ISSN No:-2456-2165

Performance of Link Loss Budget for Repeaterless Fiber Transmission in Yaesagyo Township by using ODTR Meter

[1]Tin Tin Hla, [2]Zaw Min Aung
[1]Department of Electronics Engineering
[2]Mandalay Technological University, Mandalay, Myanmar

Abstract:- Fiber optic transmission is that an electrical is converted into light (light source) which is transmitted through along the optical fiber into the receiver where the light signal is converted into electrical signal (light detector). Fiber optic transmission has many advantages over other communication system. Major limiting characteristic of in an optical fiber communication is the loss of the optical signal as it goes through the fiber. The performance if the optical fiber is related the end to end loss in the passive optical fiber cable between the transmitter and receiver. The passive fiber optic link may include fiber optic cable, fiber optic connectors, fiber optic adapters, fiber optic splices and fiber optic "hardware" (housings and connector panels).

In this paper the insertion loss and reflection loss are measured by ODTR meter. And then the link loss budget of optical transmission in Yaesagyo Township is calculated by using the standard value. The actual link loss is measured by using Optical Time Domain Reflectometer (ODTR) device. The estimated data and actual measurement data are analyzed.

Keywords:- *Link Budget, ODTR Meter, Fiber Cable.*

I. INTRODUCTION

As with any communications system, optical fiber systems consist of a source and a destination that are separated by numerous components and devices that introduce various amounts of loss or gain to the signal as it propagates through the system. Figure 1 shows two typical optical fiber communications system configurations. It is a repeaterless system where the source and destination are interconnected through one or more sections of optical cable. With a repeaterless system, there are no amplifiers or regenerators between the source and destination.

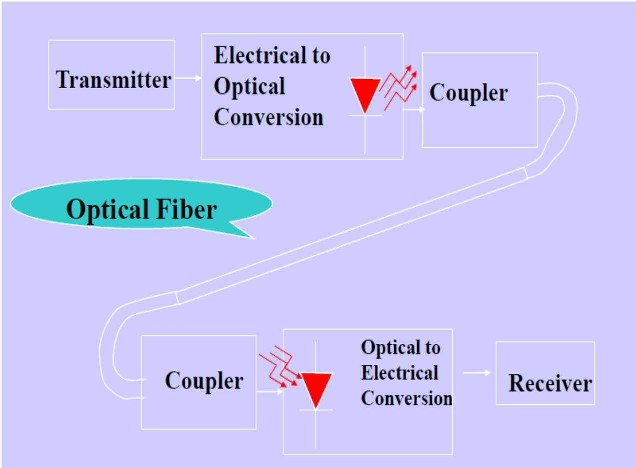

Fig 1:- OFC Point to point link [2]

II. LINK BUDGET

The link budget consists of alight power source, a light detector, and various cable and connector losses. Losses typical to optical fiber links include Cable losses, Connector losses, Source-to-cable interface loss, Cable-to-light detector interface loss, Splicing loss, Cable bends. The predominant losses in optical fiber cables are Absorption loss Material, or Rayleigh, scattering losses Chromatic, or wavelength, dispersion, Radiation losses, Modal dispersion, and Coupling losses. If the optical input power is P1 (dBm) and the optical output power is P2 (dBm), the power loss is P1 - P2 dB. In order to see how much power is lost between input and output, refer to the dB value in this power conversion table: [1]

dB	Power Out as a % of Power In	% of Power lost	lost Remarks
1	79%	21%	-
2	63%	37%	-
3	50%	50%	1/2 the power
4	40%	60%	-
5	32%	68%	-
6	25%	75%	1/4 the power
7	20%	80%	1/5 the power
8	16%	84%	1/6 the power
9	12%	88%	1/8 the power
10	10%	90%	1/10 the power
11	8%	92%	1/12 the power
12	6.3%	93.7%	1/16 the power
13	5%	95%	1/20 the power
14	4%	96%	1/25 the power
15	3.2%	96.8%	1/30 the power

Table 1:- Power Conversion Table[1]

When direct line (LD) optical input into the fiber is 0dBm and output power is 15dBm, optical loss for the fiber is calculated as:

I
nput Output Optical Loss:
0dBm - (-15dBm) =15dB

In the power conversion table, 15dB for optical loss equals 96.8 percent of lost optical power. Therefore, only 3.2 percent of optical power remains when it travels through the fiber.

III. FIBER OPTIC CONNECTORS

A. Choice of connector style

Fiber optic connectors are manufactured in a variety of different styles, (e.g. SC, ST, LC, MTP). While US industry standards allow the use of any connector with a reference TIA FOCIS document (Fiber Optic Connector Intermateability Standard), consideration should be given to compatibility with current cable plant hardware and system electronics. The cable plant connectors should be different from the electronics, hybrid patch cables will be required for connecting the cable plant to the electronics. In addition to color codes, incompatible connectors, e.g. SC and LC, can be used where one facility has two types of fibers such as 50/125 and 62.5/125 or multimode and single mode to prevent mating incompatible fiber optic cables.

B. Connector Color Codes

The TIA-598 standard color code for connector bodies and/or boots is:

Beige for multimode connectors
Blue for single-mode connectors
Green for APC (angle physical contact) single-mode connectors

These color codes should be used in addition to the cable color codes or colored strain-relief boots on the connectors to also designate which type of optical fiber is in the cable being connected.

C. Connector Performance

Connector performance shall be within the limits of applicable industry standards. Loss and reflectance limits specified in industry standards is often higher than achieved routinely by experienced installers or specified by manufacturers. Users may specify a more stringent requirement and if so, that specification shall be used for acceptance.

IV. FIBER OPTIC SPLICES

❖ *Types of Splices*

Splices are a permanent joint or connection between two fibers. There are two basic types of splices, fusion and mechanical.

A. Fusion splice

These “weld” the two fibers together with heat, usually in an electric arc. Fusion splicers are generally automated and produce splices that have minimal losses. Fusion splicing should not be performed in a dusty or explosive atmosphere as the electric arc may cause an explosion or fire.

B. Mechanical splices

These align two fibers in a ferrule or v-groove with index-matching gel or adhesive between the fibers to reduce loss and back reflection. Mechanical splices are used for temporary restoration as well as permanent joints.

C. Splice Performance

Splice performance shall be within industry standard limits as specified in TIA-568. Splice performance may be specified by end users at a different value, and if so, those values shall be used for acceptance.

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:- The following chart shows the different fiber optic standards as defined by the IEEE.[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:- The numbers listed are averages, and are standard for new fiber.[5]

V. OTDR TECHNOLOGY

The OTDR injects light energy into the fiber through a laser diode and pulse generator. A coupler fed to the photodiode separates the returning light energy from the injected signal. The optical signal is converted to an electrical value, amplified, sampled, and displayed on a screen.

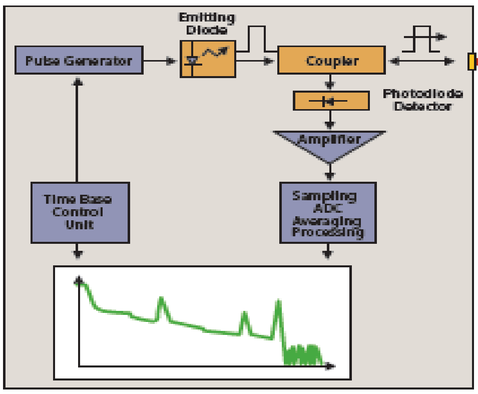

Fig 2:- A schematic diagram showing OTDR technology [3]

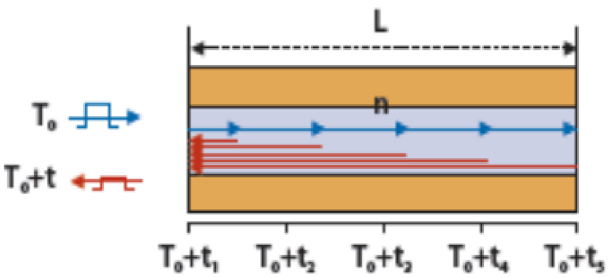

Fig 3:- The OTDR pulse generation principle [3]

The OTDR display shows a vertical scale of attenuation in decibels (dB) and a horizontal scale of distance in kilometers (km) (or feet). Numerous acquisition points are plotted, representing the backscatter signature of the fiber under test. range can be defined as the difference between the extrapolated point of the backscatter trace at the near end of the fiber and the upper level of the noise floor at the fiber end.

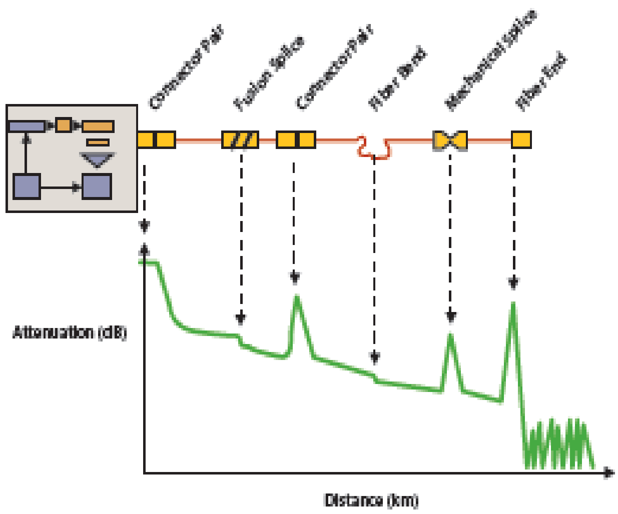

Fig 4:- A typical OTDR trace [3]

Dynamic range is expressed in decibels (dB). The measurement is performed over a 3-minute period, and the results are averaged. Depending on the noise level reference, there are many definitions of dynamic range.

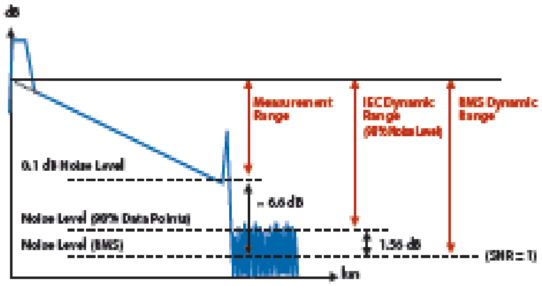

Fig 5:- Different definitions of dynamic range[3]

➢ *Acceptance Testing Without the Use of Launch and Receive Cables [4]*

The OTDR enables technicians to qualify components between both ends of a fiber link. However, neither the front-end connector nor the far-end connector can be qualified when the OTDR is directly connected to the link at the front end and nothing is connected at the far end. In this case, a reference backscattered signal is unavailable; so, loss measurements at the end connector points cannot be determined.

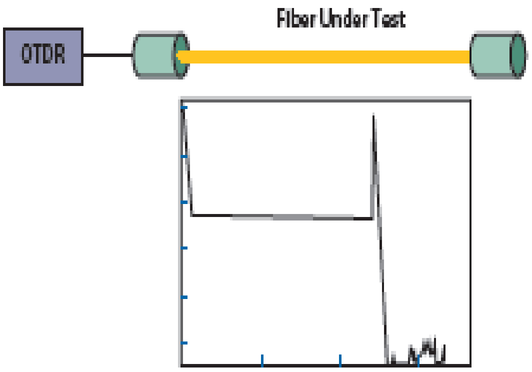

Fig 6:- Acceptance test without the use of launch and receive cables [4]

➢ *Fault Location*

When a cable is damaged, the resulting break may be highly reflective or non-reflective. It is generally much easier to determine an accurate distance to a reflective break. Therefore, it is sometimes helpful to measure several broken fibers until a reflective break is detected.

Fig 7:- Fault location using an OTDR [4]

VI. ESTIMATION OF LINK LOSS BUDGET IN YAESAGYO

➢ *MGY0011-MGYM0129*

Trenching Length - 4.67 km
Cable Length - 5 km
No of Joints - 1
Termination at Tower side - 1
<u>Work schedule- 15 Nov 2017 to 22 Dec 2018</u>
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- 7days (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
Link Loss = [fiber length (km)×fiber attenuation per km]+ [splices loss×number of splices]+[connector loss×number of connectors]
Link Loss = [(5km)×0.35dB/km]+ [0.01dB×1]+[0.75dB×2]
= 3.26dB

If we consider the Safety margin (3dB)
Link Loss = [fiber length (km)×fiber attenuation per km]+ [splices loss×number of splices]+[connector loss×number of connectors]+[safety margin]
Link Loss =[(5km)×0.35dB/km]+ [0.01dB×1]+[0.75dB×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 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)×fiber attenuation per km]+ [splices loss×number of splices]+[connector loss×number of connectors]

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

If we consider the Safety margin (3dB)

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

Link Loss = [(3.52km)×0.35dB/km]+[0.01dB×1]+[0.75dB×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)×fiber attenuation per km]+[splices loss×number of splices]+[connector loss×number of connectors]

Link Loss = [(3.52km)×0.22dB/km]+[0.01dB×1]+[0.75dB×2]

= 2.2844dB

If we consider the Safety margin (3dB)

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

Link Loss = [(3.52km)×0.22dB/km]+[0.01dB×1]+[0.75dB×2]+3dB

= 5.2844dB

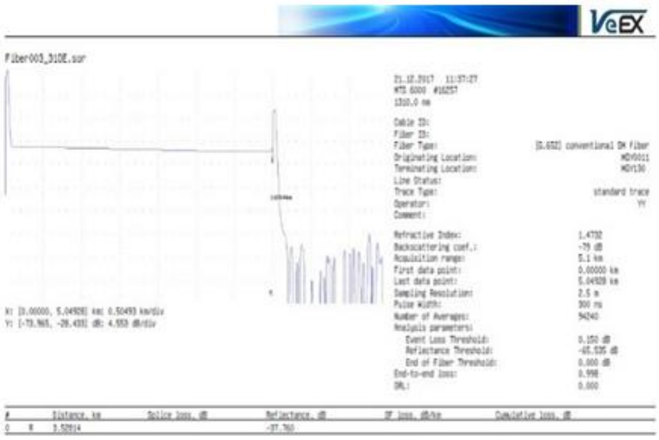

Fig 8:- OTDR measurement for FIO02 (with 1310nm)

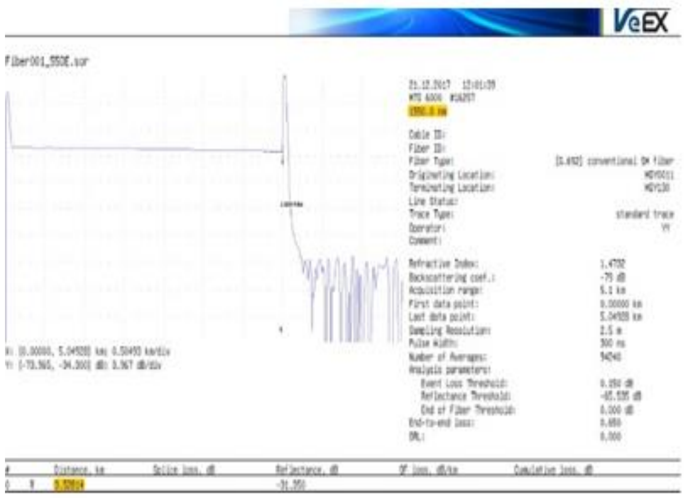

Fig 9:- OTDR measurement for FIO02 (with 1550nm)

❖ *Cable Measurement Test &Results (1)*

Date : 21 Dec-17
Cable Link :**<u>MGY0011-MGYM0130</u>** - No of Mobile Cable
1 Hand Over
2 After Pull Cable
3 Finish hanging Cable

ISSN No:-2456-2165

No	Fiber No	Length (km)	Attenuation (OTDR) (dB)	Theoretical Loss(dB)	Note nm
1	FIO 01	3.526	1.11	2.742	1310
2	FIO 02	3.528	1.175	2.742	
3	FIO 03	3.528	0.998	2.742	
4	FIO 04	3.526	1.251	2.742	
5	FIO 05	3.526	1.166	2.742	
6	FIO 06	3.526	1.177	2.742	
7	FIO 07	3.526	1.064	2.742	
8	FIO 08	3.528	1.199	2.742	
9	FIO 09	3.528	1.203	2.742	
10	FIO 10	3.528	1.159	2.742	
11	FIO 11	3.528	1.131	2.742	
12	FIO 12	3.528	1.177	2.742	
13	FIO 13	3.528	1.249	2.742	
14	FIO 14	3.528	1.213	2.742	
15	FIO 15	3.528	1.079	2.742	
16	FIO 16	3.528	1.12	2.742	
17	FIO 17	3.528	1.26	2.742	
18	FIO 18	3.526	1.16	2.742	
19	FIO 19	3.526	1.207	2.742	
20	FIO 20	3.526	1.145	2.742	
21	FIO 21	3.528	1.342	2.742	
22	FIO 22	3.528	1.167	2.742	
23	FIO 23	3.526	1.214	2.742	
24	FIO 24	3.528	1.057	2.742	
25	FIO 25	3.528	1.199	2.742	1310
26	FIO 26	3.528	1.199	2.742	
27	FIO 27	3.528	1.129	2.742	
28	FIO 28	3.528	1.283	2.742	
29	FIO 29	3.528	1.136	2.742	
30	FIO 30	3.528	1.271	2.742	
31	FIO 31	3.526	1.104	2.742	
32	FIO 32	3.528	1.259	2.742	
33	FIO 33	3.526	1.18	2.742	
34	FIO 34	3.526	1.187	2.742	
35	FIO 35	3.528	1.123	2.742	
36	FIO 36	3.528	1.206	2.742	
37	FIO 37	3.528	1.109	2.742	
38	FIO 38	3.528	1.161	2.742	
39	FIO 39	3.528	1.519	2.742	
40	FIO 40	3.528	1.145	2.742	
41	FIO 41	3.526	1.239	2.742	
42	FIO 42	3.528	1.187	2.742	
43	FIO 43	3.526	1.191	2.742	
44	FIO 44	3.528	1.178	2.742	
45	FIO 45	3.528	1.213	2.742	
46	FIO 46	3.528	1.143	2.742	
47	FIO 47	3.528	1.48	2.742	
48	FIO 48	3.526	1.143	2.742	

HANDOVER RECEIVER

Table 4

❖ *Cable Measurement Test &Results (2)*

Date : 22-Dec-17

Cable Link : **MGY0011-MGYM0129** -No of Mobile Cable

1 Hand Over

2 After Pull Cable

3 Finish hanging Cable

No	Fiber No	Length (km)	Attenuation (OTDR) dB	Theoretical Loss (dB)	Note (nm)
1	FIO 01	5.034	1.719	3.26	1310
2	FIO 02	5.034	1.649	3.26	
3	FIO 03	5.034	1.653	3.26	
4	FIO 04	5.034	1.62	3.26	
5	FIO 05	5.034	1.649	3.26	
6	FIO 06	5.034	1.69	3.26	
7	FIO 07	5.034	1.677	3.26	
8	FIO 08	5.034	1.677	3.26	
9	FIO 09	5.034	1.695	3.26	
10	FIO 10	5.034	1.687	3.26	
11	FIO 11	5.034	1.677	3.26	
12	FIO 12	5.034	1.684	3.26	
13	FIO 13	5.034	1.701	3.26	
14	FIO 14	5.034	1.686	3.26	
15	FIO 15	5.034	1.671	3.26	
16	FIO 16	5.034	1.693	3.26	
17	FIO 17	5.034	1.705	3.26	
18	FIO 18	5.034	1.695	3.26	
19	FIO 19	5.034	1.704	3.26	
20	FIO 20	5.034	1.708	3.26	
21	FIO 21	5.034	1.693	3.26	
22	FIO 22	5.034	1.699	3.26	
23	FIO 23	5.034	1.701	3.26	
24	FIO 24	5.034	1.713	3.26	
25	FIO 25	5.034	1.71	3.26	1310
26	FIO 26	5.034	1.688	3.26	
27	FIO 27	5.034	1.69	3.26	
28	FIO 28	5.034	1.678	3.26	
29	FIO 29	5.034	1.677	3.26	
30	FIO 30	5.034	1.687	3.26	
31	FIO 31	5.034	1.675	3.26	
32	FIO 32	5.034	1.664	3.26	
33	FIO 33	5.034	1.683	3.26	
34	FIO 34	5.034	1.671	3.26	
35	FIO 35	5.034	1.667	3.26	
36	FIO 36	5.034	1.674	3.26	
37	FIO 37	5.034	1.692	3.26	
38	FIO 38	5.034	1.682	3.26	
39	FIO 39	5.034	1.688	3.26	
40	FIO 40	5.034	1.57	3.26	
41	FIO 41	5.034	1.674	3.26	
42	FIO 42	5.034	1.674	3.26	
43	FIO 43	5.034	1.573	3.26	
44	FIO 44	5.036	1.544	3.26	
45	FIO 45	5.034	1.549	3.26	
46	FIO 46	5.034	1.56	3.26	
47	FIO 47	5.034	1.555	3.26	
48	FIO 48	5.034	1.552	3.26	

HANDOVER RECEIVER

Table 5

VII. 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 measured with the OTDR meter and the data are also shown in the results table. For 3.52 km optical fiber cable, the power loss budget is 2.742dB although the maximum actual measurement loss is 1.283dB and the minimum is 0.998dB. For 5km fiber cable, the power loss budget is 3.26dB although the maximum actual measurement loss is 1.719dB and the minimum loss is 1.552dB. The actual power loss is less than the theoretical loss so that the transmission system is acceptable for 4G transmission system.

REFERENCES

[1]. Introduction to Optical Fibers, dB, Attenuation and Measurements, http://kbase:8000/paws/servlet/ViewFile/29000/db_29000.xml?convertPaths=1, 4/20/2005
[2]. Single-Mode Fiber, Splicing and OTDR splice measurements, www.draka.com
[3]. Reference Guide to Fiber Optic Testing, SECOND EDITION Volume 1,
[4]. Installing and Testing Fiber Optics, The Fiber Optic Association, 2016
[5]. Power Budgets and Loss Budgets, Internet source