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A Review of Optical Loss in Various Optical Fiber Connector

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ABSTRACT

Fiber optics is used widely as a transmission medium in local networks. Optical fiber has a wide range of losses to be aware of, including Rayleigh dispersion loss, coupling loss, splicing, bending, and damping loss on connectors. Researchers have developed different types of optical fibers to create the best ones. To prevent sudden and significant deterioration in network quality, it is necessary to carry out routine maintenance such as scheduled measurements of fiber optic network service quality. This maintenance activity can help in making decisions related to increasing network capacity in the future. One of the parameters that is often measured in service quality measurements is the attenuation of the transmission and the power of the received signal.

Keywords : *Fiber optic connector, Types of fiber optic connectors, Optical loss*

1 Introduction

Optical fiber is a technology that allows data transmission at high speeds and large capacities through very thin glass fibers. To connect optical fibers to each other, components called fiber optic connectors are used. Fiber optic connectors have an important role in maintaining the quality of optical signals transmitted between optical fibers.(Syahputra, 2021). Connectors are optical fibers to connect with other equipment or cables, and are capable of transmitting optical signals(Saputra, Harahap &; Zulfin, 2015). However, different types of connectors have different optical loss characteristics. FC connectors have the optical characteristics of small and stable loss, and have a sturdy and durable construction. SC connectors are more suitable for use in telecommunications because of their smaller size and ease of use, but their optical loss characteristics are slightly greater than FC connectors. A OTDR can be used in ensuring a connection loss in the connector and in the loss itself caused by a bend or a pressure that occurs on the cable. With the value of attenuation that exceeds a certain range limit, reaching 15 to 28 dB.(Z &; Fausiah, 2019). ST connectors have the advantages of ease of use and installation, but have greater optical loss characteristics than SC connectors(Arief Darmawan, Bagoes Eko Y, Sunaryo, 2017). One important aspect in the performance of fiber optic connectors is the optical loss characteristics. Optical loss refers to the amount of decrease in light intensity as the optical signal passes through the connector. This loss can occur due to several factors, such as differences in the refractive index between optical fiber and connectors, dispersion, reflection, and friction between the connector surface and optical fiber, as well as the presence of connections or splices in each part of the cable so that the occurrence of bending on the cable that exceeds 45 ° (Z &; Fausiah, 2019).

In addition, there are also types of LC connectors that have a smaller size than SC and FC connectors, making them ideal for use in limited spaces. LC connectors have low loss optical characteristics and are suitable for data networking and telecommunications applications. A telecommunications system on an optical fiber has attenuation with transmissions per km that may be smaller than other transmissions(Yudatama &; Riyanto, 2010). An optical fiber has the ability to transfer data up to 2.5 Gbps over a distance of more than 200 km, which is about 80 times farther than copper cable. In addition, optical fiber also has the capacity to transfer more than 1,500 times more data than copper cables (Pahlawi, 2020).

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The optical loss characteristics of fiber optic connectors are very important in determining the quality of optical signal transmission. Power requirements will experience interference due to large optical loss problems in a system in fiber connector(Nugroho A K et al., 2019). Optical fiber is a method of sending data with a high ability to hold information and very high data transfer rates. (Z &; Fausiah, 2019).

Maintenance can help in determining decisions to increase network capacity in the future. One of the determinants of service quality that is often measured is the measurement of transmission attenuation levels and the power of the received signal (power receive)(Syahputra, 2021). However, the performance and advantages of optical fiber that are maintained at any time can also experience interference (*trouble*) on the transmission process. Thus, regular maintenance and cleaning of connectors is also required to ensure optimal performance and prevent damage to connectors(Yanuary &; Lidyawati, 2018). This research has been carried out to to find out the types of fiber optic connectors and their optical loss characteristics and o determine the factors that affect the characteristics of optical loss in fiber optic connectors.

2 Research Methodology

2.1 Transmission Power

An information to be sent *(transmission)* and acceptable *(receive)* Through fiber optic media is in the form of light. Light in optical fiber will propagate so that it passes through a fixed reflected core, so this principle is referred to as the principle *Total internal bounces*(Handika, 2011). Fiber optic transmission media is generally divided into 3 main components, namely: (1) Transmitter functions to convert input electrical signals into light signals that will be transmitted through optical fiber, (2) Transmission media or Optical Fiber and (3) Receivers that function in taking signals through incoming digital light, then deciphering it. Loss-loss transmission simulations on optical fibers can be displayed using OTDR. A power drop can occur along the cable before it reaches the connection point, while a power increase can occur immediately after the connection point between the first and second wires, as well as at the end of the cable(Handika, 2011)(Siswanto, 2005).

2.2 Optical Loss

Optical loss in fiber optic connectors refers to the amount of optical signal loss that occurs when light passes through the connector. This loss is caused by several factors, including reflection, dispersion, and absorption.

The main factors that contribute to optical loss in fiber optic connectors include:

a. Reflection: Reflection occurs when light bounces back from the interface between two different optical mediums, such as a fiber optic connector interface. Reflection can occur if the interfaces are not connected appropriately or if there is a mismatch of the refractive indices between the two optical components. This reflection results in signal loss and can cause interference with data transmission.
b. Dispersion: is a distortion that occurs when a light beam passes through the core of an optical fiber due to the presence of modes(Ila, 2020). This can cause signal distortion which can reduce the quality of data transmission and increase optical loss in connectors.
c. Absorption: is an event of the process of absorption of light by a material that is crossed by the ray(Cahya Kurniawati, 2017). Absorption occurs when optical light is absorbed by surrounding materials, such as connector cover layers or dirt particles on connector surfaces. This absorption reduces the intensity of light transmitted through the connector and causes optical loss.
d. Insertion Loss: Insertion loss is the amount of power loss that occurs when an optical signal enters a connector and passes through the interface border between one optical fiber and another. This is common due to mismatches in interface geometry or material and can be caused by wear, deformation, or production inaccuracies in connectors.

2.3 Connectors

An optical connector is a device used to connect fiber optic cables. Optical connectors have a function similar to electrical connectors as a physical appearance, but optical connectors have a higher level of precision. Connectors are required when optical fiber needs to be removed, for example when replacing transmitters or receivers, or when performing fiber optic maintenance.

Fiber optic connectors are used to join the two ends of a fiber optic, either at the point where the fiber optic ends at the transmitter or receiver. Since each optical fiber always ends where the transmitter is at one end and the receiver at the other, the connector will suffer a loss. The following factors affect connector loss at a given cable length:

a. Mismatch in core dimensions
b. Horizontal core placement error
c. Separation occurs in prolonged gaps
d. Loss occurs in the optical gap
e. Error in the placement of a certain angle
f. Non-optimal preparation of fiber ends
g. Contaminants present

2.4 Research Method

The following stages of the research process are carried out:

a. Identification of the problem is by reformulating the background, formulation to the objectives in this research conducted.
b. Literature study, In conducting a literature study, researchers first examine after determining the research topic and determining the formulation of existing problems(Kartiningrum, 2015). Then collect and re-analyze existing data both from books, jumal, to other references that are in accordance with the research topic on the characteristics of optical loss in types of fiber optic connectors. The method used in this literature study involves a series of activities related to the collection of library data. The steps include reading, taking notes, and managing material relevant to the research. This literature study is a component of every researcher in research, especially in an academic context, has a crucial component that aims to develop theoretical and practical aspects. One of the steps taken by every researcher is to conduct a literature study to find relevant foundations, theoretical foundations, frameworks, and formulate research hypotheses. By categorizing, allocation, organization, and use of various literature references in the field being studied, researchers can gain a deep and comprehensive understanding of the case under study(Ila, 2020).

Analysis of optical loss characteristics in these types of fiber optic connectors.

2.5 Flow Chart

In simple terms, the process of analyzing optical loss characteristics in the types of fiber optic connectors with a flow-like diagram in the following figure 1.

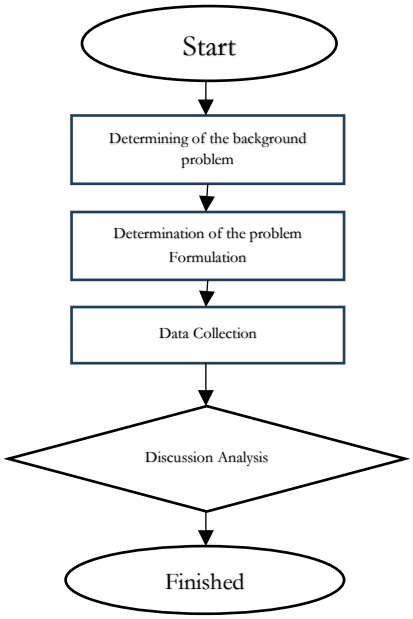

Figure 1. Flow Chart

3 Results and Discussion

3.1 Optical Loss Characteristic in types of fiber optic connectors

Optical Loss characteristics consist of several fiber optic connectors including the following:

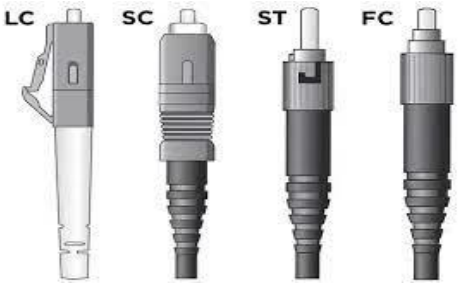

Figure 2. Picture types of fiber optic connectors

a. **LC (Lucent Connector):** Fiber Optic Connectors are connectors that also have low optical loss, often less than 0.3 dB.
b. **MPO/MTP (Multi Fiber Push-ON/Pull-Of) :** Fiber Optic Connectors that have a low optical loss rate, often less than 0.35 dB (Yanuary &; Lidyawati, 2018).
c. **FC (Fiber Connector)**: serves as a connector model on a single fiber with a high degree of accuracy when connecting cables using transmitters or receivers(Bayudin, n.d.).
d. **SC (Subscriber Connector):** works in a single fiber unplug system. These connectors are economical, simple, and can be manually set with high accuracy when used with other devices that generally have low optical losses of less than 0.3 dB.
e. **ST (Straight Tip)**: these connectors are similar in shape to bayonet locking connectors or BNC connectors. Such connectors are often used to connect double fiber or single fiber cables

Table 1. Data and Graph analysis of the advantages of fiber optic connector characteristics

Connector Type	Loss(dB)	Damping Reaction (dB)	Fiber Type	Application
Fiber Connector (FC)	0,5 - 10	0,2	Single mode & Multimode	Datacom & telecommunications
Lucent Connector (LC)	0,15 for Single Mode 0,10 for Multimode	0,2	Single mode & Multimode	High-desinty Interconnect, datacom & telecommunications
MPO or MTP	0,3	0,35	Single mode & Multimode	Adapter Panel
Subcriber Connector (SC)	0,2 – 0,45	0,1	Single mode & Multimode	Datacom & telecommunications
Straight Tip (ST)	0.4 for Single Mode 0,5 for Multimode	0,4 for Single Mode 0.2 Multimode	Single mode & Multimode	Inter-inta/ intra-building, security, U.S., & Navy

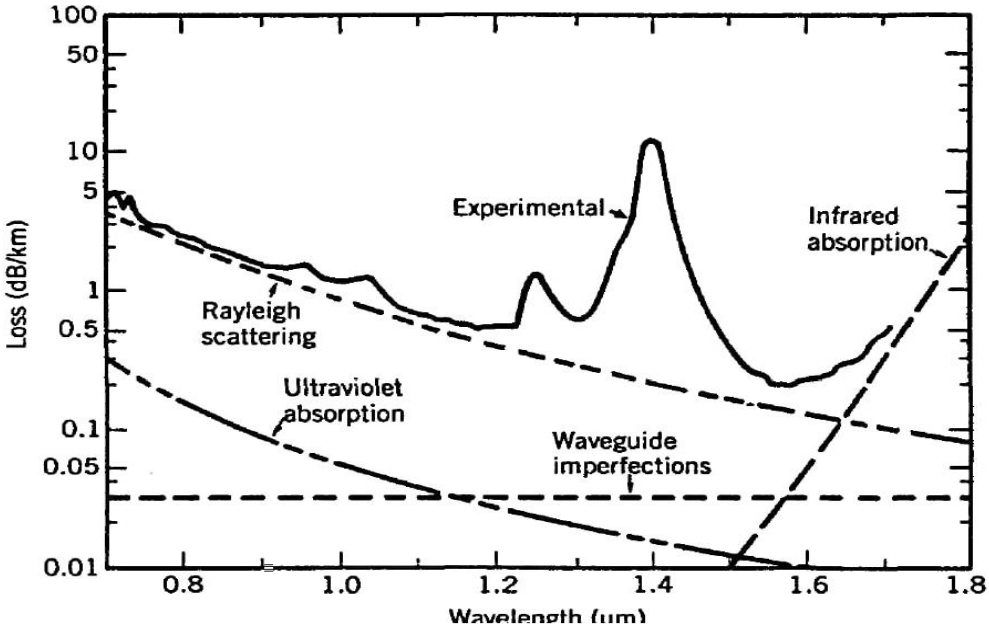

Figure 3. Graphic Image analysis of the advantages of fiber optic connectors

Based on the data table and analysis graph above, it can be said that the FC connector (Fiber Connector) is the most superior fiber connector and is widely used with an accuracy of 0.5 to 1dB.

3.2 Mechanical Properties of Fiber Optic

a. *Fiber Bending*, heavy fiber bending can cause increased optical loss. The increasing size of the curvature in optical fibers, the less losses due to curvature that occurs (Parapat, 2023).
b. *Cable Bending*, bending of the cable during the installation process must be kept from getting smaller, because this condition can reduce fiber and cause additional optical loss.
c. *Crush*, or more pressure can cause the fiber to break so that it breaks, therefore it can cause optical loss.

d. *Impact* is a certain heavy object discarded so that it shifts with the optical cable, the mass of the heavy object can cause the optical fiber to break, and cause an increase in optical loss.
e. *Cable Torsion*, or a torque added to a cable can cause damage to cable pads and fibers.

3.3 Fiber Optic Connector Objects

Fiber Optic Connector Structure

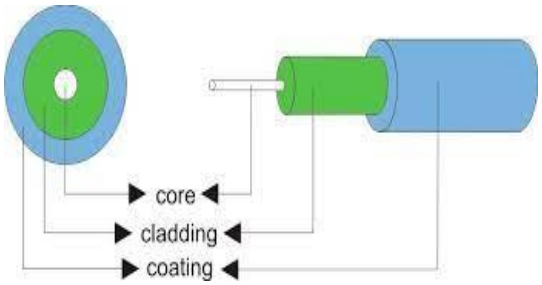

Figure 4. Fiber Optic Structure

a. Core, used for the leading medium of light or the place of propagation of light from one point to another. The core is made of glass material with a very good shape that has a diameter of 5-10, the size of the core affects the characteristics of the optical fiber.
b. Cladding (blanket), useful for placing the reflecting boundary so that the transmitted optical light can be reflected larger in the core until light can be accompanied to the end.
c. Coating (jacket), useful for protecting mechanical fiber optics is very resistant to outside intruders(Osman et al., 2018)

Types of Optical Fiber

a. Single mode, The connector on this fiber optic has a very small core, measuring about 0.00035 inch in diameter. Named single mode because using this cable connector the possibility of a light mode occurs
b. Multi mode, Is a fiber optic connector with more cores than fiber optic connectors alone. This type of sinle model has a diameter ranging from 0.0025 inches equivalent to 62.5 microns.

Fiber Optic Connector

Fiber optic connecting requirements can be made a good connector if as follows: Low battery removal, able to repeat, predictable, resistant life, no decrease in efficiency in the long term, connecting objects resistant to pressure, compatible with the surroundings, connectors can be made with varying temperatures, have a lot of pressure, to withstand vibration (Silalahi et al., n.d.).

3.4 Disadvantages and advantages of Fiber Optic Cables

Not much different from other connector cables for example, there are UTP connectors or STP connectors used. In fiber optic network cables, there is an insulation layer (referred to as coating) that has various color variations (Silalahi et al., n.d.).

Advantages of Fiber Optic Cable

a. Can stream a lot of data at large speeds, until Gbps can be reached and bandwidth grows, Has a small size and light than other connectors, Has a small interference, is more guaranteed and safe and can channel the network further if equated with the usual electricity network connector, if used network amplifiers are usually more in remote locations (50-100 km).

b. The existence of a fiber sensor that has specific advantages such as a remote monitoring capability, as well as resistance to extreme and interference environments as anti-electromagnetic(Ahmad et al., 2021)
c. High level of security due to no distortion.
d. It can transmit data over a long radius without using a signal amplifier.
e. Not disturbed by electromagnetic waves because it uses light as a transmission medium (Prime et al., 2022).

Disadvantages of Fiber Optic

a. Difficult maintenance and treatment.
b. The price is expensive compared to other types of cables such as UPT which have low prices.
c. It can't be put in a sharp place.
d. Expensive installation costs and maintenance costs (Ahmad et al., 2021)
e. Requires a strong enough light source.
f. Fiber optics can be easily broken or lose transmission if wound within a small radius.

4 Conclusion

Connectors are critical components in fiber optic cable systems, and are often used in applications such as telecommunications, computer networks, and the medical industry. Fiber optic connectors have several types, namely LC, ST, FC, and SC. Where each type of connector has disadvantages and advantages. Fiber optic connectors have experienced optical loss. Optical loss in fiber optic connectors refers to the amount of optical signal loss that occurs when light passes through the connector. Broadly speaking, optical fibers can experience various types of losses, such as Rayleigh spread losses, coupling losses, and losses due to splicing and bending. In addition, there is also damping loss in the connector which causes additional loss to the optical fiber. This loss can occur due to several factors, such as differences in the refractive index between optical fiber and connectors, dispersion, reflection, and friction between the connector surface and optical fiber, as well as many connections or splices in each cable, resulting in a cable indentation above 45°.

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