Measurement of Splice Loss in Optical Fiber Using Optical Time Domain Reflectometer

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Abstract
One of the effects of high splice loss in optic fiber is the weakening of the strength of signal as it travels down the fiber. This effect may be as a result of poor splicing technique or splicing method. If not checked or controlled can lead to poor quality network or communication failure. The two major splice techniques are fusion splicing and mechanical splicing. All splices are allowed 0.3 dB maximum by EIA/TIA 568 standard. Any splice loss more than this becomes a threat to effective signal transmission. Fusion splicing is more reliable in adverse environment than mechanical splicing. An Optical Time Domain Reflectometer (OTDR) was used to measure the maximum splice loss for the 36 core single mode fiber over span length of 18.335 km. The values obtained from cores 20, 21, 23, 24 and 35 are within the accepted or standard values so are certified ok for transmission but, the rest had values greater than the accepted standard. The cores with high splice losses are responsible for the poor communication network along the links. Hence, re-splicing is recommended for those links in order to minimize the losses.

Keywords
Fusion Splicing, Mechanical Splicing, OTDR, Splice loss.

I. Introduction

Fiber splice is a permanent joint required to create continuous link for transmission of signal or light pulses from one fiber length to another [1]. It is used to establish long haul optical fiber links. The two main ways of connecting one fiber to another are mechanical splice and fusion splice [1-2]. In fusion splicing, the fibers are melted together to form a continuous fiber. The source of heat is usually an electric arc, but can also be a laser, or a gas flame, or a tungsten filament through which current is passed. Cleaved fiber ends are fused permanently together using an electric arc. During splicing, fibers area is held in V-grooves for alignment. A variety of splices has been developed to cater for multimode and single-mode fibers. However, in mechanical splicing the fiber ends are cleaved, polished, and aligned with one each other and the gap in between is filled with an epoxy resin which has the same refractive index as the fiber core. There are many ways of aligning the outside of the fibers. One common method is to use a glass tube into which each end of the fiber is pushed [2-3]. A small amount of the epoxy resin is placed on the end of one of the fibers before insertion. Usually, there is a small hole in the tube at the point of the join so that excess epoxy can escape. Mechanical splicing technique though has the lowest cost but it doesn't give better splicing when compared with fusion splice. The quality of the joint depends on [4]:

- The concentricity of the fiber,
- The accuracy of the outside diameter of the fiber, and
- The circularity of the outside of the fiber.

However, this makes a solid permanent connection and is used for fiber-to-fiber joins in most cases. In similar techniques, epoxy glues are often used for pig-tailingmicro-optic devices (like circulators). There is a wide range of epoxies available which will meet most requirements. Advances in the technology have significantly improved performance. System operators typically use mechanical splicing for emergency restoration because it is fast, inexpensive, and easy. All splices are allowed 0.3 dB maximum by EIA/TIA 568 standard [8]. Any splice loss more than this becomes a threat to effective signal transmission. A good-quality fusion splice is determined by two parameters: splice loss and tensile strength [5]. Fusion splicing is more reliable in adverse environment than mechanical splicing.

An optoelectronics device Optical Time Domain Reflectometer (OTDR) can be used in the measurements of splice loss in optical fiber. A typical OTDR consists of eight basic components: the directional coupler, laser generator, time circuit, signal-board computer, Digital Signal Processor (DSP), and analogy to digital converter, sample-and-hold circuit, and avalanche photodiode as shown in fig. 1 [6].

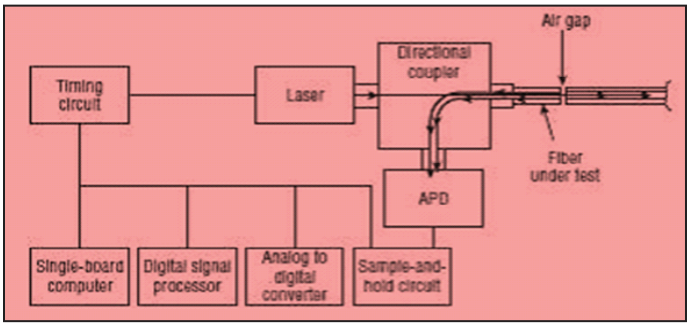

Fig. 1: Block Diagram of OTDR

Fig. 1 shows how light pulses are launched from the laser through the directional coupler into the optical fiber. The directional coupler channels light returned by the optical fiber to the avalanche photodiode. The avalanche photodiode then converts the light energy into electrical energy. The electrical energy is sampled at a very high rate by the sample-and-hold circuit. The sample-and-hold circuit maintains the instantaneous voltage level of each sample long enough for the analogy to digital converter to convert the electrical value to a numerical value. The numerical value from the analogy to digital converter processed by the DSP and the result is sent to the single-board computer to be stored in memory and displayed on the screen. The entire process is typically repeated many times during a single test of an optical fiber and coordinated by the timing. The OTDR will send the light constantly during certain period. The OTDR capture each sample in round–trip time means the actually transmitting time is half of what the OTDR counts. The OTDR shows the time or distance on the horizontal axis and amplitude on the vertical axis. The horizontal axis's unit is shown in meters or kilometers, and dB (decibel) in vertical axis. The trace generated by the OTDR can be used to identify the splice loss as seen in fig. 2.

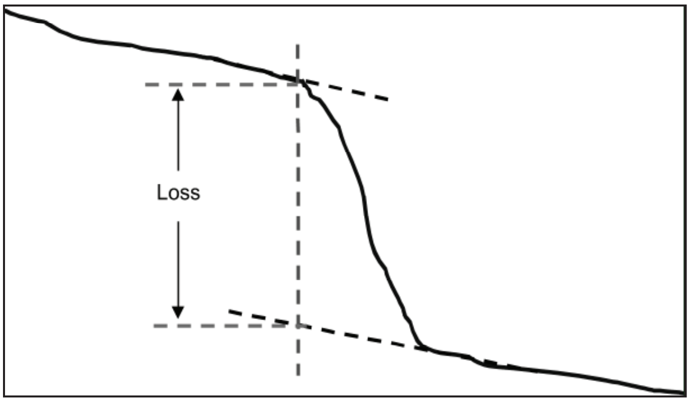

Fig. 2: Splice Loss Trace

II. 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: New Jos University Teaching Hospital (JUTH) to Main Camp, University of Jos
Fiber Type: SM 36CORE FIBER STERLITE
Device: MTS 6026VSR
Module: 7508 Num.8126 VSRE
The OTDR parameters were set as:
Wavelength: 1550 nm
Range (Km): 40.886
Acq. Time: 10s
Resolution: 1.25m
Index: 1.466480

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 (fiber core 01) under test via the patch panel. 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 a readable format which was retrieved with an external drive and results tabulated as seen in Table 1. The procedure was repeated for fiber core 02 to 36 and results displayed in Table 1.

III. Results

Table 1: Splice loss for 36 core fiber

Fiber Core	Splice Loss (dB)
1	0.672
2	0.866
3	0.698
4	0.484
5	0.351
6	0.545
7	0.629
8	0.559
9	0.585
10	0.569
11	0.579
12	0.544
13	0.595
14	0.553
15	0.553
16	0.626
17	0.631
18	0.636
19	0.626
20	0.131
21	0.131
22	-
23	0.134
24	0.150
25	-
26	-
27	-
28	-
29	1.318
30	1.289
31	1.072
32	0886
33	0.789
34	0.350
35	0.275
36	-

IV. Discussion

The results from the OTDR show high splice losses at cores 1 -19 and 29 -34 and moderate/acceptable splices at cores 20, 21, 23, 24 and 35. By implications, the fiber cores with high splice loss will contribute immensely to the cumulative loss in the fiber link which leads to poor transmission quality. In order to minimize the losses, re-splicing of these cores is necessary. Whereas, the fiber cores with acceptable splice losses are certified ok for transmission.

V. Conclusion

An OTDR was used in the measurements of splice losses in 36 core singlemode optical fiber. High splice losses were observed in some while acceptable losses were observed in others. As a result of these findings, professionalism is critical i.e. splice losses should be checked again by OTDR testing from either one side or from two sides of the fiber link. And based on the estimation the splice loss is either approved or rejected.

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