Pearson Technologies Inc.

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OTDR Subtleties- Short Segment, Singlemode, Attenuation Rates

Introduction

Short, singlemode segments exist in many data centers, local area networks, and telephone central offices. Technicians can, and often do, interrogate these short segments with an OTDR. The common, working assumption is that the OTDR measurements will be accurate and repeatable. This assumption is not always valid because there is a minimum, singlemode, segment length, below which the OTDR attenuation rates are inaccurate and non-repeatable. The OTDR technician needs to recognize such situations. Without such recognition, the OTDR technician can misinterpret the measured attenuation rates. In this article, we present a method the OTDR technician can use to approximate: the minimum segment length, below which inaccurate rates occur; and an estimate of the difference between actual and OTDR-measured attenuation rates.

In the complete technical note, we present additional detail and the seven principles that enable understanding the behavior of short segment, singlemode attenuation rates. The complete note is available at: “OTDR Subtleties-Short Segment Singlemode Attenuation Rates” is available as a pdf at: http://www.ptnowire.com/free-resources.html

The Method

Since attenuation rates of short, singlemode segments are inaccurate, the OTDR technician needs to: estimate the minimum segment length and the difference between the actual and the measured rates. These two estimates will differ for different OTDRs and at different wavelengths.

To determine the minimum segment length, below which the attenuation rates become inaccurate, the technician tests a cable or fiber at 1310nm. My experience indicates a minimum length of approximately 2000m. He determines the attenuation rate of the entire fiber by placing cursors near, but not at, the ends of the fiber. See the solid cursor locations in Figure 1. This cursor placement eliminates potential end effects, such as extended dead zone due to high reflectance connectors or bend radius violations at the inner end of the reel due to less than perfect winding.

He records this rate. From this rate, he determines upper and lower limits for the attenuation rate. For example, if the attenuation rate of the entire fiber is 0.33 dB/km, and he allows a difference of ±0.01 dB/km between actual and measured rates, a desirable but impractical value, he calculates an upper limit of 0.34 dB/km and a lower limit of 0.32 dB/km.

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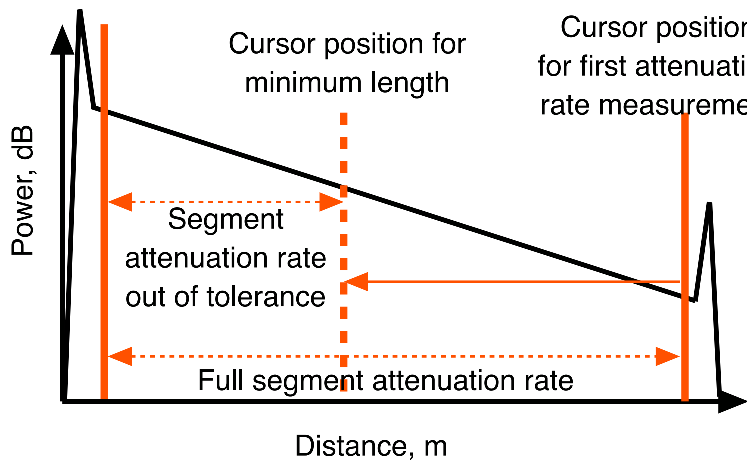

Figure 1: Cursor Positions for Full and Minimum Length Attenuation Rates

He moves the far end cursor on the trace to decreased length (i.e., to the left in Figure 1) , as shown by the arrow from the right cursor to the dotted curser. As he moves the cursor, he monitors the rate of this sub-segment. He continues moving the cursor until the sub-segment rate is outside of the upper and lower limits. In this example, the limits are 0.34 dB/km and 0.32 dB/km. He records this segment length for ±0.01 dB/km. We call this ‘minimum segment length 1’. With this method, the technician knows that the measured attenuation rate for this sub-segment length, the position of the dotted cursor, will be within ±0.01 dB/km of the actual value.

To determine tolerances for segment lengths below minimum segment length 1 [at ±0.01 dB/km,] the technician calculates limits at ±0.02 dB/km. With this second tolerance, the limits are of 0.35 dB/km and a lower limit of 0.31 dB/km. He moves the far end cursor from its position (from using ±0.01 dB/km) on the trace to decreased length (i.e., to the left in Figure 1) , as shown by the arrow from the right cursor to the dotted curser. While monitoring the sub-segment rate, he continues moving the cursor until the sub-segment attenuation rate is outside of the upper and lower limits. With this second step, he knows that the actual attenuation rate will be within ±0.02 dB/km of the measured value. We call this ‘minimum segment length 2’.

To determine tolerances for segment lengths below minimum segment length 2, [at ±0.02 dB/km], the technician he calculates limits at ±0.03 dB/km. With this third tolerance, the limits are 0.36 dB/km and 0.30 dB/km. He moves the far end cursor, from its position for minimum segment length 2, on the trace to decreased length (i.e., to the left in Figure 1) , as shown by the arrow from the right cursor to the dotted curser, until the sub-segment attenuation rate is outside of the upper and lower limits. We call this ‘minimum segment length 3’. With this third step, he knows that the actual attenuation rate will be within ±0.03 dB/km of the measured value.

The technician repeats this test with two additional traces, recording the sub-segments lengths for each trace. Repeating this test on 3 different traces is necessary to define a range of lengths. The minimum segment length has significant variability.

The technician repeats this test 3 times at 1550nm, recoding the sub-segment lengths for each tolerance and each run.

With the method described, the technician creates a table similar to Table 1. This table characterizes the OTDR. Note that the data from two OTDRs indicate different minimum lengths for different OTDRs and for different wavelengths.

OTDR	Tolerance dB/km	1310nm min. length range	1550nm min. length range
OTDR 2	±0.01	870-1173m	593-1701
	±0.03	512-795m	327-895m
OTDR 3	±0.01	370-1374m	688-1874m
	±0.02	327-579m	520-1204m
	±0.03	211-437m	241-1030m

Table 2: Summary of Results with Three Tolerances

This method is based on testing performed by Pearson Technologies Inc. This testing indicated that the accuracy and repeatability of OTDR attenuation rates are acceptable until the segment length is below a minimum value. Below this minimum, the measured rates become increasingly inaccurate, as shown in Figure 2. In the full technical note, we present the cause of this behavior.

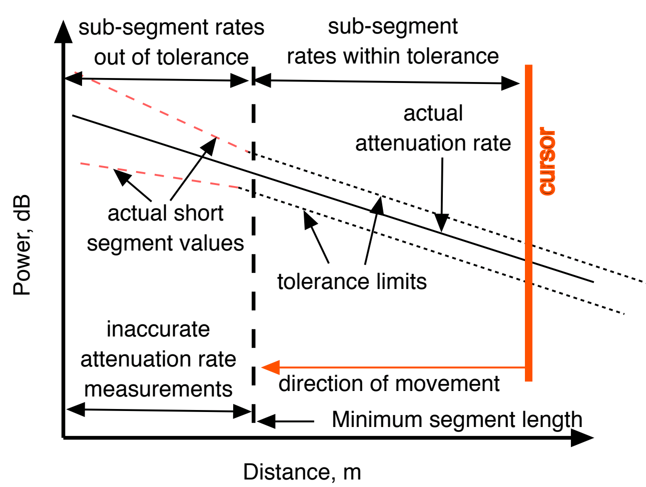

Figure 2: Details of Minimum Length Determination

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About the Author
Eric R Pearson, President, Pearson Technologies Inc., has been active in fiber optic communications for 41 years. He has been recognized as a Master Instructor by both the Fiber Optic Association and BICSI. He is credentialed by the FOA as a Certified Fiber Optic Specialist in Testing, Connectors, Splicing, and Instruction. Pearson Technologies provides installation and design training, and technical services in lawsuits involving patents and cable damage liability and costs. When complete, Mastering The OTDR-Singlemode Subtleties will be available on Amazon.


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