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Fiber Optic Network Service Quality Measurement

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ABSTRACT

This optical fiber is the initial signal / source in the form of an electrical signal at the transmitter is converted by an electro-optical transducer (Diode / Laser Diode) into light waves which are then transmitted through the fiber optic cable to the receiver / receiver located at the other end of the optical fiber. The purpose of the study was to determine the quality of fiber optic network services. The method used is the measurement of fiber optic quality using the Rise Time Budget method which functions to determine whether network performance has been able to meet channel capacity according to the intended standard. The results of the research on the calculation of the downstream received power level are - 25.0929 dBm on ONT 1 and -25.1097 dBm on ONT 2. While the results of measuring the downstream received power level using the OPM (Optical Power Meter) tool, namely -24.09 dBm on ONT 1 and -24.10 dBm on ONT 2. These results are quite good because these results are lower than the standard provisions, in the standard provisions if ONT wants maximum usage is -28dBm so that the results of the received power level results obtained are classified according to the power link budget eligibility standards.
Keywords*: Fiber Optics; Quality; Network.*

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Introduction

Technological advances in the field of telecommunications are increasingly rapid. The use of more efficient networks continues to be developed. The network being developed by PT. telkon is using a fiber cable network. Fiber access local network is a transmission system that is currently under development, especially its use in residential telecommunications services. Optical transmission can provide telecommunication services in the form of telephone, internet, and television. The development of the use of optical transmission is currently quite popular because the implementation is very efficient and has a large bandwidth so that optical transmission is very promising in meeting the telecommunications service needs of customers.

The working principle of this optical fiber communication system is that the initial signal / source in the form of an electrical signal at the transmitter is converted by an electro-optical transducer (Diode / Laser Diode) into light waves which are then transmitted through a fiber optic cable. then transmitted through the fiber optic cable to the receiver / receiver located at the other end of the optical fiber. At the receiver, this optical signal is converted by an Opto-electro transducer (Photo Diode / Avalanche Photo Diode) into an electrical signal again. In traveling the optical signal from the transmitter to the receiver will experience light attenuation along the optical cable, caused by cable connections and connectors in the device, therefore if the transmission distance is far away, a repeater or several repeaters are needed to amplify the light waves that have experienced attenuation along the way.

There are several components that are taken into consideration in designing an optical network. One of them is fiber optic transmission loss (attenuation). This transmission loss is one of the important characteristics of optical fiber. These losses result in decreased light power, decreased bandwidth of the system, and reduced overall system capacity. Fiber optic losses include: absorption losses, losses in the core and cladding, connector and splice losses.

Based on the description of the background, the problem is how the quality of fiber optic network services.

While the research objective is to find out the quality of fiber optic network services.
Optical Fiber is a type of cable with material made of glass that is very thin and smaller than a strand of hair. The light source used in optical fiber is LED (Light Emitting Diode). The basic structure of optical fiber is divided into several parts.
The basic structure of optical fiber includes Core (Core) serves to determine the light propagating from one end to the other. Cladding (layer) functions as a mirror, which reflects light so that it can propagate to the other end of the mirror. Coating (jacket) functions as a mechanical protector as a color coding refractive index, the Core is always greater than the Cladding refractive index. The physical structure of Optical Fiber can be seen in the figure below.

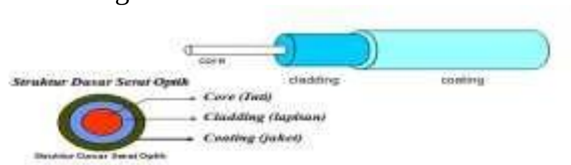

Fig 1. Fiber Optic Structure

The core is made of quartz material with high quality, is the main part of the optical fiber because the actual light propagation occurs in this part, has a diameter of 10 µm ~ 50 µm, the size of the core greatly affects the characteristics of the optical fiber. Cladding is made of glass material with a smaller refractive index than the core, is the sheath of the core, the refractive index relationship between the core and cladding will affect the propagation of light in the core. Coating is made of plastic, serves to protect optical fibers from damage such as fire, electricity, slipping vehicles and so on.
Light Propagation in Optical Fiber Light propagation in a medium in three ways, namely propagating straight, bouncing, and refracted. The following example can be seen below Figure 2.2 Light propagation in optical fiber.

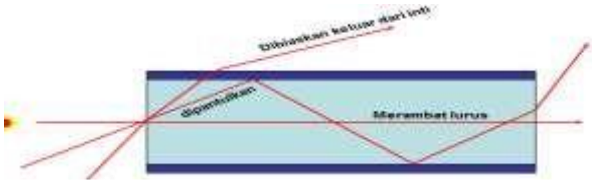

Fig 2. Light propagation in optical fiber

The structure of the Fiber Optic cable is different from the copper multipair cable, if the term pair or pair is known in copper cables, then the term pair or pair is not known in fiber optic cables. In general, the Fiber Optic cable structure consists of Tube and Fiber (or the general term in the field is called core). On the Tube and Core to recognize the order given different colors And the following is the color sequence of the fiber optic cable. Here's an example of the picture below,

Fig 3. Color sequence of optical fiber

There are advantages and disadvantages in fiber optic cables. Here are the disadvantages of optical fiber. First . The optical cable installation process is fairly expensive compared to other network cables due to the material and installation process. During the fiber optic installation process, several special tools and electronic devices are required which are very expensive. So that indeed to install this fiber optic network requires a large fee

Second. Because the installation process uses special tools, if there is damage, it must be repaired by technicians who understand how to operate these tools. So that it will increase the cost of installation.
Third. There is still a possibility of data loss, due to the attenuation of light waves at a very long distance. So a repeater is needed to reduce attenuation.
Fourth. In operation, optical fiber requires a really strong light source to transmit data well. It must also be installed on a path that turns or has angles and curves. So that light waves can pass smoothly
Of the many disadvantages of optical fiber, it turns out, this technology still has several advantages as follows :
First. Fiber optic cables are able to transmit signals farther than other network cables, even without network amplifiers, signals can be transmitted for long distances.
Second. Fiber optic cable material is more durable and can withstand various possibilities of damage due to environmental conditions such as heat or humidity. So that maintenance costs become less.
Third. Fiber optic cables are strong against electromagnetic interference coming from around the cable. Because it does not carry any electric current, optical fiber is immune to the effects of electromagnetic interference.
Fourth. The bandwidth of fiber optic cable is classified as having a large capacity of about 1 GB per second. This is utilized by internet and telephone companies to provide high bandwidth with excellent quality.
Fifth. Higher security. Fiber optic cables have minimal distortion so the possibility of tapping is smaller. So that fiber optic cables are very suitable for telecommunications that require higher security. In addition, because it does not emit electromagnetic energy, eavesdropping is almost impossible.
Sixth. Fiber optic cables are not flammable because the constituent material is glass fiber and is not a conductor. There is no danger of sparks like in electrical cables. Sparks can be a very dangerous threat, especially in chemical factories.
Interference in the optical network includes interference with bandwidth configuration, interference at the STO, interference with ODC and ODP, and interference with customers. Interference with the configuration is in the service bandwidth capacity setting, for example, the customer wants to subscribe to 10MB but the customer only receives 2MB.
Meanwhile, interference with ODC and ODP is usually only in the form of broken cables, patchcord adapters that are loose or not fitting so that light bias occurs, then passive spiltter damage. Interference at the customer is usually due to the cable being folded so that the fiber or glass in the cable breaks, the fiber optic cable is hit by an object for a long time, causing the network performance to not be optimal. The most common interference is interference from natural factors, such as strong winds, falling trees, cables eaten by rats, and other animals that can cause damage to fiber optic cables.

Research Method

Measurement of optical fiber quality using the Rise Time Budget method which functions to determine whether network performance has been able to meet channel capacity according to the intended standard. In measuring the link budget, several measuring instruments are used, namely OTDR and Power Meter. This tool is a tool that is often used such as:
Optical Domain Reflecto Meter (OTDR)

OTDR is one of the main equipment for both installation and maintenance of fiber optic links, OTDR is used to get a visual representation of fiber optic attenuation along a link plotted on a screen with distance depicted on the X axis and attenuation on the Y axis. In general, the function of OTDR is to measure attenuation, measure connection loss, measure loss between two points, measure cable distance, and localize interference. Information about attenuation, connection loss, connector loss and the location of interference and loss between two points can be known from the OTDR display. The working principle of the OTDR measuring instrument can be explained as follows, OTDR emits light pulses from a laser diode source into an optical fiber with a predetermined distance or until the end point of the optical fiber network. The power emitted by OTDR has been set at the initial setting. Some signals are returned to the OTDR, the signal is directed through a coupler to an optical detector where the signal is converted into an electrical signal and displayed on the screen.
Power Meter

This measuring instrument is used to measure the total loss in an optical link either during installation (final test) or maintenance. Attenuation is measured in decibels (dB). Loss or attenuation is expressed in L(dB) = Pin (dBm) - Pout (dBm) or L(dB) = 10×Log (Pin / Pout). Measurement configuration of an optical link. When making measurements or testing often use patchcord, so the condition of this patchcord must be guaranteed performance and quality. Every patchcord that will be used must be tested, the patchcord measurement results compared to the manufacturer's technical specifications, and clean all connectors.

Technical specifications, and clean all connectors before testing using cotton / tissue or spray air such as dush off.

Result

Feasibility parameters are a measure used to determine whether a fiber optic implementation is classified as good or less good by using formulas or using measurement tools. In this study using the power link budget parameter. Power link budget is a parameter used to determine the total attenuation of a fiber optic system. The unit of total attenuation of a fiber optic system is dB (decibel).

Power margin is the remaining power of the transmit power after deducting the loss during the transmission process, reducing with the safety margin value and reducing with the receiver sensitivity value. The required power margin must have a value ≥ 0 (zero).

To calculate the power link budget can be calculated by the formula: $\alpha tot = L.\alpha\ Fiber + Nc.\alpha c + Ns.\alpha s + Sp$

For the power margin equation is $M = (PT - PR) - \alpha tot - SM$

For the received power equation is: $Pr = PT - \alpha tot – SM$

Description: α tot = Total system attenuation (dB)

L = Optical fiber length (km)

α fiber = Optical fiber attenuation (dB/km)

Nc = Number of connectors

αc = Connector attenuation (dB / piece)

Ns = Number of splices

αs = Splice attenuation (dB/splice) Sp = Splitter attenuation (dB)

PR = Detector maximum power sensitivity (dBm) PT = Optical source output power (dBm)

Pr = Received power (dBm)

Table 1. Power link budget calculation

DATA	REDUCTION RATE
METRO output power attenuation	0 dBm
GPON OLT output power	4 dBm
Splitter 1: 2	3.70 dB
Spliter 1: 4	7.25 dB
Spliter 1: 8	10.38 dB
Optical fiber attenuation G.652 (1490)	0.28dB/km
Splice attenuation	0.10 dB/splice
SC connector	0.25 dB
Number of Splice connections	6 splices
Number of SC connectors	8 connectors

The cable length distance from OLT to FTM is 0.03 KM; from FTM to ODC, which is 0.48 KM; distance from ODC to ODP, which is 0.028 KM; from ODP to the first rosette, which is 0.042 KM; from the first rosette to ONT is 0.002 KM. The total distance from OLT (Sto Cibinong) to ONT 1 (customer's house) is 0.0582 KM. The following is the calculation of the downstream power link budget at ONT 1, the calculation of fiber optic attenuation from OLT to ONT 1 is as follows:

$\alpha tot = (L.\alpha Fiber) + (Nc.\alpha c) + (Ns.\alpha s) + Sp$

$= (0.582 \times 0.28) + (8 \times 0.25) + (6 \times 0.10) + (3.70 + 7.25 + 10.38)$

$= 24.09296$ dB

Calculation of receiving power level as follows:

$Pr = PT - \alpha tot - SM$

$= 5 - 24.09296 - 6$

$= -25.09296$

The cable length distance from OLT to FTM is 0.02 KM; from FTM to ODC, which is 0.54 KM; distance from ODC to ODP, which is 0.035 KM; from ODP to the first rosette, which is 0.045 KM; from the first rosette to ONT, which is 0.002 KM. The total distance from OLT (Sto Cibinong) to ONT 2 (customer's house) is 0.642 KM. The following is the calculation of the downstream power link budget at ONT 2,

Calculation of fiber optic attenuation from OLT to ONT 1 is as follows:

$\alpha tot = (L.\alpha Fiber) + (Nc.\alpha c) + (Ns.\alpha s) + Sp$

$= (0.642 \times 0.28) + (8 \times 0.25) + (6 \times 0.10) + (3.70 + 7.25 + 10.38)$

$= 24.1097$ dB

Calculation of receiving power level as follows: $Pr = PT - \alpha tot - SM$

$= 5 - 24.1097 - 6$

$= -25.1097$ dBm

Table 2. Acceptability level results

ONT	DISTANCE	CALCULATION
FIRST	0,582 KM	-24.0929 dBm
SECOND	0,642 KM	-25,1097 dBm

The results of power link budget measurements on the first ONT and the second ONT using an OPM (Optical Power Meter) measuring device. Power Link Budget measurement results on the first ONT (downlink).

Fig4. Attenuation on the first Optical Power Meter

Power Link Budget measurement results on the second ONT (downlink)

Fig 5. Attenuation on the second optical power meter

Based on these measurements and calculations, it is stated that it is classified according to the feasibility standard. Because these results are lower than the ITU-T G-984 standard, which is the maximum attenuation is -28 dBm, so the results are classified according to the standard feasible power link budget.

Conclusion

The results of the calculation of the downstream receiving power level are -25.0929 dBm on ONT 1 and -25.1097 dBm on ONT 2. While the results of measuring the downstream receiving power level using the OPM (Optical Power Meter) tool, namely - 24.09 dBm on ONT 1 and -24.10 dBm on ONT 2. These results are quite good because these results are lower than the standard provisions, in the standard provisions if ONT wants maximum usage is -28dBm so that the results of the receiving power level results obtained are classified according to the power link budget eligibility standards.

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