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Applications Engineering Note

Unidirectional OTDR Measurements and “Gainers”

AEN 7, Revision: 4

This Applications Engineering Note (AE Note) addresses specific limitations of unidirectional optical time-domain reflectometer (OTDR) measurements. For theory of operation and typical uses of an OTDR as well as guidance for interpreting test results, consult AE Note 134.

OTDRs are widely used to characterize or troubleshoot telecommunications systems. They are used to measure the fiber attenuation, analyze discrete events (e.g. splices or connectors) and locate damaged link components.

Limitations of Unidirectional Measurements

OTDRs do not directly measure attenuation. Rather, they measure light scattered back to a source. A test light pulse loses power as it propagates along a fiber or as it passes through a splice or connector mating; likewise the backscattered light from that pulse’s interactions with link components usually loses power along the fiber, too.

An OTDR accurately interprets that loss of power as attenuation. However, some conditions *increase* the backscattered light and *an OTDR interprets increased backscatter as an increase in forward power*. Such an occurrence is called a “gainer,” (Figure A), and is commonly observed in spliced links.

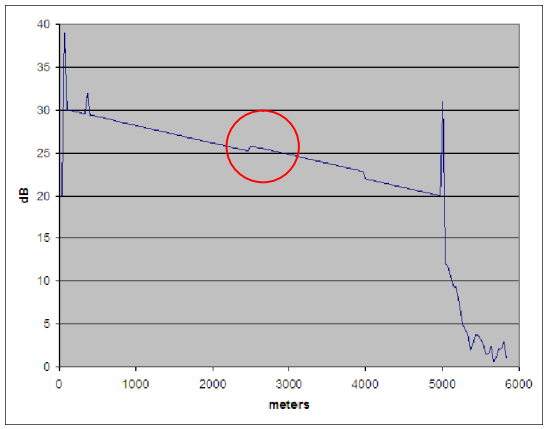


Figure A: OTDR Display of a "Gainer"

Actually gaining power in a passive optical link is impossible, and recognizing this is simple, but an OTDR measurement of the same link, from the *opposite* direction, causes backscattered light to sharply drop. An OTDR correctly interprets this as attenuation, but incorrectly reports exaggerated loss compared to the real attenuation.

Any feature that causes an abrupt change in backscattered light could cause a gainer or exaggerated loss. Two event types potentially cause these phenomena. They are easily distinguished in the field and the technique for accurately measuring each is the same.

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Published: 5/23/2016

The most common cause is mismatched mode-field diameter (MFD) splices (which can occur with connectors, but is more common with splices). Figure A shows a typical MFD mismatch in the gainer direction. *Note the attenuation slope does not change, indicating both fibers are the same type*. Measured the opposite direction, the OTDR would indicate an exaggerated loss for this mating.

AE Note 006 explains actual attenuation due to MFD mismatch, but unidirectional OTDR measurements vary by up to 0.30 dB under normal field conditions, e.g. a real splice of 0.1 dB could measure from -0.20 dB to +0.40 dB (Table 1).

Table 1: Unidirectional Loss Difference from *Actual* Loss		
RANGE	Dissimilar Fibers (Thumb Rule)	Similar Fibers
± 0.05 dB	51%	54%
± 0.10 dB	75%	78%
± 0.15 dB	89%	91%
± 0.20 dB	96%	97%
± 0.25 dB	99%	99%
± 0.30 dB	99.6%	99.8%

Additionally, it is possible, though unlikely, that a change in backscatter from splicing different *types* of fiber produces a gainer or exaggerated loss. Gainers or exaggerated losers are commonly due to differing MFDs.

A dissimilar *type* fiber mating, unlike a simple MFD mismatch results in a *changed attenuation slope* in addition to the exaggerated loser or gainer. (Figure B)

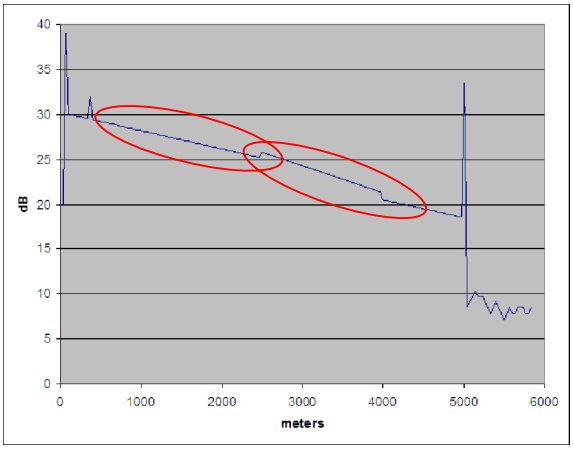


Figure B: Change in MFD and Backscatter

Examples shown are for single-mode fibers, but the same phenomena can occur in multimode fibers. Observed results are similar, though typically more exaggerated.

Additional Information

AE Note 006: *Effects of Splicing Dissimilar Single-Mode Fibers*
AE Note 134: *OTDR Testing*

Direct additional questions to Corning Technical Support: 1-800-743-2671.

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Published: 5/23/2016