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Network Design and Activation Fiber to The Building (FTTB) and Measurement of The Damage Value of Optical Distribution Frame (ODF) To Optical Distribution Cabinet (ODC)

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ABSTRACT

The need for high-speed internet continues to increase with technological developments. Fiber to the Building (FTTB) is a solution for providing fast internet access to commercial and residential buildings. However, the main challenge in maintaining network quality is attenuation in fiber optic cables, especially at connections. This research aims to analyze the effect of pigtail cable length and connection quality on the total attenuation from the Optical Distribution Frame (ODF) to the Optical Distribution Cabinet (ODC) in the FTTB network, both before and after activation. The research method uses pigtail cables of varying lengths, from 30 cm to 150 cm. Some connections are carried out according to Standard Operating Procedures (SOP), while others are not, to measure the effect of connection quality on attenuation. Measurements were carried out using an Optical Power Meter (OPM) and Passive Optical Network (PON) technology with an SFP of 8 dB. The research results show that connections that comply with the SOP produce lower attenuation, namely 7.16 dB on a 150 cm cable, 7.09 dB on a 120 cm cable, and 6.99 dB on a 100 cm cable. On the other hand, connections that do not comply with the SOP produce higher attenuation, namely 8.15 dB on an 80 cm cable, 8.08 dB on a 50 cm cable, and 8.02 dB on a 30 cm cable. This research contributes to the optimization of FTTB network installations.

INTRODUCTION

Information and communication technology development is increasingly increasing demand for high-speed internet services. Cloud applications, video streaming, teleconferencing, and the Internet of Things (IoT) demand reliable and fast connectivity. Fiber to the Building (FTTB) technology is presented as a solution by providing high-speed connectivity directly to commercial and residential buildings. FTTB is one of the developments of the local fiber access network (JARLOKAF) which is used to connect optical communications in multi-story buildings, with optical conversion points (TKO) which are usually placed in basement telecommunications rooms (Fajriana et al., 2023).

Fiber optic cable as a transmission medium has the advantage of sending signals in the form of stable light (Hafizt, 2021). However, signal quality often decreases along with its use due to attenuation along the cable route caused by distance, connector connections, and the optical devices used (Agus Prianto, 2022). Connections that do not comply with standards can cause increased losses, reduce transmission power, and reduce network reliability (Mardhatillah et al., 2022).

Although various studies have discussed attenuation in fiber optic cables, in-depth analysis of the impact of connection losses on FTTB networks is still limited. Therefore, this study aims to fill this gap by analyzing the effect of connection losses on the total attenuation of the FTTB network, both before and after activation. The measurement focuses on the pigtail cable connection that connects the Optical Distribution Frame (ODF) to the Optical Distribution Cabinet (ODC) to ensure the FTTB network operates optimally according to the specified quality standards.

LITERATURE REVIEW

Fiber to The Building (FTTB)

Fiber to The Building (FTTB) or also known as Fiber To The Basement or Fiber To The Building technology is a general term to obtain bandwidth according to needs, which is called the basic network architecture for data connections designed or placed in multi-storey buildings. For local fiber access networks, this network architecture uses fiber optic as a transmission medium (Anggita et al., 2020). The TKO point is located in a special room in the building or in the

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basement.

FTTB architecture

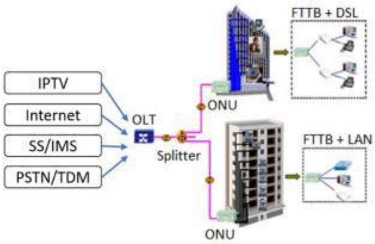

Figure 1. FTTB Network Architecture

The FTTB architecture in Figure 1 is usually used for customers in buildings. This architecture allows the pulling of fiber optic cables up to the building. The location of the TKO point to customers is around 100 meters. TKO is located inside the building and is usually located in the telecommunications room in the basement or on several floors of the building.

FTTB Network Device

The FTTB network devices include:

1. **Optical Line Terminal (OLT)**

   OLT is a device that is connected to the fiber network backbone optics. OLT functions to convert electrical signals into light signals later it can be transmitted using fiber optic cable. OLT works to coordinate multiplexing on other devices at the common end of the network called Optical Network Unit (ONU) or Optical Network Terminal (ONT).

2. **Optical Distribution Frame (ODF)**

   ODF is the termination point for transitional fiber cables from fiber optic cables outdoor with indoor fiber optic cable and vice versa.

3. **Optical Distribution Cabinet (ODC)**

   ODC is a special place in the shape of a box/dome made from special materials. ODC functions as a connection installation site single-mode optical network. In the ODC there are several devices such as: connector, splicer, and splitter and is also equipped with fiber management certain capacity in passive optical access networks (PON) (Di et al., 2018).

4. **Closure**

   Closure is a device that functions as a place used for connecting and protecting fiber optic cables. The purpose of the presence of a closure is to provide safe protection for the connection optical fiber from mechanical damage, dust, humidity, and environmental factors.

5. **Optical Distribution Points (ODP)**

   ODP is the initial termination device for using drop cables before entering the customer's house. The ODP device components consist of an optical pigtail, adapter connector, Splitter room, fiber optic management room with capacity certain areas and equipped with places for incoming and outgoing cables (cables distribution and drop cables).

6. **Rosette**

   The rosette is a passive device that is placed in the customer's home, which becomes the final termination point of the indoor/drop core fiber optic cable.

7. **Optical Network Unit (ONU)**

   ONU is a converter of optical signals transmitted over fiber into an electrical signal. These electrical signals are then sent to each customer.

Things that Affect Fiber Optic Cable Performance.

According to (Nurwijaya & Simangunsong, 2024) Fiber optic cables are experiencing interruptions, and breaking up is a problem that often occurs in modern communications infrastructure. Interference and breakage of optical cables can occur causing disruption in the delivery of data and information between locations. When If the optical cable experiences interference, data transmission through the cable can occur stops or there is a significant decrease in signal quality. Apart from distractions as mentioned in the research above, there are several disturbances in the optical fiber among others:

a. Losses

Loss is simply the calculation or amount of light lost between the ends of the fiber optic cable. Examples of loss in optical fiber include:

1. bending loss: this occurs when light passes through an optical fiber curved, where the signal source angle is smaller than the critical angle so the light cannot be perfectly reflected but refracted. (Wibisono Gunawan, Hantoro Dwi Gunadi, 2020)
2. Mode Coupling Losses: this occurs when this is done coupled/connected to a fiber optic cable with a light source. (Student, 2005)
3. Connection loss: this is caused by efforts to connect the cable Optical fiber (splice) is not perfect so that the light from the optical fiber is one cannot be propagated completely into the other fiber. (Siswanto, 2005)

b. Dispersion

Dispersion is the widening of a pulse that occurs when a signal propagates along the optical fiber. Dispersion is caused by the difference in propagation time between different modes. Dispersion is influenced by the age of the optical fiber, the older it gets as the optical fiber ages, dispersion will also get worse. According to (Octavia et al., 2019) dispersion is divided into three caused by different mechanisms including:

1. Dispersion Between Modes (intermodal dispersion)
2. Material dispersion (material/chromatic dispersion)
3. Waveguide dispersion

c. **Connector Problems**

Common connector problems include loose connector end surfaces dirty or damaged, improper installation, and improper physical contact adequate. Troubleshooting connectors requires cleaning, checking, and thorough re-alignment to ensure reliable signal transmission optimal.

d. **Fiber Optic Break**

Fiber optic breakage refers to physical damage experienced by a cable fiber optics, which results in interruption of signal transmission and communication in along the affected cable. Optical fiber breaks can occur due to various reasons, such as accidental cable cutting, consequential damage rodents, or construction-related incidents.

METHOD

In this section, each researcher is expected to be able to make the most recent contribution related to the solution to the existing problems. Researchers can also use images, diagrams, and flowcharts to explain the solutions to these problems.

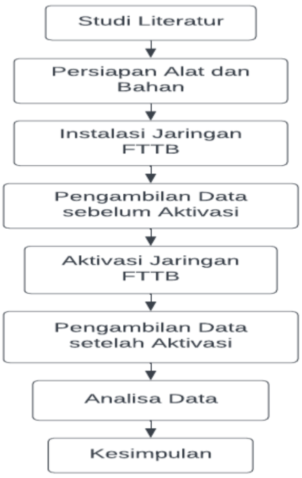

Figure 2. System flow chart

In the design created, we will analyze the losses of long pigtail cable connections, where each long pigtail cable connection from ODF to ODC has varying cable lengths including color (Grey) with a cable length of 150cm, color (Purple) with a cable length of 130cm, color (Green) with a cable length of 100cm, where the cable length is 150cm – 100cm during the connection process by the SOP. In comparison, the color (Blue) with a cable length of 80cm, color (Red) with a cable length of 50cm, and color (Brown) with a cable length of 30cm where the cable length is 80cm -

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30cm. During the process of connecting the cable, a bend occurs, causing the connection to not be by the SOP.

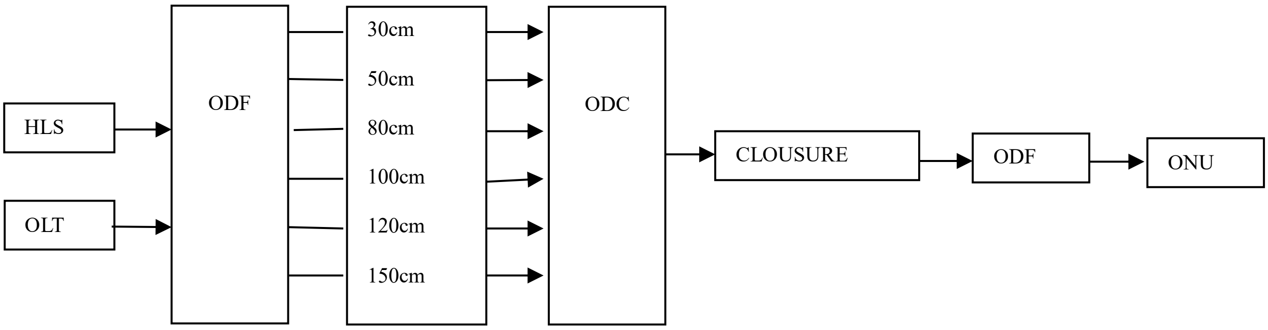

Figure 3. System SOP

RESULT

The following is an explanation regarding the measurements carried out, namely using an Optical Power Meter (OPM) with different light sources before and after activation. Before activation, measurements are carried out using a High Light Source (HLS), while after activation using an Optical Line Terminal (OLT). In the network, purple fiber optic cable is used as the transmission medium. The following are the measurement results for each Fiber to The Building (FTTB) network:

1. FTTB Network Network Measurement Results Before Activation

Input Power Measurement Results Calibration measurements are used as input values.

Calibration results are carried out before and after activation. The calibration process was carried out 3 times, then the results of the calibration were averaged. The following are the calibration results between HLS and OPM.

Table 1. HLS and OPM Calibration Results

th try	PTx (dBm)
1	-7,39
2	-7,39
3	-7,39
Average	-7,39

Attenuation Measurement Results on the FTTB Network for Each Pigtail Cable Length in ODF Before Activation.

This measurement aims to determine the connection losses on the pigtail cable on the ODF side using the Fusion Splicing connection method using the Fusion Splicer tool. The pigtail cable lengths used are 30cm, 50cm, 80cm, 100cm, 120cm, and 150cm cable lengths each with one connection. The results of connection losses obtained in the pigtail cable connection process for cable lengths of 30cm, 50cm, 80cm, 100cm, 120cm, and 150cm are 0.01 dB. There is a connection process for cable lengths of 150cm, 120cm and 100cm according to the SOP. Meanwhile, for cable lengths of 80cm, 50cm and 30cm, there is a connection process that does not comply with the SOP or there is a bend during the connection process, this causes the attenuation value to be higher than the attenuation value for the connection in comply with the SOP. This measurement was carried out to determine the effect of cable length in the pigtail cable used in the central ODF which is connected to the ODC on the total attenuation in the FTTB circuit with a source originating from the HLS. To get the attenuation value on an FTTB network device before activation, subtract the input power from the output power (PTx – PRx). The attenuation value of the ODF with a cable length of 150cm is -7.39 dBm – (-14.91dBm) = 7.52 dB. The measurement results can be seen in Table 2.

Table 2. Results on ODF Before Activation According to SOP

Cable color	cable length (cm)	P_Tx (dBm)	P_Rx (dBm)	Attenuation (dB)
gray	150		-14,91	7,52
Purple	120	-7,39	-14,70	7,31
Green	100		-14,64	7,25

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Meanwhile, for a cable length of 30cm, the attenuation value is -7.39 dBm – (-15.47dBm) = 8.08 dB. This is caused by a bend during the connection process. The measurement results can be seen in Table 3.

Table 3. Results on ODF before activation do not comply with SOP

Cable color	cable length (cm)	P_Tx (dBm)	P_Rx (dBm)	Attenuation (dB)
Blue	80		-15,56	8,17
Red	50	-7,39	-15,54	8,15
Brown	30		-15,47	8,08

2. FTTB Network Network Measurement Results After Activation

The FTTB measurement after activation uses an input source from the OLT. The SFP used in the OLT is the 8 dB EPON SFP for PON technology. And the network source used in fiber optic cables is colored purple. The following are the measurement results of the FTTB device after activation.

Input Power Measurement Results

Input power measurements are obtained from the calibration results between the OLT and OPM. The technology used is PON technology. The calibration process was carried out 3 times, then the results of the calibration were averaged. The calibration results are used as input. Below are the calibration results between OLT and OPM.

Table 4. Input Power

th try	PTx (dBm)
1	7,56
2	7,61
3	7,62
Average	7,60

Attenuation Measurement Results on the FTTB Network for Each Pigtail Cable Length in ODF After Activation.

This measurement was carried out to determine the effect of cable length in the pigtail cable used in the central ODF which is connected to the ODC on the total attenuation in the FTTB circuit with a source originating from the OLT. Measurements were carried out using PON technology with SFP 8dB. The measurement results can be seen as follows:

To get the attenuation value on an FTTB network device before activation, subtract the input power from the output power (PTx – PRx). The attenuation value of ODF with a cable length of 150cm is 7.60 dBm – 0.44dBm = 7.16dB. The measurement results can be seen in Table 5.

Table 5. Attenuation Measurements in ODF After Activation According to SOP

Cable color	cable length (cm)	P_Tx (dBm)	P_Rx (dBm)	Attenuation (dB)
gray	150		0,44	7,16
Purple	120	7,60	0,51	7,09
Green	100		0,61	6,99

Meanwhile, for a cable length of 30cm, the attenuation value is 7.60 dBm – (-0.42dBm) = 8.02dB. This is caused by a bend during the connection process. The measurement results can be seen in Table 6.

Table 6. Attenuation Measurements in ODF After Activation Does Not Comply with SOP

Cable color	cable length (cm)	P_Tx (dBm)	P_Rx (dBm)	Attenuation (dB)
Blue	80		-0,55	8,15
Red	50	7,60	-0,48	8,08
Brown	30		-0,42	8,02

DISCUSSION

After data collection, the next step is to analyze the results obtained. The discussions carried out were in the form of FTTB network plans before and after activation as well as research on the length of the ODF central pigtail cable before and after activation.

The results of attenuation measurements before and after activation were carried out on the transmission line from ODF central to ODC using pigtail cables of varying lengths, namely 30 cm, 50 cm, 80 cm, 100 cm, 120 cm, and 150 cm. Each cable uses one connection, and there are differences in connection quality that affect the measurement results. Before activation, cable connections with lengths of 150 cm, 120 cm, and 100 cm were carried out in accordance with Standard Operating Procedures (SOP), while cables with lengths of 80 cm, 50 cm, and 30 cm experienced cycles during the connection process, which caused the connection to be incorrect. SOUP. This measurement uses a High Light Source (HLS) light source with an input power of -7.39 dBm and a wavelength of 1310 nm, which is the standard for optical attenuation measurements.

In measurements before activation, cables with lengths of 150 cm, 120 cm, and 100 cm show attenuation of 7.52 dB, 7.31 dB, and 7.25 dB, respectively with an output power of -14.91 dBm, -14 .70 dBm, and -14.64 dBm. Meanwhile, cables with lengths of 80 cm, 50 cm, and 30 cm show higher attenuation, namely 8.17 dB, 8.15 dB, and 8.08 dB, respectively with an output power of -15.56 dBm. -15.54 dBm, and -15.47 dBm. The high attenuation in cables that are connected not according to the SOP is caused by cable curvature that occurs during connection, which reduces the efficiency of optical power transmission.

After activation, measurements are carried out using a signal source from the Optical Line Terminal (OLT) installed with a Small Form-factor Pluggable (SFP) EPON with an output power of 8 dB on the PON1 port. The input power used is 7.60 dBm, while the wavelength used is 1490 nm for transmit and 1310 nm for receiver, according to SFP specifications. The measurement results show that a cable with a length of 150 cm has the lowest attenuation of 7.16 dB and an output power of 0.44 dBm, indicating that this cable is the most efficient in transmitting signals. In contrast, a cable with a length of 30 cm has the highest attenuation of 8.02 dB and an output power of -0.42 dBm, which indicates that this cable is the least efficient with significant power losses.

The difference in attenuation values before and after activation is mainly caused by differences in the light sources used. Before activation, measurements use HLS, which has a built-in attenuation of -7 dBm and uses a standard wavelength of 1310 nm. The measurement process between HLS and Optical Power Meter (OPM) must use the same wavelength so that signal reception by the OPM is optimal. Meanwhile, after activation, measurements use a signal source from the OLT, where the SFP has been designed to work at a more efficient wavelength, namely 1490 nm for transmit and 1310 nm for receiver. This makes the attenuation after activation smaller than before activation.

CONCLUSION

In this final project, the effect of pigtail cable length on ODF Center for FTTB Network Activation. From here, it can be concluded that:

1. Installation and activation of the FTTB network starting from OLT installation to Installation of ONU and cables, as well as OLT activation to activate the network and ensure all devices are working. Standardization of damping for activation is below -28dB, and attenuation is obtained in network installations FTTB i.e. 20.22dB qualifies for activation.
2. On an FTTB network, the power input before activation comes from HLS at a cable length of 150cm, produces an output power of -14.91dBm attenuation 7.52dB. Meanwhile, after activation, with power input comes from the OLT with a cable length of 150cm, the output power is 0.44dBm produces attenuation of 7.16dB. This shows that Using input power from the OLT produces high output and value the attenuation is small.
3. Loss measurement results from ODF to ODC with varying cable lengths shows that the shorter the cable, the lower the attenuation value and the higher the output power. At a length of 150cm the attenuation is 7.52dB, 120cm attenuation 7.31dB, 100cm attenuation 7.25dB, connection according to SOP. Meanwhile, the attenuation of the 80cm length is 8.17dB, the attenuation of the 50cm length is 8.15dB and the attenuation of the 30cm is 8.08dB, this occurs because there is a curve when connections that produce higher attenuation values.

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