Implementation of FTTH GPON Underground Network in Marigold Cluster

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Abstrak

Penelitian ini merancang jaringan Fiber To The Home (FTTH) berbasis Gigabit Passive Optical Network (GPON) dengan metode underground di Cluster Marigold. Tujuannya adalah mengatasi masalah kabel udara yang berantakan, risiko kecelakaan, dan polusi visual, sekaligus memenuhi etika teknik terkait keselamatan dan estetika. Menggunakan topologi tree dan konfigurasi two-stage splitting, infrastruktur ini menggunakan pipa HDPE dan 39 unit hand hole. Hasil pengukuran teknis melalui OTDR dan OPM menunjukkan daya terima antara -17,95 dBm hingga -18,71 dBm, sesuai standar ITU-T G.984. Dengan power margin rata-rata 8,65 dB, jaringan bawah tanah terbukti lebih andal dan minim gangguan fisik dibandingkan kabel udara. Inovasi ini memberikan kontribusi pada standar infrastruktur digital yang profesional, aman, dan berkelanjutan bagi masyarakat perkotaan.

Kata kunci: *FTTH, GPON, Jaringan, Redaman, Underground.*

Abstract

*This research designs a Fiber To The Home (FTTH) network based on Gigabit Passive Optical Network (GPON**)** using an underground method in the Marigold Cluster. The objective is to address issues related to messy aerial cables, accident risks, and visual pollution, while also complying with engineering ethics concerning safety and aesthetics. Using a tree topology and a two-stage splitting configuration, the infrastructure employs HDPE pipes and 39 hand hole units. Technical measurement results using OTDR and OPM indicate a received power range between -17.95 dBm and -18.71 dBm, which complies with the ITU-T G.984 standard. With an average power margin of 8.65 dB, the underground network proves to be more reliable and less prone to physical disturbances compared to aerial cabling. This innovation contributes to the development of professional, safe, and sustainable digital infrastructure standards for urban communities.*

Keywords: *FTTH, GPON, Network, Attenuation, Underground*

1. Introduction

Telecommunication cable management issues are still frequently found in urban areas of Indonesia. Disorganized aerial cable installations not only reduce environmental aesthetics but also increase the risk of accidents and degrade network service quality. This condition demands a more secure, well-organized, and sustainable network infrastructure solution.

Fiber To The Home (FTTH) technology based on Gigabit Passive Optical Network (GPON) is a solution capable of providing high-speed internet services with high efficiency. This network architecture enables passive optical signal distribution through splitters, thereby supporting network scalability [2]. However, most existing implementations still rely on aerial cabling methods, which are vulnerable to external disturbances.

Previous studies have shown that the use of a tree topology can improve signal distribution efficiency [1]. Nevertheless, the implementation of underground methods in residential cluster environments is still rarely studied comprehensively. Therefore, this research aims to implement an FTTH GPON network using the underground method in the Marigold Cluster and analyze its performance based on technical parameters

2. Research Method

The research stages include field survey, network design, underground installation, testing using OPM and OTDR, and performance analysis. The overall research procedure is systematically illustrated in a flowchart to provide a clear understanding of the process.

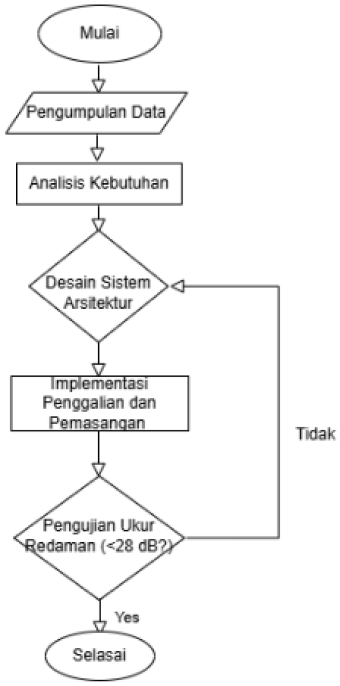

Figure 1 Research Flowchart

Furthermore, to ensure optimal system performance, a monitoring process is conducted, including signal performance evaluation and attenuation analysis. The monitoring workflow is presented in the following figure.

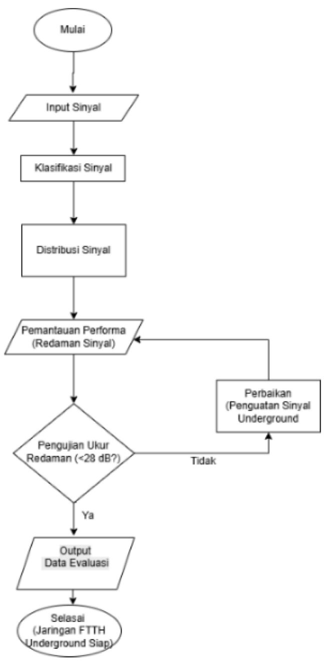

Figure 2 Monitoring Flowchart

3. Literature Study

GPON technology uses a passive architecture based on ITU-T G.984 standards [6]. The underground method improves cable protection and network stability.

4. Result and Discussion

4.1 Network Topology Design

The implementation of the FTTH GPON network in the Marigold Cluster uses a tree topology that enables efficient signal distribution from the OLT to end users through passive splitters. The network topology structure is illustrated in the following figure.

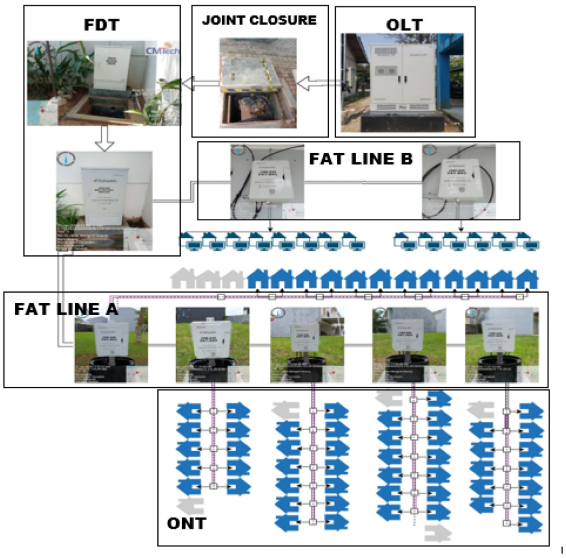

Figure 3 FTTH Tree Topology

4.2 Underground Infrastructure Design

The network is designed using an underground method, where cables are installed within HDPE pipes to improve safety and environmental aesthetics. The network layout based on KMZ data is shown in the following figure.

Figure 4 Underground Network Design (KMZ)

4.3 Splitter 1:8 Measurement Results

Table 1 Output splitter port (FDT)

Port Output	***Power Level (dBm)***
1	*-8,18*
2	*-8,20*
3	*-8,17*
4	*-8,20*
5	*-8,21*
6	*-8,29*
7	*-8,28*
8	*-8,39*
Rata-rata	*-8,24*

4.4 OPM Measurement Results

Table 2 OPM FAT A01

Fiber Number	***Wave Length (nm)***	***Test (dBm)***
1	*1490*	*-18,64*
2	*1490*	*-18,64*
3	*1490*	*-18,41*
4	*1490*	*-18,41*
5	*1490*	*-18,44*
6	*1490*	*-18,45*
7	*1490*	*-18,43*
8	*1490*	*-18,46*

Table 3 OPM FAT A02

Fiber Number	***Wave Length (nm)***	***Test (dBm)***
1	***1490***	***-18,17***
2	***1490***	***-18,16***
3	***1490***	***-18,17***
4	***1490***	***-18,18***
5	***1490***	***-18,39***
6	***1490***	***-18,37***
7	***1490***	***-18,43***
8	***1490***	***-18,46***

Table 4 OPM FAT A03

Fiber Number	***Wave Length (nm)***	***Test (dBm)***
1	***1490***	***-18,44***
2	***1490***	***-18,41***
3	***1490***	***-18,41***
4	***1490***	***-18,63***
5	***1490***	***-18,62***
6	***1490***	***-18,61***
7	***1490***	***-18,28***
8	***1490***	***-18,32***

Table 5 OPM FAT A04

Fiber Number	**Wave Length (nm)**	**Test (dBm)**
1	**1490**	**-18,31**
2	**1490**	**-18,33**
3	**1490**	**-18,32**
4	**1490**	**-18,43**
5	**1490**	**-18,41**
6	**1490**	**-18,41**
7	**1490**	**-18,74**
8	**1490**	**-18,75**

Table 6 OPM FAT A05

Fiber Number	**Wave Length (nm)**	**Test (dBm)**
1	**1490**	**-18,58**
2	**1490**	**-18,59**
3	**1490**	**-18,61**
4	**1490**	**-18,60**
5	**1490**	**-18,81**
6	**1490**	**-18,81**
7	**1490**	**-18,83**
8	**1490**	**-18,85**

Table 7 OPM FAT B01

Fiber Number	**Wave Length (nm)**	**Test (dBm)**
1	**1490**	**-18,06**
2	**1490**	**-18,07**
3	**1490**	**-18,07**
4	**1490**	**-18,21**
5	**1490**	**-18,21**
6	**1490**	**-17,86**
7	**1490**	**-17,87**
8	**1490**	**-17,88**

Table 8 OPM FAT B02

Fiber Number	**Wave Length (nm)**	**Test (dBm)**
1	**1490**	**-17,92**
2	**1490**	**-17,97**
3	**1490**	**-17,97**
4	**1490**	**-17,96**
5	**1490**	**-17,94**
6	**1490**	**-17,96**
7	**1490**	**-17,96**
8	**1490**	**-17,96**

4.5 Power Budget Analysis

Table 9 Power Budget

FAT	**Tx**	**Rx**	**Loss**	**Margin**
A01	1.92	-18.48	20.40	8.52
A02	1.92	-18.29	20.21	8.70
A03	1.92	-18.46	20.38	8.53
A04	1.92	-18.46	20.38	8.53
A05	1.92	-18.71	20.63	8.29
B01	1.92	-18.02	19.94	8.97
B02	1.92	-17.95	19.87	9.04

The power budget calculation results indicate that all network links meet the GPON feasibility standards, where the total link loss values are below the maximum allowable limit of 28 dB according to the ITU-T G.984 standard [6]. The obtained power margin values, ranging from 8.29 dB to 9.04 dB, are significantly above the minimum requirement of 3 dB, indicating a highly reliable system performance [3].

These results are consistent with previous studies, which state that GPON-based FTTH networks are capable of maintaining stable signal transmission with efficient power distribution [2][3]. The visualization of transmitted power, received power, and power margin is presented in Figure 5.

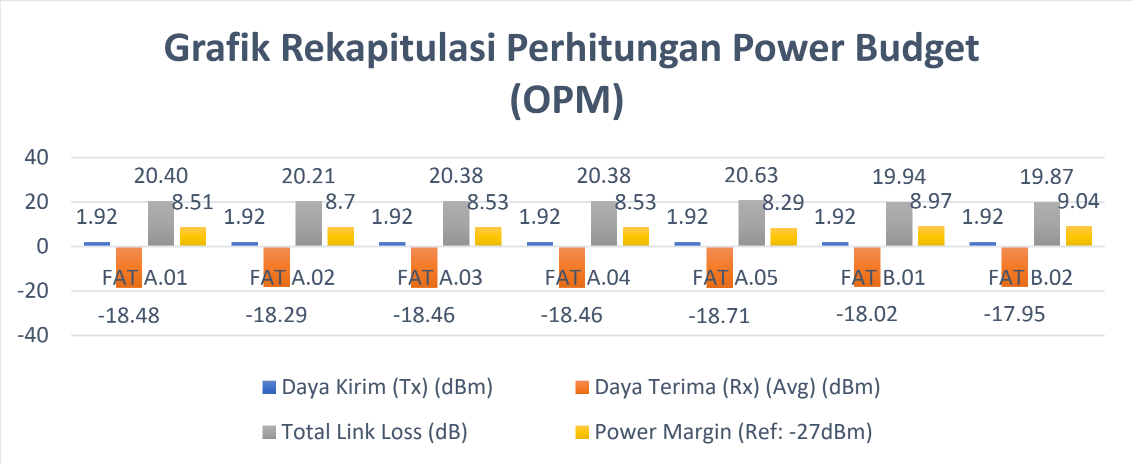

Figure 5. Power Budget Graph

4.6 OTDR Analysis

Table 10 OTDR Line A

FAT	*Jarak*	*Loss 1310*	*Loss 1550*
A01	*0.1299*	*4.923*	*4.051*
A02	*0.1870*	*5.365*	*4.775*
A03	*0.2923*	*8.787*	*7.122*
A04	*0.2659*	*7.867*	*6.644*
A05	*0.3280*	*6.069*	*2.153*

Table 11 OTDR Line B

FAT	*Jarak*	*Loss 1310*	*Loss 1550*
B01	***0.1209***	***0.047***	***0.030***
B02	***0.1520***	***0.056***	***0.196***

OTDR analysis is used to evaluate the physical quality of the optical fiber based on attenuation values at wavelengths of 1310 nm and 1550 nm. The measurement results show varying attenuation levels along the fiber links, influenced by factors such as splicing, connectors, and bending losses [3].

Although some attenuation values appear relatively high, the overall link performance remains within acceptable limits since the total loss still complies with the GPON standard [6]. This finding aligns with the theory that underground fiber installations tend to provide better protection against environmental disturbances compared to aerial installations, thereby improving network stability [7]. The results are illustrated in Figure 6.

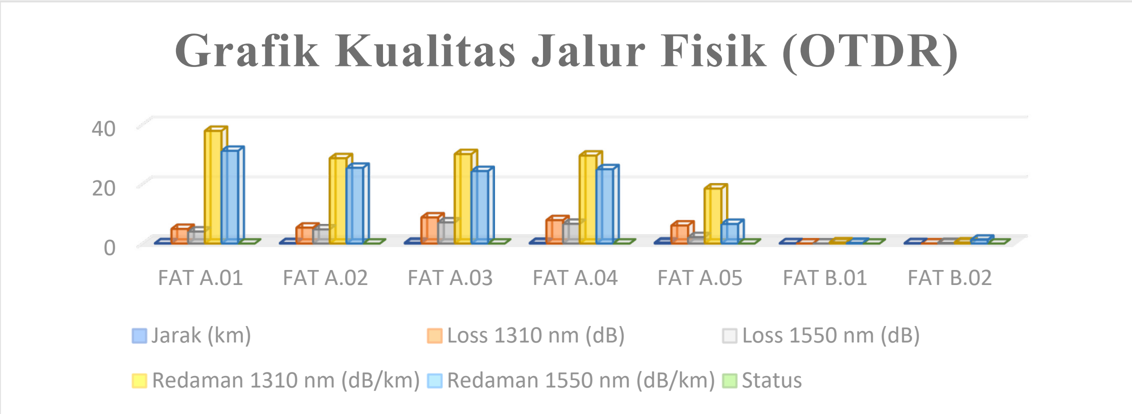

Figure 6 OTDR Graph

4.7 Case Study of Technical Calculation

4.7.1 Case 1: Total Link Loss (FAT A.01)

$$Total\ Link\ Loss = P_{tx} - P_{rx}$$
$$= 1.92 - (-18.48) = 20.40\ dB$$

Interpretation:
*The result is below the maximum GPON threshold of 28 dB, indicating that the network link is **feasible**, in accordance with ITU-T standards [6].*

4.7.2 Case 2: Power Margin

$$Margin = P_{sensitivity} - P_{rx}$$
$$= -27 - (-18.48) = 8.52\ dB$$

Interpretation:
*The margin exceeds the minimum requirement of 3 dB, indicating **very good performance** and strong signal reliability [3].*

4.7.3 Case 3: Splitter Loss

$$Loss = P_{input} - P_{output}$$
$$= 1.92 - (-8.24) = 10.16\ dB$$

Interpretation:
The splitter loss is within the acceptable limit (<10.5 dB), demonstrating optimal splitter performance, consistent with GPON design principles [2].

4.7.4 Case 4: Fiber Attenuation per km

$$Loss/km = \frac{Total\ Loss}{Distance}$$
$$= 4.923/0.1299 = 37.9\ dB/km$$

Interpretation:
The relatively high attenuation value is influenced by multiple connectors and splices. However, it remains acceptable since the total link loss still meets system requirements [3].

5. Conclusion

The implementation of the FTTH GPON underground network in the Marigold Cluster demonstrates excellent performance in terms of received power, power margin, and attenuation, all of which comply with the ITU-T G.984 standard [6].

Compared to conventional aerial cabling, the underground deployment method significantly improves network reliability, reduces physical disturbances, and enhances environmental aesthetics [7]. These results confirm that GPON-based FTTH networks are highly suitable for modern urban infrastructure development due to their efficiency, scalability, and stability [2][3].

Therefore, this approach contributes to the advancement of professional, safe, and sustainable telecommunication infrastructure systems.

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