Comparative Analysis of Fiber Optic Networks Using Converter Devices with Splitters and Without Splitters in AI Building Malang State Polytechnic

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***Abstract*— A converter device is a tool for connecting copper cable network devices with fiber optic networks. This research uses a one to two splitter that connects two devices through one dropcore cable, this can reduce installation and maintenance costs. Testing in this study was carried out by measuring the power in the circuit using OPM and network speed using OpenSpeedTest software. The final result of this research is the loss calculation value and local network speed. The use of a converter device with a one to two splitter produces a loss value between 0.46 dB until 2.76 dB, while the use of a converter device without a splitter produces a loss value between 0.15 dB until 0.6 dB. The local network speed of using a converter device with a splitter shows an average PC 1 download parameter of 977.6 Mbps and 983 Mbps upload, as well as PC 2 with 977 Mbps download and 985.6 Mbps upload. While the use of a converter device without a splitter shows an average PC 1 download parameter of 977.6 Mbps and upload of 994.1 Mbps, as well as PC 2 with a download of 976.6 Mbps and upload of 995.9 Mbps.**

***Keywords*— Converter Device, Loss, Network Speed, OpenSpeedTest, Splitter.**

I. INTRODUCTION

Telecommunications has become a fundamental aspect of modern life, serving as a critical enabler for the access, exchange, and dissemination of information [1]. Its importance is evident from the pervasive presence of networks in nearly every environment, designed to facilitate seamless communication between individuals, organizations, and devices. Traditional copper-based technologies, which have long been employed in telecommunication access networks, are increasingly facing limitations in meeting the growing demand for higher data throughput. These constraints have spurred the development and adoption of alternative technologies capable of supporting modern data-intensive applications [2]. One widely utilized solution is the Unshielded Twisted Pair (UTP) cable, commonly implemented as a LAN (Local Area Network) network cable in computer networking systems [3].

With the ever-increasing demand for higher data transmission rates, optical fiber technology has emerged as the preferred medium for modern telecommunication networks [4]. Optical fiber offers significant advantages over copper, primarily due to its superior data transmission speed, greater bandwidth capacity, and reduced signal attenuation over long distances [5]. Additionally, optical fiber allows for more efficient data handling and higher overall network reliability [6].

These advantages have made optical fiber the primary choice for upgrading or replacing legacy copper infrastructure in access, metro, and backbone networks. A critical component in bridging UTP-based networks with optical fiber networks is the media converter. A media converter is a network device designed to convert electrical signals carried over UTP cables into optical signals suitable for fiber optic transmission, and vice versa [7].

Typically, each converter requires a dedicated optical fiber connection and an independent power source for operation. However, this research explores an innovative approach by implementing a 1:2 optical splitter to connect multiple media converters simultaneously. The use of such splitters offers the potential for significant cost savings by reducing the amount of dropcore fiber required. Splitters operate by dividing a single optical signal into multiple outputs or combining multiple signals into a single pathway [8], thereby optimizing the utilization of optical fiber infrastructure.

By integrating a 1:2 splitter within a converter configuration, this study seeks to assess the impact on network efficiency[9], cost-effectiveness [10]-12], and system reliability[13]-[15]. This approach is anticipated to reduce installation and maintenance expenses by minimizing the need for additional fiber connections while maintaining acceptable signal quality across all endpoints. Moreover, this research aims to provide a comprehensive evaluation of the potential challenges and technical considerations associated with using splitters in media converter configurations, including signal loss, bandwidth sharing, and the effects on overall network performance. The findings are expected to contribute to a deeper understanding of best practices for deploying optical fiber networks in scenarios where multiple devices must be

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connected cost-effectively without compromising the quality of service.

II. METHOD

A. Stages of Research

In the research design, the author will describe the steps to be carried out in this study which are shown in Figure 1.

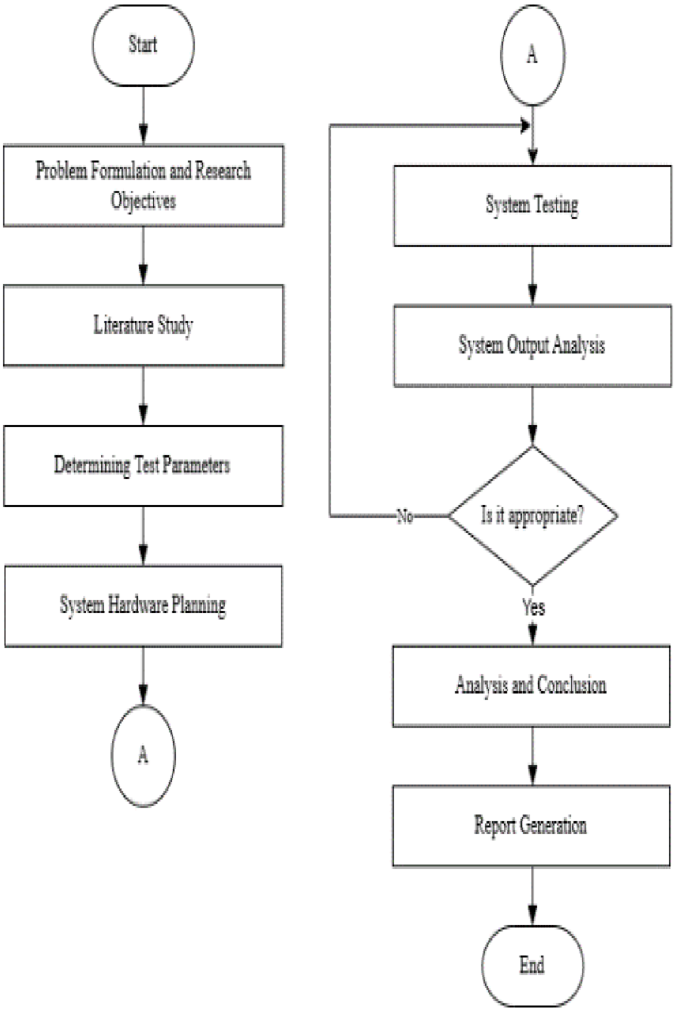

Figure 1. Research stages

Fig. 1 is the stages of the research, the first stage is to formulate the problem as well as the objectives of the research, where the problem identification and its limitations are carried out in order to focus on the formulation of the problem and objectives. The second stage involves a literature study by collecting references that support the research. In the third stage, the test parameters, namely power loss and local network speed, were determined. The fourth stage includes designing the system hardware, using converter devices connected with and without splitters.

The fifth stage is system testing to prepare for data collection. Furthermore, the sixth stage analyzes the data by reviewing it based on the data obtained. The seventh stage involves drawing conclusions from the analysis results. Finally, the eighth stage is the preparation of the research report after the data and analysis have been collected.

B. System Design

1) Scheme Of Experimental Design 1: This experiment uses two single gigabit converter devices as inputs which are divided into two parts. In the first part, the single gigabit converter A device is connected with two single gigabit converter B devices. Conversely, the single gigabit converter B device is connected with two single gigabit converter A devices into an optical signal. Furthermore, the single gigabit converter will be connected using a patchcord cable and divided using a 1:2 splitter to connect the converter devices.

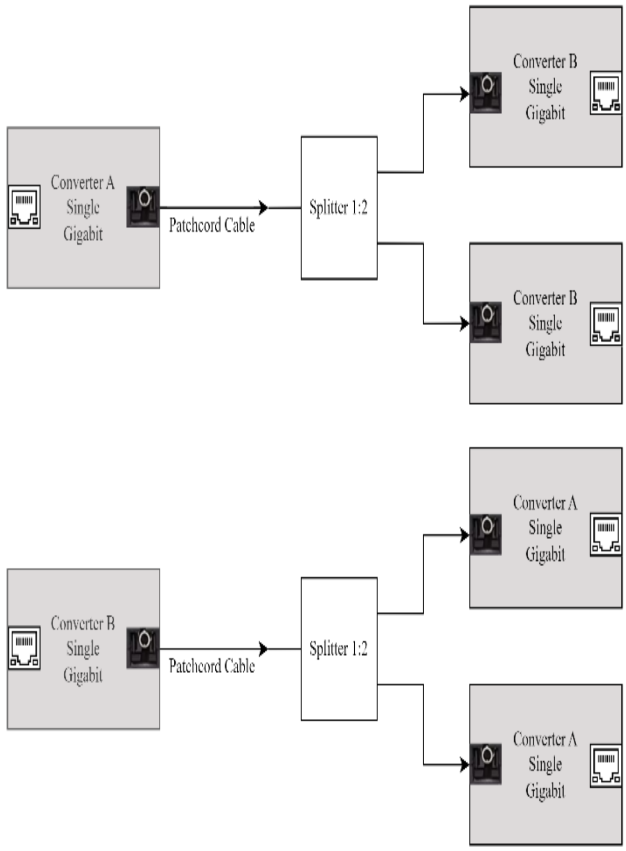

Figure 2. Scheme Of Experimental Design 1

Fig. 2 shows the circuit of experiment 1 which aims to analyze the use of the converter by connecting one converter device with two other converter devices in one circuit using a 1:2 splitter.

2) Scheme Of Experimental Design 2: The working system for Experiment 2 involves a gigabit converter circuit that incorporates the use of an optical splitter to optimize fiber utilization. The system begins with four single gigabit converter devices as the input sources. These devices are organized into two groups, with each group consisting of two single gigabit converters. The outputs from these converters are transformed into optical signals by the converters themselves.

Once converted, the optical signals are transmitted via patchcord cables to a 1:2 optical splitter. The splitter functions to divide each input optical signal into two separate output signals, enabling a single optical fiber path to serve multiple destinations. From the splitter, the divided optical signals are carried through a 250-meter-long dropcore fiber cable to their respective endpoints.

This experimental setup is designed to test the feasibility and performance of connecting multiple gigabit converters using a single splitter while minimizing the amount of fiber optic cabling required. The design allows for evaluating potential signal degradation, bandwidth sharing, and overall network reliability when multiple devices share a single fiber path. By using this configuration, the experiment aims to demonstrate the effectiveness of splitter integration in reducing installation costs and optimizing network resources without significantly impacting data transmission quality.

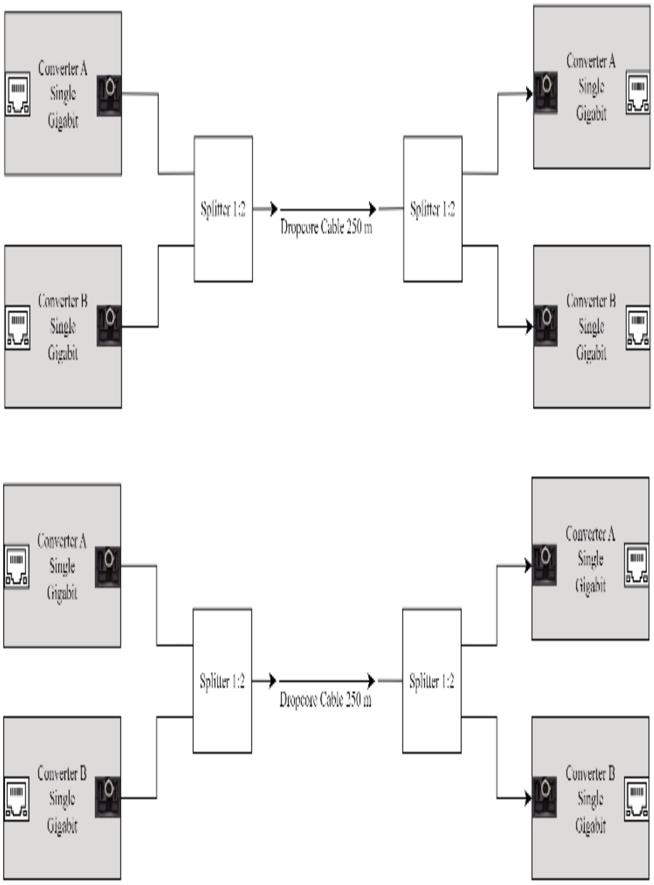

Figure 3. Scheme Of Experimental Design 2

Fig. 3 illustrates the experimental setup for Experiment 2, which is designed to minimize the use of dropcore cables. By incorporating a 1:2 optical splitter, the system reduces the number of dropcore cables required from four to only two, while still maintaining proper data transmission between the gigabit converter devices and their endpoints. This configuration demonstrates how splitter integration can optimize fiber usage and reduce overall installation costs without compromising network performance.

3) Scheme Of Experimental Design 3: Experiment 3 is conducted to evaluate and compare the performance of a converter system that uses an optical splitter against an alternative configuration. The experimental setup for this design will be shown in Fig. 4, which depicts the arrangement of converters, splitters, patchcords, and dropcore cables. The comparison aims to analyze the differences in signal integrity, bandwidth efficiency, and overall system reliability between the splitter-based configuration and the standard approach without splitters.

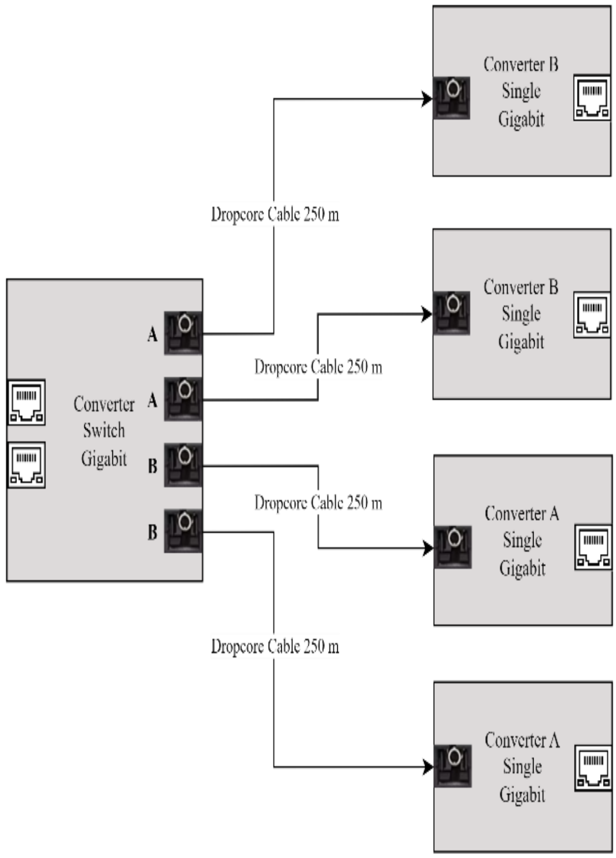

Figure 4. Scheme Of Experimental Design 3

The working system of experiment 3 consists of a gigabit switch converter circuit without a splitter. Where from the input using one gigabit switch converter device which has 4 fiber optic ports and 2 LAN ports which are connected to four single gigabit converter devices into optical signals. Then the gigabit switch converter device will be connected using a dropcore cable with a length of 250 meters.

C. Literature Review

Measurement of test parameters in this study using Optical Power Meter to determine the power obtained and

OpenSpeedTest software to determine the speed of data transmission on the network between the use of converter devices with Splitter and Without Splitter. Here are some basic theories that support this study.

1) *Optical Power Meter*

OPM is used to measure the power emitted, namely measuring the attenuation of the optical fiber that is running [9]. The way OPM works can be seen from the value of the input power emitted and the value of the output power received by OPM with units of dBm (Decibell milliwatt) because the data taken represents power units in algorithmic units [10].

2) *OpenSpeedTest*

An application designed to test any connection from 1 Kbps to 1 Gbps. The algorithm automatically detects stable download and upload speeds from the server. OpenSpeedTest internet speed test is the connection speed between the client and the connected server, the final hail will be the average value of the fastest burst download upload speed over the bandwidth [11].

3) *Attenuation*

The performance and quality of fiber optic systems are affected by several things including attenuation, dispersion, microbending, absorption and so on. An attenuation that appears in the fiber optic system can reduce the performance and transmission quality of the fiber optic cable. This phenomenon causes a decrease in the voltage level of the signal received at the end of the cable due to the characteristics of the medium used [12]. Attenuation is the decrease in the voltage level of the received signal due to the characteristics of the media. If the system performance is below standard, it causes less information to reach the receiver or even the loss of the transmitted information signal [13].

4) *Decibel (dB)*

Decibel (dB) is a unit used to express the relative difference in signal strength. The decibel is expressed as the base 10 logarithm of the power ratio of two signals, as shown below [14] :

$$dB=10 \times \log_{10}\left(\frac{P_1}{P_2}\right) \quad (1)$$

Where $\log_{10}$ is the 10-based logarithm, P_1 and P_2 are the powers being compared.

5) *Loss*

The optical power that arrives depends on the number plus the fiber and minus the losses along the way, the link loss budget is the loss of each element in the link. The link loss budget equation is calculated in Equation 1 as follows [15].

$$\text{Loss (dB)}=P_{in}\text{ (dBm)} - P_{out}\text{ (dBm)} \quad (2)$$

$$P_{\Gamma} = P_s - P_r$$

Description :

P_{Γ} = Optical power transmit/total loss (dB)

P_s = Optical power source (dBm)

P_r = Optical power receiver/minimum receiver sensitivity (dBm)

III. RESULTS AND DISCUSSION

A. Device Set Results

1) Experiment Result 1

This experiment will show the results of the experiment 1 circuit using one single gigabit converter device connected to two single gigabit converter devices using a 1:2 splitter which is divided into two parts as shown in Fig. 5.

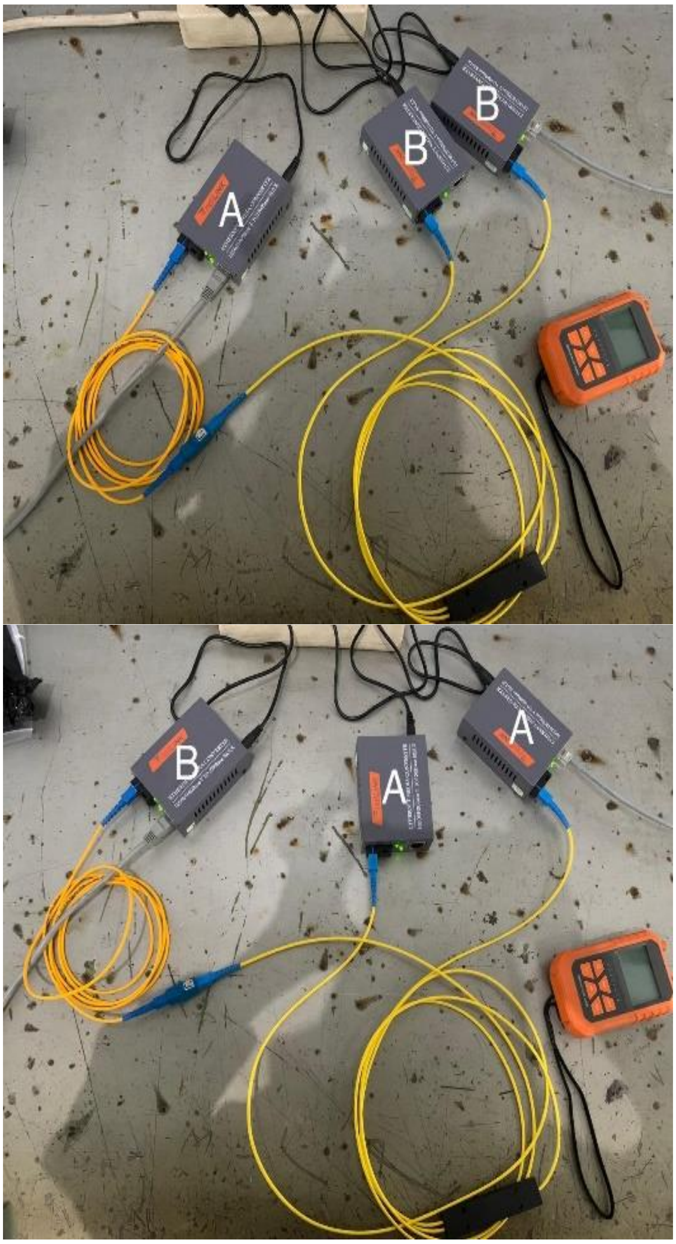

Figure 5. Experiment 1 circuit

2) Experiment Result 2

Fig. 6 shows the results of the experiment 2 circuit using two single gigabit converter devices connected to two single gigabit converter devices using a 1: 2 splitter and a 250 meter dropcore cable which is divided into two parts.

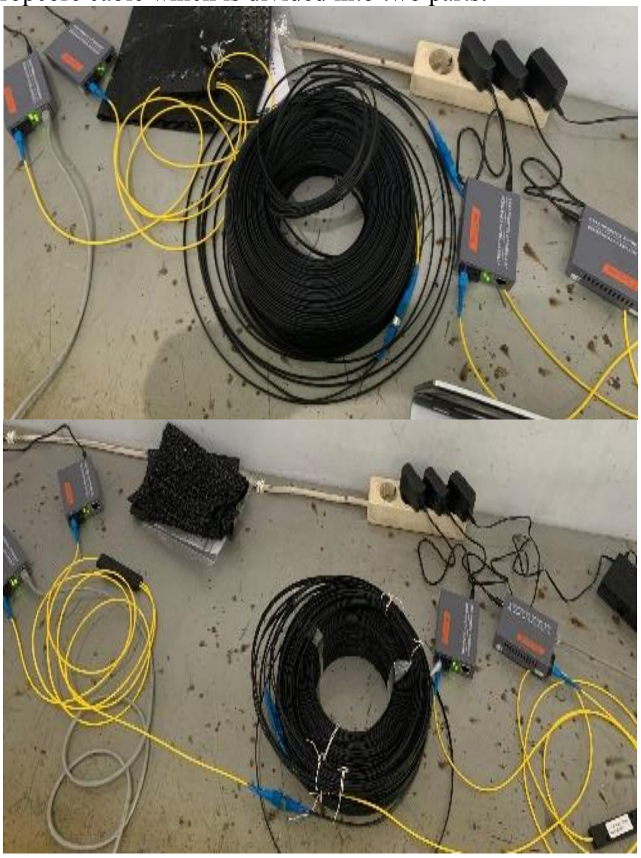

Figure 6. Experiment 2 Circuit

3) *Experiment Result 3*

Fig. 7 shows the circuit results of experiment 3 using a gigabit switch converter device connected to four single gigabit converter devices without using a splitter.

Figure 7. Experiment 3 Circuit

B. *Power Measurement using Optical Power Meter (OPM)*

1) *Measuring Power in Experiment 1*

The measurement results in Experiment 1 with the measured parameters are loss - loss will be discussed in this sub chapter. The type of cable used in the measurement is a Patchcord cable with a length of 2 meters and a 1:2 splitter.

The following are the results of power measurements using OPM in Experiment 1.

TABLE I
POWER DATA COLLECTION USING OPM IN EXPERIMENT 1

Component Name	**Test point (dBm)**		
	TP 1	**TP 2**	**TP 3**
Converter B1 *Single Gigabit* (1550)	-5,36	-1,67	-6,71
Converter B2 *Single Gigabit* (1550)	-5,36	-1,67	-6,54
Converter A1 *Single Gigabit* (1310)	-6,41	-2	-6,92
Converter A2 *Single Gigabit* (1310)	-6,41	-2	-6,87

Table 1 obtained the power value to calculate the loss value using Equation (1.2). Then the loss value in Experiment 1 can be seen in the calculation below :

a. *Converter B1 Single Gigabit (1550)*
Unknown : TP 1 = -5,36 dBm
TP 2 = -1,67 dBm
TP 3 = -6,71 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -5,36 dBm - (-1,67 dBm)
= -3,69 dB
Loss (dB) = TP 2 – TP 3
= -1,67 dBm - (-6,71 dBm)
= 5,04 dB
Total Loss = -3,69 dB + 5,04 dB
= 1,35 dB

b. *Converter B2 Single Gigabit (1550)*
Unknown : TP 1 = -5,36 dBm
TP 2 = -1,67 dBm
TP 3 = -6,54 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -5,36 dBm - (-1,67 dBm)
= -3,69 dB
Loss (dB) = TP 2 – TP 3
= -1,67 dBm - (-6,54 dBm)
= 4,87 dB
Total Loss = -3,69 dB + 4,87 dB
= 1,18 dB

c. *Converter A1 Single Gigabit (1310)*
Unknown : TP 1 = -6,41 dBm
TP 2 = -2 dBm
TP 3 = -6,92 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -6,41 dBm - (-2 dBm)
= -4,41 dB

Loss (dB) = TP 2 – TP 3
= -2 dBm - (-6,92 dBm)
= 4,92 dB
Total Loss = -4,41 dB + 4,92 dB
= 0,51 dB

d. *Converter A2 Single Gigabit (1310)*
Unknown : TP 1 = -6,41 dBm
TP 2 = -2 dBm
TP 3 = -6,87 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -6,41 dBm - (-2 dBm)
= -4,41 dB
Loss (dB) = TP 2 – TP 3
= -2 dBm - (-6,87 dBm)
= 4,87 dB
Total Loss = -4,41 dB + 4,87 dB
= 0,46 dB

The calculated values for the losses in Experiment 1 are shown in Table 2 as follows.

TABLE II
LOSS CALCULATION VALUE IN EXPERIMENT 1

Component Name	Total Loss (dB)
Converter B1 *Single Gigabit* (1550)	1,35
Converter B2 *Single Gigabit* (1550)	1,18
Converter A1 *Single Gigabit* (1310)	0,51
Converter A2 *Single Gigabit* (1310)	0,46

2) Measuring Power in Experiment 2

The measurement results in Experiment 2 with the measured parameters are loss - loss will be discussed in this sub chapter. The type of cable used in the measurement is a dropcore cable with a length of 250 meters and a 1:2 splitter.

The following are the results of power measurements using OPM in Experiment 2.

TABLE III
POWER DATA COLLECTION USING OPM IN EXPERIMENT 2

Component Name	Test point (dBm)			
	TP 1	TP 2	TP 3	TP 4
Converter A1 *Single Gigabit* (1310)	-6,33	-4,51	-5,83	-8,03
Converter B1 *Single Gigabit* (1550)	-7,43	-5,93	-6,4	-10,19
Converter A2 *Single Gigabit* (1310)	-7,99	-3,2	-4,74	-10,29
Converter B2 *Single Gigabit* (1550)	-9,59	-3,8	-6,07	-11,72

Table 3 obtained the power value to calculate the loss value using Equation (1.2). Then the loss value in Experiment 2 can be seen in the calculation below :

a. *Converter A1 Single Gigabit (1310)*
Unknown : TP 1 = -6,33 dBm
TP 2 = -4,51 dBm
TP 3 = -5,83 dBm
TP 4 = -8,03 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -6,33 dBm - (-4,51 dBm)
= -1,82 dB
Loss (dB) = TP 2 – TP 3
= -4,51 dBm - (-5,83 dBm)
= 1,32 dB
Loss (dB) = TP 3 – TP 4
= -5,83 dBm - (-8,03 dBm)
= 2,2 dB
Total Loss = -1,82 dB + 1,32 dB + 2,2 dB
= 1,7 dB

b. *Converter B1 Single Gigabit (1550)*
Unknown : TP 1 = -7,43 dBm
TP 2 = -5,93 dBm
TP 3 = -6,4 dBm
TP 4 = -10,19 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -7,43 dBm - (-5,93 dBm)
= -1,5 dB
Loss (dB) = TP 2 – TP 3
= -5,93 dBm - (-6,4 dBm)
= 0,47 dB
Loss (dB) = TP 3 – TP 4
= -6,4 dBm - (-10,19 dBm)
= 3,79 dB
Total Loss = -1,5 dB + 0,47 dB + 3,79 dB
= 2,76 dB

c. *Converter A2 Single Gigabit (1310)*
Unknown : TP 1 = -7,79 dBm
TP 2 = -3,2 dBm
TP 3 = -4,74 dBm
TP 4 = -10,29 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -7,79 dBm - (-3,2 dBm)
= -4,59 dB
Loss (dB) = TP 2 – TP 3
= -3,2 dBm - (-4,74 dBm)
= 1,54 dB
Loss (dB) = TP 3 – TP 4
= -4,74 dBm - (-10,29 dBm)
= 5,55 dB
Total Loss = -4,59 dB + 1,54 dB + 5,55 dB
= 2,5 dB

d. *Converter B2 Single Gigabit (1550)*
Unknown : TP 1 = -9,59 dBm
TP 2 = -3,8 dBm
TP 3 = -6,07 dBm
TP 4 = -11,72 dBm
Calculations :

Loss (dB) = TP 1 – TP 2
= -9,59 dBm - (-3,8 dBm)
= -5,79 dB
Loss (dB) = TP 2 – TP 3
= -3,8 dBm - (-6,07 dBm)
= 2,27 dB
Loss (dB) = TP 3 – TP 4
= -6,07 dBm - (-11,72 dBm)
= 5,65 dB
Total Loss = -5,79 dB + 2,27 dB + 5,65 dB
= 2,13 dB

The calculated values for losses in Experiment 2 are shown in Table 4 as follows.

TABLE IV
LOSS CALCULATION VALUE IN EXPERIMENT 2

Component Name	Total *Loss* (dB)
Converter A1 *Single Gigabit* (1310)	1,7
Converter B1 *Single Gigabit* (1550)	2,76
Converter A2 *Single Gigabit* (1310)	2,5
Converter B2 *Single Gigabit* (1550)	2,13

3) Measuring Power in Experiment 3

The measurement results in Experiment 3 with the measured parameters are loss - loss will be discussed in this sub chapter. The type of cable used in the measurement is a dropcore cable with a length of 250 meters.

The following are the results of power measurements using OPM in Experiment 3.

TABLE V
POWER DATA COLLECTION USING OPM IN EXPERIMENT 3

Component Name	Test point (dBm)	
	TP 1	TP 2
Converter A1 *Switch Gigabit* (1310)	-2,29	-2,77
Converter A2 *Switch Gigabit* (1310)	-2,04	-2,64
Converter B1 *Switch Gigabit* (1550)	-3.18	-3,7
Converter B2 *Switch Gigabit* (1550)	-4,6	-4,75

Table 5 obtained the power value to calculate the loss value using Equation (1.2). Then the loss value in Experiment 3 can be seen in the calculation below :

a. *Converter A1 Switch Gigabit (1310)*
Unknown : TP 1 = -2,29 dBm
TP 2 = -2,77 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -2,29 dBm - (-2,77 dBm)
= 0,48 dB

b. *Converter A2 Switch Gigabit (1310)*
Unknown : TP 1 = -2,04 dBm
TP 2 = -2,64 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -2,04 dBm - (-2,64 dBm)
= 0,6 dB

c. *Converter B1 Switch Gigabit (1550)*
Unknown : TP 1 = -3,18 dBm
TP 2 = -3,7 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -3,18 dBm - (-3,7 dBm)
= 0,52 dB

d. *Converter B2 Switch Gigabit (1550)*
Unknown : TP 1 = -4,6 dBm
TP 2 = -4,75 dBm
Calculations :
Loss (dB) = TP 1 – TP 2
= -4,6 dBm - (-4,75 dBm)
= 0,15 dB

The calculated values for losses in Experiment 3 are shown in Table 6 as follows.

TABLE VI
LOSS CALCULATION VALUE IN EXPERIMENT 3

Component Name	Total *Loss* (dB)
Converter A1 *Switch Gigabit* (1310)	0,48
Converter A2 *Switch Gigabit* (1310)	0,6
Converter B1 *Switch Gigabit* (1550)	0,52
Converter B2 *Switch Gigabit* (1550)	0,15

C. Local Network Speed Testing Results

1) Local Network Speed Testing Results on Experiment 1

The network speed testing in Experiment 1 was conducted using the Command Prompt (CMD) on a laptop by executing the ping command to assess connectivity and latency between devices. This setup was designed to distribute the network signal efficiently through a 1:2 splitter, which divides the optical signal into multiple paths. However, the test results indicated that no connection could be established between the devices. The ping test confirmed that the devices were unable to communicate, likely due to improper signal distribution or degradation in signal quality caused by the splitter, which may have attenuated the signal beyond acceptable levels. Fig. 8 provides a detailed view of the network connection setup, while Fig. 9 illustrates the network connectivity testing process, highlighting the failure of device interconnection under this configuration. These results demonstrate that, although the system was designed to optimize signal distribution, the specific configuration in Experiment 1 was insufficient to maintain a stable and functional network connection, emphasizing the need to carefully consider splitter placement, signal strength, and device compatibility in fiber optic network designs. This finding also suggests that additional testing and adjustments are necessary to ensure reliable connectivity when implementing splitters in practical network setups.

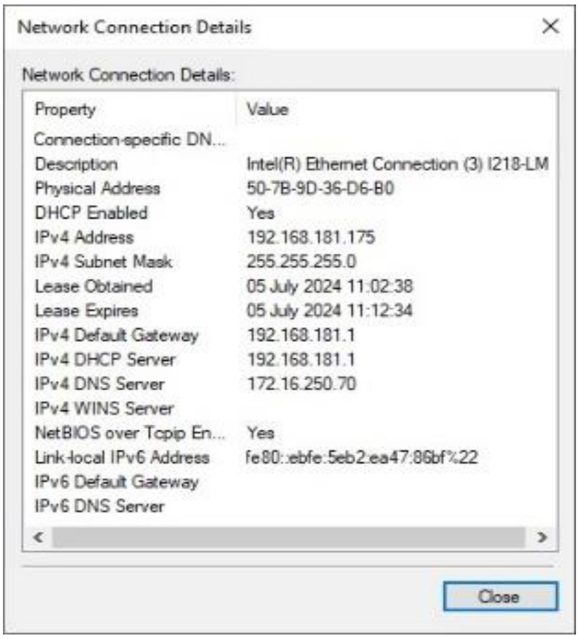

Figure 8. Network Connection Details

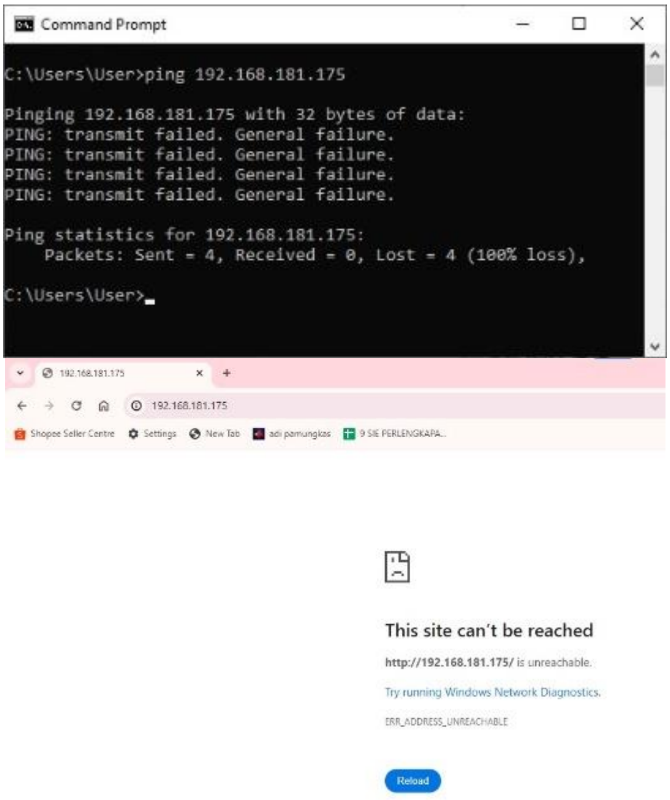

Figure 9. Network Connectivity Testing

2) Local Network Speed Testing Results on Experiment 2

Experiment 2 used four single gigabit converter devices as both input and output using a 1:2 splitter. The results of this experiment were different from the first, as all devices were successfully connected to the network. Network speed testing using OpenSpeedTest software was carried out 3 times, the data is stated in Table 7.

TABLE VII
NETWORK SPEED TEST RESULTS EXPERIMENT 2

Ip 192.168.181.xxx pada PC 1			
Testing To-	**1**	**2**	**3**
Download	978,9 Mbps	974,5 Mbps	979,4 Mbps
Upload	970,5 Mbps	994,5 Mbps	984,1 Mbps
Ip 192.168.181.xxx pada PC 2			
Download	975,8 Mbps	978,1 Mbps	977,1 Mbps
Upload	983,5 Mbps	983,9 Mbps	989,4 Mbps

The use of splitters in Experiment 1 and Experiment 2 shows that these devices can minimize the use of dropcore cables. With a 1:2 splitter, one fiber optic line can be divided into two lines which reduces the need for dropcore cables. However, only in Experiment 2 did this configuration successfully connect to the network, suggesting that a larger number of inputs helps in more effective signal distribution.

3) Local Network Speed Testing Results on Experiment 3

In Experiment 3, one gigabit converter switch device was used which has two LAN ports and four fiber optic ports. This configuration was successfully connected to the network. Network speed testing using OpenSpeedTest software was carried out 3 times, the data is stated in Table 8.

TABLE VIII
NETWORK SPEED TEST RESULTS EXPERIMENT 2

Ip 192.168.181.xxx pada PC 1			
Testing To-	**1**	**2**	**3**
Download	977,1 Mbps	977,5 Mbps	978,3 Mbps
Upload	988,4 Mbps	1010,8 Mbps	983,0 Mbps
Ip 192.168.181.xxx pada PC 2			
Download	974,6 Mbps	977,6 Mbps	977,8 Mbps
Upload	993,2 Mbps	985,1 Mbps	1009,4 Mbps

In Experiment 3, which did not use a splitter, the dropcore cable line could only be used for one converter device. However, the resulting network was better and more stable.This shows that although the use of splitters can reduce the number of cables required, the quality and stability of the connection is more assured with the use of dropcore cables that do not split the signal.

IV. CONCLUSION

The loss calculation results in Experiment 1, Experiment 2, and Experiment 3 show that although there are variations in the measured loss values, the difference between using a splitter and no splitter does not show a significant effect on the overall performance of the converter device.The results of the local network performance comparison in Experiment 1 showed that the use of a splitter did not successfully connect to the network, due to the degradation of signal quality due to its use. Dividing the input signal into two, which can reduce the signal strength received by each output converter. This decrease in signal quality can cause both output converters to not be able to receive a strong enough signal to function properly, whereas in Trial 2 and Trial 3 it successfully resulted in a stable connection.

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