Fiber to The Home (FTTH) Network Design with Addition of Optical Distribution Point (ODP) Using the Branching Method

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ABSTRACT

Optical fiber is a transmission medium that uses light as a signal conductor. In order for optical fibers to be used and the benefits are felt, a network architecture is needed, namely FTTH. FTTH consists of active devices such as OLT and ONT as well as passive devices consisting of ODC, Closure, and ODP. In this design, it uses OLS as a light signal transmitter and produces input power. However, over time and the increase in population capacity and the number of access services available, of course, there are more and more requests for the installation of optical networks in customers' homes. Therefore, the most available FTTH device is ODP in order to be able to withdraw cables to customers' homes and continue to expand FTTH. Therefore, this study will discuss the addition of new ODP with the branching method. Using OPM as a measuring tool and calculating the power link budget to find out that the resulting attenuation value is no more than 28dB.

1. Introduction

The advancement and development of telecommunications technology is a great potential to be able to improve and realize various types of more sophisticated communication services with fast and easy access. The need for high-speed and large-capacity communication in the telecommunications sector is currently very much needed to support the development of information technology that is increasingly developing in the era of modern society. The presence of fiber optic cables as a transmission medium in the world of telecommunications is one of the solutions to problems in transmission media. Optical fiber as a transmission medium [1] [2] is able to improve communication system services in the form of data, voice, and video [3]. Because of the availability of large bandwidth so that it is able to send data at high speed, as well as guaranteed confidentiality of the data sent.

The increasing need for internet access and the increase in various types of multimedia services, an access network architecture that is able to deliver these services well is needed, namely the FTTH (Fiber to the Home) network architecture. FTTH or Fiber to The Home is an access network architecture technology that uses fiber optic as its main medium up to the customer's home [1][4][5]. With the use of optical fiber as its main medium, FTTH technology has several advantages when compared to network technology that still uses copper cables or even wireless technology [6]. One of the advantages of optical fiber is that it has a very fast data transmission speed to reach gigabits per second. Therefore, the construction of the FTTH network design was carried out in building G, 3rd floor of the Padang State Polytechnic. The design of the FTTH network starts from the construction of ODC, ODP, OTP, ROSET, and ONT [7]. For connecting between devices, several types of cables are needed, including aerial cables or distribution cables as a link between ODC and ODP [8], drop core cables connecting ODP with OTP, and indoor cables for OTP connecting with ROSET.

One of the devices that must be widely available is ODP. ODP serves as a place for distributing optical fiber to the customer's home. ODP consists of three types including ODP Pole Solid, ODP Closure Area, and ODP Pedestal. The three ODPs have the same function but are different in terms of installation [9]. ODP is a device that always because with the passage of time and the increasing public demand for internet services, an adequate and adequate ODP is also needed. Every house that wants to use a fiber optic network is carried out a new installation in the house, this over time will cause a full terminal ODP or full ODP. Because if there is no ODP available that can accommodate customer requests, it cannot be done to install an internet network in a house. Under different conditions, there are home customers who want to use fiber optic network services but the ODP distance to the customer's home is too far [10]. Both of these things cause obstacles to the installation of new networks in the customer's home. Therefore, the expansion of the FTTH network continues to be carried out. One way to expand the FTTH network is by adding ODP. Because in 1 ODP that uses a 1:8 passive splitter [11][9] it can accommodate a maximum of 8 customers, in addition to a 1:8 passive splitter, as for ODP which uses a 1:4 passive splitter, the use of a passive splitter depends on the needs of an area. In the previous study, the addition of ODP was carried out by using google earth to find out the placement point of ODP so that new ODP branching could be carried out [12]. Furthermore, branching has been carried out in Jabodetabek areas, but the branching method is carried out using closure [13]. However, the weakness of the study [12] does not discuss further about what kind of branching method is used. This paper discusses one of the methods for adding ODP, namely the branching method or branching ODP. The branching method is done by using a 1: 2 passive splitter and a drop core cable. Expanding the FTTH network, of course, must still pay attention to the attenuation value according to the ITU-T G.984 standard, which cannot be more than 28dB [12][14]. To find out the attenuation value, measurements were made with OPM [9] and calculations using the power link budget method [11][15].

2. Literature Review

FTTH (Fiber to The Home)

Fiber to the Home (FTTH) is a series of optical signal transmissions from STO (Automated Telephone Center) or the provider center to the customer's home by using optical fiber as a medium for transmitting information. The development of this technology cannot be separated from the progress of the development of fiber optic technology that can replace conventional cable users. And supported by the desire to get a service known as Triple Play, which is a service for fast internet access in an infrastructure in the customer unit.

FTTH structure

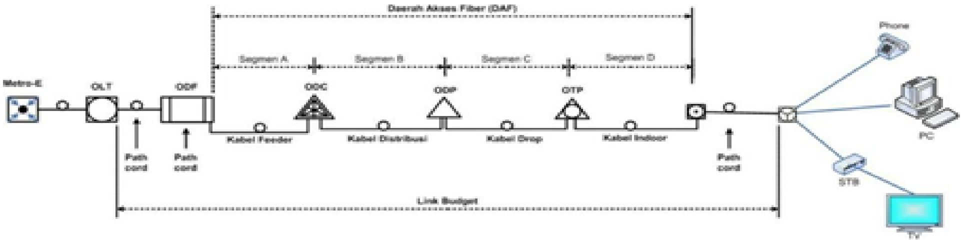

Figure 1. FTTH structure

FTTH Device

1. Metro Ethernet/Metro E

Metro Ethernet network, which has the meaning of the word, is a metro or large-scale data communication network that covers an urban scale, using Ethernet technology. If viewed in a real sense, Metro-E technology is one of the developments of Ethernet technology that can cover a wider area and urban scale equipped with various services found on Ethernet networks in general. So that a metro-scale network can be formed using Ethernet technology as usual.

Figure 2. Metro Ethernet

2. Optical Line Termination (OLT)

Optical Line Termination (OLT) is a device that functions as the endpoint of passive optical network (PON) services. This device has two main functions, namely:

1) Perform conversion between electrical signal and optical signal.

2) Coordinate multiplexing on other devices at the end of the network which is commonly referred to as Optical Network Terminal (ONT) or Optical Network Unit (ONU).

Figure 3. Optical Line Termination

3. Optical Distribution Frame (ODF)

Is a fiber cable termination point of transition from outdoor fiber optic cable with indoor fiber optic cable and vice versa.

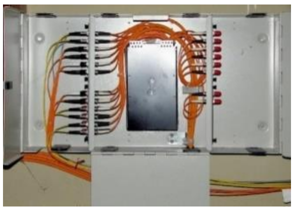

Figure 4. Optical Distribution Frame

4. Frame Termination Management (FTM)

It is a fiber optic-based access network infrastructure, especially the FTTH access network which is located in the central office position. The FTM device functions as management of optical cable termination on access and cross connect networks as well as patch cord interconnection between O-Access, E-Access, and E-Trans.

Figure 5. Frame Termination Management

5. Optical Distribution Cabinet (ODC).

The outdoor device in the FTTH access network is the Optical Distribution Cabinet (ODC). ODC is a room in the form of a box or dome made of special material that functions as a single-mode optical network connection installation, which contains connectors, splicers, and splitters and is equipped with a fiber management room with a certain capacity on a passive optical access network. (Passive Optical Network / PON).

ODC serves as a termination place between the feeder cable and the distribution cable. It can be concluded that in the ODC there is a splitter from the center or OLT which will later be shared with ODP.

Figure 6. Optical Distribution Cabinet

6. Closure

Joint Closure is a box or place to put the results of the connection of fiber optic cables. For example: If a fiber optic cable breaks because it is cut or burned, then the cable is spliced, and the result of the connection is put in the Closure. For Closure Capacity, there are variations ranging from 6 core closures, 12core closures, 24core closures, 48core closures to 256core closures.

Figure 7. Closure

7. Optical Distribution Point (ODP)

Optical Distribution Point (ODP) is an initial termination device for the use of drop cable, before entering the customer's house. There are three types of ODP, namely ODP Pedestal, ODP Pole, and ODP Closure. ODP device components consist of optical pigtail, adapter connector, splitter room, fiber management room with a certain capacity and equipped with a place for cable entry and exit (distribution and drop cables).

Figure 8. Optical Distribution Point

8. OTP or ROSET

OTP (Optical Termination Premises) / Rosette is a passive device placed in the customer's house, which is the final termination point of the optical fiber indoor / dropcore cable.

Figure 9. OTP or ROSET

9. Optical Network Termination (ONT)

Optical Network Terminal (ONT) is an active device located on the customer's side. ONT can change the light signal that is emitted into electrical signals which will then be forwarded again into voice and data signals. On the ONT there are 4 LAN ports and 2 telephone ports. Special LAN 4 is used for STB. Not all devices are connected using a UTP cable to the ONT, because the ONT can also be connected wirelessly by entering the appropriate password. The physical form of the ONT can be seen in the image below.

Figure 10. Optical Network Termination

3. Method

3.1. Research Flow

In the design process of this research using an experimental method consisting of a research flow chart which can be shown in Figure. 10 so that a system is formed that becomes a goal, then the work data obtained are analyzed so that a conclusion can be drawn**.**

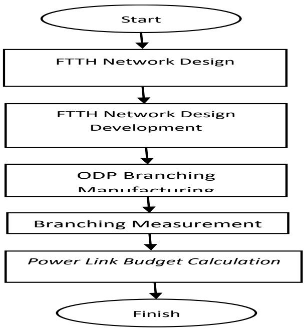

Figure 11. Research Flow

3.2. Block Diagram Design Stage

3.2.1. Branching Using Passive Splitter Method 1:2

In this branching method, the author uses a 1: 2 passive splitters for branching. In a technical sense, after the design of the FTTH network is built, of course, there is already an ODP Pole Solid with a 1: 8 passive splitters, it can be continued with branching which produces ODP closure area. For ODP Closure Area, a 1:8 passive splitter is attached, the input in the passive splitter is not connected to the core on the aerial cable. Which means that the aerial cable in the ODP Closure Area only functions as a support for the ODP Closure Area, therefore the passive splitter input is 1: 8 which in the ODP Closure area is connected to one of the outputs in the 1: 2 passive splitters, namely output 1. As for output 2 of the 1:2 passive splitter, it is connected directly by the drop core cable to the OTB without being connected first to the ODP closure area as shown in figure 12.

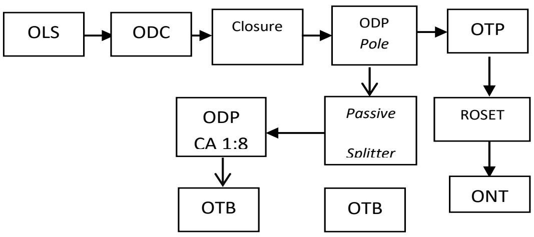

Figure 12. Block Diagram Branching Using Passive Splitter Method 1:2.

3.2.2. Branching By Using Drop core Cable

In this method, the author uses a drop core cable as a tool for branching. The main ODP used is ODP Pole Solid with a 1:8 passive splitter and produces a new ODP as a result of branching, namely ODP closure area which uses a 1:4 passive splitter. So that the main ODP can accommodate 7 customers because the 8th output of the ODP Pole Solid is used to install drop core cable connectors for branching.

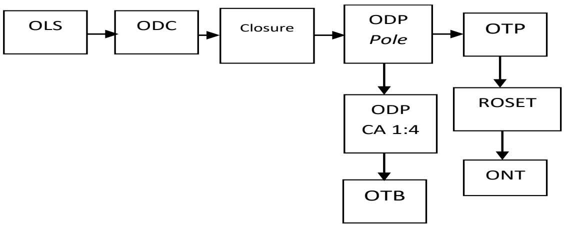

Figure 13. Block Diagram Branching by Using Drop core cable

3.2.3. Power Link Budget

Link budget is the sum of all losses that come from components in an optical network architecture [11]. These components are connectors, adapters, fiber optic connections, and fiber optic cable lengths. The calculation of the power link budget is carried out to find out that the device that has been built produces a attenuation value of no more than 28dB to maintain the quality of fiber optic network performance. Here is the equation for calculating the power link budget. [20]

$\alpha Total = L. aserat + Sp + Nc\ .\ ac + Ns\ .\ as$ + Na . aa

Information:

L: Cable Distance (Km)

$\alpha Total$: Total Attenuation (dB)

$aserat$: Attenuation Fiber Optic (dB/Km)

as: Splice Attenuation (dB/pcs)

αc: Connector Attenuation (dB/pcs)

αa: Adapter Attenuation (dB/pcs)

Na: Number of Splices

Ns: Number of Connectors

Nc: Number of Connector

Sp: Splitter Attenuation (dB)

3.3. Study of literature

In this stage, literature discussion activities are carried out from a research, namely Designing Transmission Attenuation Systems in Single Mode Aerial Fiber Optic Cables for Connection Loss in Passive Splitter Devices, where the authors collect data and learn relevant basic theories from various sources such as books, internet, resource persons and research that has been done related to the research that will be carried out by the author.

3.4. Testing and Measurement

At this stage, the authors carry out the testing and attenuation measurements for each cable connection that is carried out according to the design.

3.5. Analysis, Drawing Conclusions, and Making Reports

This is the final stage in the research process, that is, after all the test data has been collected, the writer will analyze the data, then draw conclusions as the material for the report.

4. Results

4.1. Measurement Results on FTTH Devices

The measurement results are carried out to see the power received in each FTTH device. For the input power value is generated from calibration on OPM and OLS. Starting from ODC, ODP, OTP, and ROSET devices. The measurement results can be seen in the table.

Table 1. FTTH Device Measurement Results

Device	χ (nm)	PTx (dBm)	PRx (dBm)
ODC	1310	-7,25	-13,66
ODP			-25,27
OTP			-25,61
ROSET			-25,65

4.2. Result of Branching Measurement Using Passive Splitter 1:2

Because it uses OLS as the input value, calibration is carried out first before measurements are made and the value shown in the table is the attenuation value resulting from the input power value or PTx which is subtracted by the PRx receiving capacity. Measurements are carried out on ODP, OTP, or OTB devices. Measurements on ODP are to see the effect of branching, while in OTP or OTB to see the power received at the customer's home. Before branching, measurements will be taken first to see how much power is received in ODP and OTP, this is done to see whether branching has an influence on the main ODP. like table 2.

Table I. Measurements before branching

Device	χ (nm)	Ateenuation (dB)
ODP	1310	18,27
OTP		18,40

Furthermore, when ramification is carried out, the power generated by sortie 1 in passive separator 1: 2 is measured to see the effect of ramification on ODP and OTB. The measurement results carried out when branching using a 1: 2 passive splitters produce a high attenuation above the standard attenuation value of 28dB. Here looks like table 3.

Tabel 3. Measurements of Branching Results (OTB Port 1)

Device	χ (nm)	Attenuation (dB)
ODP	1310	31,60
OTP		32,57

After measurements are made at output 1 OTB, measurements are taken at output 2 passive splitters 1: 2 on ODP and OTB. The ODP measured is ODP Pole Solid. The results of this measurement resulted in a attenuation that was still up to standard as in table 4.

Tabel 4.II Measurement of Branching Results (OTB Port 2)

Device	χ (nm)	Attenuation (dB)
ODP	1310	23,31
OTP		23,52

To see the effect of branching, measurements were again carried out on the main ODP, namely ODP Pole Solid and OTP. From the measurement results when branching is carried out, it is known that branching does not have a attenuation effect on the main ODP or OTP as in table 5.

Tabel 5. Measurement After Branching

Device	χ (nm)	Attenuation (dB)
ODP	1310	18,21
OTP		18,55

4.3. Branching Measurement Result with Drop core Cable

Similar to the research on the branching method with a 1:2 passive splitter, measurements were taken on ODP, OTP, and OTB to see the effect of branching that produces a new ODP with a patch cord cable. Before branching with a drop core cable, it will first be carried out the measurement of the power received by OTB as in table 6.

Tabel 6. Measurements before branching

Device	χ (nm)	Attenuation (dB)
ODP	1310	18,44
OTP		18,73

Branching is carried out on the ODP Pole Solid with a dropcore cable so as to produce an ODP closure area, then measurements are taken on the OTB to see the power received as in table 7.

Tabel III Measurement of branching results

Device	χ (nm)	Attenuation (dB)
ODP	1310	25,34
OTP		26,56

To see the effect of branching with the dropcore cable, power measurements are carried out on the OTB as shown in table 8.

Tabel 8. Measurement after branching

Device	χ (nm)	Attenuation (dB)
ODP	1310	18,40
OTP		19,83

4.3. Discussion

4.3.1. Discussion Of FTTH Network Design

In the results of this FTTH network design, the author measures the performance and feasibility of each device to see whether the attenuation value of each device used is still within the standard limits that have been set. Measurements use HLS as an input source that is calibrated first, after obtaining calibration results, make sure during the measurement, HLS and OPM always remain on, if one of the measuring instruments turns off, recalibration is carried out. After calibration, the optical signal transmit power is obtained, which is -7.25dBm.

Measurements are carried out starting from the ODC device that uses a 1: 4 passive splitters with an input connected to HLS, then one of the outputs from the ODC is connected to a pigtail cable that has been connected previously with one of the cores on the aerial cable, namely a purple core. The measurement of acceptability in ODC is -13.66dBm, which means the attenuation on the ODC can be calculated with transmit-acceptability or PTx-PRx. So that it is obtained a attenuation value of -7.25dBm-(-13.66) dBm= 6.41dB. This value is equal to the value of the 1:4 passive splitter used in ODC. The results of this measurement are in accordance with the 1: 4 passive splitter standards used, which is <7.4dB.

Followed by an aerial cable that connects ODC with ODP. The ODP used is the ODP Pole Solid which uses a 1:8 passive splitter. The acceptability of ODP is -25.25dBm. To determine the attenuation on the ODP, calculations were carried out by means of transmit power-receiver power which means PTx-PRx. Obtained attenuation -7.25dBm-(-25.27dBm) = 10.49dB. Then the attenuation in ODP is 10.49dB, where this value is equal to the 1:8 passive splitter attenuation value which is still up to standard, which is <10.8dB. After the attenuation is known on the ODP, it is continued to withdraw the drop core cable from the ODP to the OTP on the customer's side of the house. The measurement value on the OTP was -25.61dBm. To calculate the attenuation value on the OTP, a scattering power is carried out with the receiving power, which means PTx-PRx. Obtained attenuation in the OTP, namely -7.25dBm-(-25.61) dBm = 18.36dB. From OTP proceed to ROSET which is connected by indoor cable. The measurement on the ROSET was obtained, which was -25.65dBm. Calculating the attenuation value on the ROSET, the transmit-receiving power or PTx or PRx. Then a attenuation of -7.25dBm-(-25.65dBm) = 18.4dB is obtained. This value is the total attenuation value in the FTTH network design, which is still in accordance with the standard, namely <28dB.

4.3.2. Discussion Branching Passive Splitter 1:2

The high attenuation is due to the large number of passive splitters used. Starting from the 1:4 passive splitter in ODC, 1:8 passive splitter in the main ODP, namely ODP Pole Solid, 1:2 passive splitter which is used as branching media, and finally there is a 1:8 passive splitter contained in ODP results, namely ODP Closure Area. Each passive splitter has a maximum attenuation value. Therefore, it can be known that branching using a 1: 2 passive splitter that produces ODP closure area, and continued with the withdrawal of drop core cables to the customer's home carried out from the ODP Closure Area is strongly discouraged due to the high attenuation received at the customer's home and causes poor performance of the fiber optic network.

4.3.3. Discussion Branching Kabel Drop core

The branching method using the drop core cable method does not affect or add attenuation to the main ODP or ODP Pole Solid. This is because the output commonly used drop core cable is connected to the customer's home, this time connected to ODP so as to produce a new ODP, namely ODP closure area. In ODP closure Area, a 1:4 passive splitter is used because the 1:4 passive splitter does not provide a large enough attenuation. This is evident in the acceptability and attenuation produced in ODP Pole Solid and OTB.

4.3.4. Discussion Power Link Budget

Link power budget is carried out to see whether the total attenuation produced is in accordance with the standard, namely 28dB, as well as to compare the results of the calculation and measurement values.

a. Calculations on the design of the FTTH network

α_{Total} $= L.\, aserat + Nc\, .\, ac + Ns\, .\, as$ + Na . aa + Sp

= (0,018x0.35) + (12x0,25) + (4x0,1) + (5x0,5) + (6,41+10,49)

= 22,80 dB

b. Calculation before branching passive splitter 1:2

α_{Total} $= L.\, aserat + Nc\, .\, ac + Ns\, .\, as$+ Na . aa + Sp

= (0.018x0.35) + (10x0.25) + (2x0.1)+ (4x0.5) + (6.41+10.49)

= 21.60 dB

c. Calculation of branching results (Output 1)

α_{Total} $= L.\, aserat + Nc\, .\, ac + Ns\, .\, as$+ Na . aa + Sp

= (0.018x0.35)+(12x0.25)+ (2x0.1)+ (5x0.5)+(6.4+10.49+10.49+3.1)

= 36.69 dB

d. Calculation of branching results (Output 2)

α_{Total} $= L.\, aserat + Nc\, .\, ac + Ns\, .\, as$+Na.aa+$Sp$

= (0.018x0.35)+(11x0.25)+ (2x0.1)+ (5x0.5) + (6.4+10.49+3.1)

= 25.45 dB

e. Calculation of the influence of branching

α_{Total} $= L.\, aserat + Nc\, .\, ac + Ns\, .\, as$+ Na . aa + Sp

=(0.018x0.35)+(9x0.25) + (2x0.1)+ (5x0.5) + (6.41+10.49)

= 21.85 dB

f. Calculation before branching with drop cores

α_{Total} $= L.\, aserat + Nc\, .\, ac + Ns\, .\, a$ + Na . aa + Sp

=0.018x0.35)+(10x0.25)+(2x0.1) + (4x0.5) + (6.41+10.49)

= 21.60 dB

g. Calculation of branching results with drop cores

α_{Total} $=L.\, aserat+Nc.ac + Ns.as$+ Na . aa + Sp

=(0.018x0.35)+(8x0.25)+(2x0.1)+(4x0.5) + (6.41+10.49+6.41)

= 27.51 dB

h. Calculation after branching with drop core

α_{Total} $= L.\, aserat + Nc\, .\, ac + Ns\, .\, as$ + Na . aa + Sp

= (0.018x0.35) + (9x0.25) +(2x0.1)+(4x0.5)+ (6.41+10.49)

= 21.35 dB

5. Conclusion

From the research that has been carried out, it can be seen that the construction of the FTTH network design starts from ODC, ODP, OTP, ROSET, and ONT. In this development, it uses a 1:4 passive splitter in ODC and a 1:8 passive splitter in ODP.

1. In the construction of the FTTH network design, measurements of each device are carried out to ensure that the devices used have a standard attenuation so that it does not affect the network performance received at the customer's home. There is a difference in the attenuation value generated by the measurement with OPM compared to the power link budget. This is caused by the connecting factor and the device used.
2. ODP branching is carried out so that later it can continue to expand the FTTH network so that every home that wants to use the fiber optic network can be fulfilled. Branching is also useful for adding ODP if it is found that the ODP is full or an ODP is found that is far from the customer's home. Therefore, ODP branching is carried out by two methods, namely by using a 1: 2 passive splitter and a drop core cable to see what branching is more effective.
3. After measuring and calculating with the power link budget, it can be seen that branching using a 1: 2 passive splitter produces a attenuation that exceeds the 28dB attenuation standard. This is because the passive splitter provides an additional fairly high attenuation compared to the drop core cable. The 1:2 passive splitter gives a red man of approximately 3.4dB while the drop core cable only provides a attenuation of 0.1-0.2dB only. Therefore, it is recommended to branching using a drop core cable. In addition to the commonly used drop core cables, drop core cables do not provide high attenuation.

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