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MEASUREMENTS OF SINGLE-MODE FIBER OPTICS ATTENUATION/LOSS USING BIDIRECTIONAL TEST TECHNIQUE

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ABSTRACT

One of the effects of attenuation in fiber link is the weakening of the strength of signal as it travels down the fiber. This effect, if not checked or controlled, leads to poor quality network or communication failure. An Optical Time Domain Reflectometer (OTDR) was used to measure the actual attenuations in single-mode fiber using bidirectional techniques. This method handled the limitations posed by the mono-directional technique. The OTDR was able to establish the attenuation in every portion of the fiber under test. Averaging the two mono-directional results (bidirectional analysis) gave a better attenuation limit of 0.191dB/km for 1550 nm signal over the span length of 16.60 km which is within the acceptable standard range of 0.20 dB/km to 0.30 B/km. Hence, quality signal transmissions can be achieved along these routes (fiber core 05 to core 32).

Keywords: *Attenuation, OTDR, Bidirectional, Mono-directional*

INTRODUCTION

Attenuation is the loss or weakening of signal or light pulse strength as signal travels along a communication link (Agrawal, 2002). In fiber optics links, attenuation may be **caused** by scattering, bending, or dispersion. Attenuation cannot be totally eradicated in a communication link but can be controlled or minimized before or after installation of fiber optics. Optical Time Domain Reflectometor (OTDR) is an optical device that can be used to monitor level of attenuation in fiber links (Ilyas and Moftah, 2003). OTDR testing detects events along a fiber optics by monitoring the reflections of the transmitted signals (Dharamvir, 2012). This testing technique could be mono-directional or bidirectional (Douglas, 2010). Mono-directional testing offers some advantages over bidirectional especially in cost implication. This method of testing can compromise the detection of certain events which affects the measurements of the attenuation hence, the need for a better test procedure (Bidirectional OTDR analysis). Bidirectional testing is performed at both ends of the fiber link in order to obtain optimal accuracy. Measurements from OTDR are affected by both real splice loss and the back-scattering ratio difference between the fibers before and after the splice (Etten and Plaats, 1991). Averaging two readings obtained from mono-directional testing helps to eliminate the impact of backscattering coefficients.

However, to optimize attenuation measurements on single-mode fiber, obtaining a good quality mono-directional result is very critical. With good quality mono-directional results, it is possible to optimize the attenuation measurements accuracy through bidirectional testing. Bidirectional analysis also reveals hidden events (where two connectors are close enough to each other to be within the event dead zone of the OTDR) and eliminates dreaded gainers (positive events i.e. apparent negative splice loss). In 2014, Lathief measured attenuation in fiber optics using mono-directional test technique and achieved an attenuation limit of 0.43dB/km over a distance of 40.612 km for 1550 nm signals which is far beyond the standard value range of 0.2 dB/km to 0.3 dB/km as stated by Raghuwanshi (2014). However, this paper presents a bidirectional test analysis which promises more accurate results when compared with standard values.

MATERIALS & METHODS

Materials:

1. Single-Mode Patch cords
2. Power meter
3. Optical Time Domain Reflectometer (OTDR)
4. Media Converter/Transmission Equipment
5. Flash drive

OTDR test procedures

Location: Maina, British America Quarters, Jos (A), to Onward Fisheries, Farin-Gada, Jos (B).
Fiber Type: SM 96 CORE FIBER STERLITE
Device: MTS 6000 Num.2487
Module: 8126LR Num.16131

The OTDR parameters were set as:

Wavelength:	1550 nm
Range (Km):	20.422
Acq. Time:	20s
Resolution:	64cm
Index:	1.46800

A power meter was used in testing for continuity along the cable before the measurements were taken. A single-mode patch cord was attached to the OTDR and to cable plant (Core 05, fiber no. 5) under test via the patch panel at point A as shown in Figure 1. The OTDR was preset manually as stated above and it emitted light power pulses along the cable in a forward direction by the injection laser. The light pulses then bounced back and were measured by the factoring out of time and distances. The backscattered light was detected by the Avalanche photodiode receiver. The output of the photodiode receiver was driven by an integrator which improved the Signal to Noise Ratio (SNR) by giving an arithmetic average over a number of measurements at one point. This signal was fed into a logarithmic amplifier and the average measurements for successive points within the fiber were plotted and recorded with the chart recorder. The media converter was then used in converting the trace to readable format and retrieved with an external drive. The same procedure was repeated for cores 06 to 32 and also at point B for all the fiber cores and results tabulated as seen in Table 1.

Figure 1: OTDR connected to fiber under test

RESULTS

Table 1: Bidirectional test results (Distance=16.60km)

Fiber No.	Loss (dB/km)		
	A-B	B-A	Ave. loss
1	Patched	Patched	Patched
2	Patched	Patched	Patched
3	Patched	Patched	Patched
4	Patched	Patched	Patched
5	0.188	0.186	0.187
6	0.197	0.186	0.192
7	0.195	0.180	0.188
8	0.166	0.194	0.180
9	0.186	0.194	0.190
10	0.226	0.192	0.209
11	0.226	0.197	0.212
12	0.196	0.182	0.189
13	0.186	0.187	0.187
14	0.207	0.175	0.191
15	0.148	0.194	0.171
16	0.218	0.178	0.198
17	Patched	0.197	0.197
18	Patched	0.119	0.119
19	Patched	0.216	0.216
20	Patched	0.189	0.189
21	0.228	0.181	0.205
22	0.223	0.193	0.208
23	0.191	0.185	0.188
24	0.190	0.189	0.190
25	0.173	0.185	0.179
26	0.217	0.192	0.205
27	0.112	0.196	0.154
28	0.188	0.192	0.190
29	0.186	0.270	0.228
30	0.165	0.186	0.176
31	0.197	0.185	0.191
32	0.198	0.219	0.209

DISCUSSION

Attenuation as an undesirable factor in every communication link must be monitored and kept at it barest minimum and within the specified tolerable specifications (0.2 dB/km to 0.30 dB/km). Cores 01 to 04 were patched (i.e. carrying traffic) so measurements were not taken from them. During the mono-directional test (A – B) it was observed that the OTDR measured more backscattering power or energy after the event than before it as seen in Table 1. This demonstrated the limitations associated with this method. The table above clearly shows the differences in attenuations or losses from A-B and B-A. Averaging these losses from cores 05 to 32 gave an accurate loss measurement or attenuation of 0.191 dB/km. This shows that the fiber cores are good for quality signal transmission.

CONCLUSION

An attenuation limit of 0.191dB/km for 1550 nm single- mode signal over the span length of 16.60 km achieved using bidirectional test analysis was within the acceptable standard range of 0.20 dB/km to 0.30 dB/km. The bidirectional test analysis has shown to be of great value than mono-directional testing in calculating fiber cable-plant loss budgets. It offers high degree of accuracy especially for fiber spans too long for the OTDR to reach from a mono-directional test.

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