Application Note

The Impact of Sampling Resolution on OTDR Testing

Sampling resolution not only influences distance accuracy, it also impacts other parameters, such as acquisition time, distance measurement range, and dynamic range. Therefore, take care when modifying this parameter. This paper describes the impact of sampling resolution on OTDR measurements.

The Affects of Sampling Resolution on Parameters

Impact of Sampling Resolution on Distance Accuracy

Sampling resolution for an OTDR is defined as the minimum distance between two consecutive sampling points acquired by the instrument. The error generated by this parameter is a fixed value, that is, the sampling value itself (it is not directly related to the link length itself). However this sampling resolution also considers the fact that the OTDR can record a maximum of acquisitions points for a given distance range. Figure 1 shows an example of a sample resolution error.

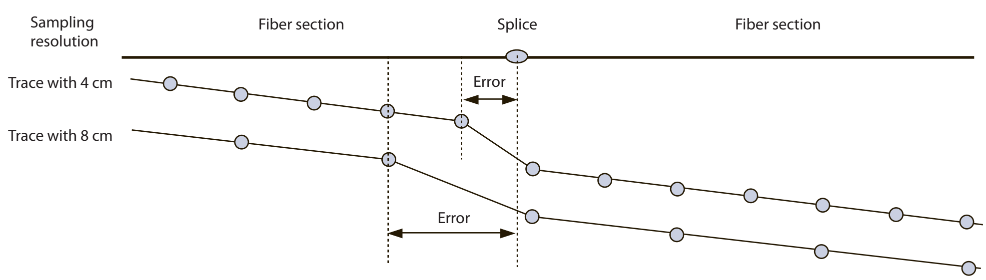

Figure 1. Example of sampling resolution error

A maximum of acquisition points of typically 128,000 and a fiber length of 10 km and a distance range of 10 km on the OTDR generates an error of 10,000,000/128,000 = ±8 cm.

A maximum of acquisition points of typically 128,000 and a fiber length of 2 km and a distance range of 2 km on the OTDR generates an error of 2,000,000/128,000 = ~1.5 cm, however, the minimum sampling is typically 4 cm, so the error will be ±4 cm.

Consequently, not having a component located exactly at one of those sampling points can result in an error of ± sampling resolution (excluding the other parameters affecting the distance accuracy).

Therefore this parameter provides a small impact on distance accuracy, because most current OTDRs are now well optimized, such as those from JDSU.

Users who mostly rely upon distance accuracy can optimize it using other parameters, such as Index of Refraction (IOR) and clock accuracy. For more information on this, please refer to the JDSU application note on "Ensuring Distance Accuracy with an OTDR."

Impact of Sampling Resolution on Acquisition Time

OTDR users often are inclined to set the highest sampling resolution (smallest value of resolution). However, doing this will immediately increase the acquisition time for a given distance of fiber length to achieve similar dynamic range/signal-to-noise ratio (SNR), as Figure 2 shows. *In reality, to reach the same dynamic range, acquisition time is proportional to the change of sampling resolution setting.*

For example, the acquisition time it takes to make a given trace/dynamic range for a 0.5 meter sampling resolution is approximately 4 times longer than a similar trace with a 2 meter resolution setting. Understanding this is critical when evaluating any fiber link, as testing time becomes increasingly important. The JDSU OTDRs optimize testing time by enabling users to eventually set their own sampling resolution (and with automatic setups).

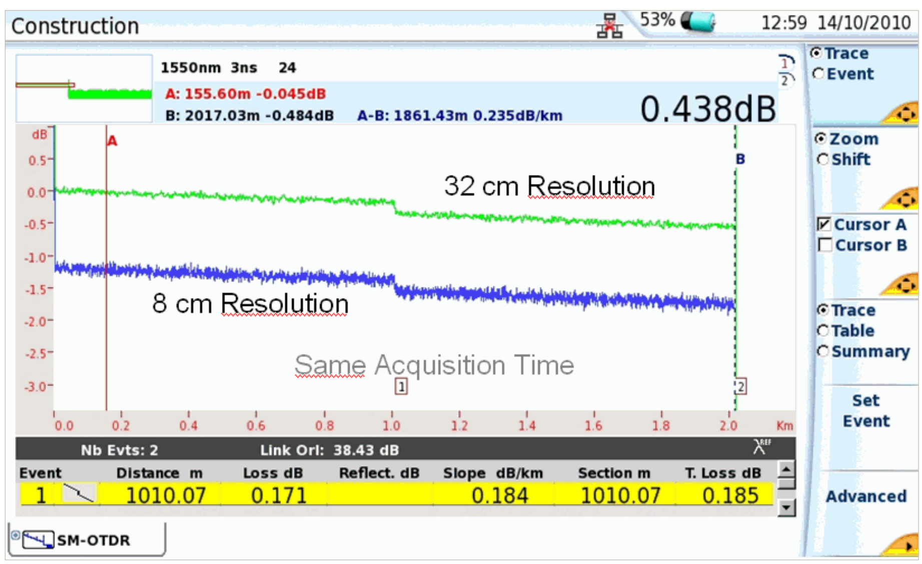

Figure 2. High resolution requires more acquisition time to achieve optimized trace

Impact of Sampling Resolution on the Distance Measurement Range

Regardless of the sampling resolution, it is critical to optimize the distance measurement range to be as close as the fiber length. *In reality, to reach the same dynamic range, acquisition time is proportional to the change in distance measurement range.* Figure 3 illustrates this. For example, using the same sampling resolution and expecting the same dynamic range, the acquisition time for testing a 2 km fiber length with 8 km distance measurement range is approximately 4 times longer than similarly testing with a 2 km distance measurement range. Understanding this is critical when evaluating any fiber link, as testing time becomes increasingly important. The JDSU OTDRs optimize the testing time by enabling users to set shorter distance measurement ranges, down to 2 km or even 500 m.

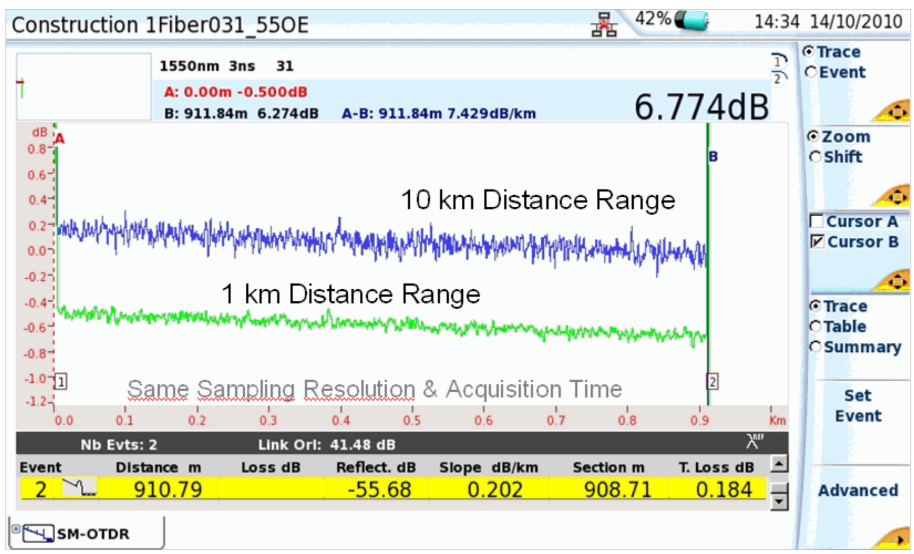

Figure 3. A 1 km distance measurement range on a 900 m link optimizes trace and speeds up tests

Impact of Sampling Resolution on Dynamic Range/Noise on the Trace

Investigating a long link using too many sampling points with given pulse width can lead to noisy results, poor SNR and, therefore, poor fault detection, as well as erroneous event measurement.

Parameters such as pulse width, the number of sampling points, the measurement distance, and averaging can all affect the SNR. As a whole, these parameters impact the end results considerably. The influence of these factors on event detection measurement is difficult to predict as they each interact differently. Changing one parameter will modify others, something of which users may not be aware or may not want to do. In Auto mode, the OTDR itself can optimize all the parameters necessary to meet the needs of users. *In some cases, the Auto mode, or optimizing the setup of all parameters, does not use the highest available sampling resolution due to suppression of highest sampling resolution* disadvantages mentioned previously.

For users who do not want to select the Auto mode, there are tradeoffs between distance accuracy and acquisition time. While distance accuracy is critical on a very short link, users can still achieve very fast acquisition times, due to small distance measurement range. On long links, similar distance accuracy may not be needed, but fast acquisition time remains critical.

Impact of Doubling the Maximum Sampling Resolution: 128,000 versus 256,000

Doubling the maximum sampling resolution has a strong impact on acquisition time and noise/SNR as stated earlier. The only benefit of providing a higher number of data points than 128,000 is debatable for following reasons:

- No difference in distance accuracy exists up to a 5 km range.
- OTDR vendors with 128,000 or 256,000 data points all have equal shortest sampling resolutions of 4 cm.
- The benefit of distance accuracy when doubling the number of data points (256 k vs.128 k) *is only 5 cm at 10 km range and provides a benefit of up to 70 cm at 160 km!*

When identifying a component or troubleshooting a network, a resolution with 128,000 acquisition points is sufficient, especially considering the sampling resolution parameter proves less relevant for distance accuracy than other parameters. This is also only applicable for users of OTDRs who can set and check the highest resolution when configuring of OTDR. Otherwise, this insignificant benefit is lost immediately!

Conclusion

Many parameters are influenced by the sampling resolution: distance accuracy, acquisition time, distance measurement range, and dynamic range and, therefore, users must use care when setting them. JDSU considers 128,000 acquisition points sufficient for achieving accurate results, primarily because additional acquisition points does not increase distance accuracy and, if not used properly, will lead to longer acquisition time or higher noise on the OTDR trace.

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