AN-127

Measuring RL on Short Cables: A Detailed Approach

Overview

In the 1990s, a new method of testing return loss revolutionized the fiber optics industry. Requiring no mandrels or matching gel to measure the return loss of a cable, the optical time-domain reflectometry (OTDR) method streamlined the production process by cutting down on the amount of work required to reference and take return loss measurements. However, this technology brought with it a small caveat: the laser's pulse width along with a few other factors limit the resolution of the measurement. This is easily seen in the following traces recorded on a singlemode OP930.
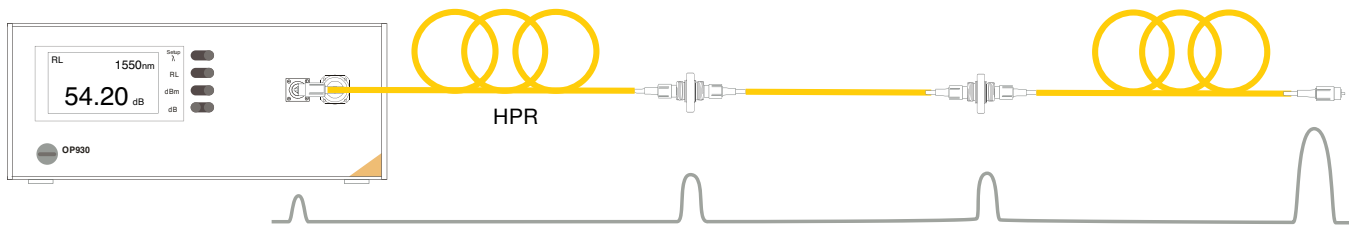

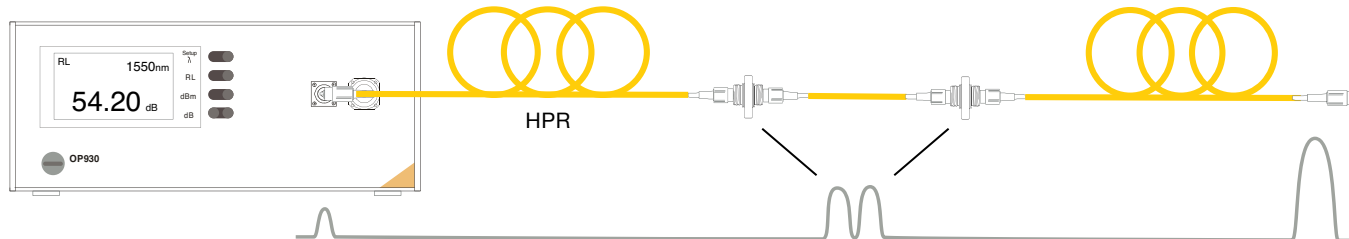Figure 1: Return Loss scan of 3.0 meter PC-PC cable

Figure 2: Return Loss scan of 1.5 meter PC-PC cable

Compare the two scans; while one clearly shows both front- and back-end reflections, the other shows the two peaks beginning to merge into one large peak rather than two small peaks. At 1.5 meters, the peaks are close enough to each other that they begin to interfere with one another and resulting in the cable's "worst case scenario" overall. This allows the user to provide an "order-of-magnitude" RL test; if the cable passes, it definitely passes, but if it fails, further tests would be necessary to determine if the cable is truly failing. With the industry-wide move towards 100G Ethernet and beyond, more cables are needed in less space which in turn requires the increased use of shorter cables.

The principal aim of this Application Note is to provide testing methods for cables which are shorter than the recommended length rather than to instruct how to perform a reference cycle or measure standard-length cables, although these topics will be briefly discussed. For a more detailed walkthrough of how to perform reference cycles and test cables with OptoTest equipment, please consult the manual for the device or software application or other pertinent Application Notes.

Referencing Return Loss

Referencing return loss is an important step and an improper reference can lead to inaccuracy in measurements during tests. To reference return loss, connect the launch lead(s) to the front panel and leave the endface of the final launch lead unmated. If the final endface of the launch assembly is an angle-polished connector (APC), a three to six inch APC-to-PC reference reflector cable can be mated to that endface to provide a reference point for the unit.

APC side

PC side

Figure 3: Reference Reflector

Measuring Return Loss on Cables 3 to 2,400 Meters Long

Cables that measure three meters and longer can be tested with relatively few restraints. In general, any far-end reflection will not influence the measurements of the connector-under-test.

Using the mandrel-free method allows the user to test without implementing a mandrel wrap, a vital factor for high output production lines and when testing multimode fibers, especially bend-insensitive multimode fiber (BIMMF). This method also eliminates the needs for messy index matching gels and index matching blocks.

Please note that creating the 14dB Fresnel reflection is important to a proper reference and therefore creating highly accurate test results.
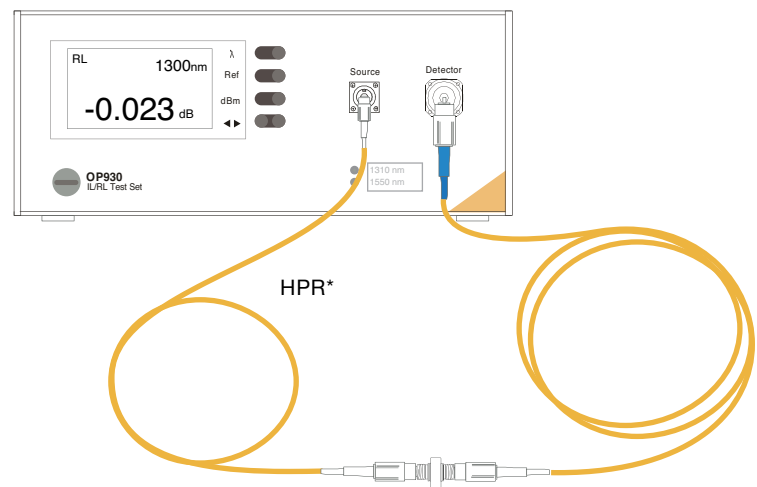
RL   1300nm
-0.023 dB
OP930
IL/RL Test Set

Source   Detector

1310 nm
1550 nm

HPR*

Figure 4: Standard cable setup to measure ILRL on a connector for any cable 3m to 2400m

Measuring Return Loss on Cables Shorter than 3 Meters

In order to yield the most accurate results for a device-under-test (D.U.T), OptoTest units use the OTDR method of measuring return loss with methods that have been developed specifically for testing return loss on cables less than two meters apart. This section will focus on effective and efficient test methods which will provide the most accurate return loss results.

It is important to note that although mandrels can be used to attenuate the far end reflection of a cable, mandrels alone cannot always be counted on to sufficiently reduce a large reflection enough to ensure that only the front end reflection is being measured. This is especially true for multimode cable because it will only increase the attenuation for the high order modes and not the more tightly coupled modes.

*HPR High Performance Reference Cable

Measuring Return Loss on Cables between 1.5 and 3 Meters

Cables in this range can usually be tested using standard procedures if the second end of the cable is an unmated APC connector or has a similarly small reflection.
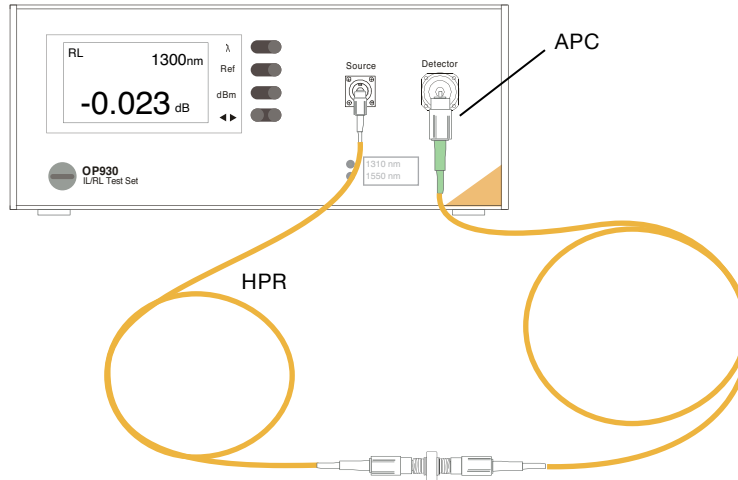

Figure 5: Test setup for cables with an open APC connector (1.5 m to 3.0 m)

If the reflection associated with the second connector is larger than approximately 45dB, other test methods will need to be employed to ensure the accuracy of the return loss measurement.

The recommended method for testing these cables is to utilize a golden cable with a high quality polish because it will yield more consistent results. Since current PC-PC connections typically exhibit return loss values lower than -40dB for multimode or -53dB for singlemode, it does a significantly better job of reducing the reflection on the second connector than a matching block which will typically yield about a -30dB reflection.
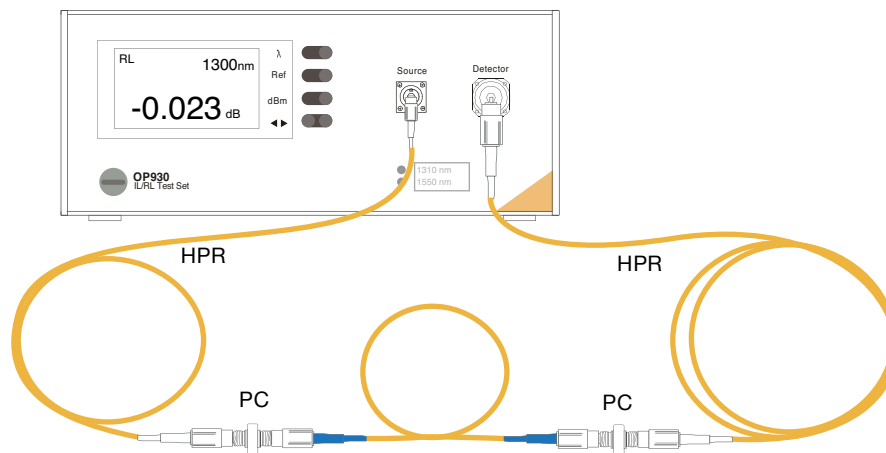

Figure 6: Test setup for PC-PC cables. The second PC connection diminishes the rear reflection on the DUT

Matching gel will also typically suffice for negating the effects of the second reflection on cables of this length, but is not quite as repeatable or consistent of an option as the termination cable method and it takes more time to clean up matching gel residue left on the ferrule than to disconnect a golden cable.

Measuring Return Loss on Cables Shorter

For cables shorter than 1.5 meters, it becomes increasingly necessary to have their 2nd reflection negated in order to provide accurate readings on the front reflection.
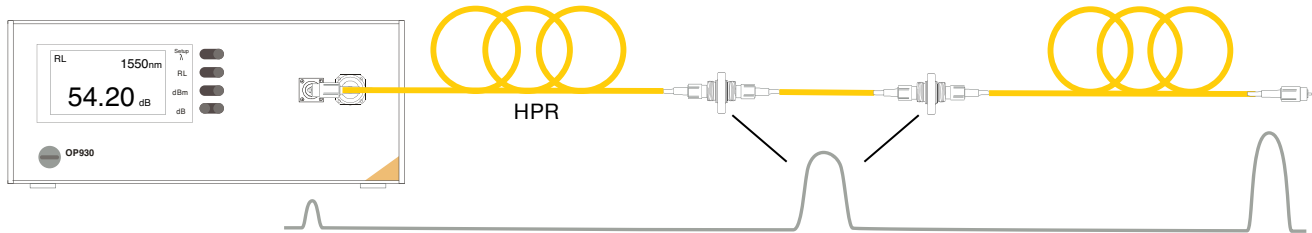
Figure 7: Return Loss scan of 1.0 meter PC-PC cable showing that the pulses are so close that they cannot be distinguished from each other and look more like one wide pulse

For cables in this range, it is best to utilize a combination of matching gel and a termination stub to get accurate RL measurements. Another effective combination for cables in this category would be a termination cable and a mandrel to isolate the front connector's reflection from the combination of the two connectors' reflections. The combination of the two methods (mandrel or matching gel and termination cable) produces a back-end connection with negligible return loss so that the contribution from the front connector can be measured without noticeable interference.
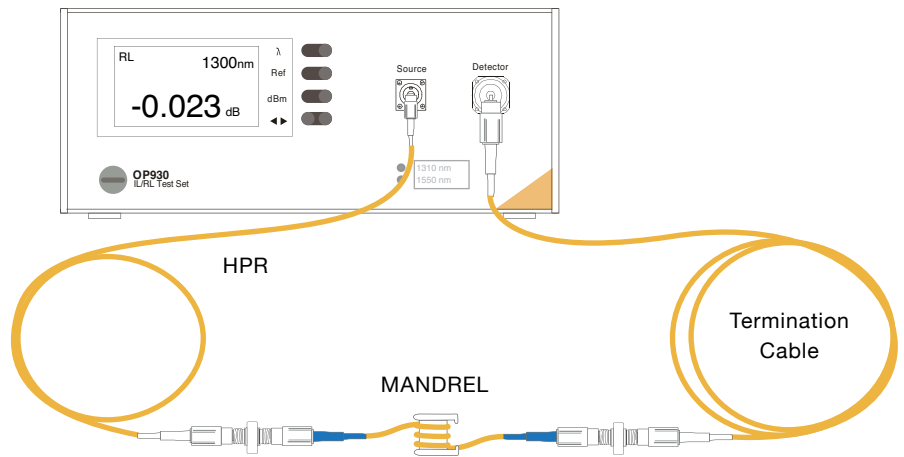
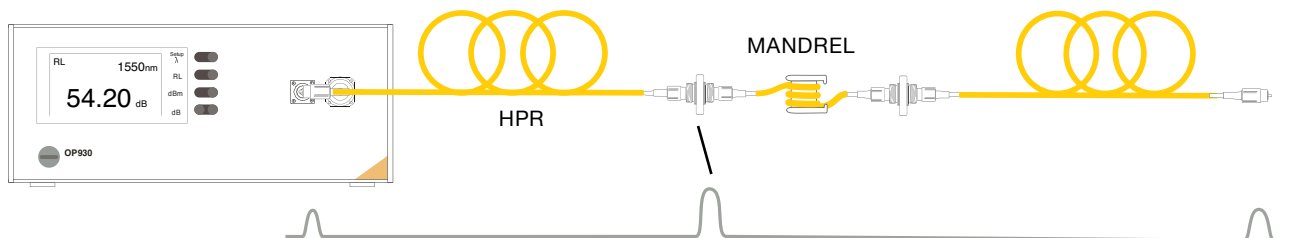Figure 8: Test setup with DUT mandrel wrapped and terminated to get rid of back reflection

Figure 9: Return Loss scan of 1.0 meter PC-PC cable with mandrel showing backend of DUT attenuated enough to not affect the front reflection measurement

Please note that if a mandrel is used, it should have a small diameter and the cable should be wrapped around it several turns. Remember that this mandrel wrap is not being used to condition the launch, but to attenuate the reflection of the back connector. Since it is harder to attenuate the more tightly coupled modes in a multimode fiber, using a mandrel in this situation is not as effective as it would be with singlemode fiber.

Summary

In summation, the OTDR-style return loss meter is by far the most accurate way to test return loss regardless of cable lengths, fiber core size, and connector types. The back-end connector on cables shorter than three meters can interfere with the front end return loss values—yielding a worst case scenario overall. However, by utilizing a golden cable or another method of attenuating the reflection of the second connector, the true return loss of the first connector can be tested accurately.

In short, the following table can be used to determine what method to use when testing short cables:

		Cable Length	Far-End Termination	Singlemode Cable	Multimode Cable
Table 1	A	Longer than 3 meters	Angle-polished or UPC-polished	No restrictions based on cable length	No restrictions based on cable length
	B	Between 1.5 and 3 meters	Angle-polished	No restrictions based on cable length	3 meter termination cable
			UPC-polished	3 meter termination cable	3 meter termination cable
	C	1.5 meters and shorter	Angle-polished	Termination cable with mandrel before the back-end connection	Termination cable with matching gel in the back-end connection
			UPC-polished	Termination cable with mandrel before the back-end connection	Termination cable with matching gel in the back-end connection