Performance analysis of sistem komunikasi kabel laut (SKKL) using edfa amplifier link java-bali using optisystem

Deni Anggara Hendriawan¹, Dadiek Pranindito¹, Dodi Zulherman¹
¹Departemen of Telecommunication Engineering, Institut Teknologi Telkom Purwokerto, central Java 35147, Indonesia
E-mail: 15101012@ittelkom-pwt.ac.id

Abstract. The underwater communication cable is an example of an undersea backbone link communication system that connects between islands and between countries. Backbone is the main track or channel in a network with very high speeds. Because the distance to be traveled in the link of this sea cable communication system is very far, it is necessary that devices such as optical amplifier to overcome the lost power when transmitted so that the communication can be delivered to the receiver. Optical amplifier used in the form of EDFA (Erbium Doped Fiber Amplifier), EDFA is an optical amplifier used to increase signal level that works on Waves 1530 nm to 1570 nm. This research analyzes the influence of the use of optical amplifier against SKKL network on link java-Bali by using Brancing Unit configuration and without Brancing Unit, Brancing Unit is a device to divide the optical path and connect more than one landing station, and measure the performance based on the performing parameters such as BER (Bit Error Rate), Q-Factor, Power Receive, and SNR (Signal to Noise Ratio). This research successfully simulates the configuration of Brancing Unit and without Brancing Unit. Simulated results by varying the power of 0, 2, 4, 6 and 8 dBm, Of the two configurations used have a good performance with the highest value of the BER parameter of 2.83×10⁻¹⁵, Q-Factor of 24.35139, Power Receive of -16.1937 dBm, and Signal to Noise Ratio of 31.1411947 dB power at 8 dBm.

1. Introduction
Fiber optic communication System One of the placement is in the sea, the underwater communication cable is an example of an undersea backbone link communication system that connects between islands and between countries. Backbone is the main track or channel in a network with very high speeds. Because the distance to be traveled in the link of this sea cable communication system is very far, it is necessary that devices such as optical amplifier to overcome the lost power when transmitted so that the communication can be delivered to the receiver. Optical amplifier used in the form of EDFA (Erbium Doped Fiber Amplifier), EDFA is an optical amplifier used to increase signal level that works on Waves 1530 nm to 1570 nm.

In a journal title “Performance Analysis of Hybrid Optical Amplifiers in the Long Haul Ultra-Dense Wavelength Division Multiplexing” using a hybrid optical amplifier is only effective at a maximum distance of 205 km based on the Q-factor and BER values. This study uses two parameters namely Q-factor and BER[1].

While in the journal “Design Of Using Optical Amplifier On Sistem Komunikasi Kabel Laut Network In Indonesia Global Gateway”, using configuration repeater-ed and repeater-less the best...
value is at a distance of 390 km with configuration repeater-ed. From the results obtained, repeater-ed gives better results compared to repeater-less [2].

The research was compiled with references from a journal titled “Design Of Using Optical Amplifier On Sistem Komunikasi Kabel Laut Network In Indonesia Global Gateway” written by Bima Kurnia Marahasakti A. Karel. The journal is used as a reference to create an amplifier configuration scheme with branicing unit and without branicing unit. Based on the above background then the author takes the title “Performance Analysis Of Sistem Komunikasi Kabel Laut (SKKL) Using Edfa Amplifier Link Java-Bali Using Optisystem” By using the schematics or configuration of Bracing Unit and without Branicing Unit. namely using the type of EDFA (Erbium Doped Fiber Amplifier).

2. Basic Theory

2.1 Submarine Cable

The undersea cable is a cable that is placed on the ground or at the bottom of the sea connecting the landing Station 1 with other landing stations. The underwater optic cable is designed to be suitable for both shallow and deep water use, which is necessary to ensure the protection of optic fibre against water pressure, longitudinal water propagation, chemical contamination and the influence of hydrogen contamination. Basically, the fiber optic cable used on land and marine has the same characteristics, which distinguishes it from its protective coating more on the sea cable is useful to protect the cable from the seabed hydrostatic pressure, Protection against marine life, fish bites, abrasion, and to avoid aggression and ship activities[3].

2.2 Branicing Unit

Branicing Unit (BU) is a tool used to connect more than three landing points (three terminal stations) with only one subsea cable. The placement of the two Branicing units on the same cable widen the number of landing points that are reachable with the same sea cable, as well as the optical path divider, the wavelength. In addition it saves cost because it is more efficient compared to making new lines[5].

2.3 Amplifier

Amplifier is used to extend the distance covered by a network to minimize the power of the lost optical signal. Example of an amplifier that is EDFA, EDFA is an optical amplifier that is used to increase signal levels that work on waves 1530 nm to 1570 nm. When pumped by an external laser source either 980 nm or 1480 nm, the signal gain can be as high as 30 dB. Because EDFA allows signals to be regenerated without having to be transformed back into an electrical signal, the system becomes faster and dependable[3].

2.4 Power Link Budget

Power Link budget is the power of total damping value allowed on an optical network from the transmitter/sender side to the receiver. Power link budget is used for the requirement that planning does not exceed the threshold of power needed[4]. To calculate the equation of power link budget can use the equation as follows:

\[ \alpha_{\text{tot}} = L_f \cdot \alpha_f + \alpha_{BU} \]  \hspace{1cm} (1)

Once the value is obtained, next look for the power value the receiver receives with the formula calculation:

\[ P_{RX} = P_{TX} - \alpha_{\text{tot}} \]  \hspace{1cm} (2)

Description :
- \( \alpha_{\text{tot}} \) : Total system attenuation (dB)
- \( L_f \) : Fiber Optic length (Km)
- \( \alpha_f \) : Optical fiber Attenuation (dB/Km)
- \( \alpha_{BU} \) : Branicing Unit Attenuation
\[ P_{Rx} \]: Power Receive (dBm)  
\[ P_{Tx} \]: Power Transmitter (dBm)

2.5 SNR (Signal to Noise Ratio)

Signal to Noise Ratio is the value of comparing optical signal power transmitted to the system Noise\[4\]. To calculate the value of Signal to Noise Ratio (SNR) can use the following equation:

\[
SNR = \frac{(Pr \times R \times M)^2}{2 \times q \times Pr \times M^2 \times F(M) \times Be + \frac{4 \times K_B \times T \times Be}{R_L}}
\]  

(3)

Description:

Pr : Power on APD (Watt)  
R : responsivitas detektor (A/W)  
M : Detector reinforcement  
q : Electron charge (1.69x10^{-19} C),  
F(M) : noise figure  
Be : receiver electrical bandwidth (Hz),  
KB : konstanta Boltzman(1.38x10^{-23} J/K),  
T : Temperature (K)  
RL : Resistansi (Ohm).

2.6 Q-Factor

Q-Factor is a parameter that determines whether the quality of the optical signal in a network is good. Q-Factor is used to evaluate from polarization and dispersion influences\[4\]. Attenuation can be caused by transmitter and receiver side analogue functions The standard value of Q-factor is worth 6 ITU-T G. 976. Q-Factor can be calculated using the formula as follows:

\[
Q = \frac{SNR}{10^{\frac{SNR}{20}}}
\]  

(4)

Description:

SNR: Signal to Noise Ratio

2.7 BER (Bit Error Rate)

BER (Bit Error Rate) is the value of errors in bits that occur during the delivery process on the transmission medium\[4\], the standard for the BER value is \(10^{-9}\) recommendation ITU-T G. 976. To calculate the value of the BER using the following equation:

\[
BER = \frac{1}{Q \times \sqrt{2\pi}} e^{\frac{Q^2}{2}}
\]  

(5)

Q = quality factor  
BER = Bit Error Rate

3. Research Methods

This work was conducted by several step that describe in the flowchart in section 3.1

3.1 Research Flowchart

The research process in Figure 1 begins with determining the landing point of the landing station. in this study the landing station used was from Java (Rungkut) to Bali (Kali Asem) For distance, it can be done using Google earth (Maps) and can use data from PT Telkom.
Next, determine the parameters that comply with ITU-T standards recommendation ITU-T G. 976 to simulate the system and use some data from the field. Simulate the optical software after doing the point of completion, distance and parameters used. In this design using EDFA amplifier in accordance with the field and using several frequency allocations,

![Research Flowchart](image)

**Figure 1.** Research Flowchart

After completing the simulation, it is then determined the standard BER value is $10^{-9}$ after conducting a simulation then analyzing the simulation results such as BER, Q-Factor, and receiving power and drawing conclusions from the analysis results obtained on optical simulation.

### 3.2 Submarine Cable Communication Model System

In Figure 2 is composed of transmitter block, transmission and receiver. Transmission block consisting of PRBS serves as an information signal pembagkit in the form of digital signal, NRZ Pulse Generator serves as an encoding, and Mach-Zehnder Modulator serve to modulating optical signal before it is transmitted into the fiber Optical. Transmission blocks consist of optical fiber as transmission medium, amplifier to minimize lost power, and Brancing Unit to connect/divide line more than 1 landing. On the receiver block there is a demultiplexing to break the information to reach the receiver.
Figure 2. Submarine cable communication model system

3.3 Transmitter Parameter
In the table 1 are the parameters in the transmitter block that are in accordance with the specifications of the Indonesia Global Gateway (IGG).

| NO | Parameter                        | Value       |
|----|----------------------------------|-------------|
| 1  | Aggregated bitrate              | 8 Tbps      |
| 2  | Bitrate per channel              | 100 Gbps    |
| 3  | Transmisi power (mux output min/max) | -40 dBm/5 dBm |
| 4  | Line codes                       | NRZ         |
| 5  | Channel spacing                  | 40 GHz      |
| 6  | Number of channel                | 10          |

3.4 Transmission Parameter
In general, the parameters of the transmission media (table 2) in the marine cable communication system are the same as the parameters found on terrestrial or terrestrial fiber optic networks. Attenuation coefficient is determined by the maximum value at one or more wavelengths in the region of 1310 nm and 1550 nm.

| Attribute                        | Detail | Value         |
|----------------------------------|--------|---------------|
| Attenuation Coefficient          | wavelength | 1550 nm      |
|                                  | 1550 nm | 0.16 db/km  |
|                                  | 1625 nm | To be determined |
| Typical Chromatic Dispersion Parameters | D1.550 | 16 ps/nm.km |
|                                  | S1.550 | 0.06 ps/nm.km |

The attenuation coefficient can be calculated across a spectrum of waveforms. Chromatic dispersion is the spread of light pulses in optical fibers caused by different speeds or different wavelengths. Chromatic dispersion is caused by two things, namely material dispersion and waveguide dispersion.

3.5 Receiver parameter
In the table above is the receiver side parameter with each parameter having the value of each of these parameters used to calculate the Signal to Noise Ratio value. Response responsiveness (R), detector amplifier (M), electrical receiver bandwidth (Be), Temperature (T), Obstacle (RL) with different units.
**Table 3.** Receiver Parameter [2]

| No | Parameter                          | Value |
|----|-----------------------------------|-------|
| 1  | Gain                              | 3     |
| 2  | Responsivitas detektor            | 1 A/W |
| 3  | Receiver electrical bandwidth     | 20 GHz|
| 4  | Temperature                       | 298 K |
| 5  | Resistansi                        | 50 Ohm|

4. Analysis of Simulation Results

In Figure 2 is a simulation without using the Java-Bali Brancing Unit link that is simulated using Optics 7.0 software, using 10 channels/frequencies, multiplexing to combine multiple information into one channel, demultiplexing to solve information from one information to several information, simulation this Java-Bali link is 442.04 km, and the amplifier used is EDFA (Erbium Doped Fiber Amplifier). In this simulation using 5 power variations namely 0, 2, 4, 6, and 8 dBm. The use of sections to divide the text of the paper is optional and left as a decision for the author. Where the author wishes to divide the paper into sections the formatting shown in table 2 should be used in this study using a configuration Brancing Unit and without brancing unit.

4.1. The Result of the BER Value without Brancing Unit.

**Table 4.** BER Value

| No | Frequency   | Power (dBm) |
|----|-------------|-------------|
|    |             | 0  | 2  | 4  | 6  | 8  |
| 1  | 195.74 THz  | 1.06E-21  | 7.61E-43 | 1.15E-70 | 9.76E-114 | 7.65E-147 |
| 2  | 195.70 THz  | 5.62E-17  | 3.23E-34 | 1.02E-61 | 2.69E-98  | 2.04E-129 |
| 3  | 195.66 THz  | 6.06E-22  | 2.98E-43 | 2.69E-67 | 5.16E-115 | 1.30E-147 |
| 4  | 195.62 THz  | 1.22E-20  | 1.92E-40 | 3.51E-63 | 1.17E-109 | 3.69E-143 |
| 5  | 195.58 THz  | 1.28E-18  | 1.21E-35 | 1.63E-65 | 1.70E-93  | 1.29E-123 |
| 6  | 195.54 THz  | 6.44E-20  | 1.02E-38 | 3.15E-74 | 1.81E-101 | 1.03E-131 |
| 7  | 195.50 THz  | 8.30E-18  | 5.15E-35 | 1.68E-63 | 4.44E-96  | 4.94E-127 |
| 8  | 195.46 THz  | 6.49E-18  | 2.09E-35 | 2.01E-71 | 5.18E-100 | 2.12E-133 |
| 9  | 195.42 THz  | 5.00E-17  | 3.24E-33 | 8.47E-78 | 1.19E-87  | 2.83E-114 |
| 10 | 195.38 THz  | 5.56E-17  | 4.16E-32 | 1.08E-78 | 1.75E-86  | 1.81E-118 |
|    | Average     | 1.78E-17  | 4.53E-33 | 1.07E-62 | 1.87E-87  | 2.83E-115 |

From table 4, the BER results all the values meet the specified standard, which is $1 \times 10^{-9}$, each variation of the BER value varies depending on the value of the power which greatly affects the results of BER obtained, the greater the value of the BER the better.

4.2. Q-Factor Value without Brancing Unit.

**Table 5.** Q-Factor Value

| No | Frequency   | Power (dBm) |
|----|-------------|-------------|
|    |             | 0  | 2  | 4  | 6  | 8  |
| 1  | 195.74 THz  | 9.49914  | 13.67 | 17.7321 | 22.6325 | 25.7753 |
| 2  | 195.70 THz  | 8.28745  | 12.1368 | 16.5336 | 21.0051 | 24.1702 |
In table 5 of all values in the variations of power 0, 2, 4, 6, and 8 dBm meet the standards of the standard Q-factor values specified, namely 6. The greater the Q-factor value the better, in simulation without Brancing Unit the power variation is very influential, the greater the power value the better the Q-Factor results.

4.3. Power Receive Value Brancing Unit.

Table 6. Power Receive Value

| No | Frequency     | 0   | 2   | 4   | 6   | 8   |
|----|---------------|-----|-----|-----|-----|-----|
| 3  | 195.66 THz    | 9.5609 | 13.7373 | 17.2911 | 22.7621 | 25.8446 |
| 4  | 195.62 THz    | 9.24066 | 13.2618 | 16.7358 | 22.215 | 25.4449 |
| 5  | 195.58 THz    | 8.72744 | 12.4034 | 17.051 | 20.4727 | 23.6114 |
| 6  | 195.54 THz    | 9.06004 | 12.9593 | 18.183 | 21.3502 | 24.3882 |
| 7  | 195.50 THz    | 8.51449 | 12.288 | 16.7767 | 20.7616 | 23.9425 |
| 8  | 195.46 THz    | 8.543 | 12.3607 | 17.8298 | 21.192 | 24.5457 |
| 9  | 195.42 THz    | 8.3036 | 11.9483 | 18.6331 | 19.8074 | 22.6849 |
| 10 | 195.38 THz    | 8.29205 | 11.7355 | 18.7441 | 19.6725 | 23.1062 |

Average | 8.802396 | 12.65011 | 17.55156 | 21.18711 | 24.35139 |

In table 5 of all values in the variations of power 0, 2, 4, 6, and 8 dBm meet the standards of the standard Q-factor values specified, namely 6. The greater the Q-factor value the better, in simulation without Brancing Unit the power variation is very influential, the greater the power value the better the Q-Factor results.

4.3. Power Receive Value Brancing Unit.

Table 6. Power Receive Value

| No | Frequency     | 0   | 2   | 4   | 6   | 8   |
|----|---------------|-----|-----|-----|-----|-----|
| 1  | 195.74 THz    | -24.22 | -22.22 | -20.302 | -18.22 | -16.22 |
| 2  | 195.70 THz    | -24.355 | -22.355 | -20.263 | -18.355 | -16.355 |
| 3  | 195.66 THz    | -24.251 | -22.251 | -20.357 | -18.251 | -16.251 |
| 4  | 195.62 THz    | -24.057 | -22.057 | -20.25 | -18.057 | -16.056 |
| 5  | 195.58 THz    | -24.114 | -22.114 | -20.057 | -18.114 | -16.114 |
| 6  | 195.54 THz    | -24.185 | -22.185 | -20.114 | -18.185 | -16.185 |
| 7  | 195.50 THz    | -24.116 | -22.116 | -20.187 | -18.116 | -16.116 |
| 8  | 195.46 THz    | -24.122 | -22.122 | -20.121 | -18.122 | -16.122 |
| 9  | 195.42 THz    | -24.287 | -22.287 | -20.199 | -18.287 | -16.287 |
| 10 | 195.38 THz    | -24.231 | -22.231 | -20.135 | -18.231 | -16.231 |

Average | -24.1938 | -22.1938 | -20.1985 | -18.1938 | -16.1937 |

From table 6 the results use as many as 5 power variations using simulation values meet the prescribed standards, namely -30 standard attenuation value, if it exceeds the loss value -30 it can be said the network is loss or not connected even if it can still be connected This unit all values meet the standards

4.4. SNR (Signal to Noise Ratio) Value Brancing Unit.

Table 7. SNR value

| No | Frequency     | 0   | 2   | 4   | 6   | 8   |
|----|---------------|-----|-----|-----|-----|-----|
| 1  | 195.74 THz    | 16.248987 | 20.248987 | 23.950814 | 28.248987 | 32.248987 |

7
| No | Frequency       | Power (dBm) |
|----|----------------|-------------|
|    |                | 0           | 2           | 4           | 6           | 8           |
| 2  | 195.70 THz     | 18.57991    | 22.57991    | 22.856361   | 30.57991    | 34.57991    |
| 3  | 195.66 THz     | 11.866556   | 15.866556   | 26.635772   | 23.866556   | 27.866556   |
| 4  | 195.62 THz     | 13.584484   | 17.584484   | 19.875584   | 25.584484   | 29.584484   |
| 5  | 195.58 THz     | 15.189186   | 19.189186   | 21.583271   | 27.189186   | 31.189186   |
| 6  | 195.54 THz     | 14.724854   | 18.724854   | 23.185888   | 26.724854   | 30.724854   |
| 7  | 195.50 THz     | 14.07071    | 18.07071    | 22.72406    | 26.07071    | 30.07071    |
| 8  | 195.46 THz     | 14.657155   | 18.657155   | 22.035763   | 26.657155   | 30.657155   |
| 9  | 195.42 THz     | 15.904581   | 19.904581   | 24.68418    | 27.904581   | 31.904581   |
| 10 | 195.38 THz     | 16.585524   | 20.585524   | 22.68575    | 28.585524   | 32.585524   |
|    | **Average**    | **15.1411947** | **19.1411947** | **23.0215268** | **27.1411947** | **31.1411947** |

From table 7 the SNR value of these results can be classified into categories 0.00 dB - 0.69 dB Bad, 0.70 dB - 10.9 dB Fair, 11.0 dB - 19.9 dB good, 20.0 dB - 28.9 dB excellent, and 29.0 dB above the outstanding. From the SNR results, the SNR value can be said to be good (synchronous signals can run smoothly) with 0 dBm and 2 dBm power; SNR 4 dBm and 6 dBm values can be said to be good (stable connection), and 8 dBm is very good.

4.5. BER Value use Brancing Unit

| No | Frequency       | Power (dBm) |
|----|----------------|-------------|
|    |                | 0           | 2           | 4           | 6           | 8           |
| 1  | 195.74 THz     | 8.82×10^{-14} | 6.66×10^{-25} | 2.94×10^{-40} | 1.88×10^{-56} | 1.52×10^{-69} |
| 2  | 195.70 THz     | 3.42×10^{-12} | 9.66×10^{-22} | 2.44×10^{-34} | 8.12×10^{-47} | 4.70×10^{-56} |
| 3  | 195.66 THz     | 5.77×10^{-10} | 6.54×10^{-18} | 3.75×10^{-29} | 1.94×10^{-41} | 9.39×10^{-52} |
| 4  | 195.62 THz     | 4.34×10^{-10} | 8.92×10^{-18} | 2.90×10^{-28} | 1.94×10^{-39} | 8.42×10^{-49} |
| 5  | 195.58 THz     | 4.89×10^{-15} | 2.38×10^{-26} | 6.85×10^{-40} | 1.02×10^{-51} | 3.12×10^{-59} |
| 6  | 195.54 THz     | 9.78×10^{-11} | 1.38×10^{-18} | 3.80×10^{-29} | 2.66×10^{-40} | 2.02×10^{-49} |
| 7  | 195.50 THz     | 6.32×10^{-12} | 7.66×10^{-21} | 3.98×10^{-32} | 4.45×10^{-43} | 2.16×10^{-51} |
| 8  | 195.46 THz     | 1.21×10^{-11} | 1.74×10^{-20} | 2.34×10^{-32} | 2.46×10^{-44} | 2.45×10^{-53} |
| 9  | 195.42 THz     | 8.32×10^{-11} | 7.49×10^{-19} | 8.10×10^{-30} | 1.30×10^{-41} | 1.29×10^{-51} |
| 10 | 195.38 THz     | 3.86×10^{-13} | 8.09×10^{-23} | 4.09×10^{-35} | 2.76×10^{-47} | 8.01×10^{-57} |
|    | **Average**    | **1.21×10^{-10}** | **1.76×10^{-18}** | **3.73×10^{-29}** | **2.23×10^{-40}** | **1.05×10^{-49}** |

From table 8 the results above using the Brancing Unit simulation of all the variable variation values, the BER value meets the predetermined standard of 1×10^{-9} and from these results each power used is very influential on the results the greater the value of the BER value the better.
4.6. Q-Factor Value use Brancing Unit

Table 9. Q-Factor Value

| No | Frequency  | Power (dBm) |
|----|------------|-------------|
|    |            | 0    | 2    | 4    | 6    | 8    |
| 1  | 195.74 THz | 7.36254 | 10.2341 | 13.2236 | 15.7794 | 17.5777 |
| 2  | 195.70 THz | 6.85729 | 9.50301 | 12.1548 | 14.3094 | 15.7166 |
| 3  | 195.66 THz | 6.08595 | 8.54097 | 11.1413 | 13.4249 | 15.0793 |
| 4  | 195.62 THz | 6.13079 | 8.50457 | 10.9574 | 13.0794 | 14.6233 |
| 5  | 195.58 THz | 7.74129 | 10.5537 | 13.1617 | 15.077 | 16.1768 |
| 6  | 195.54 THz | 6.36161 | 8.71571 | 11.1372 | 13.4271 | 15.0793 |
| 7  | 195.50 THz | 6.76851 | 9.28457 | 12.2996 | 14.3833 | 15.8265 |
| 8  | 195.46 THz | 6.66812 | 9.19257 | 11.7722 | 13.9035 | 15.3125 |
| 9  | 195.42 THz | 6.38867 | 8.78732 | 11.2762 | 13.9035 | 15.0574 |
| 10 | 195.38 THz | 7.16308 | 9.75799 | 12.2996 | 14.3833 | 15.8265 |
|    | Average    | 6.752785 | 9.307451 | 11.88544 | 14.03345 | 15.51081 |

In table 9 Q-Factor values with simulations using the Brancing Unit, and all channels for the Q-Factor value have good performance in accordance with the specified standard, namely 6, from the Q-factor results the value is very good at 0 dBm ie channel 195.58 THz, the simulation with 2 dBm power experienced the best increase in Q-Factor value, that is on the 195.58 THz channel, the best 4 dBm Q-factor value, that is on the canal 195.74 THz, the power 6 dBm the Q value The best-value factor is the canal 195.74 THz, and the simulation using 8 dBm of the best Q-factor value is on the canal 195.74 THz, from each power studied the value is different the higher the power Q- The obtained factor is getting better value.

4.7. Power Receive Value use Brancing Unit

Table 10. Power Receive Value

| No | Frequency  | Power (dBm) |
|----|------------|-------------|
|    |            | 0    | 2    | 4    | 6    | 8    |
| 1  | 195.74 THz | -24.733 | -22.733 | -20.733 | -18.733 | -16.733 |
| 2  | 195.70 THz | -25.313 | -23.313 | -21.313 | -19.313 | -17.313 |
| 3  | 195.66 THz | -25.364 | -23.364 | -21.364 | -19.364 | -17.313 |
| 4  | 195.62 THz | -25.37 | -23.37 | -21.37 | -19.37 | -17.37 |
| 5  | 195.58 THz | -25.451 | -23.451 | -21.451 | -19.451 | -17.451 |
| 6  | 195.54 THz | -25.382 | -23.382 | -21.382 | -19.382 | -17.382 |
| 7  | 195.50 THz | -25.376 | -23.376 | -21.376 | -19.376 | -17.376 |
| 8  | 195.46 THz | -25.435 | -23.435 | -21.435 | -19.435 | -17.435 |
| 9  | 195.42 THz | -25.404 | -23.404 | -21.404 | -19.404 | -17.404 |
| 10 | 195.38 THz | -25.042 | -23.042 | -21.042 | -19.042 | -17.042 |
|    | Average    | -25.287 | -23.287 | -21.287 | -19.287 | -17.287 |
In table 10 From this frequency the smallest power is obtained by the highest value of power receive while the highest power is the lowest value. In the simulation using Brancing Unit the value meets the specified standard which is worth -40 dBm, if it exceeds -40 dBm the network is loss or not connected even though it is connected at -40 dBm the quality of the network is poor and from this simulation all values are below -40 dBm.

4.8. SNR Value use Brancing Unit

Table 11. SNR Value

| No | Frequency | 0      | 2      | 4      | 6      | 8      |
|----|-----------|--------|--------|--------|--------|--------|
| 1  | 195.74 THz| 12.335328 | 16.335328 | 20.335328 | 24.335328 | 28.335328 |
| 2  | 195.70 THz| 9.5977552 | 13.597755 | 17.597755 | 21.597755 | 25.597755 |
| 3  | 195.66 THz| 12.653125 | 16.653125 | 20.653125 | 24.653125 | 28.653125 |
| 4  | 195.62 THz| 11.506448 | 15.506448 | 19.506448 | 23.506448 | 27.506448 |
| 5  | 195.58 THz| 4.7244301 | 8.7244301 | 12.72443 | 16.72443 | 20.72443 |
| 6  | 195.54 THz| 11.950298 | 15.950298 | 19.950298 | 23.950298 | 27.950298 |
| 7  | 195.50 THz| 11.524652 | 15.524652 | 19.524652 | 23.524652 | 27.524652 |
| 8  | 195.46 THz| 12.766703 | 16.766703 | 20.766703 | 24.766703 | 28.766703 |
| 9  | 195.42 THz| 9.2474206 | 13.247421 | 17.247421 | 21.247421 | 25.247421 |
| 10 | 195.38 THz| 17.408404 | 21.408404 | 25.408404 | 29.408404 | 33.408404 |
|    | Average   | 11.3714564 | 15.3714564 | 19.3714564 | 23.3714564 | 27.3714564 |

4.9. Comparison of Parameter Values Without BU and using BU

From table 11 shows the value of SNR (Signal to Noise Ratio) by using the Brancing Unit, from these results all channels have good performance which is obtained the best value at 0 dBm which is found on the channel 195.38 THz, at a power of 2 dBm the best value i.e. on channel 195.38, 4 dBm power SNR value is very good, that is on channel 195.38 THz, on channel 6 dBm the SNR value is very good that is on channel 195.38 THz, and simulation with power of 8 dBm best SNR value on canal 195.38 THz, from the five power variations, the worst SNR value is 0 dBm in the 195.58 THz channel of 4.72 dB.

From table 12 of the parameters BER, Q-Factor, Power Receive and SNR it is better to use a simulation without a Brancing Unit. In Brancing the unit is used to divide or connect more than 1 landing station, if implemented to save costs because it is more efficient than making a new line, placement of BU on the same cable extends the landing / landing and in the simulation using brancing units the value is smaller compared to simulation without brancing the unit because the BU device has attenuation that affects the value of the specified parameters. The simulation using BU result is smaller because at Bu there is Add/Drop system, if there is a wavelength that does not meet the criteria will be dropped and if it meets the criteria will be added, the wavelength is divided into two lanes so as to use the BU The value is smaller.

In figure 3 shows a comparison of the BER values of each configuration used, the highest BER results for the No Brancing Unit configuration at 8 dBm with a value of 2.83x10-115 and the lowest value at 0 dBm 1.78x10-17 while the highest BER value at the configuration using BU is at 8 dBm with a value of 1.05x10-49 and the lowest value at 0 dBm with a value of 1.21x10-10 based on the value of BER then the configuration without BU is the best configuration.
### Table 12. Comparison of Parameter Values Without BU and using BU

| Parameter | Power (dBm) | Without BU | BU  |
|-----------|-------------|------------|-----|
| BER       | 0           | 1.78x10^{-17} | 1.21x10^{-10} |
|           | 2           | 4.53x10^{-33} | 1.76x10^{-18} |
|           | 4           | 1.07x10^{-62} | 3.73x10^{-29} |
|           | 6           | 1.87x10^{-47} | 2.23x10^{-40} |
|           | 8           | 2.83x10^{-115}| 1.05x10^{-49} |
| Q-Factor  | 0           | 8,802396    | 6,752785    |
|           | 2           | 12,65011    | 9,307451    |
|           | 4           | 17,55156    | 11,88544    |
|           | 6           | 21,18711    | 14,03345    |
|           | 8           | 24,35139    | 15,51081    |
| Power     | 0           | -24,1938    | -25,287     |
| Receive   | 2           | -22,1938    | -23,287     |
| (dBm)     | 4           | -20,1985    | -21,287     |
|           | 6           | -18,1938    | -19,287     |
|           | 8           | -16,1937    | -17,287     |
| SNR       | 0           | 15,1411947  | 11,3714564  |
|           | 2           | 19,1411947  | 15,3714564  |
|           | 4           | 23,0215268  | 19,3714564  |
|           | 6           | 27,1411947  | 23,3714564  |
|           | 8           | 31,1411947  | 27,3714564  |

![Figure 3. BER Comparison Charts](image-url)
Figure 4 is a Q-Factor comparison of each configuration used. The highest Q-factor value results without a Brancing Unit configuration that is 24.35139 at 8 dBm, and the lowest value is 8.802396 at 0 dBm. Whereas in the configuration using BU the highest value of Q-Factor is valued at 15.51081 at 8 dBm and for the lowest value is 6.752785 at 0 dBm, from the comparison the Q-Factor value of all configurations has good performance and meets the standard value determined that is 6 for the Q-factor value.

In figure 5 from the comparison the power receive value for all configurations has a good performance and meets the specified standard value of -40 dBm for the power receive value. Based on the results of power receive and power variations, the configuration without BU is the best configuration.

In figure 6 from the comparison the SNR values of all configurations have good performance. Based on the SNR value, the configuration without BU is the best configuration.
5. Conclusion
From the results of research on marine cable communication systems some conclusions can be obtained as follows:
1. Based on the results of the Brancing Unit and No Brancing Unit configuration simulation all channels have very good performance because they have values that meet the standards of the BER (Bit Error Rate), Q-Factor, Power Receive and Signal to Noise Ratio (SNR).
2. The No Brancing Unit configuration has the highest value at 8 dBm, with BER values reaching $2.83 \times 10^{-11}$, Q-Factor value 24.35139, Power Receive value -16.1937 dBm, and SNR value reaching 31, 1411947 dB.
3. Configuration without a very good BER BER value at a frequency of 195.74 THz with a value reaching $7.65 \times 10^{-14}$ and Using a very good BER value at a frequency of 195.74 THz the value obtained is $1.52 \times 10^{-6}$ with power 8 dBm.

References
[1] P. A. Praja, A. Hambali and A. D. Pambudi, 2017, "Performance Analysis of Hybrid Optical Amplifier in long Laul Ultra-Dense Wavelength Division Multiplexing System," e-Proceeding of Engineering, vol. IV, p. 124.
[2] B. K. M. A.Karel, 2017, Perancangan Penggunaan Penguat Optik Pada Jaringan Sistem Komunikasi Kabel Laut(Skkl) Di Jalur Sistem Indonesia Global Gateway(IGG), Bandung : Telkom University.
[3] M. Johnson, 2009, Optical fibres, cables and systems, International Telecommunication Union.
[4] M. R. Hasibuan, 2017, "Perancangan Penggunaan Perangkat Pembagi Untuk Komunikasi Kabel Laut Di Jalur Indonesia Global Gateway," e-proceeding of Engineering, vol. 5, pp. 3-4.
[5] NEC, 2017, Indonesia Global Gateway (System Description), NEC Confidential.