The Importance of Verifying a Reference Reflection for Accurate RL Measurements

The Benefits of Limiting Reflectance in a Network

High return loss in a network or data center is an issue that can cause a number of problems ranging from source stability to increased BER and a lower signal-to-noise ratio. As a result, pass/fail criteria on fiber optic connections has jumped in recent years as advancements in polishing techniques have allowed for fiber optic matings with lower reflections.

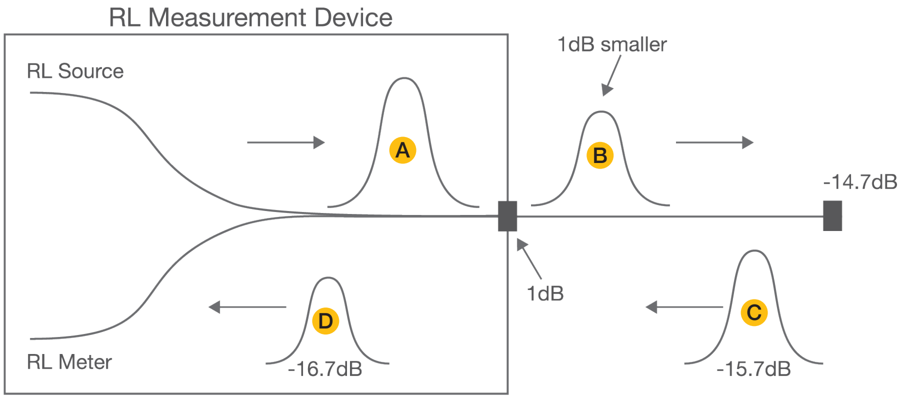
When trying to achieve low reflectance in networks and datacenters, it is important to characterize the return loss of terminated fiber optic cables with maximum accuracy. If the measurement system has a poor reference or test setup, it could be incorrectly passing cables.

The Effects of Loss on Return Loss Accuracy

Many times pass/fail requirements are positioned right at the limits of the polishing capabilities. Typical UPC polishing techniques yield return loss values in the range of 45-58dB. 55dB is a common pass/fail limit and when the polishing technique yields values from 52dB up to 58dB any sort of error in the measurement can incorrectly yield passing or failing results.

Common return loss measurement devices use an internal reference, whether it's reference reflection or backscatter level, to calculate the external reflection that is to be measured. The systems, based on calibration, assume only a small amount of loss at the front panel connection of the measurement device. This loss is calibrated out during the factory calibration process, however, when the device is in the field being used, the loss at the front panel or at any intermediate connections will vary. When the intermediate loss is low, this will not affect the return loss measurements significantly, but as it becomes larger or less stable the accuracy of the return loss measurements suffer.

Any loss that is introduced to the measurement system will affect the return loss measurement even when that loss occurs at the unit's front panel. A standard high quality connection will lose 0.1dB to 0.3dB of optical power. In a return loss measurement system, the optical signal needs to travel twice down the line; once in the forward direction and once as it travels back along the same path to the photodiode. Therefore, any loss that occurs on the optical line will introduce double that amount of loss for the return loss signal.



A = Initial pulse (0dB)
B = Pulse after going through the front panel (-1dB)
C = Diminished pulse after glass-air reflection: -14.7 + (-1dB) → -15.7
D = Pulse seen by RL measurement device: -15.7 + (-1dB) → -16.7

Figure 1: The optical signal travels twice along the same path; once in the forward direction and once in the reverse direction.

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For example, if a reference setup has 1dB of loss between the front panel and where the reflection is to be measured, then it will see 2dB of added loss for the return loss signal. This means that a connection that should measure -54dB will now measure -56dB. This cable would wrongly be assessed as a passing result. Many times, this loss is difficult to see and would not cause concern since cables/connectors are passing the requirement. Usually a set of failures on a type of connector is what will begin triggering investigations into an issue. However, in this case, the connector passed; it is likely nothing would prompt any investigation into such a result.

A Solution to Identifying Lossy Cable Setups

An open flat connector is traditionally accepted as a standard return loss artifact. A glass-to-air reflection is a specific type of Fresnel reflection and associated with measuring -14dB or a 4% reflection. However, this reflection has different values for different wavelengths and for most cases should be closer to -14.7dB. This standard artifact can be used to verify the reference setup.

If a return loss reference is taken and an open flat connection at that position measures -16.7dB, the 2dB deviation from the expected value (-14.7dB) is an indication that the optical signal is travelling through a lossy cable setup. From this measurement, it can be determined that there is excess loss in the reference setup; it informs the operator that the measurement device will be measuring 2dB higher than the actual return loss of the DUT. This 2dB should be accounted for and subtracted out when measuring the DUTs.

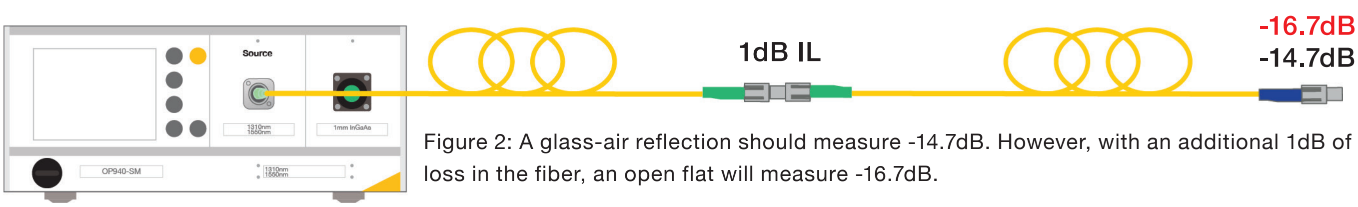

Figure 2: A glass-air reflection should measure -14.7dB. However, with an additional 1dB of loss in the fiber, an open flat will measure -16.7dB.

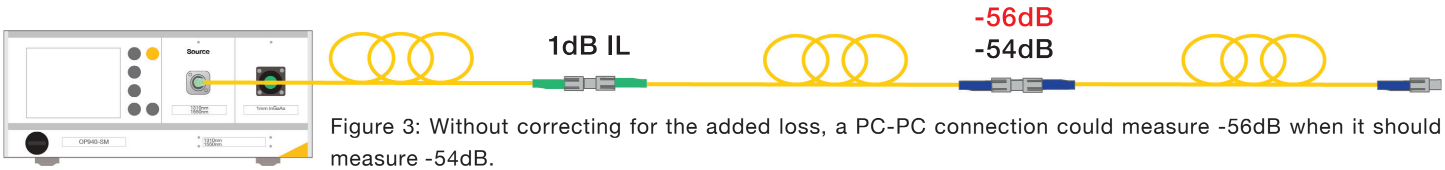

Figure 3: Without correcting for the added loss, a PC-PC connection could measure -56dB when it should measure -54dB.

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The Importance of Wide Dynamic Range for Return Loss Measurements

Unfortunately, many return loss measurement systems cannot correctly measure an open flat connector while still being able to measure the low reflections (<-65dB). Excess loss in a cable setup can be recognized during the referencing process by using a measurement system with a wide dynamic range. Most return loss test sets are configured to measure only the low reflections because most connectors measure between -45dB and -65dB. Though, it is useful to be able to measure the large reflections, such as an open flat connector.

Some measurement devices have saturated return loss measurements around -25dB, which means an accurate measurement of an open PC connector isn't possible. Typically, for devices such as these, the reference cycle will simply determine the length of a launch cable and store this distance for use during test cycles. While it is possible to reference to either an angle-polished connector or a flat-polished connector, only using a flat-polished connector for a return loss reference reflector will allow for the highest precision when it comes time for testing.

Without measuring to an open flat connector, it would be difficult to assess the quality of the reference setup and any discrepancy would be unknown to the user. For example, a unit that saturates at -25dB will measure any reflection below that value as -25dB. An open flat connector on the far side of a lossy connection, such as in the previous example (-16.7dB), and an open flat that is not subject to a lossy connection (-14.7) will both show the same value. The operator in this case would be unable to know when to correct their measurements to account for a lossy setup, leading to uncertainty and inaccuracies in the test results.

It may seem that this issue should be able to be avoided if low loss connectors are used at the instrument interface and all connections are cleaned routinely. The problem arises as the instrument gets used constantly over the course of many days and weeks; the mating adapter and fiber optic connector on its front panel can begin to degrade and introduce loss. The source of this loss may be damage, wearing of the keying mechanism over time, or the development of small cracks in the ceramic sleeve of the mating adapter. Any of these issues can cause excess loss that needs to be accounted for in the measurement, resulting in connectors that are supposed to fail that could actually be given passing marks, and potentially lead to errors in the field.

Note: There are methods for measuring loss at the front panel of instruments, but this is cumbersome and is only performed when the user actively wants to quantify this loss. If damage occurs at the front panel, the user only knows of the loss the next time the front panel loss is measured. There would likely be some time when the system was measuring incorrectly and not accounting for the excess loss.

Conclusion

Despite improvements in network technologies, return loss in networks and data centers continues to be an issue that results in decreased performance. Return loss is also a powerful indicator of connector quality. As a result, it is important that it be measured accurately and properly account for any loss between the meter and the connection under test. This is most easily done by verifying the return loss of an open flat connector. Unfortunately, many return loss test systems saturate at about -25dB in order to accommodate the increasing demand for measurements lower than -65dB. Without ensuring the quality of the optical path, it is possible that the measured return loss of fiber optic connectors is lower than it actually is and the cables are incorrectly given passing marks.

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