OTDR Event Analysis

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Introduction

Data center, enterprise, and FTTx fiber networks present a number of challenges when it comes to locating and measuring events and impairments. These challenges include multiple connectors and splices in each fiber, numerous short jumper cables, and splitters. Higher data speeds drive the need to ensure low reflectance and loss. The sheer number of fibers to be tested can prove to be a daunting task, one requiring automated event analysis. The Noyes M310 uses new, powerful techniques of analyzing OTDR traces that provides users with highly accurate and reliable automated event tables.

Why Accurate Event Analysis is Crucial

Reliable and accurate event analysis is needed to provide baseline documentation of fiber links and to effectively troubleshoot faulty networks. Events on a fiber include connectors, splices, optical splitters and macro-bends. The required measurements of events are:

- Location
- Identification of event type
- Reflectivity
- Loss

These "Tier 2" measurements are required by a number of ANSI, BICSI, TIA, and ISO/IEC standards. OTDR users assume that the event tables, maps, etc. displayed are accurate. In fact, they cannot entirely trust the event analysis provided by OTDRs. AFL Noyes has spent considerable time researching techniques to improve event analysis. As a result of this research, the M310 OTDR has the highest accuracy event analysis of any ODTR in the market.

Evaluating Event Analysis Performance

Unlike other OTDR performance specifications, such as dynamic range and dead zone, there are no industry standards to define how well event analysis performs. AFL Noyes has evaluated its new event analysis techniques, using laboratory and field measurements on many types of single mode and multimode networks that contain numerous event combinations. Comparative evaluations were performed between AFL's own OTDRs, along with those manufactured by other companies. The criteria used to judge the effectiveness of event analysis are:

- Matched event rate: Are all actual events being detected? This should be as high as possible, with 100% being perfect.
- False event rate: Are false events being detected? This is usually due to noise spikes. This should be as low as possible, with 0% being perfect. Every OTDR is subject to identifying False events.
- Pass rate: Are the results repeatable when the same network is tested multiple times? This should be as high as possible, with 100% being perfect.

The M310 is the only OTDR that optimizes all of these, providing better event analysis than any other OTDR.

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The M310 Overcomes Event Analysis Weaknesses

False Event Reduction

OTDRs have always used techniques of event detection based on the apparent magnitude of the event's insertion loss and reflectance. The user sets an "event threshold" and if the magnitude exceeds this threshold, an event is "detected" and displayed. This method is noise sensitive. Therefore, noise spikes may wrongly be classified as an event (a false event). Accuracy also decreases with range, since the noise increases and the magnitude of the event decreases with greater range. This leads to more missed events. Attempting to reduce the number of missed events by increasing the sensitivity (lowering the threshold) will increase the number of false events. This effect is shown in figure 1. The data points show the measured performance of the M310 vs. OTDRs made by other companies with respect to matched and false events. The perfect performance point is the bull's eye at the lower right. The default event threshold for these data points was 0.1 dB. Each of the non-AFL products has poorer performance than the M310 at the 0.1 dB threshold. As the M310's threshold is lowered from 0.1 dB to 0.01 dB the matched event rate increases at the expense of an increase in false events. . As OTDR "F" has its threshold changed from 0.1 dB to 0.01 dB, its matched event performance does not improve, but its false event rate increases significantly.

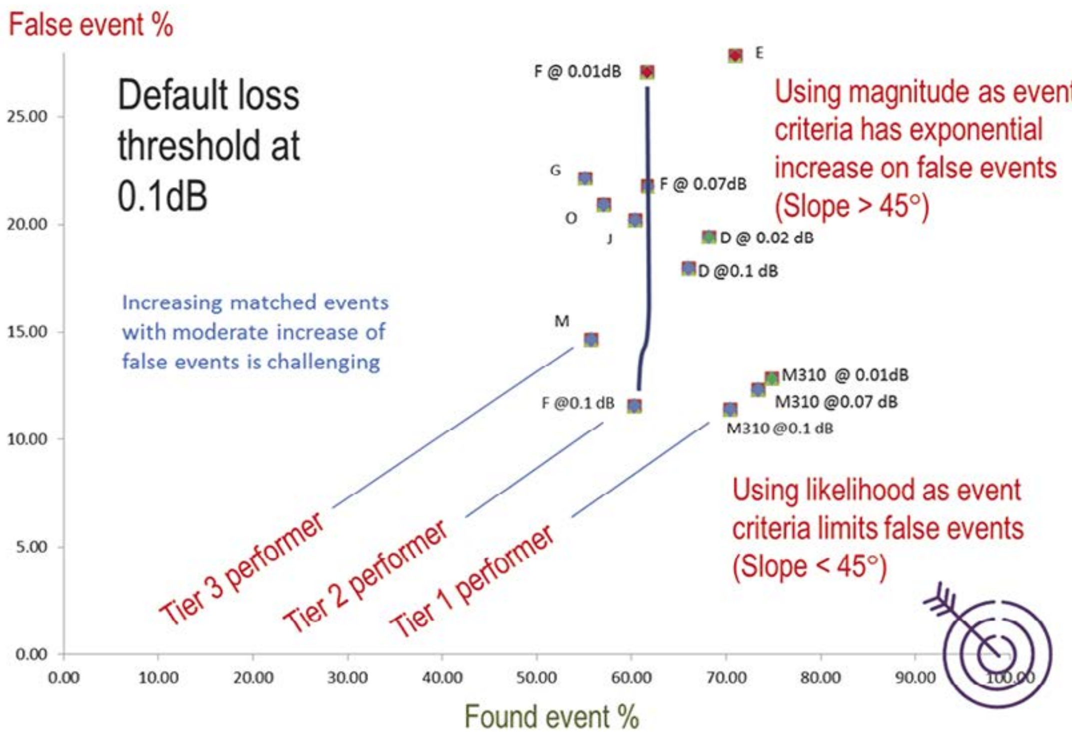

Figure 1 – Event analysis comparison of OTDRs

The M310 uses an event detection technique that permits increased sensitivity while not overly increasing the number of false events. This is illustrated in figure 2. This shows traces taken using the M310, and a non AFL product, on a network with 16 events. The M310 successfully detects the 16 events, while the non-AFL unit shows thirteen false events.

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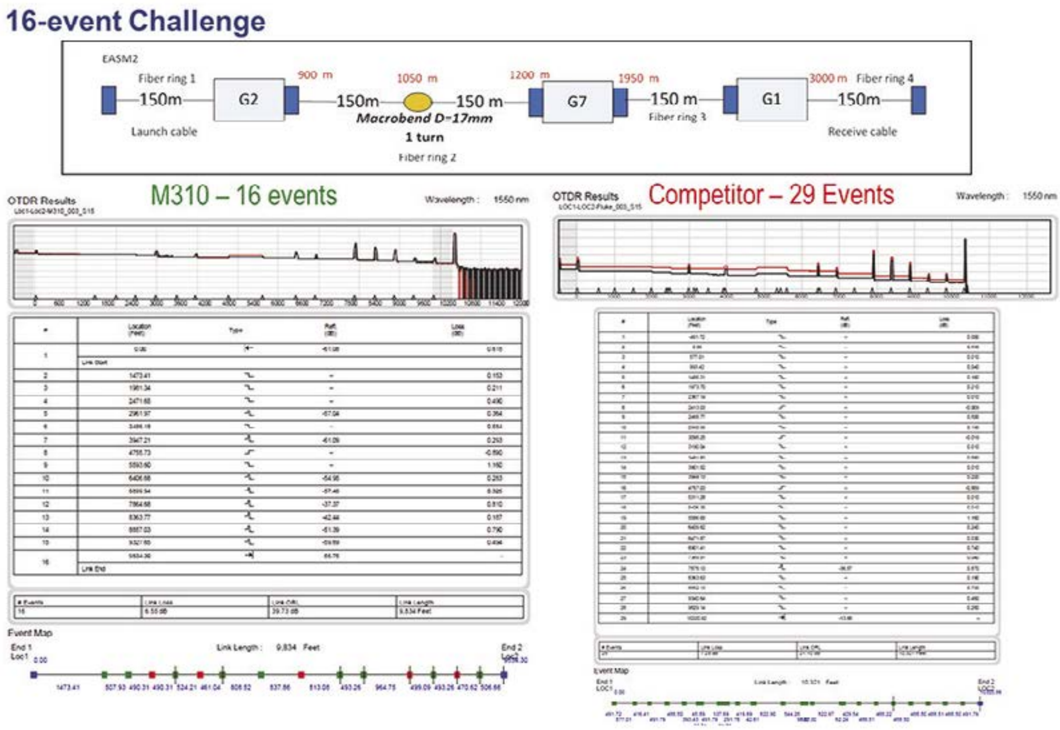

Figure 2 – False events – M310 vs. non-AFL ODTR for a 16-event network

The results in figure 2 are displayed using AFL's Test Result Manager (TRM) PC software. Figure 3 shows the test results of the same non-AFL unit, for the same 16-event network, as displayed by the unit's own test manager software. As in figure 2, there are numerous false events produced by the non-AFL unit.

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OTDR End1 FAIL

Date / Time: 07/29/2013 03:27:00 PM
Test Limit: ANSI/TIA-568-C
Limits Version: 1.7
Operator: MARK M

Tester:
Module:
Calibration Date: 05/01/2013

Launch Only   Launch Type: Singlemode   Launch Length (m): 151

Overall Results	1310 nm	1550 nm	Limit
Overall Length (m)	3149		5000.0
Overall Loss (dB)	6.51	4.56	
ORL (dB)	36.01	38.61	

		Loss (dB)			Reflectance (dB)		
Events		1310 nm	1550 nm	Limit	1310 nm	1550 nm	Limit
3149 m	End	N/A			-15.18		
2999 m	Reflection	0.26		0.75	-49.61		
2850 m	Reflection	0.62		0.75	-55.61		
2701 m	Reflection	1.02F		0.75	-43.82		
	End		N/A			-45.09	
2552 m	Reflection	0.15	0.17	0.75	-39.72	-40.95	
2403 m	Reflection	1.05F	0.81F	0.75	-35.34	-36.62	
2106 m	Reflection	0.43	0.49	0.75	-57.92	-58.69	
1956 m	Reflection	0.06	0.05	0.75	-51.01	-52.25	
1705 m	Loss	1.54F	1.15F	0.30	N/A	N/A	
1496 m	Loss	0.01		0.30	N/A		
1480 m	Loss	0.02		0.30	N/A		
1454 m	Gainer	-1.07	-0.89	0.30	N/A	N/A	
1204 m	Reflection	0.38	0.28	0.75	-56.10	-57.02	
1065 m	Loss	0.02	0.62F	0.30	N/A	N/A	
1006 m	Loss	0.02		0.30	N/A		
904 m	Reflection	0.05	0.05	0.75	-55.15	-55.86	
865 m	Loss	0.03		0.30	N/A		
846 m	Gainer	-0.02		0.30	N/A		
753 m	Loss	0.46F	0.49F	0.30	N/A	N/A	
602 m	Loss	0.18	0.21	0.30	N/A	N/A	
453 m	Loss	0.18	0.16	0.30	N/A	N/A	
392 m	Loss	0.01		0.30	N/A		
304 m	Loss	0.02	0.05	0.30	N/A	N/A	
265 m	Loss	0.02		0.30	N/A		
178 m	Gainer	-0.01		0.30	N/A		
0 m	Launch Event	0.12	0.25	0.75	-52.89	-54.17	
-102 m	Loss	0.01			N/A		
-151 m	OTDR Port	N/A	N/A		-49.35	-54.24	

-FAIL: End of fiber is inconsistent between all wavelengths

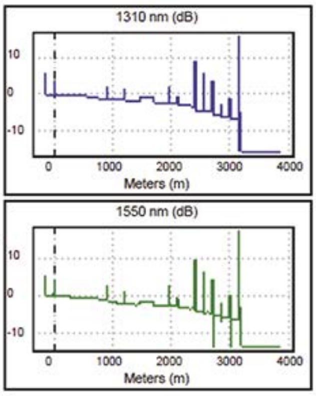

Figure 3 – 16 event network as measure on non-AFL unit

Closely Spaced Events

OTDRs always have problems in separating closely spaced events. Even when the OTDR's dead zone is short enough to show closely spaced events in the trace, the event analysis will not detect all of the events. After the first event, the OTDR's event table will have missed the subsequent close events entirely, or classify them as "hidden" events. The problem with hidden events is that the OTDR lumps them together with the first event and it does not provide an insertion loss measurement for the hidden event. In many applications a full set of measurements is needed for every event. These deficiencies become more severe as the events get close enough to merge together due to the OTDR's dead zone. This is shown in figure 4. In the top portion of the figure, the two similar magnitude events are clearly visible to the eye. In the lower portion of the figure, the second event appears as just an inflection in the decaying attenuation dead zone of the first event.

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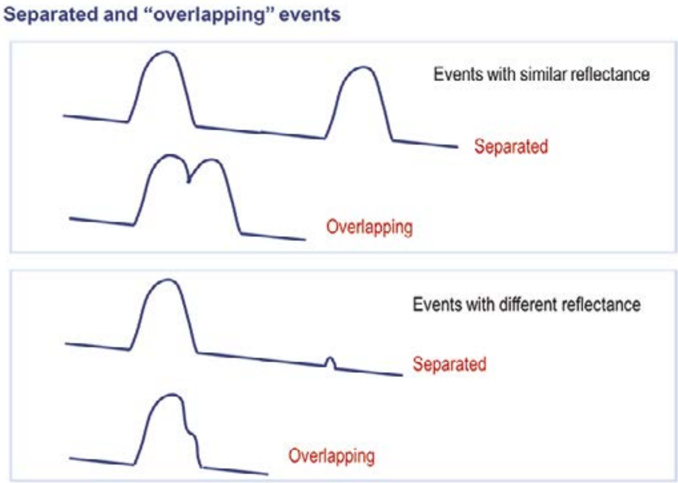

Figure 4 – Closely spaced events

Unlike one widely used non-AFL OTDR, which classifies such events as "hidden", the M310 has the capability of separating and measuring these. Figure 5 shows results from testing a 2 m jumper cable on the M310, with its powerful event analysis. The reflectance and insertion loss of the connections at both end of the jumper are measured. This is a valuable tool for verifying the performance of jumper cables. High reflectance is a concern in LANs operating at 10, 40 or 100 Gb/s, for long haul networks, and networks carrying analog video. Using an Optical Power Meter and Optical Light Source to check jumper cables will only provide an insertion loss measurement, and other OTDRs will not be capable of measuring the loss and reflectance at both ends.

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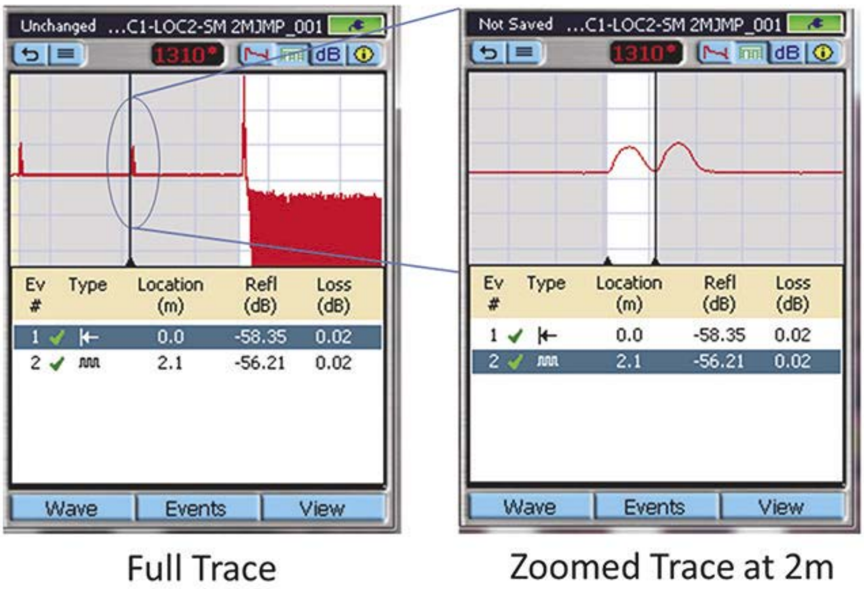

Figure 5 – Closely spaced events; M310 testing a short 2 m jumper cable's performance

Figure 6 shows the results of testing the same 2 m jumper cable on a non-AFL unit. Although the location of the two events is shown, the second connector is categorized as a "hidden" event. No loss measurements are provided, and the reflectance measurements are inaccurate.

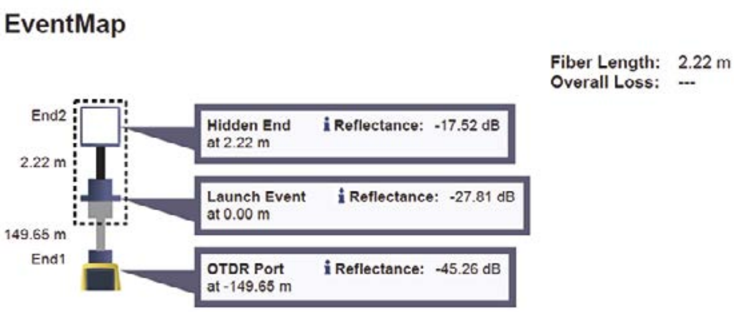

Figure 6 – 2 m jumper cable tested on a non-AFL unit

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Figure 7 shows a typical data center network configuration in which there are multiple short jumper cables and other closely spaced events – a total of nine events. The 3 m section followed by the 2 m section at the beginning of the cable is particularly challenging. This network also contains a gainer event at 15 m, followed by a non-reflective loss event at 25 m, also challenging.

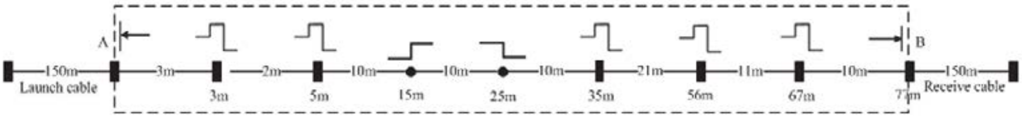

Figure 7 – Typical data center network

Figure 8 shows a zoomed portion of the beginning of the network with the first three events successfully detected and measured, including the short jumper cables (events #2 and #3). Other OTDRs would not provide loss measurements for these events.

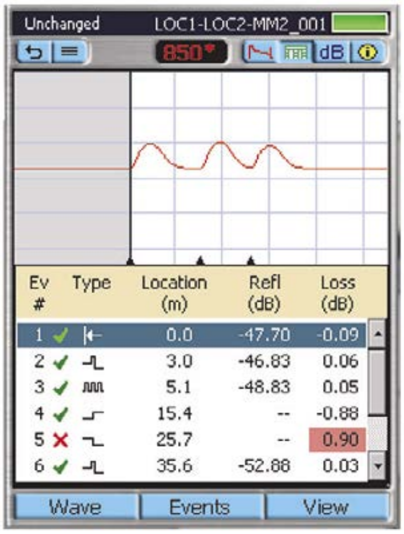

Figure 8 – Test results for a data center network with short jumper cables zoomed at beginning

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Figure 9 shows the zoomed middle portion of the network containing the gainer and non-reflective loss events (events #4 and #5). Even to a trained eye these two events are difficult to pick out from the noise.

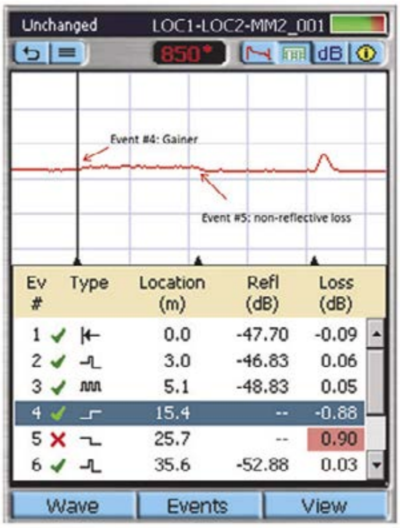

Figure 9 – Zoomed Gainer and non-reflective loss events

Figure 10 shows the zoomed end portion of the network (events #6-#9).

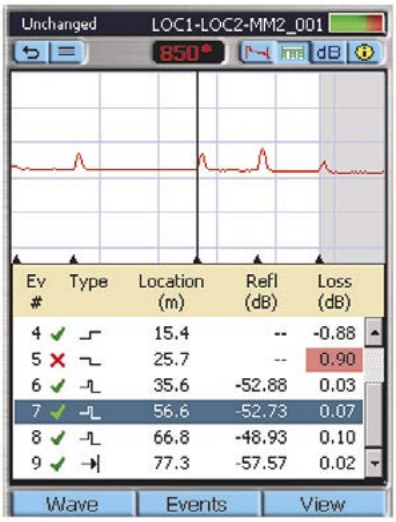

Figure 10 – Data center network zoomed end portion

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Launch and Receive Cables

All of the events in this network have been successfully detected and measured by the M310. Launch and receive cables were used, per standard practice, to be able to measure the loss and reflectance of the first and last events of the fiber under test. One of the features of the M310's event analysis capability is the ability to compensate for normal variations in the length of launch and receive cables, and accurately identify the beginning and end of the fiber under test, without needed to run a separate calibration test for the cables.

Event Analysis Checklist

Since event analysis is not defined by standard specifications, the following check list needs to be used when choosing an ODTR for best event analysis:

- How many missed event occur when shooting a typical network?
- How many false events occur when you set the threshold to your target level?
- Are the event types correctly identified?
- Can the OTDR correctly separate closely spaced events and measure reflectance and loss?
- Do you need to perform a separate launch and receive cable calibration to accurately locate the beginning and end of fiber under test?
- Does the OTDR really provide all relevant measurements for each event

Conclusion

The release of the M310's enhanced Event Analysis software is a product of extensive research into the properties of fiber optic cable events, and provides a major improvement in the performance of event analysis. This means that with the push of a single button users can be confident of obtaining accurate locations and measurements of all events, without the confusing introduction of false events. Many OTDRs on the market often miss key events related to the short length jumper cables used in data centers, and enterprise networks, that may cause outages, and at the same time introduce false events resulting in time wasted in performing additional tests. With the M310, no special knowledge, training or test setups are required to achieve fast and accurate test results.

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