around 1,000m depth. Figure 2.16 shows the light weight of optical submarine cable and for figure 2.17 shown a single armored submarine cable. (Kokusai, 2001)

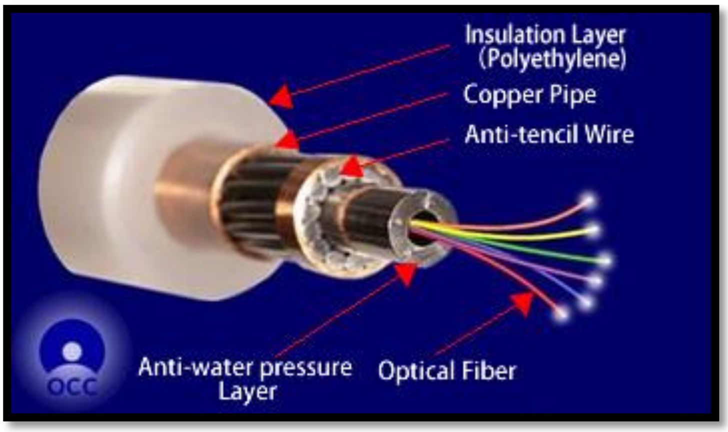

Figure 2.16: Structure of light weight optical submarine cable
<Source: Kokusai Cable Ship Co.>