090

APPLICATION NOTE

SENSITIVITY AND REPEATABILITY FOR MEASURING REFLECTANCE DRIFT IN FIBER-OPTIC CONNECTORS

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Introduction

Performing accurate and repeatable reflectance measurements on high-performance UPC and APC connectors has always been a challenge. These connectors generate very low Fresnel reflections (of the order of –55 dB to –70 dB or even less). Traditionally, continuous-wave reflectometers (source, power meter and coupler) have been plagued by stability problems associated with interference, while pulsed reflectometers (variation of OTDR) did not have the sensitivity nor the repeatability. For these reasons, it has been nearly impossible to measure transition effects and drift in the reflectance of low-reflection connectors.

Reflectance Measurements Using the IQS-12001B

With the IQS-12001B Cable Assembly Test System, EXFO has achieved some significant performance improvements in stability and repeatability of reflectance measurements. Based on advanced time-domain technology, the IQS-3250 Loss Test Module has been developed to perform mandrel-free reflectance measurements. The reflectance side of the instrument incorporates an internal reflectance reference, a power monitor and Rayleigh backscatter (RBS) correction algorithms. With the short pulse length and fast averaging, the end result is significantly improved reflectance measurement performance.

During the qualification phase of the IQS-12001B system, EXFO engineers and metrologists performed extensive measurements on various devices to determine the measurement repeatability. For obvious reasons, during this exercise, it is critical to test a device with stable reflection, so that it does not vary over the period of the test. After a few initial trial tests, we came to the conclusion that a freshly mated connector could not be used as a stable reflector.

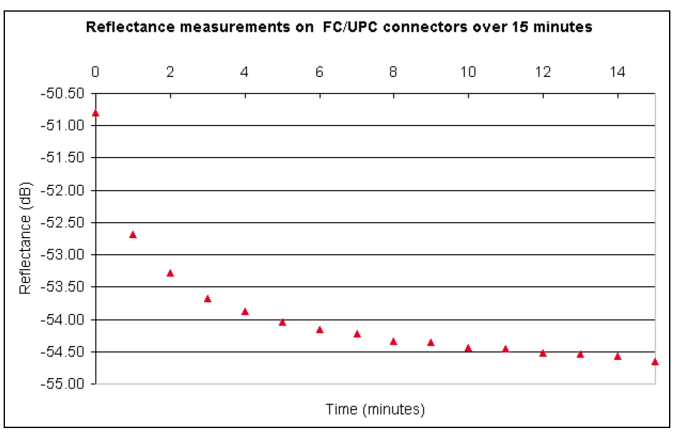

Figure 1. Reflectance measurements of UPC connector

The data shown in Figure 1 illustrates that there is a significant drift in the reflectance of the mated connector over the initial 10 minutes; in fact, over the 15-minute period, a delta of ~ 4 dB was observed.

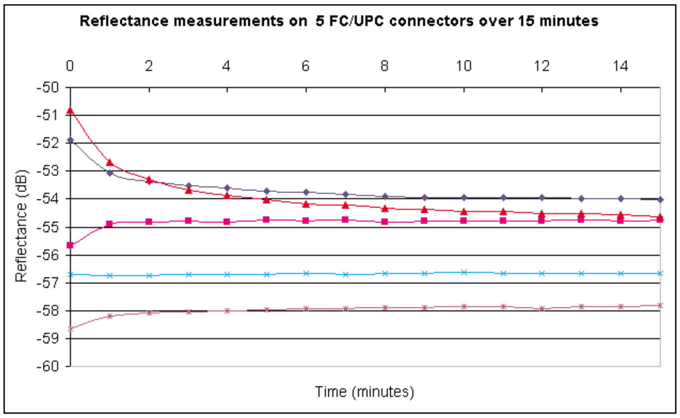

Figure 2. Reflectance measurements of five FC/UPC connectors

In the sample shown above, we can observe that in almost all cases, reflectance varies significantly over the first five minutes after mating. In some cases, the value improves and in others it degrades slightly. Additional tests at different wavelengths and using different connectors confirmed these observations.

Significance of Initial Reflectance Drift

EXFO has not done extensive research on the source of this initial reflectance transient, but we do know that the IQS-12001B system is ideally suited for this type of investigation. The effect is likely a combination of many different variables such as:

- Ferrule compression–spring material and force
- Ferrule diameter tolerance
- Ferrule length
- Mating adapter–sleeve material and tolerances
- Mated compression force
- Endface cleanliness
- Other factors…

Fiber-optic connector and adapter manufacturers should have extensive information on this subject. The objective of this application note is to raise awareness among cable assembly manufacturers regarding this potential phenomenon and to identify the possible impacts from a production testing point of view.

Most production testing engineers will not want to wait five minutes before performing reflectance measurements. It would be important to further evaluate the phenomenon under controlled conditions during the production line qualification. An additional measurement guard-band may be necessary to account for this transient. Based on the above data, waiting for 30 to 60 seconds would improve the situation, yet is obviously not an efficient way to attain high throughput.

When measuring golden devices to verify calibration and accuracy of reflectance measurements, it is important to wait for the standard to stabilize. To overcome this problem, EXFO has developed a reflectance measurement calibration kit (CKT-30) and special software routine, which can be used as part of a quality assurance program to ensure that measurement systems are within specifications.

Measurement Repeatability vs. Connection Repeatability

Now that we understand a little more about how the reflectance of a connector that has just been mated can vary with time, it is appropriate to evaluate the measurement system repeatability. Once we determine that our measurement system is providing repeatable results, we can look a little further to determine a connector's repeatability. We will see that there is a big difference between measurement repeatability and connection repeatability.

	1310 nm	1550 nm	1625 nm
	-60.3	-61.4	-61.0
	-60.2	-61.2	-60.9
	-60.2	-61.1	-61.0
	-60.2	-61.0	-61.1
	-60.3	-61.1	-61.1
	-60.3	-61.1	-61.1
	-60.3	-61.3	-61.1
	-60.4	-61.2	-61.1
	-60.3	-61.3	-61.1
	-60.3	-61.3	-61.1
Min	-60.4	-61.4	-61.1
Max	-60.2	-61	-60.9
Delta	0.2	0.4	0.2
Sdev	0.0632	0.1247	0.0699

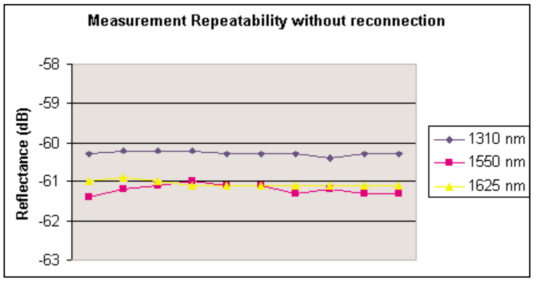

Figure 3. Data for 10 consecutive measurements in dB of a stable device (FC/UPC)

	1310 nm	1550 nm	1625 nm
	-60.2	-61.2	-60.9
	-59.4	-60.3	-59.9
	-59.8	-60.7	-60.2
	-60.4	-61.2	-60.6
	-60.4	-61.4	-60.8
	-60.6	-61.7	-61
	-60.9	-61.8	-61.3
	-60.4	-61.4	-60.9
	-60.8	-61.8	-61.3
	-61.2	-62.2	-61.5
Min	-61.2	-62.2	-61.5
Max	-59.4	-60.3	-59.9
Delta	1.8	1.9	1.6
Sdev	0.5259	0.5599	0.4993

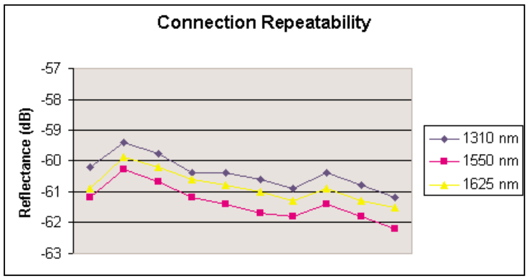

Figure 4. Data for 10 consecutive measurements in dB with reconnection and cleaning between each measurement (FC/UPC)

	1310 nm	1550 nm	1625 nm
	-60.4	-61.4	-61.2
	-56.4	-57.6	-57.2
	-57.1	-58.2	-57.7
	-53	-54.4	-54
	-55.5	-56.7	-56.2
	-57.5	-58.6	-57.9
	-56.6	-57.7	-57.2
	-57.5	-58.5	-57.9
	-53.2	-54.6	-54.2
	-55.9	-56.8	-56.4
Min	-60.4	-61.4	-61.2
Max	-53	-54.4	-54
Delta	7.4	7	7.2
Sdev	2.1533	2.0299	2.0458

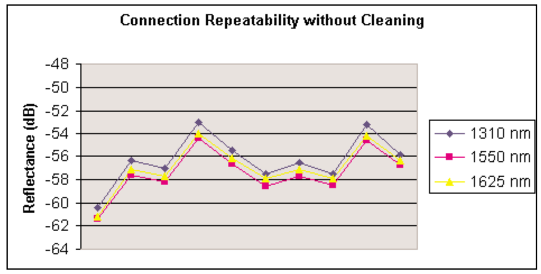

Figure 5. Data for 10 consecutive measurements in dB with reconnection between each measurement (FC/UPC). Note that for this series of data, the fiber endface was not cleaned between each connection.

The three series of data in Figures 3, 4 and 5 were acquired using the same FC/UPC connector pair. Figure 3 is typical for IQS-12001B measurement repeatability, while Figures 4 and 5 are typical for connection repeatability (i.e., where the connectors are un-mated and remated between each measurement). This demonstrates a number of important concepts:

- IQS-12001B reflectance measurements are quite repeatable.
- There is a difference between measurement repeatability and connection repeatability.
- The IQS-12001B system is able to measure small variations in reflectance.
- It is important to clean connectors between each mating, even if only temporarily disconnecting them.

Conclusion

Measuring low-reflection connectors is a challenge. Meeting that challenge requires a combination of reliable test equipment and an excellent understanding of the factors affecting reflectance measurements. This application note is not a thorough investigation into reflectance behavior of connectors, but it should demonstrate that the IQS-12001B Cable Assembly Test System is an excellent tool for connector evaluation and qualification, as well as for production testing of fiber and cable assemblies.

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