Available online at https://journal.rescollacomm.com/index.php/ijqrm/index

International Journal of Quantitative Research and Modeling

e-ISSN 2721-477X
p-ISSN 2722-5046

Vol. 4, No. 1, pp. 30-36, 2023

Fiber to the Home (FTTH) Network Design Using Gigabit Passive Optical Network (GPON) Technology Using Link Power Budget and Rise Time Budget Analysis in Cibeber Village Tasikmalaya

Nurul Ikhwan[1*], Hani Rubiani[2], Noerlaelly Barorroh Taufik Abdul Ghofur [3], Yang Zhu[4]

[1,2,3]*Electrical Engineering Universitas Muhammadiyah Tasikmalaya, Tasikmalaya, Indonesia*
[4]*Department of Business Strategy and Innovation, Griffith University, Australia*

**Corresponding author email: Ikhwan.nurul11@gmail.com*

Abstract

Fiber optic is a transmission medium that can transmit information with large capacity. One of the developments in local fiber access networks is FTTH (Fiber to The Home). The construction of the FTTH network uses Gigabit Passive Optical Network (GPON) technology so that it can provide broadband services to customers with a wider range. This research was studied by designing FTTH based on GPON technology in Cibeber Village, Manonjaya District. The existing condition of the FTTH network in Cibeber Village is that there are 2 Optical Distribution Points (ODP) for 20 customers with each ODP having 10 subscribers. From the results of the location survey by measuring the distance to each customer, the furthest distance to the customer for the two ODPs was obtained, so that 2 new ODPs were needed for the design. From the design of the new optical network infrastructure, it has been analyzed using the link power budget and rise time budget method based on the customer with the farthest distance before the addition of ODP has a Power Receive sensitivity of -16.631 dBm to -15.631 dBm on the uplink and -16.644 dBm to -15.574 dBm on the downlink, these results are in accordance with the expected standard, which ranges from -8 dBm to -27 dBm. In calculating the value of the rise time budget for customers after the addition of ODP, it has a value of 0.2044 ns to 0.2039 ns on the uplink and 0.2188 ns to 0.21574 ns on the downlink. This value is still below the standard time limit set by PT. Telkom Indonesia 0.56 ns for uplink and 0.292 ns for downlink. So based on this the results of the design are feasible to implement.

Keywords: Design, fiber optic, FTTH, ODP, GPON, link power budget, rise time budget

1. Introduction

Technology is developing increasingly sophisticated, the need for communication services at this time is not only voice, but also data and video, thus triggering an increase in the community's need for fast access services (Venkateswarlu & Renuka, 2017). This technological improvement was triggered by many discoveries and researches so that it continues to evolve and is increasingly global, for example mobile phone technology which is used for communication via voice and sms, is now developing into a sophisticated smart communication tool so that now it is not only used as a communication tool, this mobile can also use to take and send photos, record videos, listen to music, and access the internet (Puspasari et al., 2022). Based on the APJII survey report, internet user penetration in one year, from 2017 to 2018 in Indonesia increased from 54.68% to 64.8%. This proves that the internet is a primary need for Indonesian people, both individuals and private and government agencies. In this case PT. Telkom as a telecommunications operator to develop technology that can handle large bandwidth requirements so that fast access needs can be met. The solution is to use a fiber optic network. Fiber optic is one of the transmission media that can transmit information with large capacity and high reliability (Abdellaoui et al., 2021). The technology of using fiber optic cables as a transmission medium in telecommunication systems is then called JARLOKAF (Jaringan Lokal Akses Fiber) (Abdellaoui et al., 2021). JARLOKAF offers faster data transfer rates than copper cable networks and can reach extreme distances (Othman et al., 2012). One of JARLOKAF's developments is Fiber to The Home (FTTH), where the optical conversion point is located at the customer's home. The existing Fiber to The Home (FTTH) installation in Cibeber Village, Manonjaya District, Tasikmalaya Regency only has 2 Optical Distribution

Points (ODP). Two ODPs installed were used for one area of Cibeber Village which resulted in customers being far from the existing ODP, resulting in poor attenuation. This research will provide a solution to the problem of inefficient internet access connectivity. This research will design a new Fiber to The Home (FTTH) network along with the infrastructure used and analyze the network quality of the OLT (Optical Line Terminal) for the furthest customer in Cibeber Village, Manonjaya District which includes the Link Power Budget and Rise Time Budget values needed. Link Power Budget and Rise Time Budget analyzed based on standards from PT Telkom to build a new FTTH network according to the design made.

2. Literature Review

Designing a Fiber to The Home (FTTH) access network using Gigabit Passive Optical Network (GPON) technology. Case study of Graha Permai Ciputat Housing conducted by (Prat, 2008). This research was conducted at Graha Permai Ciputat Housing Complex, where the location was chosen due to the need to modernize the network. The results of this final project research based on manual calculations obtained power link budget = 21.83432 dB, rise time budget = 0.25102 ns in downstream and upstream. From manual calculations it can be concluded that the FTTH network design is feasible to implement because the parameter values are still within the maximum limits of the FTTH network feasibility standards.

Then research conducted by Kocher et al. (2013), regarding the design of a Fiber to The Home (FTTH) network using Gigabit Passive Optical Network (GPON) technology for triple play services. This research was conducted in Klaten City which is one of the cities that is densely populated by residents, especially for the Pedan Village area. Under these conditions, the FTTH network design is suitable to be implemented at this location. In the design data it can be estimated about the number of devices, specifications and the position of the equipment from STO to the customer's position. In designing the FTTH GPON network, the results obtained are the power link budget = 20.823 dB, rise time budget = 0.363 ns with a bandwidth of 1920 Mbps.

3. Materials and Methods

3.1. Materials

This research activity will be carried out in Cibeber Village, namely Jalan Raya Gunungtanjung KM 4.6, Manonjaya District, Tasikmalaya Regency, Postal Code 46197. This design location is at 7°22'41.1"S and 108°17'19.1"E. The area is shown using the Google Earth application as shown in Figure 1.

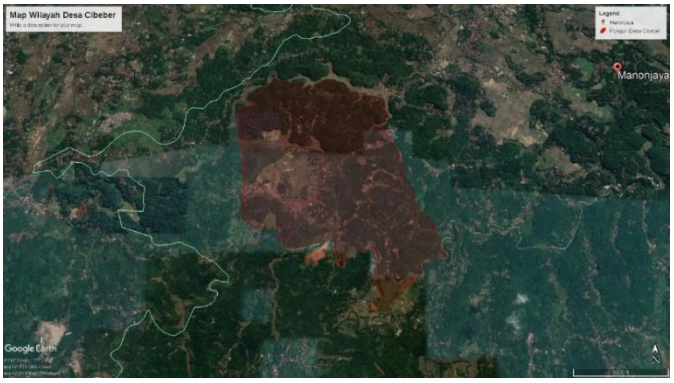

Figure 1: Location of Design Area in Cibeber Village

3.2. Methods

The research methodology used in this study included research preparation, determining the research location, then surveying the location and measuring the coordinates of ODP and subscribers on the existing FTTH network. Then from the measurement results to get the farthest distance of the customer from the existing network then the performance on the farthest customer's side is calculated using the link power budget and rise time budget method. After that, the FTTH network design was carried out with devices following PT. Telkom and its performance is calculated and then it is compared between the existing FTTH network and the Design FTTH network.

3.2.1. Research Preparation

The research begins with a literature review or literature study of previous studies to support network design, then a site survey is carried out. The location of the FTTH network design in Cibeber Village includes the coverage of the Telkom Manonjaya Sentral Telephone Otomatis (STO) shown in Figure 2. From this STO the cable route that is directed to the customer's location will be distributed using a feeder cable to the Optical Distribution Cabinet (ODC). The location was chosen to do a comparison of the existing network and the design network that will be made. Network design is made to improve performance on the customer side which is calculated using the link power budget and rise time budget. Data collection was carried out by measuring the distance between the customer and the existing 2 ODP, namely ODP Panday and ODP Baru, in order to obtain the farthest customer distance from the two ODPs in Cibeber Village, then calculating the performance of the furthest customer using the link power budget and rise method. the furthest customer time budget in Cibeber Village.

Figure 2: Manonjaya STO route to Cibeber Village

Measurements are made using a cell phone that has GPS Essential installed to get ODP coordinates and coordinates for each customer. The following is a display of customer data measurement results to obtain coordinate points.

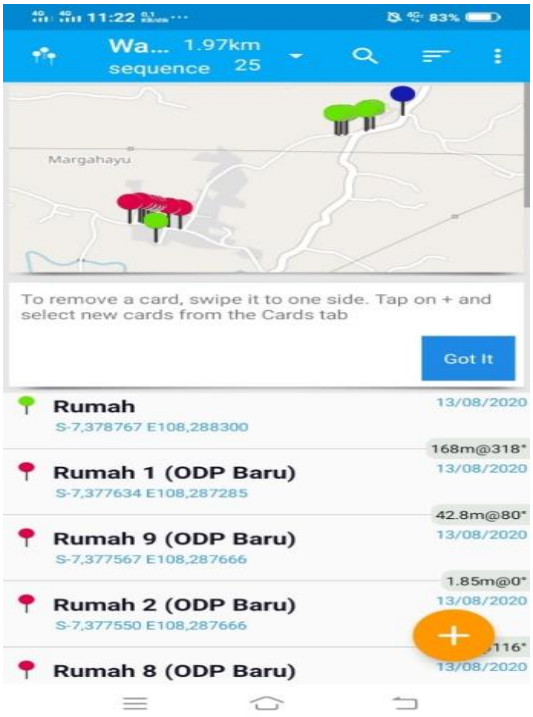

Figure 3: Existing Customer Coordinate Measurement Display

A location survey is carried out to find out important equipment such as the situation around the location, whether there is an existing ODC nearby, or if there is no possibility of remaining capacity around the existing ODC, it is necessary to survey the feeder path to the most effective STO. The ODC distances for the two ODPs, namely Panday ODP and New ODP are shown in Table 1.

Table 1: ODC distance data to the Existing Network ODP

	ODP	Distance (Km)
ODC	ODP Panday	0.18
	ODP Baru	1.41

Table 2: ODC distance data to the Design Network ODP

	ODP	Distance (Km)
ODC	ODP Panday	0,18
	ODP Baru	1,41
	ODP Sukamanah	0,06
	ODP Desa Kaler	1,22

3.2.2. Research Stages

The stages of the research begin with a good literature review from books, previous research in the form of journals, the internet and so on, then identify an existing problem then the methodological and design stages, after that the analysis of the results and finally the writing of the report. In general, the stages that will be carried out in this study can be seen in Figure 4 below:

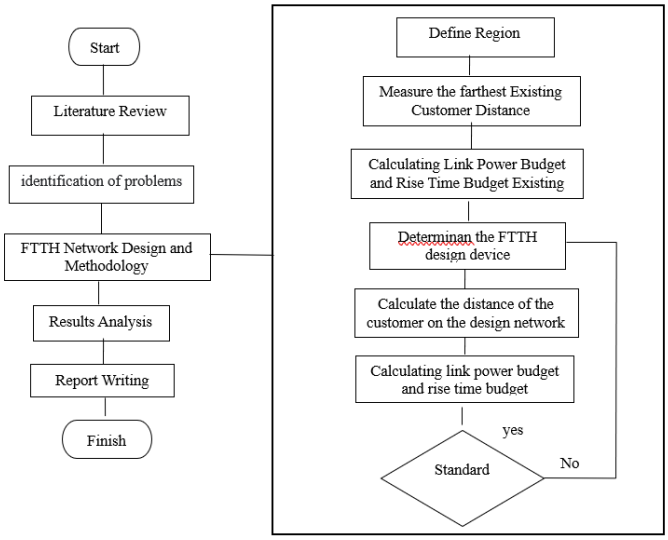

Figure 4: Research Flowchart

3.2.3. Link Power Budget Method

This link power budget calculation is based on each tool used and determines the loss and loss parameters of the device and its infrastructure. To calculate the total loss of a network using equations 1 and 2.

$$\alpha T = L.\alpha serat + Nc.\alpha c + Ns.\alpha s + Sp \quad (1)$$

$$Pr = Pt - \alpha T \quad (2)$$

3.2.4. Rise Time Budget Method

Rise time budget is a method for determining the dispersion limits of an optical fiber link. The purpose of this method is to analyze whether the overall network performance has been achieved and is able to meet the desired channel capacity. General the total transition time degradation of a digital link is less than or equal to 70 percent of one NRZ (Non Return to Zero) bit period. The calculation of the Rise time budget uses equation 3.

$$t_{total} = (t_{tx}^2 + t_{intramodal}^2 + t_{intermodal}^2 + t_{rx}^2) \quad (3)$$

4. Results and Discussion

Designing an FTTH network with GPON technology in the Cibeber Village area using Google Earth. Google Earth is a globe program that maps the earth from the superimposition of images collected from mapping satellites. The FTTH network scheme begins by determining the STO and ODC points. The location of STO Manonjaya is on Jalan RTA Prawira Adiningrat and the location of the ODC is on Jalan Panday. Then STO and ODC are connected with feeder cables. In the Cibeber Village area there are 2 ODP with the names Panday ODP and Baru ODP which have 20 customers.

4.1. Calculation Results of Link Power Budget and Rise Time Budget on Existing

The link power budget calculation uses the formula in equation 1. FTTH network in Cibeber Village, Manonjaya District, Tasikmalaya Regency, there are a total of 20 customers with a route starting from the OLT (Central Office) and then going to one ODC which is connected using a feeder cable with a length of 4 km, and a connection will be made if the feeder cable distance is exceed 4 km. This ODC will be connected to each ODP in Cibeber Village, namely ODP Panday and ODP Baru. The cable used to connect ODC and ODP uses a distribution cable with a maximum distance of 4 km, and a connection will be made if the distribution distance exceeds 4 km. Then from ODP it uses a drop cable to connect to its customers with a maximum distance of 100 m.

The customer with the furthest distance on the existing network is in House 7 with a distance of 0.09897 km which is connected to ODP Panday and for New ODP the furthest customer is House 1 with a distance of 0.0883 km. The calculation is divided into two, namely from the downlink side and the uplink side.

Table 3: Results of Attenuation Calculation of Existing Network (dB)

Attenuation	ODP Panday	ODP Baru
Uplink	20.646	21.061
Downlink	20.380	21.644

Table 4: Results of Power Receive Calculation of Existing Network (-dBm)

Power Receive	ODP Panday	ODP Baru
Uplink	15.646	16.631
Downlink	15.380	16.644

Table 5: Result of Rise Time Budget Calculation of Existing Network (ns)

Rise Time Budget	ODP Panday	ODP Baru
Uplink	0.2034	0.2044
Downlink	0.2125	0.2188

4.2. Calculation Results Link Power Budget and Rise Time Budget FTTH Design

In each existing ODP before the addition, there was a customer with the farthest distance for ODP Panday, the farthest customer, namely Rumah 7 with a distance of 0.0989 km and the farthest customer for New ODP, namely Rumah 5 with a distance of 0.1340 km. Then the FTTH network design is carried out with the addition of 2 ODP, namely ODP Sukamanah which connects the farthest customer from the existing ODP Panday network, namely Rumah 7 so that the distance becomes 0.0541 km and ODP Kaler Village which connects the farthest customer from the existing ODP New network, namely Rumah 5 so that the distance becomes 0.0695 km The calculation is divided into two, namely from the uplink and downlink sides.

Table 6: Results of Attenuation Calculation of Design Network (dB)

Attenuation	ODP Sukamanah	ODP Desa Kaler
Uplink	20.5619	20.9733
Downlink	20.3349	21.574

Table 7: Result of Power Receive Calculation of Design Network (-dBm)

Power Receive	ODP Sukamanah	ODP Desa Kaler
Uplink	15.5619	15.631
Downlink	15.3349	16.574

Table 8: Result of Rise Time Budget Calculation of Design Network (ns)

Rise Time Budget	ODP Sukamanah	ODP Desa kaler
Uplink	0.2032	0.2039
Downlink	0.2116	0.2174

4.3. Comparison of Link Power Budget and Rise Time Budget Existing and Design

From the results of calculations using the link power budget and rise time budget methods for both the existing network and the network in the design of the calculated performance parameters, namely the link power budget in the form of attenuation and power receive as well as the rise time budget on the furthest customer side of the ODP in the existing network then the design is carried out by adding an ODP to connect the farthest customer to the design ODP. And the results can be compared shown in table 9.

Table 9: Comparison Results of Link Power Budget and Rise Time Budget between Existing and Design

Customer	**Performance Parameters**		**Eksisting**	**Design**
Customer 1 (House 7) From ODP Panday moved to ODP Sukamanah	Attenuation (dB)	*Uplink*	20.646	20.5619
		Downlink	20.380	20.3349
	Power Receive (dBm)	*Uplink*	–15.646	–15.5619
		Downlink	– 15.380	–15.3349
	Rise Time Budget (ns)	*Uplink*	0.2034	0.2032
		Downlink	0.2125	0.2116
Customer2 (House 5) From ODP Baru moved to ODP Desa Kaler	Attenuation (dB)	*Uplink*	21.061	20.9733
		Downlink	21.644	21.574
	Power Receive (dBm)	*Uplink*	–16.631	–15.631
		Downlink	–16.644	–16.574
	Rise Time Budget (ns)	*Uplink*	0.2044	0.2039
		Downlink	0.2188	0.2174

5. Conclussion

The conclusions that can be obtained from the results of this study are:

1) The design of the FTTH network in Cibeber Village uses standards from PT. Telkom.
2) The design is carried out after measuring the farthest distance from a total of 20 customers connected to the 2 existing ODPs, namely ODP Panday and ODP Baru, and calculating the performance of the furthest customers.
3) The design is carried out by adding 2 ODPs, namely ODP Sukamanah and ODP Kaler Village and placing the locations of the two ODPs to connect the customers farthest from the existing network so that in total there are 4 ODPs in the design network, namely ODP Panday, ODP Baru, ODP Sukamanah and ODP Kaler Village.
4) The performance results for the farthest customers are obtained by the link power budget method with the attenuation and power receive parameters as well as the rise time budget method. The results show that among the two furthest customers who have a less good value of the three parameters, there is the farthest customer from the New ODP which has an attenuation value of 21.061 dB on the uplink and 21.644 dB on

the downlink. And the power receive value is -16.631 dBm on the uplink and -16.644 dBm on the downlink as well as the rise time budget value of 0.2039 ns on the uplink and 0.2188 on the downlink.

5) The results of the FTTH network design by adding 2 ODPs, namely ODP Sukamanah and ODP Desa Kaler show an increase in performance on the customer side, both from attenuation which was 21.061 dB to 20.9733 dB on the uplink and 21.644 dB to 21.574 dB on the downlink, receiving power from a value of -16.631 dBm becomes -15.631 dBm on the uplink and -16.644 dBm becomes -16.574 dBm on the downlink and rise time budget from a value of 0.2044 ns to 0.2039 ns on the uplink and 0.2188 ns to 0.2174 ns on the downlink.

Acknowledgments

This work was supported by Department of Electrical Engineering, Faculty of Engineering Universitas Muhammadiyah Tasikmalaya.

References

Abdellaoui, Z., Dieudonne, Y., & Aleya, A. (2021). Design, implementation and evaluation of a Fiber to The Home (FTTH) access network based on a Giga Passive Optical Network GPON. *Array*, *10*, 100058.

Kocher, D., Kaler, R. S., & Randhawa, R. (2013). Simulation of fiber to the home triple play services at 2 Gbit/s using GE-PON architecture for 56 ONUs. *Optik*, *124*(21), 5007-5010.

Othman, M. A., Ismail, M. M., Sulaiman, H. A., Misran, M. H., & Said, M. A. M. (2012). Fiber to the Home (FTTH) Design and Analysis using OCDMA Structure. *International Journal of Engineering and Industries (IJEI)*, *3*(4), 36-48.

Prat, J. (Ed.). (2008). *Next-generation FTTH passive optical networks: research towards unlimited bandwidth access*. Dordrecht: Springer Netherlands.

Puspasari, A., Nurhayaty, E., Riftiasari, D., Yuniarti, P., Suharyadi, D., Martiwi, R., & Adawia, P. R. (2022). The Effect of Service Quality Perception and Company Image On Customer Satisfaction And Their Impact On Customer Loyalty Indihome. *International Journal of Social and Management Studies*, *3*(2), 220-233.

Venkateswarlu, T., & Renuka, R. (2017). Design of Fiber to the Home (FTTH) Access Network and Implementing Online Monitoring to Increase Efficiency. *International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE) vol*, *5*, 2338-2346.