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Installation and Activation of Fiber To The Home (FTTH) Networks and Macrobending Problems in the Feeder Cable Segment

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ABSTRACT

Macrobending is a form of disturbance in Fiber To The Home (FTTH) networks that occurs due to macro-level bending of the cable caused by damage to the fiber optic. Macrobending frequently occurs in FTTH networks within the feeder cables. Feeder cables serve as connectors between the Optical Line Terminal (OLT) and Optical Distribution Cabinet (ODC) in the FTTH system. The occurrence of macrobending in feeder cables affects the quality of the FTTH network. In this study, the impact of macrobending is analyzed based on curvature diameters of 50 cm, 25 cm, and 5 cm on feeder cables before and after FTTH network activation. Before FTTH network activation, the High Super Luminescent Diode (HSL) is used as the input power source, whereas after activation, the input power source comes from the OLT using Small Form-factor Pluggable (SFP) modules. The attenuation (loss) before activation due to macrobending, with curvature diameters of 50 cm, 25 cm, and 5 cm, is found to be 0.02 dB, 0.05 dB, and 0.26 dB, respectively. After activation, the attenuation with the same curvature diameters is measured as 0.01 dB, 0.02 dB, and 0.20 dB, respectively. It is observed that as the curvature diameter decreases, the attenuation increases. The comparison of attenuation before and after network activation doesn't show a significant difference because the input power doesn't affect macrobending, rather it is influenced by the curvature diameter.

INTRODUCTION

In the telecommunications system there are several transmission media such as copper cables, wireless and fiber optic cables as distributors or mediums for sending signals. One of the transmission media currently needed is fiber optic cable media. Fiber optic cables are a solution to the transmission media in the distribution of telecommunications networks for various telecommunications network problems which are widely used in the modern era [1]. Where fiber optic cables will transmit information from telecommunications service providers to customers via light signals that pass through the medium of glass fiber cables or fiber optics. One of the popular fiber optic technologies used today is the Fiber To The Home (FTTH) Network. Passive Optical Network (PON) is an optical-based network in FTTH which is considered capable of meeting the needs of high transmission speeds and bandwidth [2]. In FTTH installations, high attenuation will occur due to interference. Interference in FTTH has 2 types of disturbance that often occur, namely loss disturbance and bending disturbance [3]. Losses are a disruption in fiber optic cables that break due to the fiber optic cable being squeezed by something or being folded for a long time so that the core in the fiber optic cable breaks and causes the quality to not be optimal [4].

Apart from losses, bending is an FTTH disturbance that affects optical network performance. Where bending will cause attenuation to increase during the installation process, bending occurs due to the bending of the optical fiber at certain radii [5]. Bending consists of microbending and macrobending. Microbending is small bends that occur in optical fibers due to non-uniformity in fiber formation or due to non-uniform pressure during wiring. Macrobending is the bending of optical fibers with a long radius compared to the radius of the optical fiber. This attenuation can be determined by analyzing the modal distribution in optical fibers [6].

Excessive bending will cause optical fibers to break which is one of the causes of losses [7]. In designing FTTH network activation, bending problems in optical networks must not be ignored and must be corrected. Apart from that, in FTTH design installations, the type of bending that can occur is macrobending. This macro bending occurs because during installation the fiber optic cable which is bent or coiled must follow the path it takes, but the bending that occurs has a longer radius compared to the radius of the optical fiber, thus causing an increase in the attenuation value [8]. By installing fiber optics not exceeding the permitted critical radius of curvature, macro bending losses can be eliminated.

This paper discusses the macrobending that occurs in the feeder cable segment which is the segment from the Optical Network Terminal (OLT) to the Optical Distribution Cabinet (ODC) and the activation of the FTTH network

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which is carried out in building G, 3rd floor, Padang State Polytechnic campus. And this research compares the macrobending that occurs before and after FTTH network activation.

LITERATURE REVIEW

Optical Fiber

Optical fiber is a transmission medium or cylindrical light wave guide, which was developed in the late 1960s as a response to the development of communication systems which increasingly required large bandwidth with high transmission rates [3]. The light source used is usually a laser or LED because it has a very narrow spectrum, so the light in the optical fiber does not come out because the refractive index of glass is greater than the refractive index of air. It is in this fiber that the light energy generated by the light source is channeled so that it can be received by the receiver. Optical fiber consists of two types, namely cable optical fiber and plastic optical fiber (Fiber Optic Plastic/FOP). Fiber optic cables are widely used for long distance transmission while FOP is only used for short distance communication.

Fiber optic structure

In general, the structure of a fiber optic cable is divided into several parts, namely:

1. Core (core)
   The core is the main part of a fiber optic cable which is located right in the middle of the cable, is shaped like a cylindrical rod and is made of high quality fine glass fiber and is used as a path for light to transmit information.
2. Sheathing (cladding)
   Cladding is a layer that covers the core of a fiber optic cable and is made of glass fiber. The cladding functions as a protector for the core and as a mirror that reflects light so that it can propagate into the core.
3. Protective (Coating)
   Coating is the outer part after cladding which is made of elastic plastic material (PVC) to protect optical fibers from external pressure. Coating functions as a mechanical protector that protects optical fibers from damage that can occur due to cable bending or other disturbances such as air humidity.
4. Strengthening fiber (Strength member)
   Strength members are made from a type of fabric fiber which is a type of thread which is very abundant and has very good resistance which strengthens the core of the cable so that it does not break easily.
5. Outer jacket
   The outer jacket is the outermost part of the fiber optic cable which is made of PVC. Functions as a protector for the entire inside of the fiber optic cable from external interference

Types of Optical Fiber

Optical fiber can be divided into two types, namely singlemode and multimode.

1. Single mode
   Singlemode fiber cable is a type of fiber that has a core with a very small diameter of around 4-10 μm and a cladding diameter of 125 μm [4]. Singlemode fiber can only transmit signals in one mode with a wavelength of 1310 nm or 1550 nm. so as to prevent chromatic dispersion. Chromatic dispersion is one of the factors that reduces the performance of optical fiber communications caused by changes in the propagation of certain frequency components contained in an optical pulse which causes widening of the optical pulse. Therefore singlemode fiber cables are suitable for large capacities and are usually used for long distance transmission with laser diode based fiber optic transmission equipment.
2. Multimode
   Multimode fiber is the opposite of singlemode fiber, namely it has a large core with a diameter of around 50-70 μm and a cladding diameter of around 100-200 μm [4]. These multimode fibers transmit signals in multiple modes, at specific operating wavelengths. This type of multimode fiber usually has poor transmission, limited capacity, and small transmission capacity.

METHOD

Research related to the effect of macrobending on feeder cable segments before and after FTTH network activation can be seen in the research flow below:

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Figure 1. FTTH network installation and activation design flow

Research Work Steps

The first research flow for FTTH network installation and activation begins with conducting a literature study on FTTH network installation and activation which will be appointed as a final assignment. Next, make a block diagram regarding the work on the final project being carried out. After that, check the tools and materials as well as the FTTH network installation. Next, check the attenuation and retrieve data before activation on the FTTH network with the aim of whether the resulting attenuation is in accordance with the standards set by ITU-T G984 and PT Telekomunikasi, namely the total attenuation value must not be more than 28 dB as well as taking macrobending data on the feeder cable. . If it is still above 28 dB, check the tools and equipment and re-install the FTTH. If the attenuation is below 28 dB then you can activate the FTTH network on FTTH devices, namely OLT and ONT. After the FTTH network is activated, the next step is to retrieve data after activation and retrieve macrobending data on the feeder cable. Next, carry out an analysis of the data taken before activation and after activation. After all the data has been analyzed, the final step is preparing the installation and network activation report as well as macrobending on the feeder cable.

Tools and materials

Tool

1. Cleaner Pen SC
2. Visual Fault Locator (VFL)
3. Handheld Light Source (HSL)
4. Optical Power Meter (OPM)
5. Winbox application

Material

1. Mikrotik
2. Optical Line Terminal (OLT)
3. Small Form-factor Pluggable (SFP)
4. Feeder Cable
5. Optical Distribution Cabinet (ODC)
6. Distribution Cable
7. Joint Box
8. Optical Distribution Point (ODP)
9. Drop Core Cable
10. ROSETTE
11. Patchcord Cable
12. Optical Network Terminal (ONT)

FTTH Network Installation

FTTH network installation consists of OLT, ODC, ODP, ODP, ROSET, and ONT devices. Where OLT is the initial part and ONT is the final part of the FTTH network. The FTTH network installation structure can be seen in the picture below.

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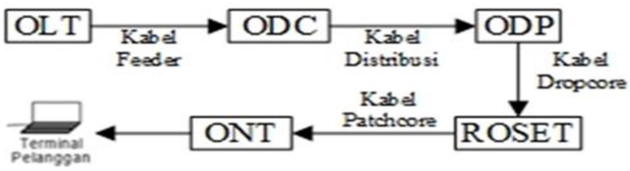

Figure 2. Block Diagram of FTTH Network Installation

Power Link Budget FTTH
Power Link Budget Calculation Results from OLT to ODP

$\alpha Total = L . aserat + Nc . ac + Ns . as$ + Na . a a
$\alpha Total$ = (0,3 km . 0,35 dB/km) + (2 . 0,25 dB) + (2 . 0,1 dB) + (0 . 0,5 dB)
$\alpha Total$ = 0,105 dB + 0,5 dB + 0,2 dB + 0 db
$\alpha Total$ = 0,805 dB

Power Link Budget calculation results for FTTH devices

$\alpha Total = L . aserat + Nc . ac + Ns . as$ + Na . a a + (Sp 1:4 + Sp 1:8)
$\alpha Total$ = (0,318 km . 0,35 dB/km) + (10 . 0,25 dB) + (4 . 0,1 dB) + (4 . 0,5 dB) + (6,41 dB+ 10,49 dB)
$\alpha Total$ = 0,113 dB + 2,5 dB + 0,4 db + 2 dB + 17,63 dB
$\alpha Total$ = 22,64 dB

FTTH Network Activation

1. Place each tool according to the arrangement shown in the illustration below.

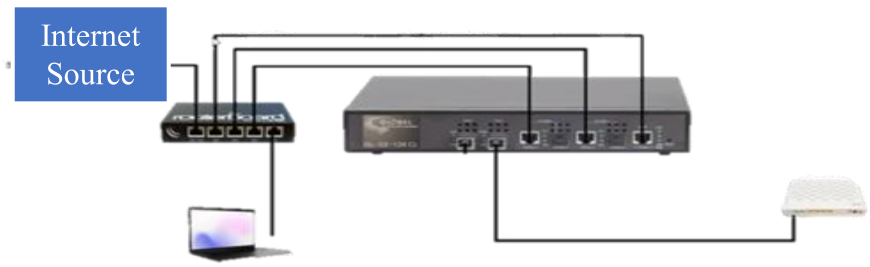

Figure 3. FTTH Network Activation Topology

In figure 3 above, you can see that port 1 on the MikroTik device is connected to an internet source which then becomes the internet source on the OLT. Port 2 on the MikroTik device is connected to the MGMT port on the OLT. Port 3 on the MikroTik device is connected to the UPLINK1 port on the OLT. Next, port 5 on the MikroTik device is connected to the laptop which is used to configure the MikroTik device and OLT. Meanwhile, the SFP module is installed on the PON port on the OLT device and connected by fiber optic cable to the FTTH network. At the end of the FTTH network, an ONT device is installed to produce output services such as voice, video, IPTV and internet data services.

2. To start setting up the MikroTik device, you can open the Winbox application. If this is your first time configuring a new MikroTik device, on the Winbox login page, you can enter "admin" as the username and leave the password field blank. After that, press the "connect" button to continue.
3. After successfully logging in and accessing the Winbox application, please open the "Interface" menu.
4. Then change each name in the interface list by double clicking on the interface to be replaced then change the name section, click apply and ok.
5. Open VLAN in the interface menu window, click the new plus sign and create a new VLAN.
6. Then open the bridge menu and add a new bridge with the name CLIENT.
7. Then open the port in the bridge window
8. Then add a bridge port with VLAN100 interface and ethernet5-laptop and if successful it will be visible in the port window.
9. Open the IP menu > address Then add the address.
10. After that, open the DHCP client then add a DHCP client with the ethernet1-INET SOURCE interface.
11. Open the PPP menu then PPPoE Servers then add PPPoE servers with CLIENT interfaces that were created on the previous bridge. Then open the secrets menu then make settings.
12. Then create a hotspot feature by opening the IP menu then Hotspot, press the hotspot setup button on the hotspot interface select CLIENT then next to DNS server then fill in IP 8.8.8.8 next then in DNS name fill in global.com in the Name of Local bar Hotspot User fill in admin and password 123, select next then ok, so a new hotspot will

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appear with the name hotspot1 on the hotspot menu.

13. Then set up NAT on the proxy by opening the IP menu then Firewall in the Firewall window, select the NAT menu, then select new NAT in the general menu, set the chain to scrnat and out interface to internet source and then in the action menu in the action section change it to masquerade.
14. Then open IP 192.168.0.88 in a web browser. In the username enter admin and in the password enter 123 according to the username and password created on the previous hotspot.
15. After connecting to the Mikrotik hotspot menu, the login menu will appear. to enter the EPON management website to view or manage the ONT connected to the OLT on the FTTH network.
16. After that, connect to the WiFi emitted by the ONT, then set the ONT/ONU on the web configuration by opening IP 192.168.1.1 in the web browser then typing admin in the username and password, filling in admin.
17. After successfully logging in to the configuration web, in the network menu, select network settings, then fill in the username and password according to those set in the PPP Secrets manual, namely TEST1 and check the enable vlan option and in the vlan id enter the vlan id that was created previously when creating the vlan interface and also check LAN1 in the LAN port binding and one of the options in the SSID port binding.
18. Select wireless settings in the network menu and set the SSID and wireless key that you want to use on the activated network.

After carrying out the activation steps on the FTTH network, to check the activation of the FTTH network you can look at the ONT which shows the light indicator is on on the words PON, INTERNET and WLAN ONT as in the picture below.

Figure 4. ONT Condition Has Been Activated by FTTH Network

Macrobending in Feeder Cable Segments Based on Diameter Curvature Before and After Activation

This research carries out an analysis of macrobending problems which aims to see the effect of the diameter of the curvature of the feeder cable on the attenuation value of the cable before and after activation. Macrobending block diagram of the Feeder Cable Segment in the image below

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Figure 5. Block diagram of macrobending in the feeder cable segment

For the macrobending curvature of the feeder cable itself, it consists of different diameters for each, namely 50 cm, 25 cm and 5 cm which are shown in the table below.

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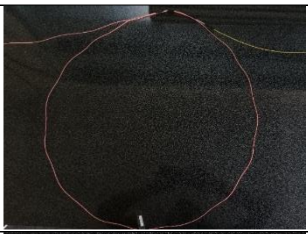
Table 1. Macrobending Based on Curvature Diameter

No	Macrobending based on diameter of curvature	Appearance
1	50 cm Pink Cable	
2	25 cm Orange Color Cable	
3	5 cm Yellow Cable	

Measurement and Retrieval of Macrobending Data Based on the Curvature of the Feeder Cable Segment Before and After Activation

Measuring the damping value in macrobending research is based on the curvature of the feeder cable with parameters before activation and after activation. Where the parameters before being activated use HSL as the input power medium which has been calibrated using OPM. Furthermore, the parameters after being activated using the OLT device as the input power medium with power that has been measured using OPM produces a power of 7.98 dBm.

RESULT

Measurement Results for Each Step That Has Been Taken

This section discusses the results and discussion of the installation and activation of the FTTH network and macrobending problems in feeder cables.

1. HSL Calibration Results for Device Measurements in FTTH Installations
   The measurement results of 3 calibration sessions will be displayed in Table 2. The HLS calibration measurement results are as follows:

Table 2. HLS Calibration Measurement Results

Trial To	Acceptance Power value (dBm)
1	-7,27
2	-7,28
3	-7,28

2. Measurement Results of FTTH Installation Devices Before FTTH Activation
   The measurement results of each FTTH device output before activation are shown in Table 3. The output measurement results of the FTTH network installation device are as follows:

Table 3. FTTH Installation Device Output Measurement Results

Device	λ (nm)	PTx (dBm)	PRx on Device (dBm)
ODC	1310	-7,28	-14,90
ODP			-25,74
ONT			-29,53

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3. FTTH Installation Device Measurement Results After FTTH Activation
The measurement results of each FTTH device output after activation will be displayed in Table 4. The output measurement results of the FTTH network installation device are as follows:

Table 4. FTTH Installation Device Output Measurement Results

Device	λ (nm)	PTx (dBm)	PRx on Device (dBm)
ODC	1310	7,98	0,05
ODP			-11,53
ONT			-14,91

4. FTTH Installation Device Measurement Results Before Activation
The results of the feeder cable macrobending measurements before activation are shown in Table 5. The measurement results are as follows:

Table 5. Measuring Results of Feeder Cable Macrobending Parameters Before Activation

Cable Color	No Treatment	With Macrobending Treatment		Attenuation Value = (PRx Without Treatment - PRx With Treatment) (dB)
	Power *Output* to ODC (dBm)	Curvature Diameter (cm)	Power *Output* di ODC (dBm)	
Blue	-7,92	-	-	-
Pink	-8,06	50	-8,08	(-8,06) - (-8,08) = 0,02
Orange	-8,27	25	-8,32	(-8,27) - (-8,32) = 0,05
Yellow	-9,82	5	10,08	(-9,82) - (-10,08) = 0,26

5. Results of Feeder Cable Macrobending Measurement Parameters After Activation
The results of the feeder cable macrobending measurements after activation are displayed in Table 6. The measurement results are as follows:

Table 6. Feeder Cable Macrobending Measurement Results Parameters after Activation

Cable Color	No Treatment	With Macrobending Treatment		Attenuation Value = (PRx Without Treatment - PRx With Treatment) (dB)
	Power *Output* di ODC (dBm)	Curvature Diameter (cm)	Power *Output* di ODC (dBm)	
Blue	7,92	-	-	-
Pink	7,90	50	7,89	(7,90) - (7,89) = 0,01
Orange	7,88	25	7,86	(7,85) - (7,85) = 0,02
Yellow	6,79	5	6,59	(6,02) - (6,59)= 0,20

DISCUSSION

After obtaining the results, the next step is to discuss and analyze the results obtained. The discussions carried out took the form of discussing the installation and activation design of the FTTH network and research on feeder cable macrobending.

1. Discussion of FTTH Installation and Activation Results

After the FTTH network installation was carried out, the author tested the feasibility of the FTTH design before activating it. Testing before activation is useful to see whether the network that has been installed complies with the total attenuation standard of no more than 28 dB.

Checking the FTTH network installation uses OPM as a measurement tool. Where in this installation the author uses the source or design input from the Handled Light Source (HLS). The input value provided by HLS can be known by calibrating. In carrying out calibration, do it in 3 sessions and choose values that often appear. The results of the 3 calibration sessions are in accordance with Table 2, where the calibration value that frequently appears is -7.28 dBm. After the calibration value is -7.28 dBm, measurements can be made at each FTTH device output. The output of each device is measured starting from ODC to ONT.

The results of measuring the output of the FTTH network installation device are displayed in accordance with table 3. In this table PTx is the sender or input value of the FTTH installation, while PRx is the power received at each output device using a measuring instrument called an Optical Power Meter (OPM). The closer the device approaches the final termination point, the smaller the PRx value. This is due to attenuation or power reduction due to connectors, passive splitters, adapters, long cable connections, and could be due to FTTH interference. Measuring the output of each FTTH device aims to know the reception value of each device and makes it easier to find device problem points when

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testing the feasibility of the FTTH network installation which will be used for later activation of the FTTH network.

In accordance with the calculated Link Budget, it is 22.64 dB. So the standard total attenuation value for the FTTH network installation that the author is building must be less than 22.64 dB and must not exceed that value. If the total attenuation value in the installation is greater than the value of 22.64 dB, then the installation is experiencing interference or is not feasible and does not comply with the appropriate standards for the link budget calculation. However, if the total attenuation value in the FTTH network installation is smaller than the total attenuation value in the link budget calculation table, then the FTTH network installation has good feasibility and transmission quality or meets standards. To find out this, the author carried out measurements and data results in table 3 to compare the total attenuation in the network installation with the total attenuation in the link budget calculation.

In table 3, the author obtained data in the form of PTx (Input or sending power) and PRx (Output or receiving power) values. PTx is filled in with the calibration value in table 2. Where the sender or PTx value is -7.28 dBm. The PRx value is obtained from measurements using OPM and is filled in according to table 3. From the PRx value on the ONT, the author can find out the total attenuation value in this FTTH network installation by carrying out the following calculations:

Total attenuation (αtotal) = PTx – PRx
αtotal = -7.28 dBm - (-29.53 dBm)
αtotal = 22.25 dB

From the total attenuation calculation in the FTTH installation above, it will be compared with the total attenuation value in the link power budget calculation, namely a total attenuation value of 22.64 dB. The total attenuation comparison value is 22.25 dB < 22.64 dB, so the total attenuation in the FTTH network installation is smaller than the total attenuation value calculated by the link budget. Thus, the total attenuation value for the FTTH network installation is smaller than the total attenuation value in the link budget calculation, while complying with the total attenuation standard of no more than 28 dB. This means that the FTTH network installation is suitable for use and has very good transmission quality for optical signals. This FTTH network installation is suitable for use and can be used to activate the FTTH network.

Next are measurements after activating the FTTH network. The steps for measuring output power for FTTH network activation are the same as how to measure output power in FTTH network installations, the main difference between the measurement results for FTTH network installation and activation lies in the input power used. In the FTTH network installation, HSL is used as input power, while in FTTH network activation, the input power comes from the OLT using an 8 dB SFP. As seen in table 4, the PTx or input power is 7.98 dB.

The output power results in the FTTH network installation are smaller than the output power results in FTTH network activation. It can be seen in table 4 that PRx or output power on the ONT has a value of -14.91 dBm in FTTH network installations, while in table 3 PRx or output power on the ONT has a value of -29.53 dBm. This happens because the input power in FTTH network activation is increased, where the installation only uses HSL as input power of -7.28 dBm, while in FTTH network activation it uses OLT as input power which comes from the SFP which is worth 7.98 dBm.

2. Discussion of Feeder Cable Macrobending Results

The results of the feeder cable macrobending research with curvature diameter before activation are in accordance with table 5. From this table, the attenuation value for the feeder cable at ODC is obtained where the attenuation value is carried out by measuring the output of the feeder cable for each color of cable without prior treatment or under normal conditions and then given macrobending treatment based on curvature diameters of 50 cm, 25 cm, and 5 cm to obtain output values with macrobending treatment.
Based on table 5 the resulting damping is based on color given the curvature of the diameter before activation as follows:

Pink cable macrobending damping with a curvature diameter of 50 cm
Attenuation = PRx without treatment – PRx with treatment
Attenuation = (-8.06 dBm) - (-8.08 dBm)
Attenuation = 0.02 dB

Attenuated macrobending orange cable with a curvature diameter of 25 cm
Attenuation = PRx without treatment – PRx with treatment
Attenuation = (-8.27 dBm) - (-8.32 dBm)
Attenuation = 0.05 dB

Yellow cable macrobending damping with a curvature diameter of 5 cm
Attenuation = PRx without treatment – PRx with treatment
Attenuation = (-9.82 dBm) - (-10.08 dBm)
Attenuation = 0.26 dB

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From the calculations above, the author can analyze macrobending at a curvature of 50 cm. The resulting attenuation is not too high, namely 0.02 dB. Furthermore, at a curvature of 25 cm the resulting attenuation is not too high, namely 0.05 dB, only a slight increase from a curvature of 50 cm. Meanwhile, at a curvature of 5 cm, the resulting high attenuation is 0.26 dB and this shows a high increase in attenuation from curvatures of 50 cm and 25 cm.

This data shows that the smaller the curvature diameter value before activation, the greater the attenuation value. The greater the attenuation value, the worse the quality of transmitting optical signals. Thus, macrobending feeder cables with a smaller curvature diameter can have a big influence on the FTTH network installation because of the reduced quality produced at the ODC which results in the FTTH network not being activated later.

Next, measure the macrobending of the feeder cable with the curvature diameter after activation according to the table 6. The method for measuring and collecting data is the same as before activation, the difference is the input used. Where the input for activation uses the OLT as the input resource.

Based on table 6, the damping produced is based on color given the diameter curvature before activation as follows:

Pink cable macrobending damping with a curvature diameter of 50 cm

Attenuation = PRx without treatment – PRx with treatment
Attenuation = (7.90 dBm) - (7.89 dBm)
Attenuation = 0.01 dB

Attenuated macrobending orange cable with a curvature diameter of 25 cm

Attenuation = PRx without treatment – PRx with treatment
Attenuation = (7.88 dBm) - (7.86 dBm)
Attenuation = 0.02 dB

Yellow cable macrobending damping with a curvature diameter of 5 cm

Attenuation = PRx without treatment – PRx with treatment
Attenuation = (6.79 dBm) - (6.59 dBm)
Attenuation = 0.20 dB

From the calculations above, the author analyzes the macrobending of the feeder cable after activation, which results in a curvature of 50 cm, the resulting attenuation is not too high, namely 0.01 dB. Furthermore, at a curvature of 25 cm the resulting attenuation is not too high, namely 0.02 dB, only a slight increase from a curvature of 50 cm. Meanwhile, at a curvature of 5 cm, the resulting high attenuation is 0.20 dB and this shows a high increase in attenuation from curvatures of 50 cm and 25 cm. From this data, it shows that the damping produced before and after activation only shows a difference in the results based on the curvature of the cable being treated, the smaller the macrobending curvature diameter, the greater the damping produced.

CONCLUSION

Based on Macrobending on the feeder cable segment before and after FTTH network activation, it can be concluded:

1. FTTH network activation can be done after installation starting from OLT to ONT and has a standard attenuation of around 15 – 28 dB on the FTTH network.
2. In the FTTH network before activation, the input power comes from the HSL which only sends light signals, while the input power in the FTTH network after activation comes from the OLT using SFP which can send internet data.
3. Macrobending on the feeder cable affects the attenuation in the FTTH network, the smaller the diameter of the curvature of the macrobending feeder cable, the greater the attenuation value.

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