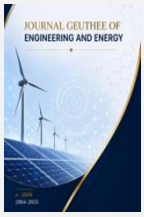
e- ISSN : 2964-2655, DOI: 10.52626/joge.v%vi%i.110



JOURNAL GEUTHEE OF ENGINEERING AND ENERGY

Homepage : https://joge.geutheeinstitute.com/index.php/jogee

Design and Performance Evaluation of GPON FTTH Networks in Taman Asri 8, Padang City

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ABSTRACT

This study addresses the absence of MyRepublic FTTH services in Taman Asri 8 Housing, Padang City, which creates a need for an appropriate fiber optic access network design to serve the 212 existing housing units. This research aims to design and evaluate a Fiber To The Home (FTTH) network based on Gigabit Passive Optical Network (GPON) technology using the Network Planning Process (NPP) method, consisting of requirement analysis, desktop survey, field survey, network design, and feasibility analysis. The network layout was developed using AutoCAD, while its performance was evaluated through Link Power Budget (LPB) and Rise Time Budget (RTB) calculations and OptiSystem simulations. The evaluation considered received optical power, BER, and Q-factor parameters. The results show that the proposed network can serve 212 homepasses through one Optical Distribution Cabinet (ODC) and 15 Optical Distribution Points (ODPs). The calculated received optical power for the nearest, middle, and farthest paths is −19.817 dBm, −20.004 dBm, and −20.185 dBm, respectively, while the simulated received power ranges from −19.181 dBm to −19.549 dBm. The rise time ranges from 0.2500 ns to 0.2506 ns, the BER ranges from 4.27181×10^{-17} to 2.81757×10^{-13}, and the Q-factor ranges from 7.20846 to 8.32338. These results satisfy the adopted performance criteria, namely received power above the ONT sensitivity limit of −28 dBm, rise time below 0.292 ns, BER below 10^{-9}, and Q-factor above 6, in accordance with the GPON performance evaluation framework. These findings indicate that the proposed GPON-based FTTH network is technically feasible for implementation in Taman Asri 8 Housing, Padang City.

Keywords: FTTH, GPON, Network Planning Process, Link Power Budget, Rise Time Budget.

Manuscript received 29 Sept 2026; revised 31 Oct 2026; accepted 05 Nov 2026.
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1. INTRODUCTION

The development of information and communication technology has increased people's need for high-speed, stable, reliable, and affordable broadband internet services. The growth of digital services such as video streaming, online learning, cloud computing, Internet of Things (IoT), gaming, and remote work activities has driven the need for access network infrastructure with large bandwidth capacity and good transmission quality [1]. Adequate network infrastructure is one of the foundations in supporting educational, business, and public service activities. Copper cable-based access technology and wireless networks have limitations in bandwidth capacity, signal attenuation, and resistance to electromagnetic interference.

Optical fiber is a telecommunication transmission medium made of glass or plastic that uses light signals to transmit information from one point to another. The light sources commonly used in optical fiber transmission are lasers and light-emitting diodes (LEDs). Optical fiber offers high transmission speeds, large bandwidth capacity, and relatively low attenuation compared

with other transmission media [2], [3]. Based on the core diameter and light propagation modes, optical fiber is generally classified into two types: single-mode fiber (SMF) and multimode fiber (MMF). Single-mode fiber allows light to propagate through a single mode and is suitable for long-distance communication, while multimode fiber supports multiple propagation modes and is generally used for shorter transmission distances [4].

Fiber To The Home (FTTH) is one of the access network solutions because it uses optical fiber that has large bandwidth, relatively low attenuation, and stable transmission quality [5], [6]. In its implementation, FTTH can use Gigabit Passive Optical Network (GPON) technology, which is a passive optical access network that allows one Optical Line Terminal (OLT) to serve many customers through a passive splitter so that the use of infrastructure can be carried out efficiently[7], [8].

The need for FTTH infrastructure is also relevant in residential areas that are experiencing a growth in the number of residences and digital activities of the community. Taman Asri 8 housing is a residential area located in Sungai Sapih Village, Kuranji District, Padang City. Based on data from the Central Statistics Agency, Kuranji District has an area of 57.41 km^2 with a population of 153,410 people by 2024, while Sungai Sapih Village has an area of 7.06 km^2 with a population of 16,193 people [9]. Based on the developer's site plan, Taman Asri 8 Housing is planned to have 367 housing units, with 212 housing units having been built at the time of the research. This condition shows the need to design an access network that is able to serve residential that has been built while considering the development of the area. The problem that needs to be considered is not only the availability of the network, but also how to determine the appropriate configuration, devices, distribution channels, and network capacity so that network performance can meet customer service needs technically.

Several previous studies have investigated the design and performance evaluation of GPON-based FTTH networks. Adiati et al. (2022) designed an FTTH-GPON network for 254 customers in a residential area using Link Power Budget and Rise Time Budget analysis, obtaining a rise time of 0.2236 ns and results that met the ITU-T G.984.1 standard [10],Dunggio (2021) designed an FTTH-GPON distribution network in Griya Dulomo Indah Housing using SAS Planet and evaluated its feasibility through Link Power Budget and Rise Time Budget calculations, with the farthest-path attenuation of 21.58605 dB and a maximum rise time of 0.2634 ns [11], Shabaneh and Melhem (2022) investigated GPON-based FTTH performance using Fiber Bragg Grating (FBG) and optical amplifiers, achieving Q-factor values of 89.5 downstream and 181.3 upstream for a 20 km fiber link [12]. Other research also uses software such as AutoCAD and OptiSystem to support the design process and simulation of network performance [13], [14].

This study proposes the design of a GPON-based FTTH network in Taman Asri 8 Housing using the Network Planning Process (NPP) approach. The research stages include needs analysis, desktop survey, field survey, network design, and feasibility analysis. Google Earth Pro is used for area mapping and customer location determination, while AutoCAD is used to design network lines, placement of Optical Distribution Cabinet (ODC), Optical Distribution Point (ODP), poles, and distribution cables. Network performance was evaluated through Link Power Budget and Rise Time Budget calculations and simulations using OptiSystem with receive power, Bit Error Rate (BER), and Q-factor parameters. This approach was used to determine the suitability of the design to GPON-based FTTH network performance parameters. The added value of this research lies in the integration of GPON-based FTTH network design with analytical and simulative performance evaluation in the actual condition of the Taman Asri 8 Housing area with 212 housing units as a design homepass. The results of the study are expected to produce a network design that can be evaluated based on technical parameters and become a reference in the development of fiber optic access networks in residential areas with similar characteristics.

2. RESEARCH METHOD

2.1. Research Design

This research focuses on the design and performance evaluation of a Fiber To The Home (FTTH) network based on Gigabit Passive Optical Network (GPON) using the Network Planning Process (NPP). The research was conducted at Taman Asri 8 Housing, Sungai Sapih, Kuranji,

Padang, from March to July 2026. The research stages consist of literature study, requirement analysis, desktop survey, field survey, network design, feasibility analysis, and network simulation.

The research procedure is shown in Figure 1. The process begins with identifying network requirements based on the number of homepass, housing layout, geographical conditions, and service needs. The next stages are desktop and field surveys, followed by FTTH-GPON network design. The designed network is then evaluated using Link Power Budget (LPB), Rise Time Budget (RTB), and OptiSystem simulation.

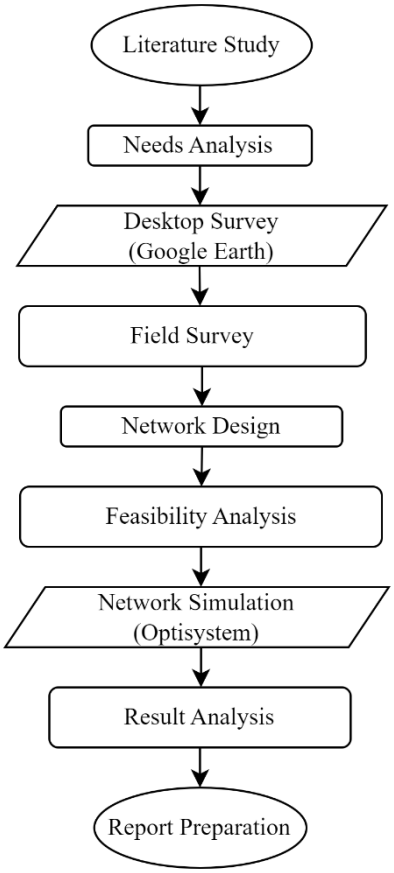


Figure 1 Research Flowchart

2.2. Research Location and Data Acquisition

The research was conducted in Taman Asri 8 Housing, Sungai Sapih, Kuranji, Padang. The study area was identified using Google Earth Pro and the housing site plan as the main references for determining the service area, homepass distribution, and potential network routes. The housing site plan indicates 367 planned housing units, while 212 units had been constructed at the time of the research and were used as the homepass target.

Data were obtained from the developer's site plan, Google Earth Pro observations, field surveys, and existing MyRepublic network information. Google Earth Pro was used to observe the study area, measure distances, and identify the feeder route, while field surveys were conducted to verify road conditions and existing pole locations. AutoCAD was used to develop the network layout, and OptiSystem was used for performance simulation.



Figure 2 Study Area of Taman Asri 8 Housing

2.3. Network Planning Process

The network planning follows the Network Planning Process (NPP), consisting of requirement analysis, desktop survey, field survey, network design, and feasibility analysis. Requirement analysis determines the number of homepass and required network capacity. The desktop survey identifies the study boundary, road access, and the existing MyRepublic network connection. The field survey verifies the actual conditions and pole positions. The collected data are then used to determine the network topology, device locations, and cable routes.

In the design stage, 212 homepass are planned to be served by one new Optical Distribution Cabinet (ODC) and 15 Optical Distribution Points (ODPs). Five 1:4 PLC splitters are placed at the ODC, while each ODP uses a 1:16 PLC splitter. The feeder route from the existing MyRepublic network to the study area is 1,265 m, and the total distribution cable length is 1,270 m.



Figure 3 Feeder Route from the Existing MyRepublic Network

Where:

: FDT Myrepublic
:l *Feeder*

2.4 FTTH-GPON Network Design

The FTTH network uses a Point-to-Multipoint (P2MP) topology in accordance with the GPON architecture. The optical signal is transmitted from the existing network through the feeder to the new ODC, then distributed through ODPs and connected to customers through drop fiber and ONT. The network design considers the distribution of homepass, existing pole locations, road access, and the distance between network devices and customers.

The network layout is developed using Google Earth Pro and AutoCAD. Google Earth Pro is used primarily for determining the feeder route, while AutoCAD is used to map the homepass, ODC, ODP, poles, and distribution routes. Three representative customer paths are selected for subsequent performance analysis: the nearest, middle, and farthest paths.

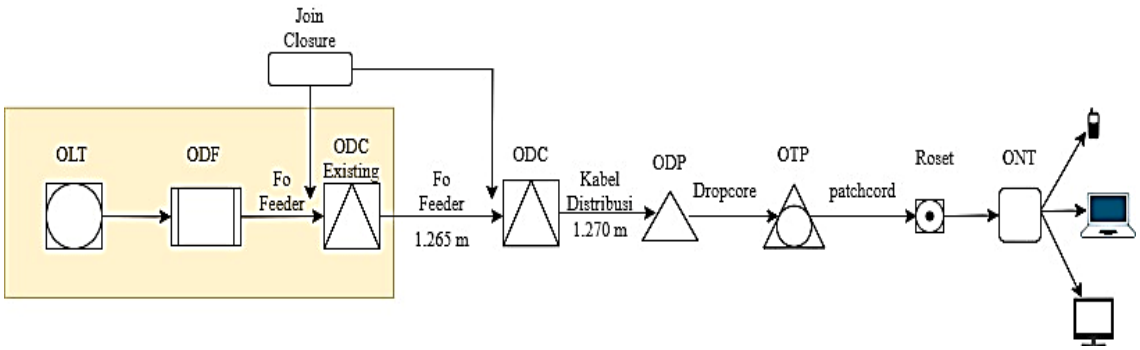


Figure 4 FTTH-GPON Network Topology

2.5 Performance Evaluation and Simulation

The designed network is evaluated using LPB and RTB calculations to determine the technical feasibility of the optical link. The analysis uses network parameters obtained from the design, including cable lengths, splitter configuration, and network components. The calculated results are then used as a reference for evaluating the transmission performance of the designed network.

Performance simulation is conducted using OptiSystem based on three representative customer paths: nearest, middle, and farthest. The simulation model consists of an optical transmitter representing the OLT, optical fiber transmission media, optical splitters, and an optical receiver representing the ONT. The observed parameters are received optical power, Bit Error Rate (BER), and Q-factor. The calculation and simulation results are compared with the applicable GPON performance criteria to determine the feasibility of the designed network.

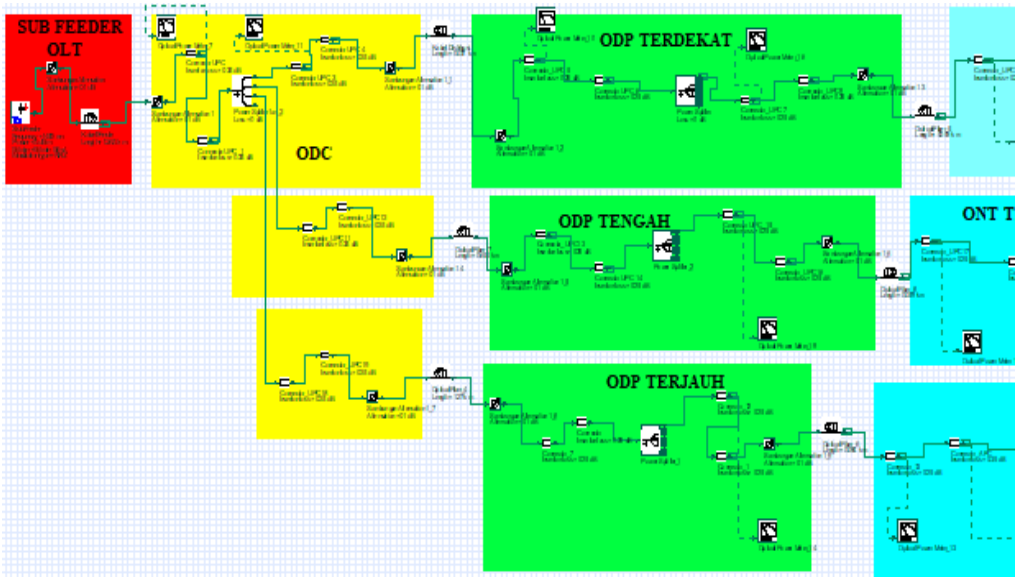


Figure 5 OptiSystem Simulation Model for FTTH-GPON

3. RESULTS AND DISCUSSION

3.1. FTTH-GPON Network Design

The designed FTTH-GPON network serves 212 homepass using one ODC and 15 ODPs. The network consists of a 1,265 m feeder and 1,270 m distribution cable, with five 1:4 PLC splitters at the ODC and 15 1:16 PLC splitters at the ODPs. The network layout is designed using AutoCAD based on the distribution of houses, road access, and existing poles.

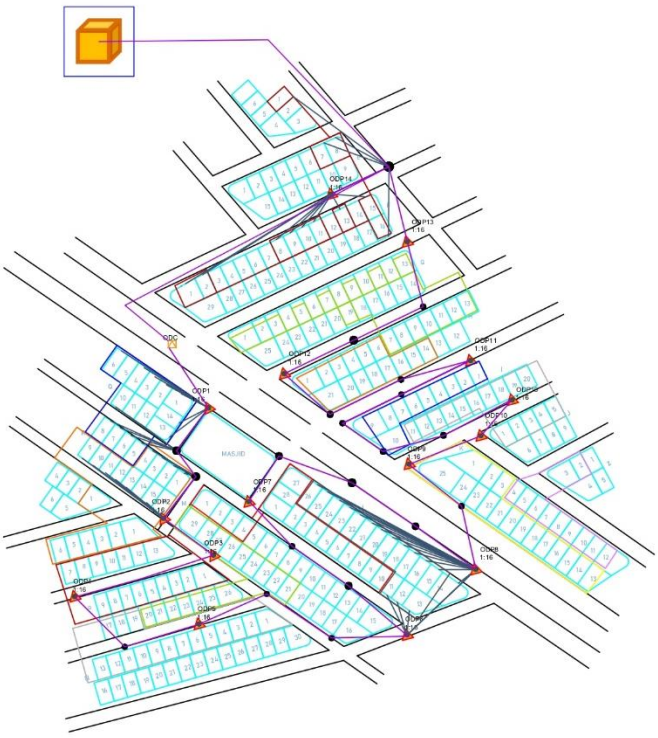


Figure 6 FTTH-GPON Network Design

Where:

: FDT

: ODC New

: Tiang

: ODP

:D1 : D2 : D3 : D4 :D5 Putih: D6 : D7
: D8 : D9 : D10 :D11 :D12 :D13 : D14
: D15

Table 1, FTTH-GPON Network Parameters

No	Parameter	Results
1	*Homepass*	212 Unit
2	ODC	1 Unit
3	ODP	15 Unit
4	*Splitter PLC* 1:4	5 Unit
5	*Splitter PLC* 1:16	15 Unit
6	Panjang Kabel *Feeder*	1.265 m
7	Panjang Kabel Distribusi	1.270 m

3.2. Link Power Budget and Rise Time Budget

The results of the analysis of Link Power Budget (LPB) and Rise Time Budget (RTB) in this study were obtained through mathematical calculations based on predetermined network parameters. LPB calculation is used to determine the total attenuation and optical power received on the customer side using the following equations[15]:

Total attenuation calculation on budget links

$$\alpha T = L.\ \alpha serat + Nc.\ \alpha c + Ns.\ \alpha s + Sp \quad (2.1)$$

Receiving-based calculations can use equations

$$Pr = Pt - \alpha T \quad (2.2)$$

Where,
αT = Total loss (dB)
$\alpha serat$ = optical fiber attenuation (dB/Km)
αc = Connector attenuation (dB/buah)
αs = Connection attenuation (dB)
Sp = Splitter Attenuation (dB)
L = Fiber optic length(Km)
Nc = Number of connectors
Ns =Number of connections
Pr = Power Receive (dBm)
Pt = Power Transmit (dBm)

Meanwhile, the Rise Time Budget calculation is carried out to determine the total time of the system up and ensure that the network is able to transmit data according to the bit rate used. This calculation uses the equation:

Rise time equation due to chromatic dispersion

$$t_f = D.\ \sigma\lambda.\mathrm{L} \quad (2.3)$$

Rise time system equation

$$t_r = \sqrt{t_{tx}^2 + t_{rx}^2} + t_F^2 \quad (2.4)$$

Similarity of the criteria for increase time budget

$$t_{sis} < \frac{0{,}7}{BR} \quad (2.5)$$

Where,
t_{tx} = Rise Time optical source (ns)
BR = Bit Rate
t_f = Optical Rise Time (ns)
D = Koefisien disperse (ns/nm.km)
L = Distance (km)
$\sigma\lambda$ = Spectral width(nm)
t_{sis} = Rise Time System (ns)
t_{rx} = Optical detector rise time(ns)

LPB analysis was performed on the nearest, middle, and farthest paths. The received power values were −19.817 dBm, −20.004 dBm, and −20.185 dBm, respectively, with all values above the ONT sensitivity limit of −28 dBm.
The calculated system rise times were 0.2500 ns, 0.2502 ns, and 0.2506 ns for the nearest, middle, and farthest paths. All values are below the maximum limit of 0.292 ns.

Table 2 Link Power Budget and Rise Time Budget Results

Path	Receive Power (dBm)	Rise Time (ns)
Nearest	−19.817	0.2500
Middle	−20.004	0.2502
Farthest	−20.185	0.2506

3.3 OptiSystem Simulation Results

The network was simulated using OptiSystem for the three representative paths. The simulated receive power values were −19.181 dBm, −19.367 dBm, and −19.549 dBm, respectively. The difference from the manual calculations was approximately 0.636 dB.

BER and Q-factor results are presented in Table 3. The BER values were below 10^{-9}, while the Q-factor values were above 6 for all paths.

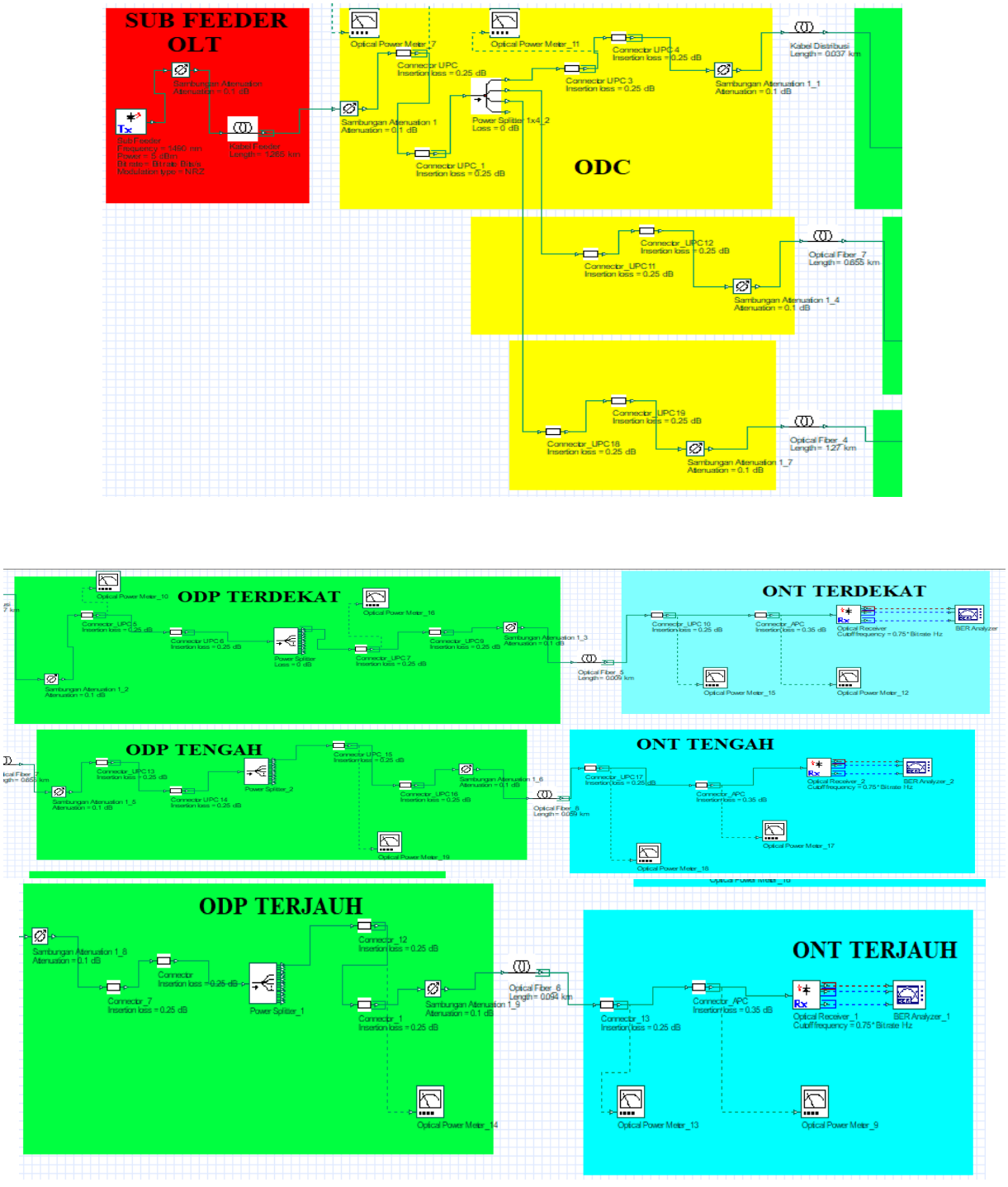


Table 3 BER and Q-Factor Results

Path	BER	Q-Factor
Nearest	4,27181 × 10^{-17}	8,32338
Middle	1,08747 ×	7,63975

	10^{-14}	
Farthest	$2{,}81757 \times 10^{-13}$	7,20846

4. CONCLUSION

This study successfully designed a Fiber To The Home (FTTH) network based on Gigabit Passive Optical Network (GPON) in Taman Asri 8 Housing, Padang, using the Network Planning Process (NPP). The designed network serves 212 homepass through one Optical Distribution Cabinet (ODC) and 15 Optical Distribution Points (ODPs), with a 1,265 m feeder and 1,270 m distribution cable.

The performance evaluation shows that the received optical power obtained from manual calculations ranges from −19.817 to −20.184 dBm, while the OptiSystem simulation results range from −19.181 to −19.549 dBm. The system rise time ranges from 0.2500 to 0.2506 ns, remaining below the maximum limit of 0.292 ns. The BER values range from 4.27181×10^{-17} to 2.81757×10^{-13}, while the Q-factor ranges from 7.20846 to 8.32338. These results indicate that the designed network satisfies the performance criteria used in the study.

The proposed FTTH-GPON design can serve as a reference for optical access network development in residential areas with similar characteristics. Further research can consider the implementation of the proposed network in the field and evaluate its performance under actual operating conditions.

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