Estimation of Link Loss Budget for Transmission with Optical Fiber Project in Yaesagyo

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Abstract:- The optical fiber transmission system include a light source and a light detector and optical fiber. This paper is detailed estimated link loss budget along optical fiber cable between source and destination at YAESAGYO Township in Myanmar. Firstly Losses in optical fiber links, cable loss connector loss and splice loss are explained and typical standard values defined by IEEE are shown in this paper. The link loss budget is the total amount of losses, insertion loss along the optical cable. It is estimated by calculating the losses of all the devices through along the cable to get the estimated total end-to-end loss along the fiber. In this paper the minimum link loss of optical cable, 12 cores 4wire are designed and calculated for repeaterless optical transmission system in YAESAGYO Township in Myanmar.

Keywords:- *Minimum Link Loss Budget, Cable Loss, Connector Loss, Splice Loss.*

I. INTRODUCTION

The optical fiber communications system consists of a light source, LED or laser devices and a optical demodulator. The source and destination are separated by numerous components, connector, splicer that are caused various amounts of loss or gain to the optical light signal as it transmits through the fiber. Figure 1 shows two typical fiber optic transmission system configurations. Figure 1a shows a optical repeaterless transmission system which means that the source and destination are interconnected through the optical fiber cable. With a optical repeaterless system, there is no amplifier or regenerator between the light source and light detector.

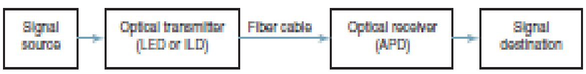

Fig 1:- Optical repeatreless communications systems

To measure optical loss, the two units, dBm and dB can be used. While dBm is the actual power level that is reference in 1 milliwatts input power, dB (decibel) is the difference between input powers and output powers.

❖ *Optical Fiber Types*

Single mode (SM) and multi mode (MM) fibers are the mainstream fibers that are manufactured and marketed today.

Windows	Wavelength	Loss
1st wavelength	850nm	3dB/km
2nd wavelength	1310nm	0.4dB/km
3rd wavelength	1550nm (C band)	0.2dB/km
4th wavelength	1625nm (L band)	0.2dB/km

Table 1:- There are four special wavelengths that they can be used for fiber optic transmission with low optical loss levels.

➢ *Overhead Fiber Cable*

Overhead fiber optic cables can be used in optical fiber communication of light signal over a long distance by using GHz frequency range. Overhead cables are fixed on utility poles and they are coated with PE jacket to protect the inner part from various environmental factors such as rain, sun, dust etc. Under the sheath, there is a metallic buffer tube which contains 1-12 fibers.

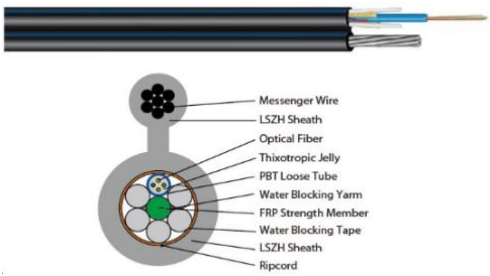

Fig 2:- Structure of Overhead Fiber Optic Cables [4]

➢ *Underground Fiber Cable*

Underground optical fiber communication system can bury direct burial underground cables without requiring additional protection. These cables are built to protect moisture, heat, soil acidity and other environmental factors. Their reliable performance will be supported for many voices, data, video and imaging applications. The direct burial fiber optic cable is appropriate for many communication systems.

Fig 3:- Structure of Underground Fiber Optic Cable [4]

ISSN No:-2456-2165

II. LINK LOSS BUDGET

The attenuation along the fiber cable is calculated between a light source and a light detector in a optical repeaterless system. The transmitter consists of LED or laser source, and the receiver contains a light detector such as an APD. Light source is connected by optical fiber with a connector and also a light detector is connected by optical fiber with connector. Therefore, the link loss budget consists of attenuation or gain of connector between power source and cable and also connector loss or gain between optical fiber cable and light detector. Typical Losses in optical fiber links consist of the following:

*Cable losses: C*able length, material, and material purity are the main important factors that cause the optical fiber cable loss. Typical values of optical fiber loss are given in dB/km and can vary several dB per kilometer.

Connector losses: Optical fiber connectors are used to connect two sections of cable. When two sections of cables are connected, light energy can escape, cause loss in optical power. Connector losses typical value of connector loss vary from a few tenths of a dB to as much as 2 dB for each connector depending on the fiber type and transmitting data rate

Source-to-cable interface loss: In the transmitter side, the light source launch the optical power into the cable is not perfect. Therefore, a small percentage of optical power is not coupled into the fiber cable depending on LED or laser aperture and the core size of the optical cable. A typical value of light source to fiber cable loss is several tenths of a dB.

Cable-to-light detector interface loss: In the receiver side, the mechanical interfacing between the light detector and the cable is also not perfect and, therefore, a small percentage of the power cannot leave the cable from entering the light detector. A typical value of the loss is a few tenths of a dB for the system.

Splicing loss: If the cable connects to each other cable, cable sections can be fused together. The splicing of two cables are not perfect that cause the loss to the system. A typical value of the loss range from a few tenths of a dB to several dB

Cable bends: If an optical cable bends at large an angle, the internal features of the cable can change. In the optical fiber cable light can propagate by the law of total internal reflection. Bending of the fiber optic cable cause refraction in the core/ cladding surfaces. A typical value of the loss by refraction is a few tenths of a dB to several dB.

$$P_r = P_t - losses$$

Where, P_r = power received (dBm)
P_t =power transmitted (dBm)
Losses = sum of all losses (dB)

➢ *Cable Loss*

Loss in optical fiber cables in transmission between light source and light detector is one of the most important characteristics of the fibers. It can reduce the system bandwidth, transmission rate, optical power efficiency, and overall system capacity. The Absorption loss Material, or Rayleigh, scattering losses Chromatic, or wavelength, dispersion, Radiation losses, Modal dispersion, and Coupling losses are the predominant factors of the optical fiber cable loss.

➢ *Absorption Losses*

Absorption losses in optical fibers are the power dissipation in copper cables; very high the absorption coefficients of the fiber material absorb the light and convert it to heat. A typical value of absorption loss is from 1dB/km to 1000 dB/km. There are three factors that cause the absorption loss in optical fibers: *ultraviolet absorption, infrared absorption,* and *ion resonance absorption.*

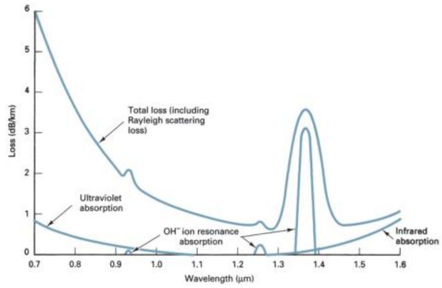

Fig 4:- Absorption losses in optical fibers [1]

➢ *Material, or Rayleigh, Scattering Losses*

During manufacturing, glass is stretched into long fibers to obtain very small diameter. In this process, the glass is in a plastic state. The tension force applied to the glass causes the cooling glass to irregularities. When light rays propagating down a fiber strike one of these unpurified material, it cause diffraction of the light signal into many directions. The diffraction of light rays result in reduction of lignt signal represents a loss in light power. This is called *Rayleigh scattering loss.* Figure 5 shows the graphical relationship between wavelength and Rayleigh scattering loss.

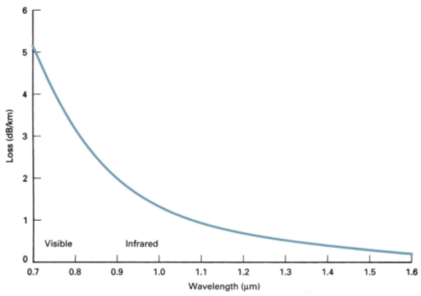

Fig 5:-Rayleigh scattering loss as a function of wavelength[1]

➢ *Chromatic, or Wavelength, Dispersion*

Light-emitting diodes (LEDs) emit light with different frequencies. Monochromatic light signal travels at a different velocity when propagating through glass. Light rays are simultaneously emitted from an LED and coupled down an optical fiber at the same time, resulting *chromatic distortion.* Chromatic distortion occurs only in a single mode fibers with transmission.

➢ *Radiation Losses*

Small bends and kinks in the fiber cause the radiation loss. There are two types of bends: microbends and macrobends. *Microbending* occur the fiber core deviate from the fiber axis as a result of differences in the thermal contraction rates between the core and the cladding material. A microbend is a geometric imperfection along the axis of the fiber cable cause Rayleigh scattering. A typical value of microbending loss is less than 20% of the total attenuation in a fiber. A large bend in the fiber cause macro bending and more than a 2 mm radius.

➢ *Modal Dispersion*

The difference in the propagation times of light rays cause the mo*dal dispersion* or *pulse spreading* and it takes different paths down a fiber. Multimode fibers can be occured modal dispersion. By using graded index fibers can reduce and by using single-mode step-index fibers can remove the modal dispersion. A pulse of light energy to spread out in time can be caused a modal dispersion as it transmits down a fiber. In multimode step-index fibers, the least amount of time to travel the length of the fiber is taken a light ray propagating straight down the axis of the fiber. The largest number of total internal reflections will be undergone by a light ray that strikes the core/cladding interface at the critical angle and, take the longest time to travel the length of the cable. A *bandwidth length product* (BLP) or *bandwidth distance product* (BDP) can express for multimode propagation

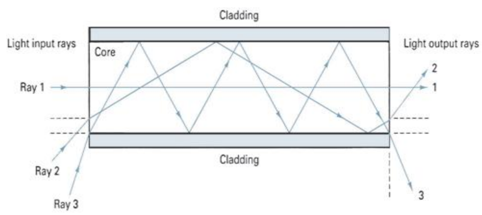

Fig 6:- Light propagation down a multimode step-index fiber [2]

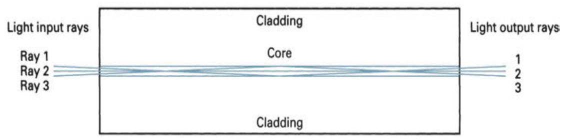

Fig 7:- Light propagation down a single-mode step-index fiber[2]

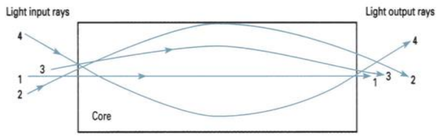

Fig 8:- Light propagation down a multimode graded-index fiber [2]

➢ *Coupling Losses*

In imperfect physical connections cause the coupling loss. In fiber cables, there are three types of optical junctions can be occurred coupling loss: light source (LED or Laser)-to-fiber connections, fiber-to-fiber connections, and fiber-to-photo detector (APD or Demodulator) connections. Lateral misalignment, gap misalignment, angular misalignment, and imperfect surface finishes cause the junction loss.

III. FIBER OPTIC CONNECTORS

The optical fiber cables are terminated in the switch with fiber optic connectors. There are many types of connectors, but the most common are SC/PC and LC/PC connectors.

➢ *Connector Types*

There are many types of connectors in circulation. The most popular connector was the ST type, a bayonet connector that has shown to be unstable. These connectors cannot get certified anymore. If we used a ST connector in a local area network, and if the installation is no longer stable, the connector may very well be the reason for the instability.

Fig 9:- ST Connector [4]

The SC connector is very popular because it can be produced at a low price and because it actually works. The only disadvantage of this connector is the size.

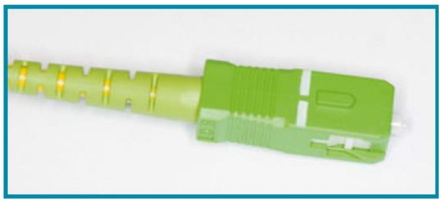

Fig 10:- SC Connector[4]

The successor to the SC and ST types is the LC, or Lucent, connector. It is so small, that if there is room for one Rj-45 connector, there will be room for two LC connectors, at the same place. Besides that, it is simple and stable, and it is produced by many manufacturers. The LC connector is available in multi mode (beige), single mode (blue) and furthermore, in a non-reflective design (green). The use of this connector type is becoming more and more widespread. But again, the biggest advantage of the LC is the small size. In a 43H rack there is room for 1920 LC connectors. There are some problems, though, with the outgoing patch cables, due to the many connectors.

Fig 11:- LC Connector [4]

Fig 12:- Rack with LC Connectors. Notice the patch cables on their way to the active equipment [4]

Fig 13:- The Passive Section [4]

The MT-Rj connector was, for some time, predicted to be the FTTD (Fiber to the Desk) connector, having two fibers and being just as small as a Rj45 connector. But now it is not so popular anymore.

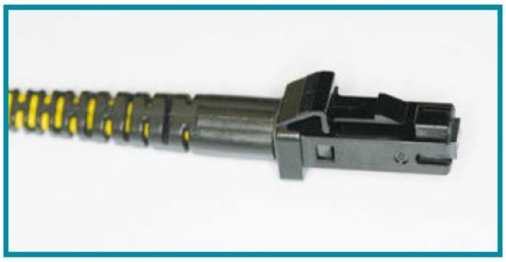

Fig 14:- MT-Rj connector [4]

The connector shown on figure 7, the FC-PC connector, was earlier on regarded as one of the best connectors, but now going out of use.

Fig 15:- FC-PC Connector[4]

Within the world of tele communications the E-2000 is being widely used. It is a high-quality type of connector and among other qualities, it is good at handling the high power in analog tv installations. E-2000 is born with a protection cap, shielding against the very dangerous laser light.

Fig 16:- E-2000

➢ *Pre-polished Connectors*

There are many plug types and many connection method. The pre-polished connectors can be used to make a small number of terminations only.

Fig 17:- Pre-polished Connectorfrom Belden

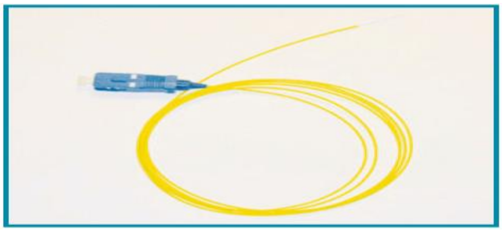

Fig 18:- A Pigtail, that is, a connector with 1 meter of fiber attached.

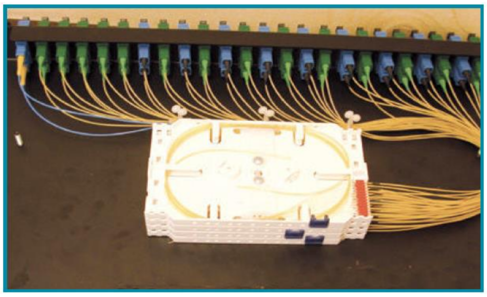

Fig 19:- Patch cable, terminated by a splicing cassette[4]

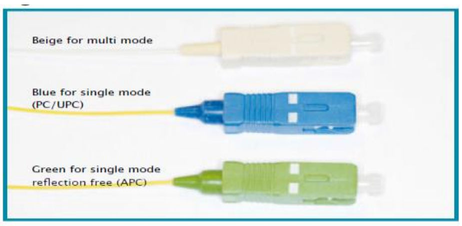

Fig 20:- 3 types of SC Connectors[4]

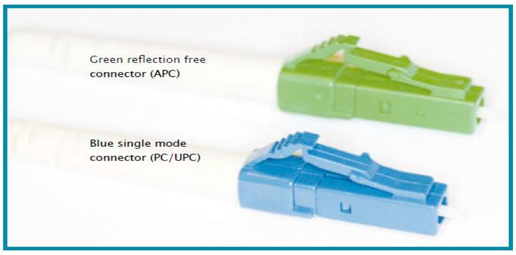

Fig 21:- 2 types of LC Connectors[4]

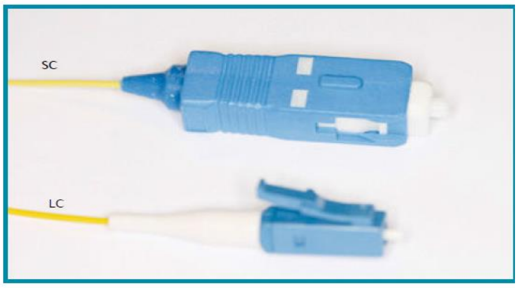

Fig 22:- LC and SC ConnectorLC is half size[4]

IV. FIBER OPTIC SPLICING

The two fiber optic cables can join together by using splicing method. Fiber splicing cause light power loss and back reflection. When the cable operates too long for a single length of fiber or when joining two different types of cable together, such as a 48-fiber cable to four 12-fiber cables. To restore fiber optic cables splicing is used when a buried cable is accidentally severed. There are two methods of fiber optic splicing, fusion splicing & mechanical splicing

➢ *Mechanical Splicing:*

Mechanical splices are simply alignment devices, the two fiber ends in a precisely aligned position is designed thus enabling light to pass from one fiber into the other. A typical value of splicing loss is 0.3 dB)

➢ *Fusion Splicing:*

In fusion splicing, a precisely alignment of the two fiber ends are connected by using the machine then the two glass ends are "fused" or "welded" together using some type of heat or electric arc. A continuous connection between the fibers ends cause very low loss light transmission. A Typical value of the splicing loss is 0.1 dB. **Fusion Splicing Method**As Ffusion splicing is a connecting of two or more optical fiber cables that have been permanently affixed by an electric welding

V. ESTIMATE A POWERE BUDGET

Fig.23 shows the power loss model of an optical fiber link. The power is lost in the fiber, connectors and splicing.

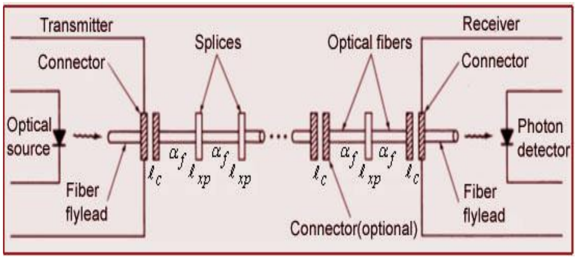

Fig 23:- The Power Loss Model of an Optical Fiber Link

The fiber loss depends upon the wavelength and also the physical conditions of the fiber.

Table.2 The following chart shows the different fiber optic standards as defined by the IEEE [5]

Standard	Data Rate (Mbps)	Cable Type	IEEE Standard Max.Distance
10Base-FL	10	Multi-mode: 850 nm; 50/125µm or 62.5/125µm	2 km
100Base-FX	100	Multi-mode: 1300 nm; 50/125µm or 62.5/125µm	2 km
100Base-SX*	100	Multi-mode: 850 nm; 50/125µm or 62.5/125µm	300m
100Base-LX	100	Single-mode: 1310nm, 1550nm, 9/125µm	100 km
1000Base-SX	1000	Multi-mode: 850 nm; 62.5/125µm Multi-Mode; 850 nm; 50/125µm	220m 550m
1000Base-LX	1000	Multi-mode: 1300 nm; 50/125µm or 62.5/125µm Single-mode; 1310 nm; 9/125µm	550 m 2 km
1000Base-LH*	1000	Single-mode: 1550 nm; 9/125µ	70km

Table 2

ISSN No:-2456-2165

Table.3 The numbers listed are averages, and are standard for new fiber [5]

Wavelength/Mode	Fiber Core Diameter	Attenuation per Kilometer*	Attenuation per Splice	Attenuation Per Connector	Modal Bandwidth (MHz-km)
850 nm multi-mode	50 µm	2.40 dB	0.1 dB	0.75 dB	500
850 nm multi-mode	62.5/125 µm	3.0dB	0.1 dB	0.75 dB	200
1300 nm multi-mode	50 µm	0.70 dB	0.1 dB	0.75 dB	500
1300 nm multi-mode	62.5/125 µm	0.75 dB	0.1 dB	0.75 dB	500
1310 nm single-mode	9 µm	0.35 dB	0.01dB	0.75 dB	N/A
1550 nm single-mode	9 µm	0.22dB	0.01dB	0.75 dB	N/A

Table 3

➢ *Estimate Total Link Loss*

This calculation will estimate the total link loss through a particular fiber optic link where the fiber lengths, as well as the number of splices and connectors, are known. This calculation is simply the sum of all worst-case loss variables in the link:

$$\text{Link Loss} = [fiber\ length\,(km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors] + [safety\ margin]$$

For a 10km single mode link at 1310nm with a connector pairs (sc/upc) and 6 slices (3km/drum):

$$\text{Link Loss} = [(10km) \times 0.4dB/km] + [0.01dB \times 5] + [0.75dB \times 1] + 3\text{dB} = 7.8\text{dB}$$

In this project, an estimated 7.8dB of power would be required to transmit across the link.

It is very important to measure and verify the actual link loss values once the link is established to identify any potential performance issues.

➢ *Estimate Fiber distance*

This calculation will estimate the maximum distance of a particular fiber optic link given the optical budget and thenumber of connectors and splices contained in the link:

$$Fiber\ Length = \frac{[Optical\ budget] - [link\ loss]}{fiber\ loss/km}$$

$$Fiber\ Length = \left\{ \begin{matrix} [(min.TX\ PWR) - (RX\ sensitivity)] - \\ [splice\ loss\ \times number\ of\ splices] - \\ [connector\ loss\ \times number\ of\ connectors] - \\ [safety\ margin] \end{matrix} \right\} \div [fiber\ loss/km]$$

For a Fast Ethernet Single Mode Link at 1310nm with connector pairs and 5 splices:

$$Fiber\ Length = \left\{ \begin{matrix} [(-8dB) - (-34dB)] - \\ [0.01dB \times 5] - \\ [0.75dB \times 2] - \\ [3.0dB] \end{matrix} \right\} \div [0.4dB/km]$$

$Fiber\ Length = 53.625$km

VI. PROJECT ACTIVITIES

➢ *Yaesagyo Fiber (48 Core Fiber)*

Fig 30:- Map of the Project

➢ *MGY0011-MGYM0129*

Trenching Length - 4.67 km
Cable Length - 5 km
No of Joints - 1
Termination at Tower side - 1
Work schedule - 15 Nov 2017 to 22 Dec 2018
Total working Days - 24 days
Trenching/Digging works - 15 days
Cable laying works - 3 days
Splicing/Jointing/testing - 1 day
Backfilling & Warning Tape laying - 4 days
Construction of Manhole & Marker Pole - 7 days
(working in parallel while cabling/backfilling)
Acceptant Test/Commissioning - 1 day

➢ *Power Loss Budget calculation*

Single mode optical cable length = 5km (3km/drum)
Number of connector =2 (SC/UPC)
Number of splices =1
Using wavelength λ= 1310nm

$$\text{Link Loss} = [fiber\ length\,(km) \times fiber\ attenuation\ per\ km] +$$

ISSN No:-2456-2165

$$[splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors]$$

Link Loss = $[(5km) \times 0.35dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$
= 3.26dB

If we consider the Safety margin (3dB)

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors] + [safety\ margin]$

Link Loss = $[(5km) \times 0.35dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$+3dB
= 6.26dB

- *MGY0011-MGYM0130*

Trenching Length - 3.25 km
Cable Length - 3.52 km
No of Joints - 1
Termination at Tower side - 1
<u>Work schedule - 15</u>
<u>Nov 2017 to 22 Dec 2018</u>
Total working Days - 13
days
Trenching/Digging works - 7 days
Cable laying works - 2 days
Splicing/Jointing/testing - 1 day
Backfilling & Warning Tape laying - 3 days
Construction of Manhole & Marker Pole - 7 days
(working in parallel while cabling/backfilling)
Acceptant Test/Commissioning - 1 day
(work in parallel with 129 route)

Power Loss Budget calculation

Single mode optical cable length = 3.52km (3km/drum)
Number of connector =2(SC/UPC)
Number of splices =1
Using wavelength λ= 1310nm

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors]$

Link Loss = $[(3.52km) \times 0.35dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$
= 2.742dB

If we consider the Safety margin (3dB)

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors] + [safety\ margin]$

Link Loss = $[(3.52km) \times 0.35dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$+3dB
= 5.742dB

Single mode optical cable length = 3.52km (3km/drum)
Number of connector =2 (SC/UPC)
Number of splices =1
Using wavelength λ= 1550nm

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors]$

Link Loss = $[(3.52km) \times 0.22dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$
= 2.2844dB

If we consider the Safety margin (3dB)

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors] + [safety\ margin]$

Link Loss = $[(3.52km) \times 0.22dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$+3dB
= 4.2844dB

- *Power Loss Budget calculation for FIO02*

Single mode optical cable length = 3.52km (3km/drum)
Number of connector =2 (SC/UPC)
Number of splices =1
Using wavelength λ= 1310nm

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors]$

Link Loss = $[(3.52km) \times 0.35dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$
= 2.742dB

If we consider the Safety margin (3dB)

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors] + [safety\ margin]$

Link Loss = $[(3.52km) \times 0.35dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$+3dB
= 5.742dB

Single mode optical cable length = 3.52km (3km/drum)
Number of connector =2 (SC/UPC)
Number of splices =1
Using wavelength λ= 1550nm

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors]$

Link Loss = $[(3.52km) \times 0.22dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$
= 2.2844dB

If we consider the Safety margin (3dB)

Link Loss = $[fiber\ length\ (km) \times fiber\ attenuation\ per\ km] + [splices\ loss \times number\ of\ splices] + [connector\ loss \times number\ of\ connectors] + [safety\ margin]$

Link Loss = $[(3.52km) \times 0.22dB/km] + [0.01dB \times 1] + [0.75dB \times 2]$+3dB
= 5.2844dB

ISSN No:-2456-2165

CABLE MEASUREMENT RECORD (48 cores)

Date 22.7.2017

Cable Link :**MGY0011-MGYM0129**		No of Mobile Cable	
1	Hand Over		
2	After Pull Cable		
3	Finish hanging Cable		

No	**Fiber No**	**Length (km)**	**Estimated Loss**	**Estimated Loss include safety margin**	**Actual loss**	**Error**	**Note**
1	FIO 01	5.034	3.26dB	5.26dB	3.2719dB	1.19%	1310nm
2	FIO 02	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
3	FIO 03	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
4	FIO 04	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
5	FIO 05	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
6	FIO 06	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
7	FIO 07	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
8	FIO 08	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
9	FIO 09	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
10	FIO 10	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
11	FIO 11	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
12	FIO 12	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
13	FIO 13	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
14	FIO 14	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
15	FIO 15	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
16	FIO 16	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
17	FIO 17	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
18	FIO 18	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
19	FIO 19	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
20	FIO 20	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
21	FIO 21	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
22	FIO 22	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
23	FIO 23	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
24	FIO 24	5.034	3.26dB	5.26dB	3.2719dB	1.19%	

Table 4

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CABLE MEASUREMENT RECORD							
Date 22.7.2017							
Cable Link :**MGY0011-MGYM0129**				No of Mobile Cable			
1	Hand Over						
2	After Pull Cable						
3	Finish hanging Cable						
No	**Fiber No**	**Length (km)**	**Estimated Loss**	**Estimated Loss include safety margin**	**Actual loss**	**Error**	**Note**
25	FIO 25	5.034	3.26dB	5.26dB	3.2719dB	1.19%	1310nm
26	FIO 26	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
27	FIO 27	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
28	FIO 28	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
29	FIO 29	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
30	FIO 30	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
31	FIO 31	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
32	FIO 32	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
33	FIO 33	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
34	FIO 34	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
35	FIO 35	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
36	FIO 36	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
37	FIO 37	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
38	FIO 38	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
39	FIO 39	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
40	FIO 40	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
41	FIO 41	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
42	FIO 42	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
43	FIO 43	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
44	FIO 44	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
45	FIO 45	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
46	FIO 46	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
47	FIO 47	5.034	3.26dB	5.26dB	3.2719dB	1.19%	
48	FIO 48	5.034	3.26dB	5.26dB	3.2719dB	1.19%	

Table 5

CABLE MEASUREMENT RECORD							
Date 21.7.2017							
Cable Link :**MGY0011-MGYM0130**			No of Mobile Cable				
1	Hand Over						
2	After Pull Cable						
3	Finish hanging Cable						
No	**Fiber No**	**Length (km)**	**Theoritical result**	**Estimated Loss include safety margin**	**Actual loss**	**Error**	**Note**
1	FIO 01	3.526	2.742dB	5.742dB	2.7441dB	0.21%	1310nm
2	FIO 02	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
3	FIO 03	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
4	FIO 04	3.526	2.742dB	5.742dB	3.7441dB	0.21%	
5	FIO 05	3.526	2.742dB	5.742dB	3.7441dB	0.21%	
6	FIO 06	3.526	2.742dB	5.742dB	3.7441dB	0.21%	
7	FIO 07	3.526	2.742dB	5.742dB	3.7441dB	0.21%	
8	FIO 08	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
9	FIO 09	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
10	FIO 10	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
11	FIO 11	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
12	FIO 12	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
13	FIO 13	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
14	FIO 14	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
15	FIO 15	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
16	FIO 16	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
17	FIO 17	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
18	FIO 18	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
19	FIO 19	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
20	FIO 20	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
21	FIO 21	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
22	FIO 22	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
23	FIO 23	3.526	2.742dB	5.742dB	2.7448dB	0.21%	
24	FIO 24	3.528	2.742dB	5.742dB	2.7448dB	0.28%	

Table 6

CABLE MEASUREMENT RECORD							
Date 21.7.2017							
Cable Link :**MGY0011-MGYM0130**			No of Mobile Cable				
1	Hand Over						
2	After Pull Cable						
3	Finish hanging Cable						
No	**Fiber No**	**Length (km)**	**Estimated Loss**	**Estimated Loss include safety margin**	**Actual loss**	**Error**	**Note**
25	FIO 25	3.528	2.742dB	5.742dB	2.7448dB	0.28%	1310nm
26	FIO 26	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
27	FIO 27	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
28	FIO 28	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
29	FIO 29	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
30	FIO 30	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
31	FIO 31	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
32	FIO 32	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
33	FIO 33	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
34	FIO 34	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
35	FIO 35	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
36	FIO 36	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
37	FIO 37	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
38	FIO 38	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
39	FIO 39	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
40	FIO 40	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
41	FIO 41	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
42	FIO 42	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
43	FIO 43	3.526	2.742dB	5.742dB	2.7441dB	0.21%	
44	FIO 44	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
45	FIO 45	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
46	FIO 46	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
47	FIO 47	3.528	2.742dB	5.742dB	2.7448dB	0.28%	
48	FIO 48	3.526	2.742dB	5.742dB	2.7441dB	0.21%	

Table 7

VII. WORK ACTIVITIES ON MGY0011-MGYM0129

Fig 31:- Cable route on map

Fig 32:- Digging Works

Fig 33

Fig 34

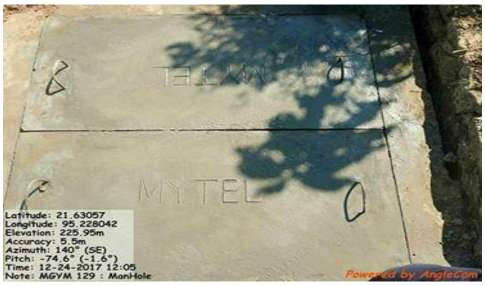

Fig 35:- Man Hole


Fig 36


Fig 37:- Cabling Works


Fig 38:- Warning Tape Laying


Fig 39:- Marker Poles

Fig 40:- Cable route on map

VIII. CONCLUSION

The optical transmission power loss budget is calculated according to the theoretical formula and the data are shown in the cable measurement results. And then the actual power losses are calculated from the actual fiber length for transmission in Yaesagyo. The estimated data and actual data that are calculated from the optical fiber length are shown in the results table. For 5km power cable, the power loss budget is -3.26dB although the maximum actual loss is -3.2719dB that does not include the safety margin. The actual power loss is more than the estimated loss. But the error is 1.19% for fiber length 5.034km, 0.21% for fiber length 3.526km and 0.28% for the fiber length 3.528km. so that the transmission system is acceptable for this error in 4G transmission system.

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