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Applications
Engineering Note

# Optical Return Loss vs. Back Reflectance

## AEN 149, Revision 1

This AE Note explains the differences between Optical Return Loss (ORL) and Back Reflectance in fiber optic systems. The driving force behind understanding these topics is the ever-increasing high-speed transmission systems and the use of DWDM in the industry today. This topic is becoming critical in verifying system performance and reliability.

A high ORL value can be very harmful to laser sources and can lead to damage directly linked to an increase in Bit Error Rate (BER) for digital systems and diminish Signal to Noise Ratio (SNR) in analog systems. The total reflected power can be due to connector back reflections, back scattering, etc.

### Back Reflection

Back reflection, expressed in decibels (dB), is defined as the logarithmic ratio of reflected signal power to the incident signal power at an optical component or specific point. These reflections are caused by changes in indexes of refraction. Some examples of these would be mechanical splices, connectors or end of systems. This type of reflection is known as a Fresnel Reflection.

The equation for Back Reflection is defined as:

$$\text{Reflection [dB]} = 10 \cdot \log_{10}\left(\frac{P_{\text{Ref}}}{P_{\text{inc}}}\right) \ (\leq 0)$$

where,

$P_{Ref}$ is the reflected power and
$P_{Inc}$ is the incident power.

By convention, back reflectance is expressed as a negative number. This means that a -65 dB reflectance is less reflected light and, consequently, better than a -55 dB reflectance.

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## Optical Return Loss

Optical Return Loss (ORL), also expressed in dB, is defined as the logarithmic ratio of incident power to the total received power back at the source caused by all parts/components of the system including the fiber itself.

The equation for ORL is defined as:

$$\text{ORL [dB]} = 10 \cdot \log_{10}\left(\frac{P_{inc}}{P_{Total}}\right) (\geq 0)$$

where,

$P_{Total}$ is the Total Received Power (back reflection + back scattering).

A value of 50 dB is better than a value of 40 dB, which means less power is reaching the source.

To better understand accepted values of ORL, IEEE 802.3 specifies for multimode systems ≥ 20 dB return loss and ≥ 26 dB for single-mode systems.

## Distance

Because ORL is a relationship that deals with the total power reflected back to the source, it is not only dependent on the reflective events in the system, but also the length of the system. If the fiber length increases, the backscattered light in the fiber increases, but the length can cause event reflection to be highly attenuated by intrinsic attenuation before reaching the source. Therefore, the effect of back reflectance of individual events could be minimal. This is, however, dependent on where in the system the reflective events are located in relation to the source. Because of this, for longer systems with no intermediate events the fiber backscatter will contributing more to the system ORL than the back reflectance caused by the end of the system. For example, systems that are greater than 40 km with no intermediate events, the ORL will flatten out and remain ≈ 35 dB due to intrinsic properties of the fiber alone.

This is the opposite for short systems where the reflected power is not attenuated allowing it to reach the source. In these systems, the back reflectance of the events is the main contributor to the ORL.

Therefore, not only are reflective events important when measuring ORL, but also their location in the system and their distance from the transmission sources play a crucial role in the total system ORL.



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