Improving connector loss and splice loss OTDR measurement accuracy of a high backscatter coefficient (high K) fiber pigtail

Application

More and more often we find "Bend Insensitive" (BI) fibers used in headend and central office (CO) jumpers as well as in pre-terminated terminal equipment. Some designs of these fibers have relatively high backscattering coefficients ("K"), primarily due to a larger mode field diameter (MFD).

(NOTE: for the purposes of this Application Note, BI fiber used had a relatively higher K than the standard G.652 fiber to which it was spliced; however, this is the result of the particular design of this BI fiber. Nothing in this document is intended to imply that all BI fiber brands or makes share this characteristic [although they may be unique in other ways]. The recommendations in this Application Note apply to "high K" [or "low K"] fiber.)

The difference in backscatter at the pigtail splice does not prevent but somewhat complicates measurement of the connector loss at the front panel or the splice loss at the front panel. If the pigtail is sufficiently long, 10 meters or so, JDSU Optical Time Domain Reflectometers (OTDRs) with pulses as short as 1 foot can perform these measurements. Depending upon their particular specifications and the actual distances involved, some instruments may or may not use these techniques. At sufficiently small distances, such as 3 or 4 meters, field OTDRs can likely measure only the combined loss of the connector and splice.

Theory

Two different measurement principles are used here.

One principle refers to bidirectional measurement or averaging the losses for each direction to negate any changes in K from one side of the event to the other. The effect of the backscatter level mismatch reverses the sign of the loss value reversing the measurement direction, allowing it to be negated mathematically. This technique is used to measure the pigtail splice between the OSP Standard K fiber and the Pre-Term High K fiber. Locate a generic discussion of bidirectional measurement in the excerpted portion of the JDSU Fiber Guide Volume 1. (The entire Fiber Guide Library, Volumes 1, 2, and Glossary are available for order or download at **www.jdsu.com**.)

The second technique uses a "High K" Receive cable. (Receive cables function similarly to Launch cables and provide a backscatter baseline used in measuring the far-end connector of a system. The excerpt section in this application note of the JDSU Reference Guide to Fiber Optic Testing Volume 1 also explains this technique.) However, in this case, without a dedicated High K launch/receive box an adjacent pigtail was used as a Receive cable that was then looped back to measure the span from the far end. As expected, a small backscatter (coefficient, K) mismatch remains; however, it can be overlooked because it remains well below the magnitude of connector loss. OTDR one-way measurement backscatter mismatches are deemed acceptable, because it is assumed that "like" fibers are spliced or connected.

Procedures

In this scenario, the technician wants to determine the connector loss for the front-panel connector at one end of the High K pre-term pigtail, called Connector 1, while also measuring the value of the splice to the OSP fiber at the other end of the High K pigtail, called Splice 1. In this scenario, the distance from the front-panel connector to the splice, or pigtail length, is about 25 m.

Forward Measurement of Splice 1

Figure 1 shows the test setup for taking forward measurements of Splice 1 using a standard fiber launch box ("standard" K fiber, for example, G.652) connected to the front panel. If the OTDR does not automatically identify all of the pertinent events due to short distances, the operator can use the Manual Measurements function on the OTDR, or the Manual Measurements feature on the PC software to assist the OTDR in identifying slopes and events, as shown here. Eliciting a loss value specifically for Splice 1 requires assisting the OTDR in identifying and measuring Connector 1 for the purposes of this illustration; however, the result will not be used here.

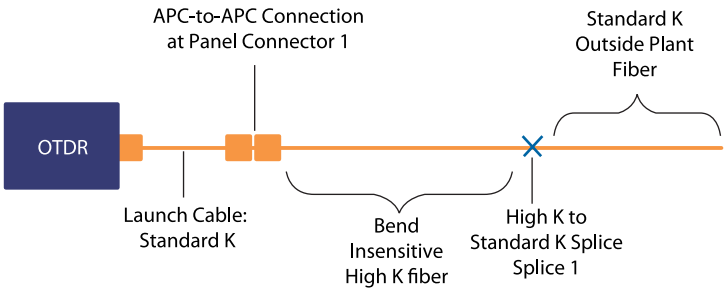

Figure 1. Test setup for forward measurement of Splice 1 using a standard K fiber

OTDR Display with Elevated K Coefficient

The OTDR display shown in Figure 2 (actually the PC emulation software) clearly shows the section of fiber with the elevated K coefficient. Note the relevant value in this trace for the unidirectional loss of Splice 1 taken from the High K fiber to the Standard K fiber of 0.541 dB. Also notice the Connector 1 value of –0.352 dB shown is a relatively large "gainer" due to the K mismatch, but we can overlook this result for now.

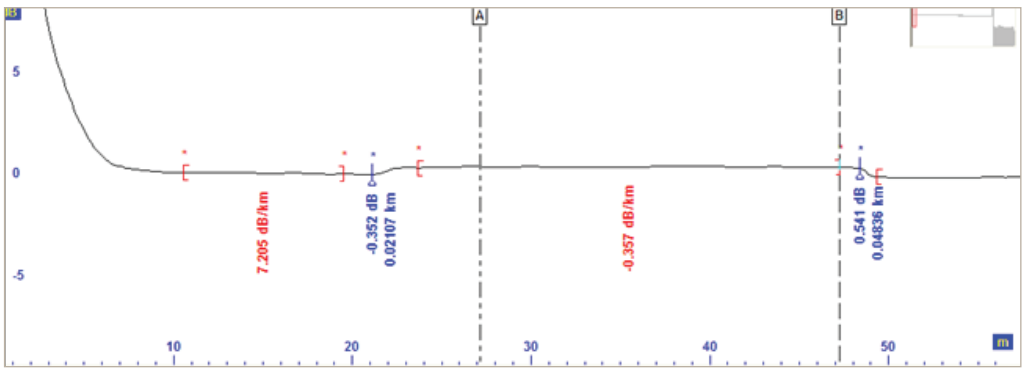

Figure 2. OTDR display of a section of fiber with an elevated K coefficient

Reverse Measurement of Splice 1 and Connector 1 (Using a "High K" Receive Cable)

Figure 3 shows the test setup using the fiber from the previous measurement that is now connected to an adjacent pre-term pigtail and then "shot" from the far end. Thus, now measuring Splice 1 in the opposite direction and applying standard bidirectional calculations. This now measures Connector 1 through an adjacent Bend Insensitive pigtail acting as a "K matching" "receive cable", which enables direct measurement of the connector loss value with minimal risk of error.

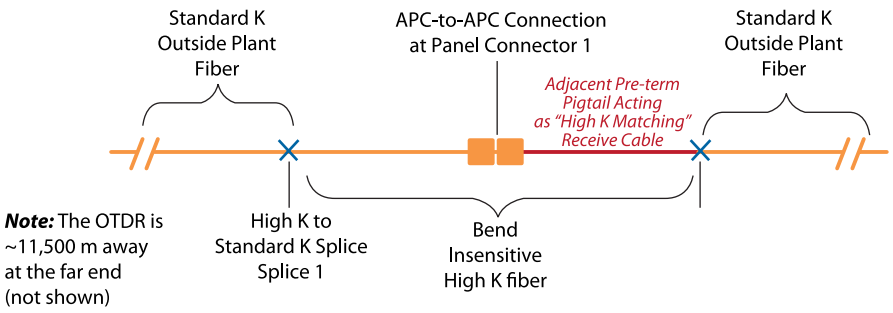

Figure 3. Test setup for reverse measurement of Splice 1 and Connector 1 using a High K Receive Cable

OTDR Display for Reverse Measurement of Splice 1 and Connector 1 using a High K Receive Cable

The display in Figure 4 shows cursors placed to identify section slopes and events that assist in measuring the relative events, which can be accomplished using the PC software or on the OTDR display.

Taking the simplest measurement first, notice Connector 1 with a loss value of 0.053 dB that can be further refined by measuring in the reverse direction and averaging. Doing so would result in a very small K difference (this is High K fiber-to-High K fiber), which is considered unnecessary as we can be confident in this value. Therefore, we accept the one-way loss measurement for the connection.

We now have the other half of the information needed to accurately determine the loss for Splice 1. The previous measurement with High K fiber-to-Low K fiber showed a loss value of 0.541 dB for Splice 1. On this trace, we measured a value for the same Splice 1 of –0.257 dB loss (a negative loss is a "gain") from Low K-to-High K fiber. The algebraic sum of the two values equals a loss of 0.284 dB; however, we measured the Splice twice. Therefore, after calculation, the actual loss value is 0.142 dB.

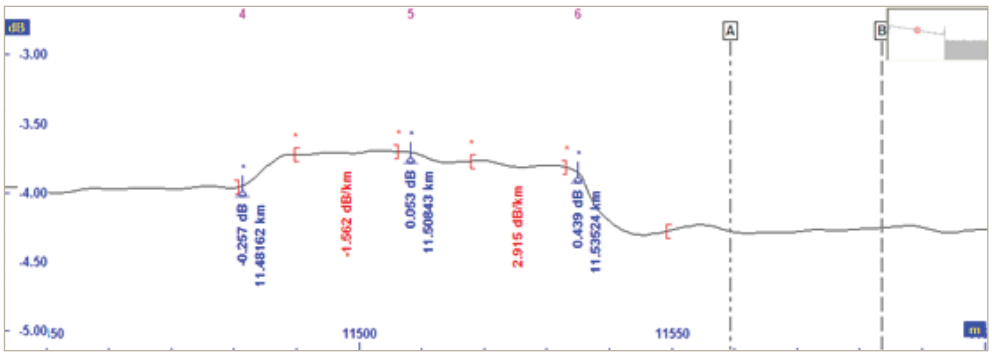

Figure 4. Cursors are placed to identify section slopes and events to assist with measuring the relative events

Conclusion

Increased use of specialty fibers, such as BI fibers, can cause concern for OTDR measurements using the standard and time-tested techniques and tools, such as unidirectional measurement and standard fiber launch boxes.

These techniques were used with certain "assumptions" (all Ks being equal), which is not necessarily true. Small measurement errors allowable under previous assumptions were often deemed acceptable variations in Backscatter coefficients in most fiber used lately.

If previous assumptions are incorrect, and a significant difference does exist in fiber types (and K coefficients) spliced or connected, the errors may not be that easy to overlook. Nonetheless, as this paper demonstrates, an OTDR of sufficiently high resolution and dynamic range, and depending somewhat on the pigtail lengths, can accurately measure the connector loss and splice loss of High K pigtails.

The technique of using a "K matching" launch or receive cable provides a simple method for measuring connector losses for these fibers. We successfully measured Connector 1 with this technique; and we did not have a dedicated cable, so we used an adjacent cable.

(Note: A very long system may have required increasing the OTDR pulse width and might have "blurred" the two events [Connector 1 and Splice 1] allowing us only to report a combined loss for the two.)

If pigtail use persists and operators want accurate connector loss information, use of a dedicated High K launch/receive cable is recommended. While we could have further refined the loss value of Connector 1 through bidirectional testing of the link, we chose not to do so as the minimal difference in K assumed between the two pigtails was deemed unnecessary.

Conducting bidirectional measurements remains an old but consistently valuable tool in these situations. As the second measurement showed, no connection was necessary to measure Splice 1, simply measuring from the opposite end proved sufficient; however, the technique used provided two important values after performing only one measurement.

Acknowledgments

We acknowledge the following individuals and companies who provided assistance in the development of this document.

Stacy Burdette
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 30168338 000 0211 HIGHKPIGTAILS.AN.FOP.TM.AE February 2011