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Effect of Connection Losses on Fiber To The Building (FTTB) Network Activation

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ABSTRACT

The Fiber To The Building (FTTB) technology uses fiber optic cables for high-speed data transmission in high-rise office buildings. However, connection loss in fiber optic cables, especially during network activation, can significantly affect the overall performance and reliability of the FTTB network. This study investigates the effects of connection loss on total attenuation in FTTB networks before and after activation, using Passive Optical Network (PON) technology. Simulations were performed on three subscriber scenarios with different treatments of drop core cables (no connection, one connection, two connections) and patch cord cables of different lengths (3m, 5m, 10m), each with additional variations in the number of connections. Attenuation measurements were taken before and after network activation, showing that increasing cable length and splices leads to higher attenuation and reduced network performance. For example, customer 1 with no connections had the lowest attenuation before activation of 19.68 dB and after activation of 19.57 dB with signal quality (ping ONU 11 ms, ping OLT 9 ms, and ping Google 31 ms) while customer 3 with the most connections had attenuation values before activation of 20.92 dB and after activation of 20.87 dB with signal quality (ping ONU 29 ms, ping OLT 28 ms, and ping Google 70 ms). This research emphasises the importance of link management and the length of cable used to minimize attenuation and ensure optimal network performance.

INTRODUCTION

Fiber optic technology provides high-speed data communication services with large capacity and high-quality transmission. Fiber To The Building (FTTB) is a technology that utilizes fiber optics for data transmission. FTTB employs fiber optic communication to facilitate multimedia network availability in office areas located in high-rise buildings to support business activities (Anggita, Rahman, Akbar, Laagu, & Apriono, 2020). However, while building and activating FTTB networks, various challenges can affect service quality. One significant challenge is the connection losses in fiber optic cables.

Attenuation in fiber optics is a significant factor that can diminish transmission power and hinder overall network performance. The attenuation in fiber optics is primarily caused by the optical cable, connector, and connection itself. High levels of attenuation can decrease transmission power and compromise the overall reliability and performance of the network (Asril, Yustini, & Herwita, 2019). The loss of fiber optic cable splicing is caused by the method used in the splicing process. If the quality of the connection is good, the data transmission process will run smoothly. On the other hand, if the quality of the connection is poor, the data transmission process will be disrupted. This can be observed from the amount of losses due to splicing and light attenuation on the connection (Albar & Rizki, 2020).

According to (Mardhatillah, Asril, Yustini, & Yulindon, 2022), connection losses significantly impact the total attenuation value, which can affect network performance. When the connection quality does not adhere to Standard Operational Procedures (SOP), it can lead to high attenuation, reduced transmission power, and lower network reliability. In a study by (Asril, Yolanda, Lifwarda, Putri, & Kasmar, 2022), it was found that the type of connection, including sleeve protection and adapter barrier, can affect the damping value. Additionally, as suggested by (Maslo, Telecom, & Goran, 2020), significant damping occurs due to a mismatch in bending and damping treatment in fusion connections.

(Soni, Nagpure, Shaikh, Nandwalkar, & Pete, 2020) stated that utilizing proper splicing techniques and fiber optic variants can reduce splice losses to nearly 0 dB. This demonstrates the potential to minimize the adverse effects of splice losses, which is crucial for maintaining the quality and reliability of FTTB networks. Thus, it is imperative to minimize splice losses, particularly during the network activation process, to ensure the quality and dependability of FTTB networks.

Previous research has mainly concentrated on the general attenuation along fiber optic cables, without thoroughly examining the specific influence of link losses on signal quality and the activation process of FTTB networks. In this study, we aim to address this gap by analyzing the impact of link losses on total attenuation in FTTB networks before and after activation using Passive Optical Network (PON) technology. This will be achieved by

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comparing three different customer scenarios. Measurements are taken along the FTTB network path from the central point to the end customer, paying particular attention to the connections of the fiber optic cables, specifically the drop core cable linking the ODF to the Rosette, and the patch cord cable linking the end termination device to the Optical Network Unit (ONU). This research aims to provide new and relevant contributions, ensuring that the FTTB network operates optimally and meets the expected quality standards.

LITERATURE REVIEW

Fiber Optic

Fiber optic is a transmission medium made of plastic or glass that transmits light from one place to another. In fiber optic cables, electrical signals are converted into light and then transmitted. The light source used for transmission is a laser or LED. Fiber optic allows for very high-speed data transmission.

Fiber To The Building (FTTB)

Fiber to the Building (FTTB), also known as fiber to the basement, is a general term for the basic network architecture of data connections designed for multi-story buildings to achieve the necessary bandwidth. This network architecture utilizes fiber optic as a transmission medium for fiber access to local networks (Anggita et al., 2020). The TKO point is situated in a specialized room inside the building or the basement.

Fiber Optic Network Devices

FTTB networks include both passive and active devices.

1. Passive Devices
   a. Optical Distribution Frame (ODF)
   Optical Distribution Frame (ODF) is a device used in fiber optic network infrastructure to arrange, manage, and distribute fiber optics. ODF serves as a central point for connecting, terminating, and distributing fiber optics in a network.
   b. Optical Distribution Cabinet (ODC)
   The Optical Distribution Cabinet (ODC) is a passive device that is installed outside the STO. It is a room where the installation process for single-mode optical network connections is carried out. This room is in the form of a box or dome made of specific materials. Some of the devices in the ODC include splitters, splicing, and connectors.
   c. Closure
   A closure is a device used to connect and protect fiber optic cables. Its purpose is to provide safe protection for fiber optic connections from mechanical damage, dust, moisture, and other environmental factors.
   d. Optical Distribution Point (ODP)
   Optical Distribution Point (ODP) is a passive device used to cover the cable before it enters the customer's home.
   e. Passive Splitter
   A passive splitter is a device used to connect networks by taking the input from one source and dividing it into multiple outputs. This is also known as splitting incoming light into several outputs. Passive splitters come in various configurations such as 1:2, 1:4, 1:8, 1:16, and so on.
   f. Roset
   Roset is a passive device located at the customer premises, which serves as the endpoint of the indoor cable/drop core fiber optic.
2. Active Devices
   Active devices, requiring electrical energy to function, are used in the FTTB network. The following are the active devices used:
   a. Optical Line Termination (OLT)
   Optical Line Termination (OLT) is a device that serves as an interface at the endpoint of the service. It converts information signals from electrical or electrical signals into light signals, which can be transmitted using fiber optic cables.
   b. Optical Network Unit (ONU)
   An Optical Network Unit (ONU) is a device on the user side that converts optical signals into electrical signals for use by user devices.
   c. Small Form Factor Pluggable (SFP)
   SFP stands for Small Form-factor Pluggable, which is a device capable of converting electrical signals into optical signals. SFPs are commonly used in fiber optic connection networks, such as routers and switches. They provide a flexible interface by allowing users to replace SFPs without having to replace the entire hardware.
   d. Mikroik
   Mikrotik functions as a router for network traffic.

E-ISSN : 2807-9035
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Fiber Optic Cable Types

1. Feeder Cable
   A feeder cable is a type of fiber optic cable used to deliver services. It serves as the main connecting fiber optic cable from the ODF to the ODC. There are three types of feeder cables:
   1. Duck cable: This type uses PVC pipe protection with a concrete cast coating.
   2. Buried cable: It is protected by HDPE pipe.
   3. Aerial cable: This type is anchored to an iron or concrete pole.
2. Distribution Cable
   Distribution cables are fiber optic cables that deliver services to smaller areas. Distribution cables typically use single-core single-tube (SCST) cables.
3. Drop Core Cable
   Drop core cable is used for terminating connections to customer homes. It is designed to be resistant to bending.
4. Patch Cord Cable
   Patch cord cable is an indoor cable used to connect passive devices with terminations. It has connectors installed at both ends.

The Performance Of Fiber Optic Cables

The performance of fiber optic cables is affected by the loss of light that travels along the cable. Light loss in fiber optics is a fundamental factor that reduces the average optical power reaching the receiver. Optical loss or attenuation in fiber optic cables occurs due to transmission attenuation, including micro and macro bending, splicing, connector damage, and compression.

1. Bending
   Bending refers to the curvature of fiber optic cables, which can disrupt the transmission of signals from the source to the destination. This bending increases the attenuation value, hampers the data transmission process, and can even result in signal loss or failure to reach the intended destination.
2. Splicing
   Poor splicing leads to an increase in the attenuation value of a fiber optic cable. This happens because the light signal from one fiber optic cannot fully propagate into the other.
3. Damaged connector
   Damaged connectors often result from frequent opening and closing of the connector on the device or the cable near the connector being pulled.
4. Dispersion
   Dispersion is the spreading out of a signal as it travels through a fiber optic cable, leading to a broadening of the signal pulse. This limits the bandwidth of the cable. As fiber optic cables age, dispersion tends to worsen.

Fiber Optic Cable Splicing Method

Fiber optic splicing is a method used to connect two ends of a disconnected fiber optic cable so that they are joined and can transmit data. The splicing process must be free of alignment errors. Low splicing losses require high quality in the splicing process. The splicing technique is divided into two categories:

1. Mechanical splicing
   Mechanical splicing is a technique where fiber optics are connected by pressing fibro II 2529 with jelly material (Albar & Rizki, 2020).
2. Fusion splicing
   Fusion splicing is a technique in which the two ends of the fiber are permanently or semi-permanently fused using electrical technology in the splicer tool (Soni et al., 2020).

METHOD

This study utilizes a simulation method to analyze the impact of fiber optic cable connections on the attenuation and performance of a Fiber To Building (FTTB) network using Passive Optical Network (PON) technology. The simulations were performed on three subscribers, each of whom received varying treatments of the drop core cable connecting the Optical Distribution Point (ODP) to the rosette. These treatments included the use of drop core cables without splices, with one splice, and with two splices.

To connect the rosette with the ONU, we use a specially treated patch cord cable. These patch cords are available in different lengths: 3 m, 5 m, and 10 m. Each length comes with the option of having no joints, one joint, or two joints.

This research focuses on measuring the total attenuation and network quality received by each subscriber in an FTTB network with PON technology. We are using different treatments of drop core and patch cord cables to understand how variations in the number of splices and cable length can affect the overall network performance. The results of this simulation are expected to provide insight into optimizing the use of fiber optic cables in FTTB networks.

E-ISSN : 2807-9035
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Research on the impact of fiber optic cable connections follows the research flow in Figure 1.

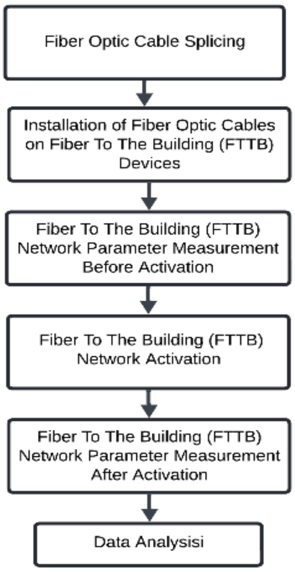

Figure 1. Research Flow

In Figure 1, we can observe the steps of the work carried out in this study. The first step involves connecting the fiber optic cable. The fiber optic cable is spliced using the fusion splicing method with a fusion splicer tool. This method involves connecting the two ends of the core using solder, utilizing electrical technology in the fusion splicer tool. Once the cables are connected, the next step is to install the fiber optic cable on the device used. In the context of this research, the drop core cable is used to connect the ODP to the rosette, and the patch cord cable is used to connect the rosette to the ONU. After installation, measurements are taken on the FTTB network device before activation. This is done using a signal source from the Handle Light Source (HLS) to check if the resulting attenuation meets the standards set by ITU-T G984 and PT Telekomunikasi. These standards state that the total attenuation value should not exceed 28 dB. Once the measurement results meet the required specifications, the FTTB network is activated. After successful activation, measurements are retaken using a signal source from an OLT with a Small Form-factor Pluggable (SFP) installed. Once all the data is collected, the obtained data is analyzed.

The measurements were taken both before and after the network was activated. The signal source before activation was from the HLS, but after activation, it came from the OLT attached to the SFP. An Optical Power Meter (OPM) was used to measure the receiving power and optical attenuation. The measurements were taken using a wavelength of 1310 nm. The measurement block diagram can be found in Figure 2.

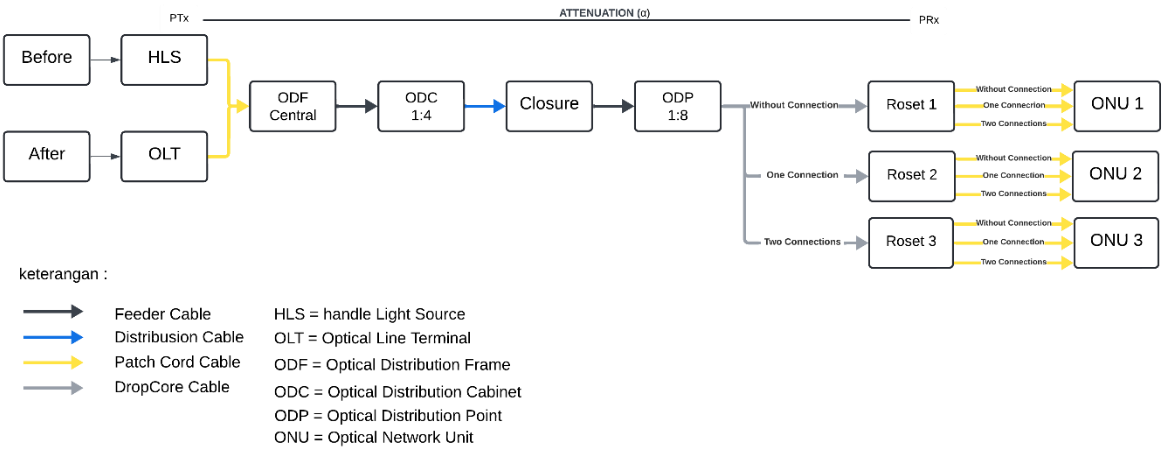

Figure 2. FTTB Network Measurement Block Diagram

E-ISSN : 2807-9035
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RESULT

The results from this study consist of measurements using OPM before and after activation at three customer locations. Before conducting the measurements, the first step is to establish a connection to the fiber optic cable. This connection is made using the fusion splicing method with a tool known as a fusion splicer. The result of the connection loss obtained during the cable connection process using a fusion splicer is 0.01 dB for each of the cable 1 and cable 2 connections. This information is shown in Figure 3.

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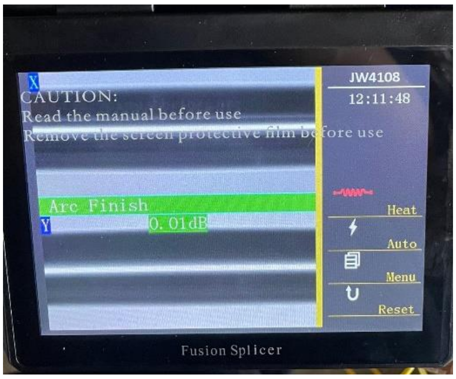

Figure 3. Fiber Optic Cable Fusion Splicer Splicing Result

Measurement Before Activation

The measurement before activation uses a signal source derived from HLS. In measurement using a wavelength of 1310 nm. To measure the attenuation of each customer, the first step is to calibrate between HLS and OPM to measure the input power value. The results of the input power measurement are shown in Table 1.

Table 1. Input Power Measurement Results Before Activation

Trial to	Calibration result (dBm)
1	-7.39
2	-7.39
3	-7.39
Mean	-7.39

After receiving the input power, measurements are taken for each customer. Three customers undergo measurements with different cable connection treatments, and the results of input power and attenuation measurements are displayed in Table 2.

Table 2. Total Damping Measurement Results of Customer for Each Patch Cord Cable Connection Type Before Activation

Cable Length (m)	Number of Connection	P_{Tx} (dBm)	Customer 1		Customer 2		Customer 3	
			P_{Rx} (dBm)	Attenuation (dB)	P_{Rx} (dBm)	Attenuation (dB)	P_{Rx} (dBm)	Attenuation (dB)
3	No Connection	-7.39	-27.07	19.68	-27.91	20.52	-27.95	20.56
	One Connection		-27.11	19.72	-27.98	20.59	-28.02	20.63
	Two Connections		-27.18	19.79	-28.07	20.68	-28.09	20.70
5	No Connection		-27.10	19.71	-28.01	20.62	-28.05	20.66
	One Connection		-27.17	19.78	-28.09	20.70	-28.10	20.71
	Two Connections		-27.23	19.84	-28.13	20.74	-28.19	20.80
10	No Connection		-27.14	19.75	-28.19	20.80	-28.14	20.75
	One Connection		-27.20	19.81	-28.25	20.86	-28.22	20.83
	Two Connections		-27.25	19.86	-28.34	20.95	-28.31	20.92

Measurement after activation

Measurement after activation involves using a signal source from an OLT equipped with SFP. The measurement utilizes a wavelength of 1310 nm at the receiver, in line with the specifications of the SFP being used. To measure the attenuation of each customer, start by calibrating and measuring the input power value between the OLT, which has been fitted with an SFP, and an OPM. The results of the input power measurements are detailed in Table 3.

E-ISSN : 2807-9035
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Table 3. Input Power Measurement Results After Activation

Trial to	Calibration result (dBm)
1	9.17
2	9.24
3	9.15
Mean	9.19

The measurements were taken after the input power was obtained, just as before activation. Three different customers were measured with different treatments on the cable connection. The results of input power and attenuation measurements are presented in Table 4.

Table 4. Total Damping Measurement Results of Customer for Each Patch Cord Cable Connection Type After Activation

Cable Length (m)	Number of Connection	P_{Tx} (dBm)	Customer 1		Customer 2		Customer 3	
			P_{Rx} (dBm)	Attenuation (dB)	P_{Rx} (dBm)	Attenuation (dB)	P_{Rx} (dBm)	Attenuation (dB)
3	No Connection	9.19	-10.38	19.57	-11.29	20.48	-11.32	20.51
	One Connection		-10.41	19.60	-11.33	20.52	-11.41	20.60
	Two Connections		-10.50	19.69	-11.41	20.60	-11.46	20.65
5	No Connection		-10.43	19.62	-11.39	20.58	-11.42	20.61
	One Connection		-10.51	19.70	-11.43	20.62	-11.46	20.65
	Two Connections		-10.57	19.76	-11.50	20.69	-11.53	20.72
10	No Connection		-10.49	19.68	-11.51	20.70	-11.52	20.71
	One Connection		-10.56	19.75	-11.57	20.76	-11.60	20.79
	Two Connections		-10.61	19.80	-11.65	20.84	-11.68	20.87

Network quality measurements were conducted along the newly constructed lines at three customer locations, with special attention given to the cable connections used. Following the earlier attenuation measurements, additional analysis was performed to evaluate the impact of attenuation on network quality. The findings from these measurements are detailed in Table 5.

Table 5. Network Quality Measurement Results

Customer	Average Packet Delivery Time (ms)		
	Ping ONU	Ping OLT	Ping Google
Customer 1	11	9	31
Customer 2	21	24	33
Customer 3	29	28	70

DISCUSSION

In this section, an analysis of the data obtained from the results is conducted. The study focuses on the measurement results obtained for attenuation and network quality on the three customers used, both before and after activation. The source before activation is from HLS and after activation is from OLT.

Analysis Before Activation

Measurements were conducted on 3 sets of rosettes intended for 3 different customers heading to the ONU, utilizing various treatments for the patch cord cables. The patch cord cables came in three different lengths: 3 m, 5 m, and 10 m. Within each cable length, there were 3 cables treated at each length, with treatments including no connection, 1 connection, and 2 connections. The measurements were taken at the final termination device on an FTTB network with PON technology. Before activation, the measurements were conducted using an HLS light source with an OPM measuring instrument. The wavelength used during the measurement was 1310 nm. The input power specified in Table 1 is -7.39 dBm, obtained from the calibration results between HLS and OPM.

The measured results align with Table 2, which displays various cable lengths (3 m, 5 m, and 10 m) and the treatments they underwent (no connection, 1 connection, and 2 connections). P_{Tx} refers to the input power obtained from calibration, while P_{Rx} is the output power obtained during measurement. Three different customers were measured, each with varying treatments on the drop core cable: customer 1 had no connection, customer 2 had one connection, and customer 3 had two connections. The damping value is calculated from the difference between input and output power.

The attenuation obtained is calculated using the formula (1):

$$\text{Attenuation } (dB) = \text{ Input power } (P_{Tx}) - \text{ output power } (P_{Rx}) \quad (1)$$

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In Table 2, measurements were taken for three customers. Customer 1 had a cable length of 3 m. The output power without connection was -27.07 dBm, with 1 connection it was -27.11 dBm, and with 2 connections it was -27.18 dBm. The attenuation for each scenario is 19.68 dB, 19.72 dB, and 19.79 dB, respectively. For the 5 m cable, the output power without connection is -27.10 dBm, with 1 connection is -27.17 dBm, and with 2 connections is -27.23 dBm. The corresponding attenuations are 19.71 dB, 19.78 dB, and 19.84 dB. Lastly, for the 10 m cable, the output power without connection is -27.14 dBm, with 1 connection is -27.20 dBm, and with 2 connections is -27.25 dBm. The attenuation for each case is 19.75 dB, 19.81 dB, and 19.86 dB.

In customer 2, who obtained measurements with a 3 m cable, the output power without connection is -27.91 dBm, with 1 connection is -27.98 dBm, and with 2 connections is -28.07 dBm. The respective attenuations obtained from the input power minus the output power for the three scenarios are 20.52 dB, 20.59 dB, and 20.68 dB. For a 5 m cable length, the output power without connection is -28.01 dBm, with one connection is -28.09 dBm, and with two connections is -28.13 dBm. The corresponding attenuations obtained from the input power minus the output power are 20.62 dB, 20.70 dB, and 20.74 dB. For a 10 m cable length, the output power without connection is -28.19 dBm, with one connection is -28.25 dBm, and with two connections is -28.34 dBm. The attenuations obtained from the input power minus the output power for the three scenarios are 20.80 dB, 20.86 dB, and 20.95 dB.

In customer 3, who obtained measurements with a 3 m cable length, the output power without connection is -27.95 dBm, with 1 connection is -28.02 dBm, and with 2 connections is -28.09 dBm. The attenuation obtained from the input power minus the output power for each cable is 20.56 dB for no connection, 20.63 dB for 1 connection, and 20.70 dB for 2 connections. When the cable length is 5 m, the output power without connection is -28.05 dBm, for 1 connection it is -28.10 dBm, and for 2 connections it is -28.19 dBm. The attenuation obtained from the input power minus the output power for the cable is 20.66 dB for no connection, 20.71 dB for 1 connection, and 20.80 dB for 2 connections. For measurements with a cable length of 10 m, the output power for no connection is -28.14 dBm, for 1 connection it is -28.22 dBm, and for 2 connections it is -28.31 dBm. The attenuation obtained by subtracting the input power from the output power for the cable is 20.75 dB for no connection, 20.83 dB for 1 connection, and 20.92 dB for 2 connections.

In each patch cord of 3 m, 5 m, and 10 m in length, it is evident that as the number of connections increases, the output power decreases and the attenuation increases. This is because output power and attenuation are inversely proportional. Similarly, when longer cables are used, the output power received decreases, and the attenuation increases. This aligns with the findings of (Mardhatillah et al., 2022), who indicated that the number of connections in the cable impacts the total attenuation. Specifically, they observed that a cable with 2 connections experiences greater attenuation than one with only 1 connection.

There is a variation in attenuation among different customers (customer 1, customer 2, and customer 3) due to the connections on the drop core cable used to link the ODP and Rosette. Customer 1 has no connections, customer 2 has one connection, and customer 3 has two connections. It is evident that the attenuation value increases in customers with additional connections on the transmission line.

In the splicing process, the attenuation is only 0.1 dB. However, during the installation process that involves splicing the optical cable, the attenuation can exceed the standard due to factors such as poor connection, unevenly cut cores, unclean cores, and incorrect core positioning during fusion splicing.

Analysis After Activation

Measurements were conducted in the same manner as before activation. This involved taking measurements on 3 rosettes used for 3 customers heading to the ONU, utilizing different treatments for the patch cord cables. There are three different lengths of patch cord cable: 3 m, 5 m, and 10 m. For each cable length, 3 cables were utilized, each with different treatments (without connection, 1 connection, and 2 connections). The measurements were taken using PON technology on the final termination device on the FTTB network. The difference in the measurement after activation lies in the input source used. After activation, the input source used in the measurements is from an OLT with an SFP installed. The SFP used in this study is a 10 dB SFP. The wavelength used during the measurement is 1310 nm at the receiver according to the specifications of the SFP. The input power used is under Table 3, which provides the average result of the calibration of the OPM measuring instrument with OLT PON1, equipped with a 10 dB SFP installed, resulting in 9.19 dBm.

The measurements obtained are consistent with Table 4. The measurements were taken for three customers. Different connections were made to the drop core cable for each customer: customer 1 had no connection, customer 2 had 1 connection, and customer 3 had 2 connections. Additionally, patch cord cable lengths of 3 m, 5 m, and 10 m were used, and the same treatment was applied to each cable length for each customer: no connection, 1 connection, and 2 connections. P_{Tx} represents the input power obtained from the calibration results, while P_{Rx} represents the output power from the measurement results. Damping is calculated as the difference between the input power and the output power.

In Table 4 which is a measurement for each customer, the measurements obtained for customer 1 with a cable length of 3 m, it can be seen that the output power obtained without connection is -10.38 dBm, 1 connection is -10.41 dBm and 2 connections are -10.50 dBm. With the attenuation obtained from the input power minus the output power on

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the cable without connection 19.57 dB, 1 connection 19.60 dB, and 2 connections 19.69 dB. In measurements with a cable length of 5 m, it can be seen that the output power obtained on the cable without a connection is -10.43 dBm, 1 connection -10.51 dBm, and 2 connections -10.57 dBm. With the attenuation obtained from the input power minus the output power on the cable without connection 19.62 dB, 1 connection 19.70 dB, and two connections 19.76 dB. In measurements with a cable length of 10 m, it can be seen that the output power obtained on the cable without a connection is -10.49 dBm, 1 connection -10.56 dBm, and 2 connections -10.61 dBm. With the attenuation obtained by subtracting the input power with output power on the cable without connection 19.68 dB, 1 connection 19.75 dB, and 2 connections 19.80 dB.

In customer 2, measurements were obtained with a 3m cable length. The output power obtained without a connection is -11.29 dBm, with 1 connection is -11.33 dBm, and with 2 connections is -11.41 dBm. With the attenuation obtained from the input power minus the output power on the cable without connection 20.48 dB, 1 connection 20.52 dB, and 2 connections 20.60 dB. In measurements with a cable length of 5 m, it can be seen that the output power obtained on the cable without a connection is -11.39 dBm, 1 connection -11.43 dBm, and 2 connections -11.50 dBm. With the attenuation obtained from the input power minus the output power on the cable without connection 20.58 dB, 1 connection 20.62 dB, and two connections 20.69 dB. In measurements with a cable length of 10 m, it can be seen that the output power obtained on the cable without a connection is -11.51 dBm, 1 connection -11.57 dBm, and 2 connections -11.65 dBm. The attenuation was obtained by subtracting the input power with output power on the cable without connection 20.70 dB, 1 connection 20.76 dB, and 2 connections 20.84 dB.

In customer 3, measurements were obtained using a 3 m cable. The output power obtained without a connection is -11.32 dBm, with 1 connection is -11.41 dBm, and with 2 connections is -11.46 dBm. With the attenuation obtained from the input power minus the output power on the cable without connection 20.51 dB, 1 connection 20.60 dB, and 2 connections 20.65 dB. In measurements with a cable length of 5 m, it can be seen that the output power obtained on the cable without a connection is -11.42 dBm, 1 connection -11.46 dBm, and 2 connections -11.53 dBm. With the attenuation obtained from the input power minus the output power on the cable without connection 20.61 dB, 1 connection 20.65 dB, and two connections 20.72 dB. In measurements with a cable length of 10 m, it can be seen that the output power obtained on the cable without a connection is -11.52 dBm, 1 connection -11.60 dBm, and 2 connections -11.68 dBm. The attenuation obtained by subtracting the input power with output power on the cable without connection was 20.71 dB, 1 connection 20.79 dB, and 2 connections 20.87 dB.

In each cable length of 3 m, 5 m, and 10 m, it is observed that the more connections there are, the lower the output power and the higher the attenuation due to the inverse relationship between received power and attenuation. Similarly, using longer cables results in lower received power and higher attenuation. The number of connections used also increases the attenuation value.

When measuring the PON technology FTTB network for each customer, it's important to consider the length of the patch cord cable on the user side, which varies between the Rosette to the ONU, as well as the number of connections. It's noticeable that the more connections on the cable, the smaller the output power received and the greater the attenuation obtained, as it is inversely proportional. This relationship is outlined in the table. Although this study found no significant difference in the output power obtained, the standard of connection attenuation is 0.1 dB, allowing for proper activation of the FTTB network. Nevertheless, it's important to note that even though the attenuation on the connection is small, a large number of connections on the cable and a poor cable connection process can greatly impact network activation.

Analysis of Network Quality Measurement

After the network is activated, network quality measurements are conducted. Activation occurs after obtaining measurements of the attenuation value on the end device of the FTTB network before activation, ensuring it is below 28 dB following ITU-T standards. Activation is performed on the active devices along the FTTB network path, specifically from OLT to ONU.

Once the activation is complete, a network quality check is carried out using the command prompt (CMD). The results of the network check are presented in Table 5. The check involves sending 100 packets from the client and observing the average time required for package delivery. Package delivery is accomplished by pinging the IP addresses of network and internet line devices, both locally and publicly. This involves conducting the ping process three times. Local pings are conducted on the ONU IP and the central device of the FTTB network, known as the OLT. Public pings are conducted by pinging Google's IP.

Ping ONU is the time required for sending data packets from the client to the ONU. Ping OLT is the time it takes to send data packets from the client to the OLT. Google ping is the time it takes to send data packets from the client to the public server, in this case, Google, which reflects the overall network performance at the global level.

Quality checks were conducted on three customers. The time it took for customer 1 to ping the ONU was 11 ms, OLT was 9 ms, and Google was 31 ms. For customer 2, the ping times were 11 ms to ONU, 12 ms to OLT, and 58 ms to Google. Customer 3 took 21 ms to ping ONU, 24 ms to ping OLT, and 33 ms to ping Google.

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Out of the 3 customers, it is evident that Customer 3 has the longest packet delivery time in both the local test (Ping ONU and Ping OLT) and in the public test (Ping Google), which corresponds to the highest network path attenuation. On the other hand, Customer 1 performed the best with the lowest packet delivery time and attenuation corresponding to the obtained values.

From the results obtained, it can be seen that the attenuation value affects the transmission and network quality. In the measurement of attenuation, the smallest attenuation value is obtained in customer 1 and the largest in customer 3. This is the same as the quality of the network, the time required in pinging/sending data packets is the least in customer 1 and the most in customer 3.

CONCLUSION

This study aims to measure and analyze the impact of fiber optic cable connection losses on the activation of Fiber To The Building (FTTB) networks. Based on the research and analysis results, the following conclusions can be drawn:

1. Measurements were taken on FTTB devices both before and after activation. A light source from HLS was used for the pre-activation measurements, while an OLT was used for the post-activation measurements. These measurements were conducted on 3 customers using PON technology to assess the impact of connection losses on attenuation and network quality. The measurements involved using patch cords with lengths of 3 m, 5 m, and 10 m, as well as varying the number of connections (no connection, 1 connection, and 2 connections). Additionally, each customer used a different number of connections on the drop core cable (no connection, 1 connection, and 2 connections).
2. Based on measurements from 3 customers using optical cables with different numbers of joints, it appears that the attenuation value increases as the number of joints increases. For instance, customer 1, using a drop core cable without joints, has the lowest attenuation of 19.68 dB, while customer 3, with 2 joints on the drop core cable, has the highest attenuation of 20.56 dB.
3. In the measurement of 3 customers, the measured attenuation value after activation is smaller than the attenuation before activation. For instance, for customer 1 with a 3m cable and no connections, the attenuation was 19.68 dB before activation and 19.57 dB after activation. Similarly, for the 10m cable with 2 joints, the attenuation was 19.86 dB before activation and 19.80 dB after activation. This difference is attributed to the use of different light sources. Before activation, the light source is from HLS, while after activation, the light source is from the OLT with the previously installed SFP.
4. Based on the measurements of 3 customers, it is evident that attenuation directly impacts network quality. Lower attenuation leads to better network quality, while higher attenuation results in decreased network quality. For instance, in customer 1, with an attenuation of 19.57 dB, the data packet delivery time is as follows: ping ONU 11 ms, ping OLT 9 ms, and ping Google 31 ms. Meanwhile, in customer 3, with an attenuation of 20.51 dB, the data packet delivery time increased to ping ONU 29 ms, ping OLT 28 ms, and ping Google 70 ms.

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