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Manufacturing A Fiber Optic Based Trainer Module Using The Star Topology Method Using Optical Distribution Point (Odp) And Optical Termination Box (Otb)

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ABSTRACT

Optical fiber is a transmission medium made from glass that is used to transmit information in the form of light. As time goes by, the need for fast telecommunications services in data exchange is increasing. However, there are problems with optical fibers such as high attenuation or connection errors that interfere with performance. In this final project, a trainer module was designed regarding splicing and measuring fiber attenuation to help students understand how to connect optics properly and correctly. This module uses devices such as ODP and OTB which are connected to each other. The research results show that the highest attenuation measured was 20.15 dB, while the lowest attenuation value was 0.29 dB. Attenuation corresponding to the calculated link budget of 1.7605 dB indicates good results, while high attenuation indicates poor quality.

INTRODUCTION

The need for telecommunications services continues to grow rapidly for the exchange of data and information that is useful in progressing various social aspects of communication, not just voice, but data and also video. So triple play services such as voice, video and data require large bandwidth and high speed internet access. This should increase signal quality, coverage area, access time, and also user data security. In the telecommunications system there are several transmission media networks, one of which is a transmission media network using copper, but currently the transmission media network using copper is not yet able to accommodate the desired bandwidth capacity because copper has a speed of up to 1 Gbps, so previously the transmission media network was used. Using copper has now been migrated to transmission media networks using fiber optics which have speeds ranging from 1 Gbps to 100 Gpbs or more.

Optical fibers are made of very fine glass or plastic and are smaller with a diameter of approximately 120 mm which can be used to transmit light signals originating from lasers or Light Emitting Diodes (LED). This technology is the most effective data sending medium, has low levels of data loss and interference, and high bandwidth. According to (Zukri, 2022) Fiber optic transmission media also requires several additional devices, one of which is

Optical Access Network (OAN) technology or Fiber Optic Access Local Network (JARLOKAF) is an access network that uses optical fiber in its implementation. There are several types of local network topology, one of which is Star Topology, where there is a central connection called a hub. A hub is a server connected to each node. The catch is that if the hub fails, the entire system will shut down. (According to Fachrid, 2023) Star topology is the most effective for transferring large amounts of data at high speed and maintaining good signal quality, but star topology requires a fairly large number of optical fibers and is complex to implement over a large area.

Humans as technology users must be able to utilize current technology and subsequent technological developments. According to (Khomsatun, 2019) Technology and Education are able to develop together along with the arrival of the new generation. The application of learning media required is getting to know technology in a practical skills program, using learning media tools that are useful for students in understanding the material in depth. The media for the practical skills learning program is a fiber optic-based trainer module which is one of the potentials that students can use to become familiar with developments in installation technology. According to experts, the feasibility level of trainer module learning media has a potential of 88.33% in the "very feasible" category and the use of trainer modules influences understanding, influences attitudes, and also influences skills.

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LITERATURE REVIEW

Based on several journals that have been read and used as references in making this proposal, in this final assignment we will design a fiber optic trainer module using the star topology method, so that we can understand how to connect and the function of each device in designing the installation.

Based on this research, the author wants to create and develop a Final Assignment based on a fiber optic trainer module that can be used for student training or practice in the Fiber Optic Communication Systems (SKSO) course. Therefore, the title of this Final Assignment is "Design of a Fiber Optic Based Trainer Module "With the Star Topology Method Using Optical Distribution Point (ODP) and Optical Termination Box (OTB)," it is hoped that this Final Assignment can be used as a learning medium for other students and can fulfill the competencies of Padang State Polytechnic Telecommunication Engineering students related to the Fiber Optic field.

- Redaman Total

  $a_{total} = PTx - Rx$ ....(1)
- *Power Link Budget*

  $a_{total} = L.a_{serat} + N_c . a_c + N_s . a_s + N_a . a_a$ ....(2)
- *Power Link Budget* pada *Patchcord*

  $a_{total} = L.a_{serat} + N_c . a_c + N_s . a_s + N_a . a_a$ *Loss patchcord* ....(3)

METHOD

The process stages that will be carried out in this research can be depicted in the following diagram:

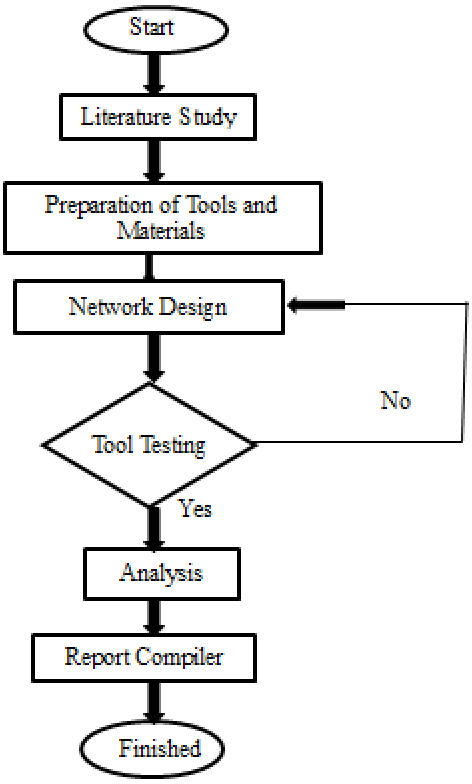

Figure 1. Design Flow

Before making the Final Assignment, the first step taken is to conduct a literature study which functions as a method for collecting theoretical reference data that is relevant to the cases or problems found. At this stage, a search is carried out in journals, theses or Final Assignments related to the title that will be appointed. This literature study was carried out by researchers after determining the research topic and establishing a formulation. After conducting a literature study, namely designing the block diagram that will be built. Then prepare tools and materials for design and

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manufacture/design tools according to the topology in previous research according to literature studies. After that, testing was carried out on the star topology network design. Measurements are carried out to see whether the power value and total attenuation value are in accordance with the power link budget calculation. Measurements were carried out to see whether network performance complies with the standards set by ITU-T G984 and PT Telekomunikasi.

RESULT

Measurements in star topology designs aim to obtain link budget measurement results and also ensure that the design is made in accordance with standards. The measuring instruments used are Optical Power Meter (OPM) and Handled Light Source (HLS).

Calibration results

There are two ways of measuring, namely:

1. One-on-one measurement method from OTB to each ODP
2. The measurement method is in line from OTB to each ODP

It can be seen in table 1 and table 2, namely the calibration results obtained before taking measurements.

Table 1. Results of one-on-one measurement calibration from OTB to each ODP

$\Lambda\ (nm)$	Test	Power Value (dBm)
1310	1	-7.13
	2	-7.14
	3	-7.13

Table 2. The measurement calibration results are in line from OTB to each ODP

$\Lambda\ (nm)$	Test	Power Value (dBm)
1310	1	- 7.42
	2	-7.52
	3	-7.52

Measurement results

Table 3. Combining Measurement Results from OTB to each ODP

No.	Measurement	Port	PTx (dBm)	PRx (dBm)	Attenuation (dB)
1.	OTB – ODP E	1	-7.13	-12.72	5.59
		2	-7.13	-8.12	0.99
		3	-7.13	-7.62	0.49
		4	-7.13	-13.73	6.6
2.	ODP E – ODP B	1	-7.13	-8.22	1.09
		2	-7.13	-9.92	2.79
		PC	-7.13	-8.05	0.92
3.	ODP B – ODP C	1	-7.13	-7.91	0.78
		2	-7.13	-7.95	0.82
		PC	-7.13	-7.42	0.29
4.	ODP C – ODP D	1	-7.13	-8.69	1.56
		2	-7.13	-9.81	2.68
		PC	-7.13	-7.47	0.34
5.	ODP D – ODP A	1	-7.13	-7.58	0.45
		2	-7.13	-10.17	3.04
		PC	-7.13	-7.58	0.45
6.	ODP A – ODP E	1	-7.13	-8.78	1.65
		2	-7.13	-8.91	1.78
		PC	-7.13	-7.83	0.7

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Tabel 4. Combination of Measurement Results in line from OTB to each ODP

No.	Measurement	Port	PTx (dBm)	PRx (dBm)	Attenuation (dB)
1.	OTB – ODP E	1	-7.48	-12.26	4.78
		2	-7.48	-8.10	0.62
		3	-7.48	-8.46	0.98
		4	-7.48	-14.46	6.98
2.	OTB - ODP E – ODP B	1	-7.48	-9.00	1.52
		2	-7.48	-11.58	4.1
		PC	-7.48	-8.05	0.63
3.	OTB - ODP E - ODP B – ODP C	1	-7.48	-9.68	2.2
		2	-7.48	-11.90	4.42
		PC	-7.48	-14.56	7.08
4.	OTB – ODP B -ODP C – ODP D	1	-7.48	-10.62	3.14
		2	-7.48	-13.80	6.32
		PC	-7.48	-15.19	7.71
5.	OTB – ODP B – ODP C - ODP D – ODP A	1	-7.48	-11.80	4.38
		2	-7.48	-16.41	8.99
		PC	-7.48	-14.99	7.57
6.	OTB - ODP B - ODP C – ODP D - ODP A – ODP E	1	-7.48	-27.63	20.15
		2	-7.48	-22.49	15.01
		PC	-7.48	-15.31	7.9

DISCUSSION

Discussion of Calibration

After making the trainer module, the next step before carrying out measurements is to carry out calibration which aims to obtain input values that will be used in measurements. HLS and OPM are connected with a patchcord cable using a connector. Measurements were carried out 3 times so that the attenuation results were more accurate. The calibration attenuation results using method 1 get the first attenuation result, namely -7.47 dBm, the second attenuation result, namely -7.52 dBm and the third calibration attenuation result, namely -7.52 dBm, to get the average attenuation result by adding up the three calibration results and dividing by three, you get the average result. average -7.42 dBm. The results of attenuation calibration using method 2 obtained the first result, namely -7.13 dBm, the second attenuation was 7.14 dBm, and the third attenuation was -7.13 dBm, so the input attenuation result for method 2 was -7.13 dBm.

Discussion of Measurement Results

Measurements are carried out using HLS to see the input power and OPM to see the output power produced by each port.

a. One-on-one measurement method from OTB to each ODP

Measurements on OTB - ODP E, HLS connected to the input port on the OTB and OPM to the output port on the ODP E, calculating the power link budget aims to estimate the total attenuation required in building the trainer module, several factors such as losses from connectors, cable length , and the fusion splicing process can increase signal attenuation, by understanding and calculating the attenuation value that occurs, you can perform an accurate power link budget, after the power link budget results are available, you can see whether the total attenuation value obtained exceeds or not the power attenuation results budget. The power link budget calculation for OTB – ODP E can use the equation 2 formula, namely:

$$a_{total} = L . a_{serat} + N_c . a_c + N_s . a_s + N_a . a_a$$
$$= (0.003 \text{ Km} . 0.35 \text{ dB}) + (2 . 0,25 \text{ dB}) + (2 . 0,1) + (2 . 05 \text{ dB})$$
$$= 0.00105 \text{ dB} + 0.5 \text{ dB} + 0.2 \text{ dB} + 1 \text{ dB}$$
$$= 1.7605 \text{ dB}$$

It can be seen in table 3, the attenuation value produced on port 1 is 5.59 dB, port 2 is 0.99 dB, port 3 is 0.49 dB, and port 4 is 6.6 dB, from the measurement results the good attenuation values are on port 2 and port 3 , because the link budget value obtained is 1.7605 dB. Meanwhile, port 1 and port 4 produce high attenuation values that exceed the maximum limit. This could be because the port 1 and port 4 adapters used are dirty and cause light transmission to be slow. Likewise for ODP E- ODP B with a power link budget attenuation result of 1.7605 dB, which means port 2 and

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also for the patchcord, the power link budget calculation for the patchcord can use the equation 3 formula, namely:

$$a_{total} = L.\, a_{serat} + N_c . a_c + N_s . a_s + N_a . a_a . Loss\ patchcord$$

= ((0.02 Km . 0.35 dB) + (2 . 0,25 dB) + (2 . 0,1) + (2 . 05 dB)) . 0.3 dB
= (0.007 dB + 0.5 dB + 0.2 dB + 1 dB) . 0.3 dB
= 0.5121 dB

The attenuation value produced in patchcord and port 2 measurements exceeds the predetermined link budget value, this is due to problems with the adapter or connection which causes high attenuation values. In the ODP B - ODP C measurements, the attenuation value results are good, not exceeding This is because the connection is good and the use of the adapter is also good, not only on the port, the patchcord also gets a good damping value. But on ODP C - ODP D the attenuation value on port 2 is not good or exceeds the attenuation value limit, the attenuation value on port 1 and on the patchcord is good because the attenuation value is not high or the attenuation value does not exceed the link budget value. It can be seen in the ODP D – ODP A measurements that the poor attenuation value is found on port 2 and also the patchcord. And in the patchcord measurement results, the attenuation value is high with a power link budget of 0.5 dB, while the total attenuation value is 0.7 dB.

b. The measurement method is in line from OTB to each ODP

It can be seen in table 4. Measurements on OTB - ODP E have 2 ports with high attenuation values, namely port 1 and port 4. In OTB-ODP E-ODP B measurements, high attenuation values are found on port 2. Calculation of power link budget for OTB-ODP E-ODP B can use the equation 2 formula by:

$$a_{total} = L.\, a_{serat} + N_c . a_c + N_s . a_s + N_a . a_a$$

= (0.003 Km . 0.35 dB) + (4 . 0,25 dB) + (3 . 0,1) + (3 . 05 dB)
= 0.00105 dB + 1 dB + 0.3 dB + 1.5 dB
= 2.80105 dB

After getting the power link budget value on optical fiber, the calculation of the power link budget on a 20 meter (0.02 km) long patchcord cable can use the equation 3 formula with a patchcord loss of 0.3 dB which is in the patchcord attenuation provisions by:

$$a_{total} = L_{pc}.\, a_{serat} + N_c . a_c + N_s . a_s + N_a . a_a . Loss\ patchcord$$

a_{total} = (0.02 Km . 0.35 dB) + (4 . 0,25 dB) + (3 . 0,1) + (3 . 05 dB) . 0.3dB
= (0.007 dB + 1 dB + 0.3 dB +1.5 dB) . 0.3 dB
= 0.8421 dB

OTB-ODP E-ODP B-ODP C has 2 high attenuation values found on port 2 and patchcord. By using equation 2, the result of calculating the power link budget for this optical fiber is 3.90105 dB, which is obtained from the total attenuation of port 2 which is 4.42 dB, by using equation 3, the result of the power link budget for patchcord cables is 2.3484 dB which has an attenuation value The total is 7.08 dB with a cable length of 40 meters or 0.04 km and a patchcord loss of 0.6 dB. To find out the cable length of 40 meters, the cable length from ODP E-ODP B + ODP B-ODP C is the same as the patchcord cable length of 20 meters, as well as the patchcord loss in the 20 meter provisions is 0.3 dB, so for ODP E- ODP B + ODP B-ODP C has a patchcord loss of 0.6 dB.

In measuring OTB-ODP E-ODP B-ODP C-ODP D, using equation 3 the power link budget result on the optical fiber is 5.00105 dB, using equation 4 the power link budget result on the patchcord is 4.514 dB, can be seen in the table 4 has 2 high attenuation values, namely at port 2 and also at the patchcord. Cable length of 45 meters or 0.45 km is found in ODP E–ODP B (20 meters) + ODP B–ODP C (20 meters) + ODP C-ODP D (5 meters) and patchcord loss 0.3 dB + 0.3 dB + 0.3 dB gain total patchcord loss 0.9 dB.

In OTB-ODP E-ODP B-ODPP C-ODP D-ODP A. by using equation 2 the power link budget result on optical fiber is 6.10105 dB, by using equation 3 the power link budget result on patchcord is 6.72 dB, which also means There is a high attenuation value on port 2 and also on the patchcord. Cable length of 47 meters or 0.47 km is found in ODP E–ODP B (20 meters) + ODP B–ODP C (20 meters) + ODP C-ODP D (5 meters) + ODP D-ODP A (2 meters) and loss patchcord 0.3 dB + 0.3 dB + 0.3 dB + 0.2 dB gain total loss patchcord 1.1 dB

Finally, in the OTB-ODP E-ODP B-ODP C-ODP D-ODP A-ODP E measurements, there are 2 high attenuations on port 1 and port 2, using equation 2 the power link budget results on optical fiber are 7.20105 dB , and by using equation 3 the power link budget results on the patchcord OTB-ODP E-ODP B-ODP C-ODP D- ODP A-ODP E are

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11.81 dB with a total attenuation value of 7.9 dB, which means that in the measurements the patchcord has a good attenuation value than the attenuation results in the previous measurement.

It can be concluded that the results of the attenuation value by measuring in line from the OTB of each ODP are greater than the results of the attenuation by measuring one by one from the OTB to the ODP, this is because the measurement method 2 is always increasing and there are more and more connections, and passing through the ODP - Other ODP resulting in higher attenuation values.

CONCLUSION

In this final project, a trainer module has been created for telecommunications engineering students studying Optical Fiber Communication Systems (SKSO) and calculated the attenuation value in each ODP, so that the following conclusions are obtained:

1. The manufacturing process using a star topology starts from OTB then goes to ODP A, ODP B, ODP C, OCP D, and ODP E.
2. OTB in star topology functions as a central point where all client device cables are connected. ODP A, B, C, D, and E function as communication endpoints in a star topology that can transmit and receive connected to the hub.
3. The trainer module located on the 3rd floor of building G of the Padang State Polytechnic was successfully carried out using the star topology method and to find out and calculate the maximum attenuation value that has been determined as in table 4.15 and table 4.16. On OTB – ODP E the maximum attenuation value obtained is 1.7605 dB. The total attenuation obtained on port 1 is 5.59 dB, this indicates that on port 1 the total attenuation value exceeds the maximum existing attenuation value, while on port 2 the total attenuation value on port 2 is obtained. namely 0.99 dB, this indicates that port 2 is good because it does not exceed the maximum limit, this could occur due to an error in the connection or also in the adapter.

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