Fiber Optic Network Performance Analysis With Fiber To The Home (FTTH) Architecture

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Abstract— Prototype is a tool used as a learning medium that has the same shape and function as the original tool or unit. The use of simulator tools as a means of learning is one of the learning methods that is very well used to find out the components, functions, and how the tool or unit works. Limitations in the delivery of lecture materials regarding Optical Networks due to the absence of modules and prototypes that help the lecture process this prototype is one of the solutions that can be used in the lecture process. Testing this prototype with measurements of damping and power obtained after configuring and installing a fiber to the home network using an optical power meter. Data analysis used in the quality of service in the system is the value of attenuation and power (power link budget) in units of dB and dBm. The results of the test get a good attenuation according to the established ratio. The practicum module is an implementation after the configuration and measurement of damping so that it can be a guide for conducting fiber optic network practicum in the Telecommunication Engineering study program.

Keywords— FTTH, Learning Module, Optical Power Meter

1. Introduction

The rapid development of telecommunication technology is caused by the customer's need for communication and information services which is increasing from time to time. The Covid-19 pandemic, which has lasted for about a year, has made many changes in our lives. The main thing is to carry out activities that were previously face-to-face in the lecture process, attend the office to work, meet face-to-face meetings with many people, turn into online-based activities to prevent the spread of the virus. Activities turn virtual such as work from home, distance learning, online meetings, shopping or selling from home through e-commerce platforms. Another addition is to pass the time by playing games or watching the latest movies online, making the need for internet access at home and data via cell phones increase sharply.

According to data from we are social-Hootsuite, as of January 2021, the number of internet users in Indonesia increased by 73.7 percent from Indonesia's population of 274.9 million or exceeded 202.6 million users. Over the past year, there has been an addition of 27 million users. Interestingly, the time used to access the internet also increased, from 7 hours 59 minutes to 8 hours 52 minutes. With use for chat (96.5%), social networking (96.3%), shopping (78.2%), financial services (39.2%), entertainment (86.2%) and others.

In terms of traffic, several telecommunications operators said there was an increase in traffic as a result of the pandemic, which reached 40%. At the household level, with the simultaneous use of father and mother as well as children to carry out activities of working from home, studying from home and selling and trading from home, the required internet speed also increases. Moreover, activities carried out using the streaming video feature. The internet speed per household, which used to be between 10 Mbps to 20 Mbps, now has to be met at least with an access speed of at least 20 Mbps.

Even some people, especially for content creators and professional gamers, the required internet speed access can reach 50 Mbps. Moreover, the development of video on demand services with the support of millennial and Gen Z creativity which produces video content such as for YouTube. Therefore, the optimal speed required by each customer is very different depending on the digital activities being carried out.

The need for an internet network affects the opening of jobs that require graduates or experts in the field of telecommunications and networks. Limitations in lectures on Fiber Optic networks in practicum and material, causing Diploma/Bachelor of Telecommunication Engineering graduates to be unable to compete and meet the needs of the telecommunications industry. Therefore, the prototypes and learning modules for Fiber to The Home Network are very basic in the Fiber Optic Network lectures which are very much needed by Telecommunication Engineering graduates.

Prototype is a tool used as a learning medium that has the same form and function as the original tool or unit. The use of a simulator tool as a learning tool is one of the best learning methods to find out the components, functions, and workings of the tool or unit. There are lots of simulators available at the Semarang State Polytechnic, especially in the Department of Electrical Engineering.

In the study of Fiber Optic courses, Telecommunication Engineering students have not been able to carry out practical work directly and know the tools used directly so that I was challenged to make a prototype of fiber optic learning, especially on the FTTH network so that it can be used to facilitate the learning of students and lecturers of Polytechnic Telecommunication Engineering. Semarang State.

Based on the explanation above, the project with the title FTTH Network Analysis on Fiber Optic Learning at the

Telecommunications Laboratory of the Semarang State Polytechnic. This prototype consists of a simulation of the distribution of the FTTH network from the OLT to the customer's house and is equipped with a learning module as a support for the implementation of the fiber optic course practicum.
The module contains measurements of power (power link budget) and attenuation using various splitters, namely 1:2, 1:4, 1:8, and 1:16 splitters and paired with 5 dB attenuators, and 10 dB using adapters and patches. cord.

2. System Design

The design of the prototype by utilizing the Optical Line Terminal (OLT) U Fiber OLT-4 located on the Telkom Laboratory Building, 2nd Floor, Telecommunication Engineering Study Program. In this project research uses a proxy which is used as a router to direct or create a route so that the network reaches its destination, namely connecting to other internet networks.

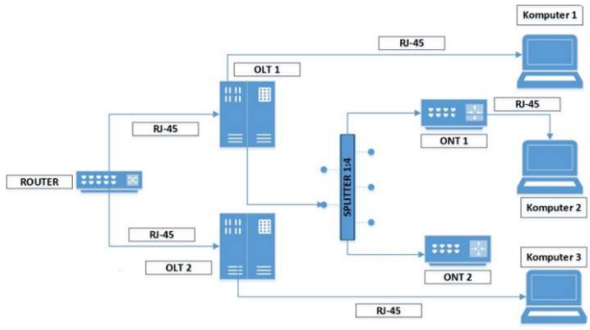


Fig 1. Diagram Schematic FTTH network prototype

Based on Figure 1 Prototype Diagram, the FTTH network prototype is designed using a physical configuration that is connecting the OLT using an RJ-45 cable then connected to a computer and mikrotik which is used as a router and for the customer side using a splitter that functions as a voltage divider then ONT which functions as a device on the customer side that provides interfaces for data, voice, and video. The main function of this ONT is to receive traffic in optical format and convert it into the desired form, such as data, voice, and video then the ONT is connected with an RJ-45 cable to lead to a computer so that it can be connected by being able to ping, get a gateway and can access internet using the NAT method. In addition to using the physical configuration is also built virtually using winbox64. The application functions to connect OLT 1 with OLT 2 and external networks so that they can access the internet through the designed configuration.

At the observation stage, the first system design was carried out, namely conducting research on the Telecommunication Engineering study program, subjects that were not yet effective in practicum and theory, both materially and supporting devices that could be used for training. And don't forget to discuss and consult with the lecturer about it. After observing the courses that have not been effective in practicum and theory are Fiber Optic Networks (JAFO) where there are no prototypes and jobsheets that can help the lecture process.

The jobsheet or practicum module in this project can be arranged after we conduct an experiment in measuring attenuation and power using an Optical Power Meter (OPM) with the replacement of the splitter used, adapter, patch cord and attenuator with different values. This jobsheet contains steps that will be used by students in conducting practical fiber optic courses.

3. System Test Result

3.1 Prototype

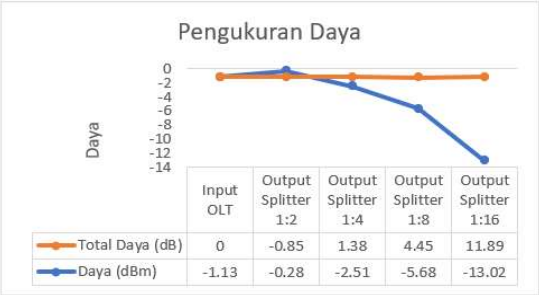
The results of the system design include system configuration in the form of a prototype FTTH network using U Fiber OLT-4. This prototype itself is already connected to an internet cable so that it can be used as a practicum media with a PING test using a command prompt and the device has been connected to the system by opening 192.168.1.1 and obtaining attenuation after measuring using an optical power meter.

Figure 2 is the result of the series of Fiber To The Home network prototypes.

Fig 2. FTTH Network Prototype

3.2 Power Measurement Test

The stage after the results of testing the use of a fiber to the home network prototype is by testing the power measurement to find out the function of the prototype can be used for making a practicum jobsheet. Figure 3 is the results of measuring the power of the fiber to the home network prototype.



	Input OLT	Output Splitter 1:2	Output Splitter 1:4	Output Splitter 1:8	Output Splitter 1:16
Total Daya (dB)	0	-0.85	1.38	4.45	11.89
Daya (dBm)	-1.13	-0.28	-2.51	-5.68	-13.02

Fig 3. Power Measurement Results

The test uses an optical power meter with lambda (λ) or a wavelength of 1310 nm used to measure singlemode with a relatively short distance (10 km). Through several power samples obtained from the 1:2, 1:4, 1:8 and 1:16 splitters, input and output are obtained as shown in the table.

From the input power and output power can be used to calculate the total power as below:

TOTAL POWER : Pin – Pout

Where :

Pin : Input Power (dBm)

Pout : Output Power (dBm)

1. Calculation of the total power on the 1:2 Splitter
   Is known :
   Pin : -01.13 dBm
   Pout :-00.28 dBm
   Wanted : Pt
   Answer : Pt: Pin – Pout
   : -01.13-(-00,28)
   : -0.85 dBm
2. Power calculation, total on Splitter 1:4
   Is known :
   Pin : 01.13 dBm
   Pout : -02.51 dBm
   Wanted : Pt
   Answer : Pt: Pin – Pout
   : - 01.13 – (-02.51)
   : 1.38 dBm
3. Calculation of total power on the 1:8 . Splitter
   Is known :
   Pin : -01.13 dBm
   Pout : -05.68 dBm
   Wanted : Pt
   Answer : Pt: Pin – Pout
   : -01.13 – (-05.68)
   : 4.55 dBm
4. Calculation of total power on Splitter 1:16
   Is known :
   Pin : : -01.13 dBm
   Pout : -13.02 dBm
   Wanted : Pt
   Answer : Pt: Pin – Pout
   : -01.13 –(-13.02)
   : 11.89 dBm

3.3 Testing of Attenuation Measurement of Fiber to The Home Network Prototype

The stages after the results of testing the use of a fiber to the home network prototype are by testing attenuation measurements to find out the function of the prototype can be used for making jobsheets. On the results of the attenuation test using an optical power meter and data detected on the U-Fiber OLT-4 1.2.2 system.

The difference between measurements using an optical power meter and with a U-Fiber system is the wavelength used when measuring using an Optical Power Meter using 2 Lambda, namely 1310 (Upstream) and 1490 (Downstream). In the measurement using the U-Fiber system using 2 units of ONT UFiber loco (Model: UF-LOCO) with standard Networking Interface Speeds, GPON WAN, ITU G.984 2.488 Gbps Downstream 1.244 Gbps 1.244 Gbps and Upstream is Tx Power, Rx Power and Connection Time recorded in the U-Fiber OLT-4 1.2.2 system. The test results are described in the following table of FTTH Network Attenuation Measurement Test Results:

Table 1. FTTH Network Attention Measurement

No	Panjang Gelombang (λ)	Splitter	Hasil Keluaran (dBm)	Patch Cord dan Adapter (dBm)	Attenuator 5 dB (dBm)	Attenuator 10 dB (dBm)	Kabel 4m (dBm)	Kabel 50 m (dBm)
1	1310	1:2	-00,28	-03,02	-15,43	-20,47	-2,83	-05,68
2	1490		-00,73	-02,70	-14,99	-20,03	-2,98	-05,28
3	1310	1:4	-02,51	-06,13	-13,96	-20,15	-06,00	-08,36
4	1490		-02,35	-05,65	-14,36	-19,74	-05,60	-07,94
5	1310	1:8	-05,68	-09,51	-17,30	-23,32	-09,87	-11,55
6	1490		-05,77	-09,11	-16,90	-23,32	-09,42	-11,17
7	1310	1:16	-13,02	-14,51	-21,33	-26,81	-12,82	-17,82
8	1490		-12,66	-14,11	-20,93	-26,43	-15,52	-17,23

The attenuation measurement test is carried out at the Telecommunications Laboratory 2nd Floor Telecommunication Engineering Study Program using various kinds of splitters, namely:

1. Splitters 1:2
2. Splitters 1:4
3. Splitters 1:8
4. Splitters 1:16

With the difference in attenuation and usability, then also by using 2 kinds of attenuators that are used as damping enhancers, namely:

1. Attenuator 5 dB
2. Attenuator 10 dB

As well as using patch cords and adapters that are used to add attenuation.

From the results of the tests carried out, the attenuation measurement got good results for the test parameters carried out. This is influenced by the performance of the OLT which is used as a medium for making prototypes. The following is

an explanation of the results of the attenuation measurement test using an optical power meter:

3.3.1 Splitter 1: 2

The measurement standard for the 1:2 splitter based on ITU-T is ± 2.8 to 4 dB, the wavelengths used are 1310 (upstream) and 1490 (downstream). The difference between dB and dBm is only in units, dB is the unit used to express the relative difference in signal strength. The decibel (dB) is expressed as the base 10 logarithm of the ratio of the power of the two signals. While dBm is a unit of Decibels in Milliwatts.

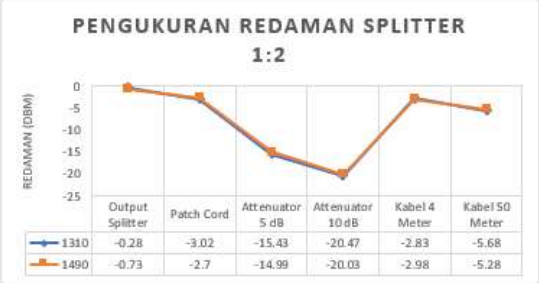


Fig 4. Attenuation Measurement 1:2

The first experiment got the output – 0.28 dBm (upstream) and -0.73 (downstream) The ONT could not be up (detected in the system) because it did not meet the standards set by the UFiber ONT. When using the 5 dB and 10 dB attenuators, they get attenuation beyond the standard set by ITU-T, this causes the ONT to not be detected on the U-Fiber system, besides that due to the use of SFP that is not compatible with UFiber OLT, the SFP used is the Warex brand which typically used on Switches (ASR, Zyxel, and BDCOM). Next is the addition of patch cords and adapters APC-UPC with a total attenuation of 0.6 dB obtained attenuation of -3.02 for upstream and 2.7 for downstream it is still standard with ITU-T. the use of 4 meter cable is also still up because it is still in accordance with the ITU-T standard. Furthermore, the use of a 50 meter precon cable gets an attenuation of -5.68 dBm, the attenuation exceeds the ITU-T standard limit but is still up (detected in the system) and the network condition is still stable but due to the high attenuation and not in accordance with the standard, it is prone to damage to the ONT when installed in the customer's house.

3.3.2 Splitter 1: 4

The measurement standard for the 1:2 splitter based on ITU-T is ± 5.8 to 7.5 dB, the wavelengths used are 1310 (upstream) and 1490 (downstream). The difference between dB and dBm is only in units, dB is the unit used to express the relative difference in signal strength. The decibel (dB) is expressed as the base 10 logarithm of the ratio of the power of the two signals. While dBm is a unit of Decibels in Milliwatts.

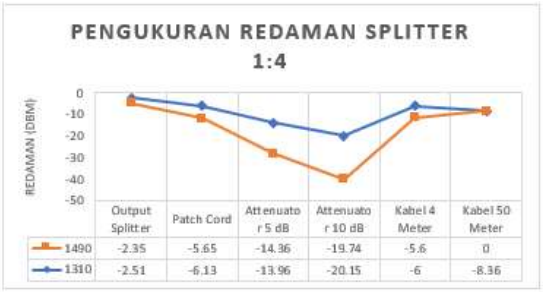


Fig 5. Attenuation Measurement 1:4

The first attempt got the output – 2.35 dBm (upstream) and -2.51 (downstream) the ONT can be up (detected in the system) this is due to the power sharing in the splitter and can cause the device to not last long.

When using the 5 dB and 10 dB attenuators, they get attenuation beyond the standard set by ITU-T, this causes the ONT to not be detected on the U-Fiber system, besides that due to the use of SFP that is not compatible with UFiber OLT, the SFP used is the Warex brand which typically used on Switches (ASR, Zyxel, and BDCOM). Next is the addition of patch cords and APC-UPC adapters with a total attenuation of 0.6 dB, the attenuation of -6.13 dBm (upstream) and -5.65 (downstream) is still standard with ITU-T. the use of 4 meter cable is also still up because it is still in accordance with the ITU-T standard. Furthermore, the use of 50 meter precon cable gets attenuation of -8.63 dBm (upstream) and -7.94 dBm (downstream), the attenuation exceeds the ITU-T standard limit but is still up (detected in the system) and network conditions are still stable but due to high damping and not in accordance with the standard causing the ONT prone to damage when it is installed in the customer's house.

3.3.3 Splitter 1: 8

The measurement standard for the 1:2 splitter based on ITU-T is ± 8.8 to 11 dB, the wavelengths used are 1310 (upstream) and 1490 (downstream). The difference between dB and dBm is only in units, dB is the unit used to express the relative difference in signal strength. The decibel (dB) is expressed as the base 10 logarithm of the ratio of the power of the two signals. While dBm is a unit of Decibels in Milliwatts.

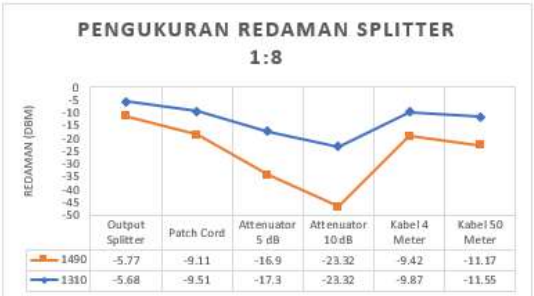


Fig 6. Attenuation Measurement 1:8

The first experiment got the output – 5.77 dBm (upstream) and -6.68 dBm (downstream) The ONT can be up (detected in the system) this is caused by power sharing in the splitter and can cause the device to not last long.
When using the 5 dB and 10 dB attenuators, they get attenuation beyond the standard set by ITU-T, this causes the ONT to not be detected on the U-Fiber system, besides that due to the use of SFP that is not compatible with UFiber OLT, the SFP used is the Warex brand which typically used on Switches (ASR, Zyxel, and BDCOM). Next is the addition of patch cords and APC-UPC adapters with a total attenuation of 0.6 dB, the attenuation is -9.51 dBm (upstream) and -9.11 dBm (downstream), this is still standard with ITU-T. the use of 4 meter cable is also still up because it is still in accordance with the ITU-T standard. Furthermore, the use of 50 meter precon cable gets attenuation of -11.55 dBm (upstream) and -11.17 dBm (downstream), the attenuation exceeds the ITU-T standard limit but is still up (detected in the system) and the network condition is still stable and still includes within the attenuation tolerance of +1.27 dBm.

3.3.4 Splitter 1: 16

The measurement standard for the 1:2 splitter based on ITU-T is ± 10.7 to 14.4 dB, the wavelengths used are 1310 (upstream) and 1490 (downstream).

The difference between dB and dBm is only in units, dB is the unit used to express the relative difference in signal strength. The decibel (dB) is expressed as the base 10 logarithm of the ratio of the power of the two signals. While dBm is a unit of Decibels in Milliwatts.
The first experiment got the output – 13.02 dBm (upstream) and -12.66dBm (downstream). The ONT can be up (detected in the system) and the attenuation value is in accordance with the ITU-T standard.

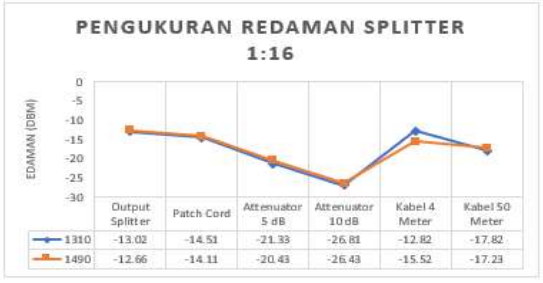


Fig 7. Attenuation Measurement 1:16

When using the 5 dB and 10 dB attenuators, they get attenuation beyond the standard set by ITU-T, this causes the ONT to not be detected on the U-Fiber system, besides that due to the use of SFP that is not compatible with UFiber OLT, the SFP used is the Warex brand which typically used on Switches (ASR, Zyxel, and BDCOM). Next is the addition of patch cords and APC-UPC adapters with a total attenuation of 0.6 dB obtained attenuation of -14.51 dBm (upstream) and 14.11 dBm (downstream) this is still standard with ITU-T. the use of 4 meter cable is also still up because it is still in accordance with the ITU-T standard. Furthermore, the use of 50 meter precon cable gets attenuation of -17.82 dBm (upstream) and -17.23 dBm (downstream), the attenuation exceeds the ITU-T standard limit but is still up (detected in the system) and network conditions are still stable but due to high damping and not in accordance with the standard causing the ONT prone to damage when it is installed in the customer's house.

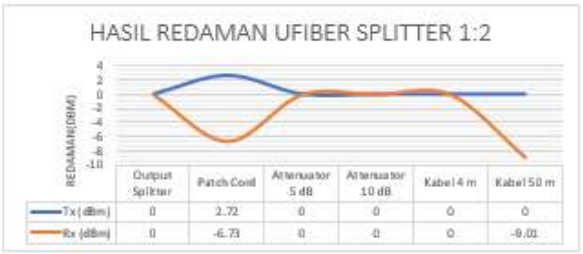
Then the next is the attenuation recorded on the UFiber OLT system with Normal Optical Power Range:
TX (Class B+): 1.5 to 5 dBm

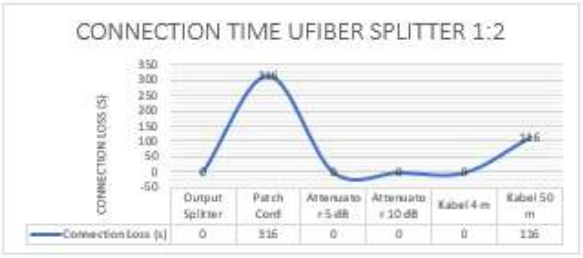
RX: -28 to -8 dBm

In this prototype, 2 ONT units are used which are used for attenuation monitoring obtained on the UFiber OLT system. The following is an explanation of the attenuation measurement test results recorded in the UFiber OLT system:

3.3.5 Spliter 1:2

In the UFiber Tx and Rx systems, the values obtained on the installation of adapters and patch cords are below the standard set by the UFiber ONT but can still be detected in the system because the attenuation obtained by using an optical power meter is in accordance with the ITU-T standard attenuation splitter 1:2. While Connection Time is the time the device or ONT is connected to the system (OLT). And other experiments get Tx, Rx, and Connection Loss values because the attenuation obtained from the optical power meter is too small for testing the output splitter and 4m cable, while for the 5 dB and 10 dB attenuators this is because the SFP is not matched even though the attenuation is still in accordance with UFiber ONT standard but the device is not up (connected to the system). Furthermore, by using a 50 meter precon cable, it complies with the ONT standard for its Tx and Rx.





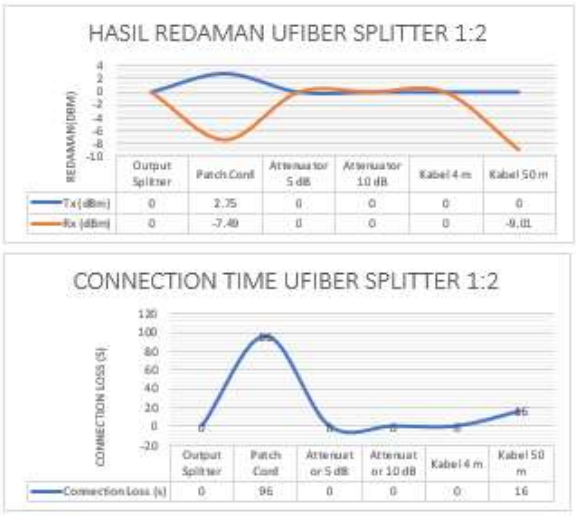


Fig 8. Results of Attenuation and Connection Loss on a UFiber System with a 1:2 splitter

3.3.6 Spliter 1:4

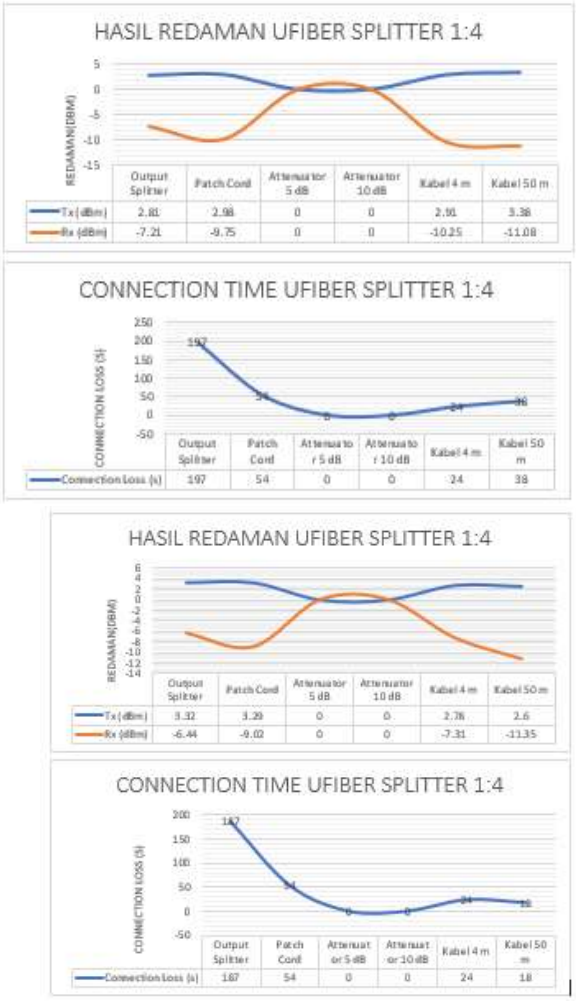


Fig 9. Results of Attenuation and Connection Loss on UFiber System with 1:4 splitter

3.3.7 Spliter 1:8

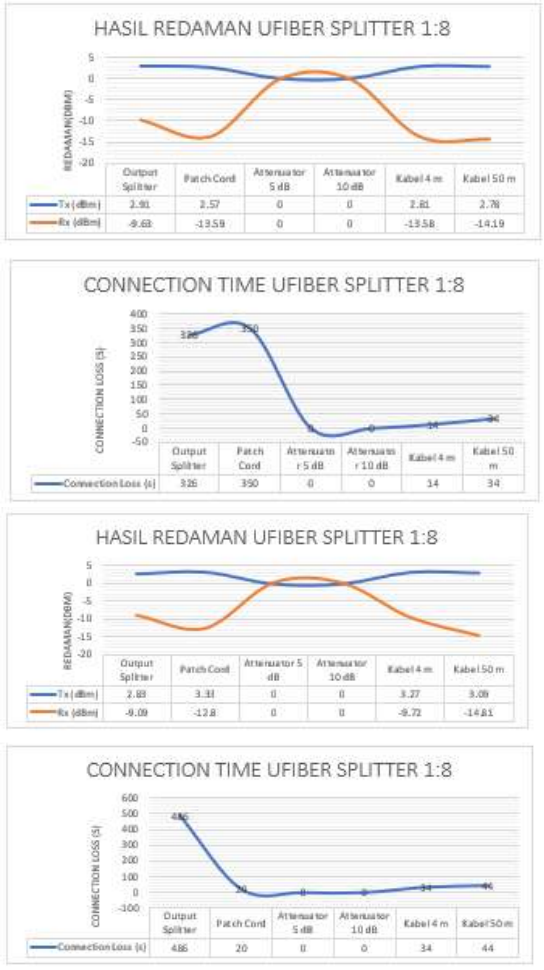


Fig 10. Results of Attenuation and Connection Loss on UFiber System with 1:8 splitter

In the UFiber system, the attenuation obtained at Tx and Rx is in accordance with the UFiber ONT standard. Meanwhile, for the 5 dB and 10 dB attenuators, this is because the SFP is not matched even though the attenuation is still in accordance with the UFiber ONT standard, but the device is not up (connected to the system). Connection Time is the time the device or ONT is connected to the system that is on the OLT.

3.3.8 Spliter 1:16

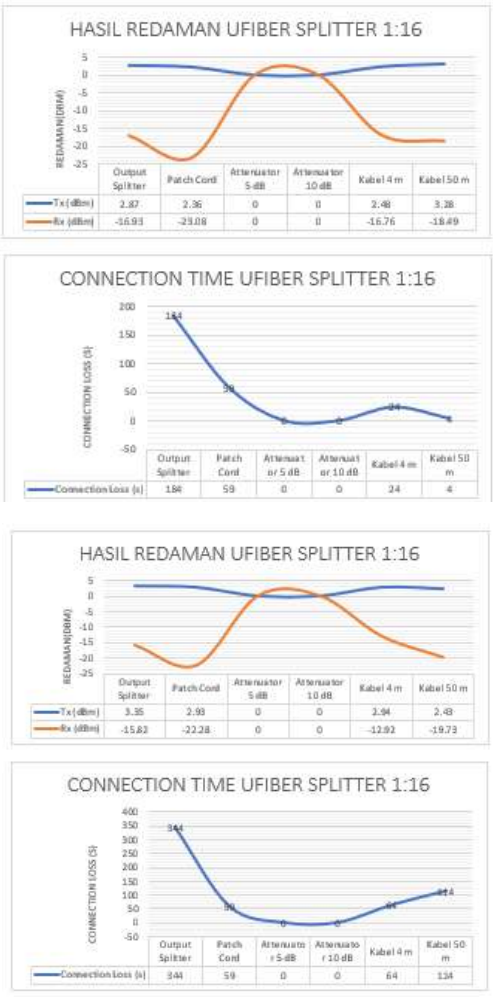


Fig 11. Results of Attenuation and Connection Loss on UFiber System with 1:16 splitter

In the UFiber system, the attenuation obtained at Tx and Rx is in accordance with the UFiber ONT standard. Meanwhile, for the 5 dB and 10 dB attenuators, this is because the SFP is not matched even though the attenuation is still in accordance with the UFiber ONT standard, but the device is not up (connected to the system). Connection Time is the time the device or ONT is connected to the system that is on the OLT.

The difference between dB and dBm is only in units, dB is the unit used to express the relative difference in signal strength. The decibel (dB) is expressed as the base 10 logarithm of the ratio of the power of the two signals. While dBm is a unit of Decibels in Milliwatts.
The first experiment got the output – 13.02 dBm (upstream) and -12.66dBm (downstream). The ONT can be up (detected in the system) and the attenuation value is in accordance with the ITU-T standard.

4. Conclusion

Based on the results of the design and testing that has been done, it can be concluded that the FTTH Network Analysis in Fiber Optic Learning at the Telecommunications Laboratory of the Semarang State Polytechnic. The following conclusions are drawn, namely:

1. The prototype of the fiber to the home network uses Ubiquiti UFiber OLT which is connected to the proxy server so that it can be used as material for making attenuation and power jobsheets.
2. Segment VLAN is a solution that is used to connect between ONTs on 1 OLT so that they can be connected to each other in a prototype fiber to the home network that is designed.
3. The practicum jobsheet is the realization of making a prototype that will be used as a support for fiber optic courses.
4. This practicum jobsheet consists of objectives, theoretical basis, tools and materials, circuit diagrams, experimental steps, worksheets, and questions and assignments. The key jobsheet consists of experimental results, answers to questions, analysis and conclusions.
5. Testing the prototype consists of measuring the power and attenuation that has been made on the jobsheet and the key to the jobsheet.
6. In power measurement, it consists of input power and output power as well as the total power produced by each splitter used, namely 1:2, 1:4, 1:8, and 1:16 splitters. The resulting input power is -01.13 dBm and after calculating theoretically the total power produced is a 1:2 splitter with a value of -0.85 dB, a 1:4 splitter with a value of 1.38 dB, a 1:8 splitter with a value of 4 .55 dBand on a 1:16 splitter with a value of 11.89 dB.
7. Attenuation measurements when using the 5 dB and 10 dB attenuators get attenuation beyond the standard set by ITU-T, this causes the ONT to not be detected on the U-Fiber system besides that due to the use of SFP that is not in accordance with the UFiber OLT, the SFP used is the Warex brand which is usually used on Switch (ASR, Zyxel, and BDCOM).
8. In the measurement, the resulting attenuation is less than the attenuation standard causing the ont not to be up (not connected to the system). And when the attenuation value exceeds the standard, the ONT is still up (connected to the system) the network condition is still stable, but due to the high attenuation and not in accordance with the standard, it causes damage to the ONT when it is installed in the customer's house.

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