Design Of Optical Fiber Network In Daik Sub District, Lingga Regency, Riau Islands Case Study At PT. Telkom Rikep, Indonesia

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Abstract. A Fiber optic network has a reliable performance in transmitting the information. This network which is developed in Daik Village, Lingga Regency, Riau Islands has high data transfer rates and large bandwidth. Its development aimed to support city administration, where the network is connected to 12 government offices. Therefore, this study aims to design a fiber network using the optic system as a simulation and theoretical calculation of parameters to determine its feasibility. The design carried out showed that the maximum attenuation value on the farthest link is 16.15 dBm, while the maximum power received is - 11.743 dBm. Also, the results for the bit error rate is 0 because the time value on the uplink and downlink are 0.2502280209 ns and 0.2533267605 ns respectively. The value of the parameter based on theoretical calculations and simulation is in line with the standards set by the International Telecommunication Union (ITU-T) and PT. Telkom standards such as Gigabit Passive Optical Network (GPON). This standard has parameter values in the form of maximum damping and receiver sensitivity of 27 dBm and -28 dBm respectively. From the digital link, the total transmission time is less or equal to 70% of the Non-Return to Zero (NRZ) bit. The results obtained indicated the design carried out is feasible because it has met the established standards such as the number of bit error rate (BER) that is 10^{-9}.

Keywords: Fiber optic, optic system, power link budget, rise time budget, bit error rate

1 Introduction

Optical fiber serves as a medium for transmitting messages (information) in the form of images, sound, data, and video [20]. This network uses a reliable light pulse method to transfer data at high speeds because it has a wide bandwidth or transmission line [13]. To reduce the telecommunications gap in each region, the Indonesian government develop a fiber optic network service infrastructure called the Palapa Ring project [16]. This project has 3 geographical points including west, middle, and east. In the western part, the area covered is the island of Kalimantan with Sumatra, and it currently reaches East Kalimantan, North, Central, and Southeast Sulawesi, as well as North Maluku. Furthermore, the eastern Palapa Ring covers East Nusa Tenggara, Maluku, Papua, and West Papua [14].

The Riau Islands are also included in the western development area with 3 facilitated regencies such as Lingga, Anambas, and Natuna. Meanwhile, the Lingga government carried out the construction of a fiber optic network in Daik Village, Lingga Regency, Riau Islands. The development of the western Palapa Ring project or the national fiber optic network continues in this regency and its surroundings [12]. This development is carried out in network requirements

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that increase yearly. A design is performed to meet the needs of a qualified network in the Lingga Regency. Therefore, this district manager requests to design a fiber optic network as the requirement for the regional government. This network is connected to the shelter source PT. Telkom which increases to twelve points of offices. The twelve connected points include Bunda Tanah Melayu Radio, the civil service police unit, the national political unit, and community protection, the media center, the library and archive, the regional building, the regional development planning agency, the disaster management agency, the regional civil service, financial management revenue, social and women empowerment, as well as inspectorate office.

Based on the development point that has been determined, a simulation design is made using GPON (Gigabit Passive Optical Network) technology which was adopted by PT. Telkom is the organizer of the development. GPON technology uses the ITU.G.984 standard, which is a standard with point to multipoint network system specifications or from one point to many points with a high bit rate. GPON technology also has high bandwidth where services are in the form of cloud computing or services that allow us to access computing resources from anywhere, anytime and can configure our own needs. want quickly and easily, as well as triple play services or services in the form of cable TV subscriptions, landline telephones and internet access [8]. Making a network simulation design using optic system software. Optic system is software that allows a network design to accurately project performance characteristics of real systems and calculate system parameters where the system is built using components or subsystems. By using optic system can easily propose different scenarios for network circuit design [15].This software has also been used by many previous studies to find out the results of network parameter values that have been designed, including research conducted by [1];[3];[5] and other studies. The optical network parameters used in this study to determine the quality of the network that has been designed are: Power Link Budget (PLB), Rise Time Budget (RTB) and Bit Error Rate (BER).

2 Descriptive Analysis

A. Optical Communications System

An optical communication system is a system that uses optical fiber as a transmission medium. Network building components Optical communication is shown in Figure 1, which consists of an optical source or transmitter used to convert electrical signals into light or optical signals, fiber optic cables as optical signal transmission media, and light detectors to convert received optical signals into electrical signals [7].

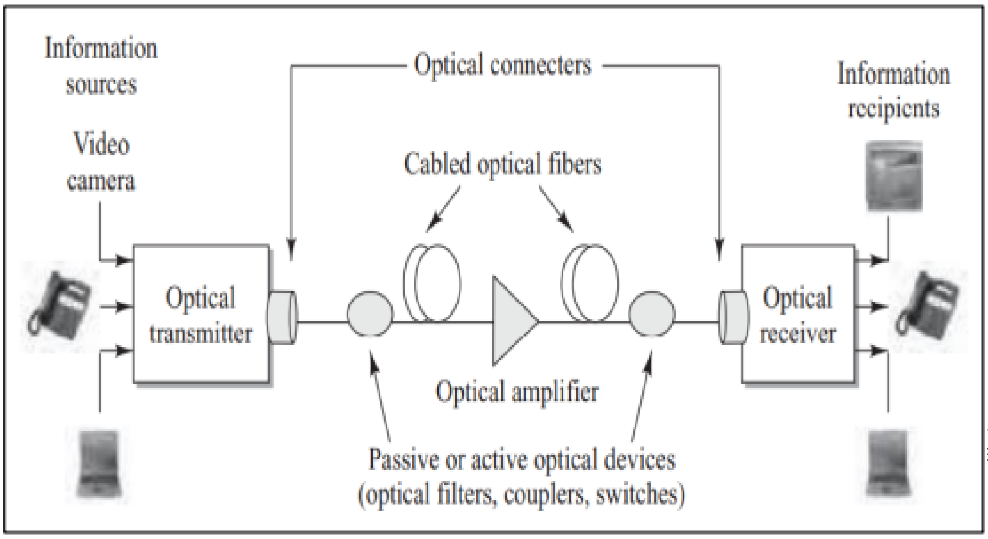

Figure 1. Optical network transmission components

components that do not require power to operate. Examples of active components are optical transmitters or transmission centers in the form of Optical Line Terminals (OLT) and Optical Network Units (ONU) which are located on the customer side. While for passive components, namely connectors, network splitters, fiber optic cables switches (switches), connections (couplers) and others [10].

The way a fiber optic network works is to carry information from one point to another in the form of light. Information delivery using logic 1 when light pulses are sent and if not sent light pulses mean logic 0. In fiber optic transmission media if light falls, the detector will convert the light into electrical signals. The end of the optical receiver consists of a photodiode that produces an electric pulse when exposed to light [7].

B. Fiber to the home (FTTH)

Fiber to the home (FTTH) network is a network to serve residential customers or home customers. The FTTH network has a service known as triple play services, namely services for fast internet access in the form of data, voice, and video (cable TV) in one infrastructure at the subscriber unit. The FTTH network has a wavelength for downstream (OLT – ONT) or from the center to the subscriber of 1490 nm with a data transfer rate of 2.488 Gbps and for an upstream wavelength (ONT – OLT) of 1310 nm with a data transfer rate of 1,244 Gbps. The FTTH network topology is shown in Figure 2.

C. igabit Passive Optical Network (GPON)

Gigabit Passive Optical Network (GPON) is an access node technology that has the function of providing multimedia services such as internet, voice, data, video and other content for residential and business customers. GPON uses the ITU.G.984 standard, namely the

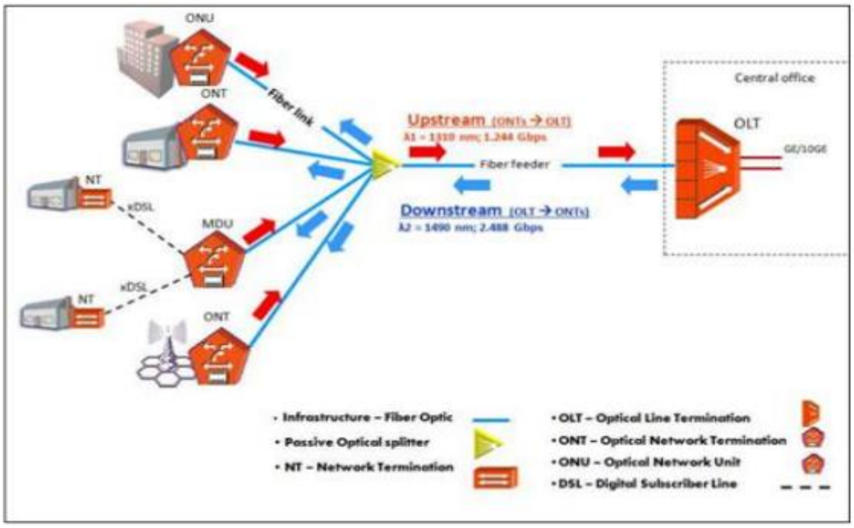

Figure 2. Network Topology Fiber to the home (FTTH)

maximum distance is 20 Km and the total attenuation does not exceed -28 dBm (PT. Telekomunikasi Indonesia.Tbk., 2015). This technology is a point to multipoint technology with a high bit rate. GPON technology standard specifications can be seen in Table 1.

Table 1. GPON standard specifications

STANDAR	ITU.G.984
Downstream speed	2.4 Gbps
Upstream Speed	1.2 Gbps
Service	*Triple Play* (Data, Voice, Video)
Maximum Splitters	1 : 64
Maximum Distance	20 km
Downlink wavelength	1490 nm
Uplink wavelength	1310 nm
Splitters	Pasif

The components that make up this technology are OLT, optical splitter and ONT. OLT is a component located in the distribution center, which has a function as a data transmission center, passive splitter as a network divider to several termination points and ONT is located on the customer side as the final termination point of signal transmission. GPON technology has a downstream wavelength (sending data from the center to the customer) of 1490 nm with a data rate of 2.44 Gbps and an upstream wavelength (sending of data from the customer to the data center) of 1310 nm with a data rate of 1.22 Gbps. The GPON technology topology is shown in Figure 3.

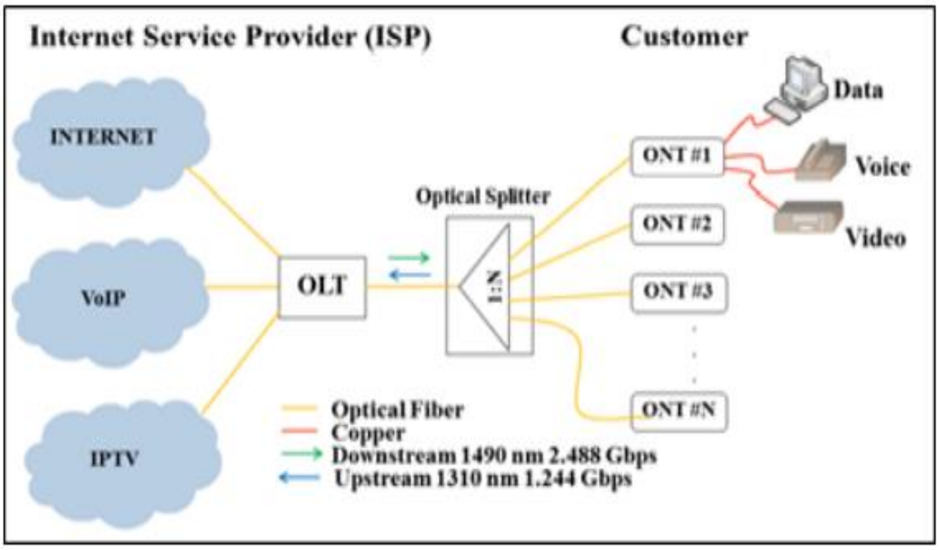

Figure 3. GPON Technology Standard Configuration

D. Optisystem Software

Optisystem is a simulation application that is used to design or perform system modeling, testing, and optimization of optical networks and virtually everything from analog video broadcasting networks to intercontinental communication backbone networks. Optisystem has several features which include layout editor, report page, scripting capabilities, MATLAB interface, to calculation of optical network quality parameters [11].

Optisystem can also perform simulations of various kinds applications, ranging from

Cable Antenna Television (CATV) network design, Wavelength division multiplexing (WDM) to Synchronous Optical Network (SONET)/Synchronous Digital Hierarchy (SDH) ring design. Another function of the optisystem is to determine and map the transmitter, link length, amplifier location and receiver design [19].

E. Fiber optic network Transmission Parameters

1. Power Link Budget (PLB)

Power Link Budget is a parameter that indicates the maximum allowable power difference between the optical transmitter and receiver. This calculation is useful to ensure that the power sent by the transmitter or data center can be received by the receiver or on the customer side not less than the minimum power level that has been standardized by ITU-T. In addition, by performing PLB calculations, it is possible to determine the maximum distance of optical fiber transmission that can be achieved [15]. In calculating the total attenuation for the power link budget using the following equation:

$$\boldsymbol{\alpha_{total} = L_{serat} + N_c \times \alpha_c + N_s \times \alpha_s + S} \quad (2.1)$$

Rated power received on ONT or on customer side using the following equation:

$$\boldsymbol{P_r = P_t - \alpha_{total}} \quad (2.2)$$

Information:
$\boldsymbol{\alpha_{total}}$= Total system attenuation (dBm)
L = Total length of optical fiber (km)
$\boldsymbol{\alpha_s}$ = fiber optic attenuation (dBm/km)
$\boldsymbol{\alpha_c}$ = Connector attenuation (dBm/pc)
$\boldsymbol{\alpha_s}$ = Connection attenuation (dBm/pc)
$\boldsymbol{N_c}$ = Number of connectors
$\boldsymbol{N_s}$ = Number of connections
S = Splitter Attenuation (dBm)
$\boldsymbol{P_r}$ = Detector receive power/ ONT sensitivity (dBm)

2. Rise Time Budget (RTB)

Rise time budget is an optical parameter calculation to determine the value of the dispersion limit (pulse widening) of the fiber optic network. Generally, the total transmission time degradation of the digital link is less or equal to 70 percent of the NRZ bit period [13]. Rise time in another sense is the response time required by the system to detect signals ranging from 10-90% to the input signal [13].

The limitation of the rise-time will cause the data to be distorted so the data will be lost. The rise time budget itself has an effect on system bandwidth, where the smaller the rise time value of a link, the wider the system bandwidth, on the other hand, if the rise time budget value of a link is large, it will narrow the system bandwidth [18]. Calculation of the rise time budget using the equation:

$$\boldsymbol{T_{total} = \sqrt{{T_{tx}}^2 + {T_{Intramodal}}^2 + {T_{Intermodal}}^2 + {T_{rx}}^2}} \quad (2.3)$$

Information:
$\boldsymbol{T_{tx}}$ = Transmitter rise time (ns)
$\boldsymbol{T_{rx}}$ = Receiver rise time (ns)
$\boldsymbol{T_{Intermodal}}$ = zero (single mode optical fiber)
$\boldsymbol{T_{Intramodal}}$ = Tmaterial + Twaveguide
$\boldsymbol{T_{tx}}$ = Receiver rise time (ns)

3. Bit Error Rate (BER)

Optical signal transmission sends information signals in the form of data bits, each data bit sent over the network is in the form of light pulses, each of which carries one data bit [9].

wever, in transmission, not all bits can be sent perfectly, for this reason, the calculation of the number of errors that occur in each number of data bits sent by a digital system or the calculation of the Bit Error Rate (BER). In optical communication networks in general, the BER value that must be met is not greater than 10-9 in accordance with the standards set by ITU-T [4]. The bit error value on a link is obtained through the calculation of the Signal Noise To Ratio (SNR) value to determine the quantum noise value of the system that will be used in the equation to find the BER value. The equation used to calculate the SNR value is:

$$SNR = \frac{i_p^2 \times M^2}{2_q\left(i_p + i_D\right)BM^2F(M) + \frac{4KT_{eff^B}}{R_L}} \tag{2.4}$$

Information:

i_p	= Primary photo current generated (W)
q	= Electron charge
M	= Additional signal power to the light detector
i_D	= Dark current (A)
B	= Bandwidth of light detector (Hz
F(M)	= Noise figure
K	= Boltzman's constant
T_{eff}	= Effective noise temperature
R_L	= equivalent resistance

After getting the SNR value, then proceed with looking for the value of the system bit error rate using equation :

$$\left(\frac{S}{N}\right)\frac{pk}{rms} = 20\ Log\ 2Q \tag{2.5}$$

Information :

$\left(\frac{S}{N}\right)\frac{pk}{rms}$ = Signal Noise Ratio (SNR)

Q = Quantum noise

$$BER = P_e(Q) = \frac{1}{\sqrt{2\pi}} \times \frac{e^{\frac{-Q^2}{2}}}{Q} \tag{2.6}$$

3. Research Flow Chart

The steps taken in conducting the research are as follows:

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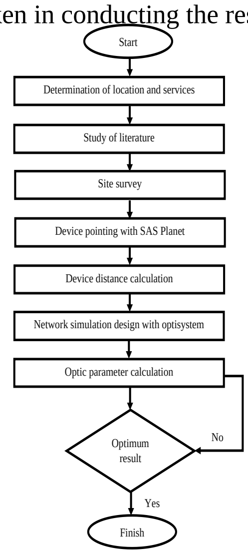

Figure 4. Flow chart

Figure 4 shows the following explanation of the research flow chart.

1. Determination of location and services
   The initial stage of the research begins with determining the service product that suits customer needs. This determination is carried out by interviewing or discussing with customers to discover their needs, location, and services.
2. Literature study
   Data and information were collected from books, articles, journals, and materials that support this research. This stage is needed to understand how the system tends to work.
3. Site survey
   A site survey is needed to examine the geographical location as the placement of the device later and also as a reference in making the form of a network circuit.
4. Device pointing with SAS Planet
   The determined location, distribution, and others support tools using the SAS Planet website.
5. Device distance calculation
   This stage is the measurement of the distance between devices using SAS Planet by drawing a line from the center of the transmission to the location point.
6. Network simulation design with optisystem
   The network simulation stage using optisystem software is based on the collected data through previous field surveys. In carrying out the simulation, the first step is to connect the devices and enter their specifications such as the power required to determine the distance that has been calculated using SAS Planet. The next step is to calculate the reference parameter for the fiber optic network to discover whether it is in line with the specified standard.
7. Calculation of optical parameters
   The calculation of optical parameters is adjusted to the specified standard such as international standardsTelecommunication Union (ITU-T) and standard PT. Telkom Indonesia.
8. Analysis of research results and conclusions
   After performing the simulation, an analysis is carried out based on the parameters, and also a conclusion about the system was made.

4. Results and Evaluation

A. Network Topology

A star tends to become the topology used for Kelurahan Daik in Lingga because the distribution of the network is from one point to another. Data transmission starts from the internet gateway or center since it is connected to the West Palapa Ring through Metro Telkom devices that travel to the Mikrotik router. It tends to move to OLT which connects the center to the distribution network using an Optical Distribution Point (ODP). This is channeled to the last termination point located at the customer through the Optical Network Termination (ONT) device. Moreover, the last point is divided into a network that tends to be accessible to the customer. Figure 5 shows the results of the network topology to serve the needs of the Daik Village, Lingga.

Network design

Network design was developed using optisystem software. Data was collected to discover the device coordinates and their distance. However, retrieval of field data was performed by visiting each predetermined termination point and connecting them. Table 2 shows the results of field data collection forthe distance from OLT to ODP.

Table 2. Distance OLT - ODP

	DEVICE	POSITION	DISTANCE
A.	OLT (*Optical Line Terminal*)	Daik, Kel Daik, Jl. Istana Robat. *Latitude*: S0°12'38.3040" *Longitude*: E104°37'00.1740"	-
B.	ODP (*Optical Distribution Point*)	ODP Telkom Daik Daik, Kec. Lingga, Kabupaten Lingga *Latitude*: S0°12'35.5595" *Longitude*: E104°37'00.1818"	OLT – ODP = 0,099 Km

The result for distance from ODP to ONT is show in Table 3.

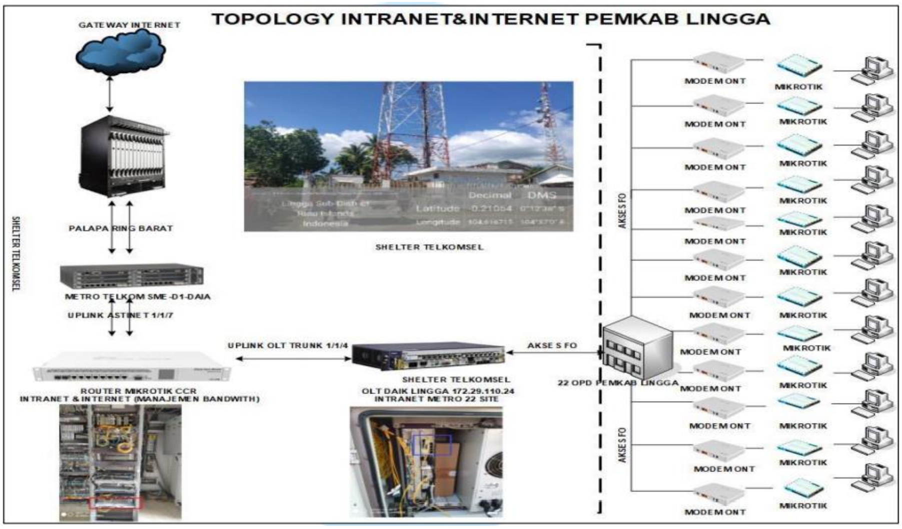

Figure 5. Network Topologi

Table 3. Distance ODP - ONT

	DEVICE	POSITION	DISTANCE
			ODP - ONT
C.	ONT (*Optical Network Terminal*)	Radio Bunda Tanah Melayu Jl. Datuk Laksemana, Daik, Kec. Lingga, Kabupaten Lingga *Latitude*: S0°12'35.1161" *Longitude*: E104°37'00.2044"	0,013 Km
		Satuan Polisi Pamong Praja (Satpol PP) Jalan Datuk Laksemane No.9, Daik, Kab. Lingga *Latitude*: S0°12'35.8637" *Longitude*: E104°36'58.5223"	0,062 Km
		Badan Kesatuan Bangsa dan Politik Jl. Masjid Jami Sultan Lingga, Daik, Kab. Lingga *Latitude*: - 0.2137407 *Longitude*: 104.6097207	0,482 Km
		Media Center Jl. Engku Aman Kelang No.63-B, Daik, Kab Lingga *Latitude*: - 0.2039063 *Longitude*: 104.6173579	1,4 Km
		Perpustakaan Umum dan Arsip Daerah Daik, Lingga *Sub-District*, Lingga *Regency* *Latitude*: -0.2124464 *Longitude*: 104.6061484	1,8 Km
		Gedung Daerah Kab. Lingga Jl. Istana Kota Baru No.1, Daik, Kab. Lingga *Latitude*: - 0.2107367 *Longitude*: 104.6002934	2,1 Km
		7. Badan Penanggulangan Bencana Daerah Jl. Istana Robat, Daik Latitude: -0.21075477 Longitude: 104.60115852	2,3Km
		8. Badan Perencanaan, Penelitian & Pengembangan Jl. Istana Robat, Daik *Latitude*: - 0.209345, *Longitude*: 104.6007971	2,4 Km
		Badan Kepegawaian Daerah (BKD) Jl. Robat Daik, Istana Kota Baru *Latitude*: - 0.208886 *Longitude*: 104.5965747	2,6 Km

		Badan Pengelolaan Keuangan Jl. Robat Daik, Istana Kota Baru *Latitude*: -0.208886 *Longitude*:104.5965747	2,6 Km
		Dinas Sosial, Pemberdayaan Perempuan dan Perlindungan Anak Jl. Robat Daik, Istana Kota Baru *Latitude*: - 0.2068656 *Longitude*: 104.5945775	2,8 Km
		Inspektorat Jl. Robat Daik, Istana Kota Baru *Latitude*: - 0.2073796 *Longitude*: 104.5943777	2,9 Km

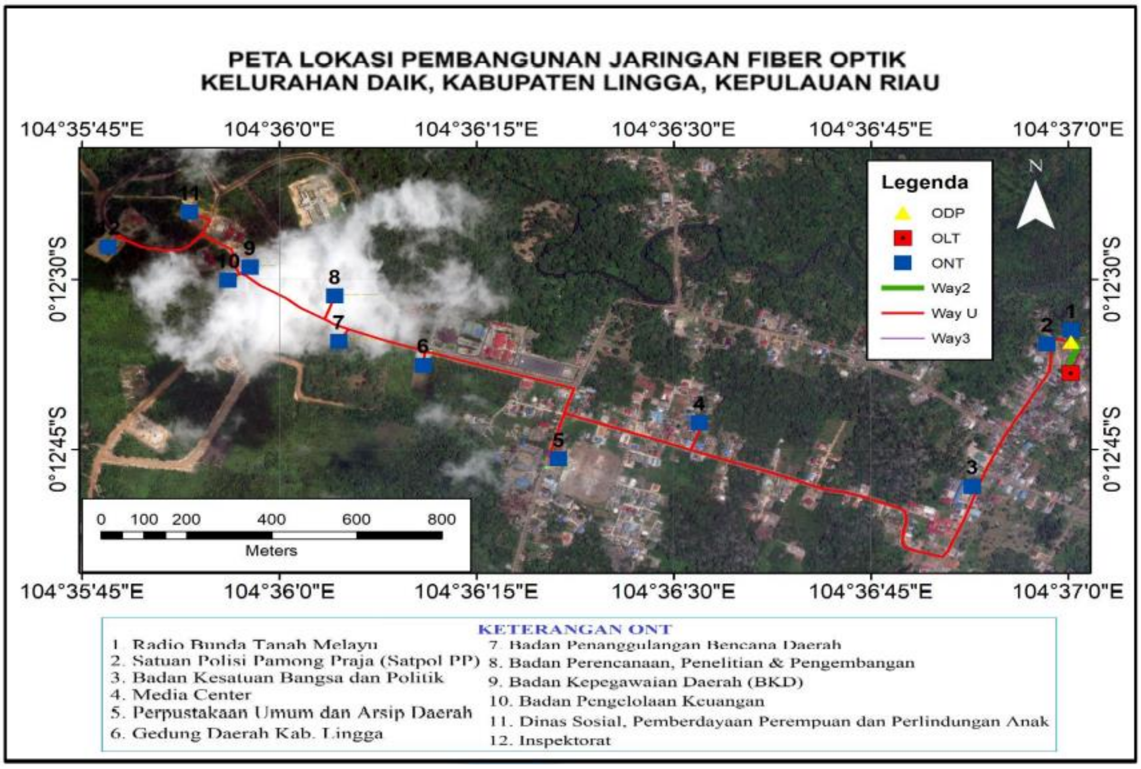

Figure 6. Map of the construction

Calculation of Power Link Budget (PLB)

PLB calculations are carried out in theory and simulation for 12 predetermined transmission links. The results obtained involve the total attenuation value and the sensitivity of the ONT using equations (2.1) and (2.2). Meanwhile, the calculation using simulation is only meant to discover the power value. The Optical Power Meter (OPM) feature is used to view the calculation results. Table 4 shows the comparison of calculations carried out in theory and simulation.

Table 4. Results of Power Link Budget (PLB)

No	Distance (Km)	Total attenuation (dBm)	Received Power (dBm)		Evaluation (Max. -27 dBm)
			Teory	Simulation	
1	0,112	15,1392	- 10,1392	- 10,733	decent
2	0,161	15,1407	- 10,1407	- 10,750	decent
3	0,58	15,6125	- 10,6125	- 10,897	decent
4	1,5	15,6246	- 10,6246	- 11,218	decent
5	1,9	15,7646	- 10,7646	- 11,358	decent
6	2,2	15,8896	- 10,8896	- 11,463	decent
7	2,4	15,9395	- 11,9395	- 11,533	decent
8	2,5	15,9746	- 11,9746	- 11,568	decent
9	2,7	16,0406	- 11,0406	- 11,638	decent
10	2,7	16,0406	-11,0406	- 11,638	decent
11	2,9	16,1146	-11,1146	- 11,708	decent
12	3	16,1496	-11,1496	- 11,743	decent

The results of the theoretical and simulation calculations meet the standards set by PT Telkom (PT Telkom Access, 2013) and the ITU-T G.984.2 standard [6] so that the design carried out can be said to be feasible. The average power difference is 0.4 dBm, which allows for parameters that are not included in the theoretical analysis, while for the simulation there is the influence of another parameter, namely the extinction ratio. Extinction ratio itself is the ratio of the optical power level for logic 1 to the power level for logic 0. This will affect the output power at the receiver [10].

The factor that affects the ONT sensitivity value is length transmission distance, where the longer the transmission distance, the higher the power value received by the ONT. In addition to affecting the ONT receive power value, the attenuation value generated along the transmission also increases with increasing transmission distance. This is due to because the damping value shows the load value of each component so that the longer the transmission distance, the more load that must be borne along the transmission link [20].

In addition to the transmission distance, the initial power inputted to the OLT or the power transmitter also affects the output power of the ONT. Where the greater the power input into the OLT, the smaller the power received in the ONT. This is in accordance with the theory used where the input power value will be reduced by the total attenuation of the component, so that the higher the power value in the OLT, the smaller the output power obtained.

B. Calculation of Rise Time Budget (RTB)

Measurement of the total allowable optical link dispersion along From the source of transmission to the receiving point, the value of the rise time of the transmitter is calculated, the value of the rise time of the optical fiber and the value of the rise time of the receiver are calculated. The calculation is divided into two parts, namely downlink with a bit rate of 1.22 Gbps and uplink with a bit rate of 2.44 Gbps. The RTB unit is nanosecond (ns), obtained from the calculation of the bit value against the nanometer wavelength (nm) in time per second (s). by using equation (2.3) the value of the rise time budget is calculated starting from the closest link to the farthest link.

The calculation results meet the standard used, namely the rise time value is less than or equal to 70% one bit period Non Return to Zero (NRZ), or seventy percent of 2.44 Gbps for downlink transmission which is 0.2917 ns and the uplink value of 1.22 Gbps is 0.5833 ns, with the value obtained, it can be said that the transmission has met the set standards. Based on the calculation, it is known that the parameters distinguish between downlink and uplink, among others, bit rate, wavelength and transmission distance. Apart from these three parameters, the values used in calculating the downlink and uplink rise time budget are the same. Transmission distance also affects the rise time of a transmission. This is in line with research (Dermawan et al., 2016) where the longer the transmission link, the greater the total transmission rise time. Table 5 shows the results of the calculation of the rise time budget for downlink and uplink transmissions.

Table 5. Results of Rise Time Budget (RTB)

No.	**Distance (Km)**	***Downlink* (ns)**	***Uplink* (ns)**	**Evaluation** Maks. Down 0.2917 (ns) Maks. Up 0.5833 (ns)
1.	0.112	0.250004667	0.250000318	decent
2.	0.161	0.250009645	0.250000657	decent
3.	0.58	0.250125142	0.250008526	decent
4.	1.5	0.250835826	0.250057024	decent
5.	1.9	0.250873343	0.250091486	decent
6.	2.2	0.251794520	0.250122650	decent
7.	2.4	0.252134183	0.250146299	decent
8.	2.5	0.252314904	0.250158370	decent
9.	2.7	0.252698046	0.250184713	decent
10.	2.7	0.252698046	0.250184713	decent
11.	2.9	0.253217491	0.250213079	decent
12.	3	0.253326760	0.250228029	decent

Table 6. Results of Signal Noise Ratio			
No.	**Distance (Km)**	***Signal Noise to Ratio (SNR)***	
		***Uplink* (dBm)**	***Downlink* (dBm)**
1.	0,112	44,68	41,80
2.	0,161	44,80	41,79
3.	0,58	43.91	41,05
4.	1,5	43,71	40,71
5.	1,95	43,63	40,64
6.	2,2	43,44	40,43
7.	2,4	43,31	40,30
8.	2,5	43,24	40,17
9.	2,7	43,11	40,11
10.	2,7	43,11	40,11
11.	2,9	42,98	39,98
12.	3	42,91	39,91

C. Calculation of Bit Error Rate (BER)

Signal to noise ratio is a calculation of the ratio between signal power to noise or interference at the same point. This measurement is useful for measuring the quality of the received signal. Measurements were made uplink with a bandwidth of 1.22 Gbps and downlink with a bandwidth of 2.44 Gbps. The standard calculation on the uplink and downlink is a value exceeding 21.5 dBm. SNR calculation using equation (2.4)

The results of SNR measurements both uplink and downlink meet the established standards, which exceed 21.5 dBm. The difference in SNR values is caused by the transmission distance. The increase in transmission distance makes the SNR value decrease. The longer the transmission distance. The more noise or noise produced due to the more burden that is borne (Zulherman et al., 2017). SNR calculation results contained in Table 6.

D. Bit Error Rate

The bit error rate is a calculation of the data bit rate error in optical fiber transmission, by doing this calculation it can be seen the number of data transmission errors. Transmission from OLT to ONT or downlink uses a wavelength of 1310 nm with a bandwidth of 1.2 Gbps and for transmission from ONT to OLT or uplink uses a wavelength of 1490 nm with a bandwidth of 2.4 Gbps.

The BER value according to the standard is not more than 10-9 or can be interpreted from 1,000,000,000 bits of the signal sent there can only be 1 wrong bit or there can only be 1 data that is not sent [2]. The calculation is done theoretically and using optisystem simulation. The calculation is theoretically divided into 2 stages, namely calculating noise or signal noise and proceeding with calculating the transmission bit error. Simulation using optisystem is carried out to calculate the bit error rate with the BER analyzer feature which will display the BER value of the transmission link that has been designed and display an eye diagram to see the performance of the system.

Based on calculations carried out theoretically the value for
downlink or uplink is zero, or it can be said that for data sent as much as 1,000,000,000 the number of errors that occur is 0. This value is very good because it meets the set standards, which is no more than $\mathbf{10^{-9}}$.The calculation results are in Table 7.

Simulation calculations using the BER analyzer feature obtained results for the maximum Q factor parameter, the Minimum BER value, the eye height value and the threshold (threshold). The standard Q factor specified is more than 6 [17]. The results of both downlink and uplink measurements show that the Q factor value obtained has met the specified standards. The minimum BER value for each link is 0 which meets the BER standard, which is a maximum of

10^{-9}. Eye height or the height of the eye opening decreases with increasing distance. The highest threshold is at a distance of 0.58 Km and the lowest is at a distance of 2.7 Km. The results of the calculation of the twelve links are in Table 8.

Table 7. Theoretical calculation results of Bit Error Rate

No.	Distance (Km)	*Uplink*	*Downlink*
1	0,112	0	0
2	0,161	0	0
3	0,58	0	0
4	1,5	0	0
5	1,95	0	0
6	2,2	0	0
7	2,4	0	0
8	2,5	0	0
9	2,7	0	0
10	2,7	0	0
11	2.9	0	0
12	3	0	0

Table 8. Calculation results with BER analyzer

Distance (Km)	*Downlink*				*Uplink*			
	Q faktor	Min BER	*Eye Height*	*Threshold*	Q faktor	Min BER	*Eye Height*	*Threshold*
0,112	51,635	0	0,000132173	$8{,}09141\times10^{-5}$	51,6496	0	0.000132532	8,61352
0,161	52,7717	0	0,000132533	$7{,}27031\times10^{-5}$	55,7874	0	0,00013226	8,15834
0,58	55,5696	0	0,000127771	$8{,}26739\times10^{-5}$	52,2293	0	0,000128122	8,13152
1,5	51,3563	0	0,000118494	$7{,}05453\times10^{-5}$	46,9635	0	0,000117221	6,69001
1,95	46,0697	0	0,000113837	$6{,}24179\times10^{-5}$	46,1359	0	0,000113668	7,08477
2,2	41,905	0	0.000110741	$7{,}18654\times10^{-5}$	46,1166	0	0,00110917	6,8566
2,4	44,577	0	0,00010911	$6{,}69257\times10^{-5}$	49,1791	0	0,000109212	6,5764
2,5	41,3813	0	0,000107105	$6{,}63031\times10^{-5}$	42,6322	0	0,000108005	6,55983
2,7	41,9109	0	0,000105699	$6{,}17017\times10^{-5}$	41,903	0	0,000105709	6,52248
2,7	42,6134	0	0,000106331	$6{,}40999\times10^{-5}$	40,9771	0	0,000105416	6,76452
2.9	43,5015	0	0,000105054	$7{,}15807\times10^{-5}$	43,4805	0	0,000104247	6,57795
3	47,3084 0	0	0,000104253	$6{,}21972\times10^{-5}$	45,9251	0	0,000103964	6,55134

By using the BER analyzer can also generate eye diagrams that are used to see the value of optical parameters. The resulting values are the rise time, fall time, jitter, eye crossing percentage and eye width. Mapping view `the overall eye diagram can be seen in Figures 7 and 8.

` Figure 7 shows the appearance of the uplink eye diagram for the farthest link, which is 3 km. Based on the graph, the value of rise time is 0.22513 seconds, fall time is 0.226888 seconds, eye width is 0.6735, percentage of crosses is 50μ, underdhoot is 0.0554054 and overshoot is 0.0726599.

While Figure 8 shows the appearance of the downlink eye diagram for the farthest link, which is 3 km. Based on the graph, the value of rise time is 0.229496 seconds, fall time is 0.233259 seconds, eye width is 0.674053, Percentage of cross 50μ, under hoot 0.0608108 and overshoot 0.0702703.

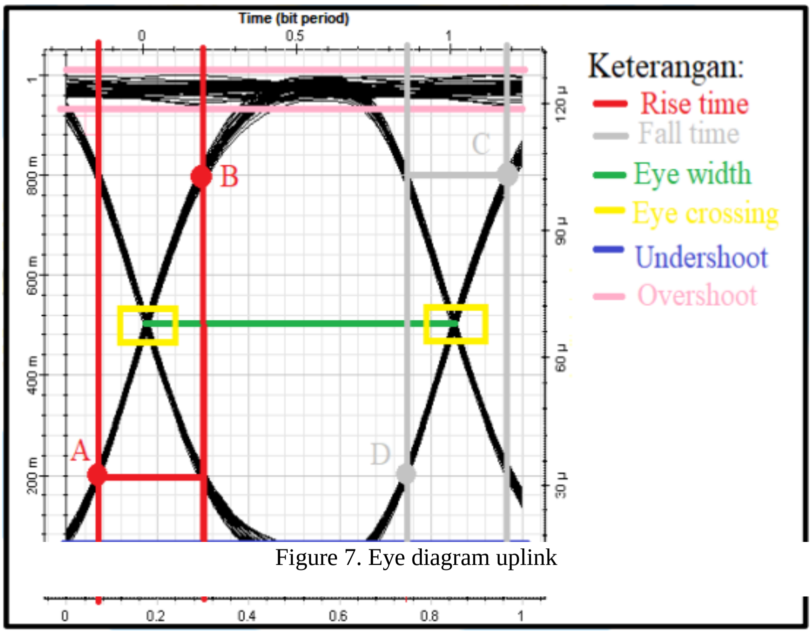

Figure 7. Eye diagram uplink

Based on the graph of the eye diagram generated through the optisystem simulation, it shows a good eye shape because there is a difference between bit 1 and bit 0. The graph also does not show any jitter or time deviation from the ideal time. This can be seen from the absence of widening at the cross eye. In addition, the waveform has good pulse symmetry because the cross between the duration of level 1 and level 0 is at the 50% point or right in the middle of the chart.

The resulting value in the calculation of uplink and downlink is not too far apart. There is only a difference of a few numbers behind the comma for the rise time, fall time undershoot, overshoot and eye width parameters. The difference in the Q-factor value is 1.3833, besides that the values for the minimal BER and eye crossing percentage are the same. In the calculation by differentiating the wavelength, the results obtained between uplink and downlink are not much

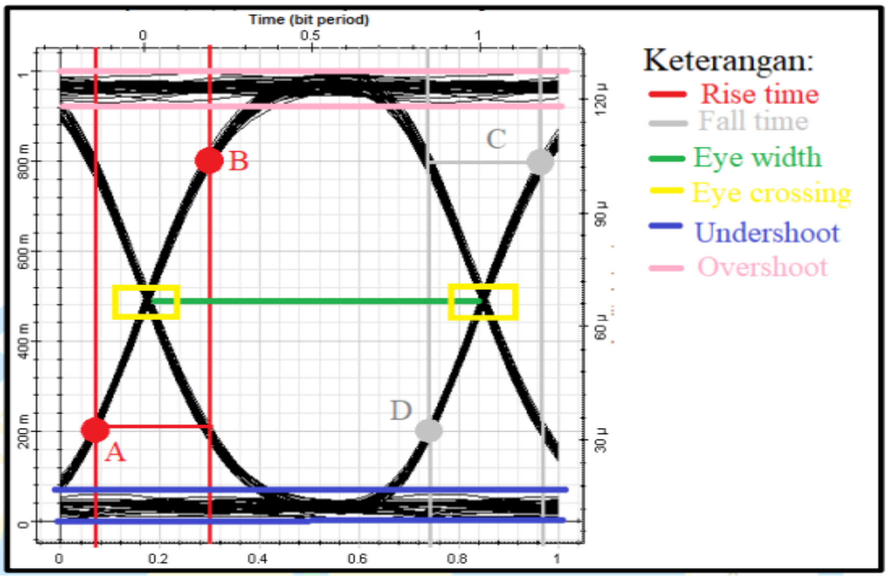

Figure 8. Eye Diagram Downlink

different. The graph shows an almost perfect graphic form because there are no bit errors, resulting in a very good eye opening shape, namely wide and no messy pulse bands. This is because the input power to the transmitter is 5 dBm which is the maximum power in GPON technology. The higher the power used, the better the resulting transmission performance [15].

5. Conclusions

Based on data analysis, the design of fiber optic networks in Daik Village becomes feasible to implement because it meets the standards set by PT. Telkom and ITU-T. This is supported by the value of each parameter that is still in the specified number range.

The Power Link Budget parameter for theoretical calculations has an attenuation and the farthest value of 15.1392 dBm and 16.1496 dBm with a length of 0.112 Km and 3 Km respectively. Also, the power received through manual and simulation calculations on the closest links is -10.1392 dBm and – 10,733 dBm, while the farthest links are -11.1496 dBm and – 10,733. DBm. The received power still meets the established standards such as a maximum and minimum of -27 dBm and -8 dBm respectively.

Furthermore, the total transmission time is less or equal to 70% of one NRZ bit with a value equal to or less than the downlink of 2.917 ns and uplink 0.5833ns. The results for the closest downlink and uplink values are 0.250004667 ns and downlink 0.250000318 ns, while for the farthest distances are 0.253326760 ns and 0.250228029 ns respectively. Therefore, the network performance is good because it meets the established standards.

The bit error value for each downlink and uplink transmission is 0. With this performance, the network meets the established standards such as the number of bit errors that is not more than 10^{-9}.

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