Technical Note 002

Return loss measurement

1. Purpose

The purpose of the return loss measurement, also abbreviated RL, is to determine the fraction of the back reflected power respect to the incident optical power in a passive optical component.

2. References

The reference for the return loss measurement is following:

- International Standard IEC 61300-3-6 'Fibre optic interconnecting devices and passive components - Basic test and measurement procedures - Part 3.6: Examinations and measurements - Return loss'

3. Definition

The measurement of return loss is performed according to different methods. The measurement methods are defined by the standard IEC 61300-3-6. In paragraph 4.1 and 4.2 two measurement methods are explained, measurement method 1, also called OCWR method, for Optical Continuous Wave Reflectometry, and measurement method 3, also called OLCR method, for Optical Low Coherence Reflectometry.

The return loss measurement is a measurement of a relative value which is expressed in deciBel (dB) and defined with following formula:

$$RL = -10 \cdot \log\left(\frac{P_{reflected}}{P_{incident}}\right) \quad [dB] \qquad (1)$$

Where $P_{incident}$ is the incident power level expressed in W and $P_{reflected}$ is the reflected power level expressed in W of the passive optical component under test, also called DUT, Device Under Test.

In the fibre optic the power level can also be given in a logarithmic scale and expressed in dBm. The formula to transform the power level from mW to dBm is given below:

$$P_{dBm} = 10 \cdot \log\left(\frac{P}{P_0}\right) \qquad [dBm] \qquad (2)$$

Where P_{dBm} is the power level expressed in dBm, P is the power level expressed in mW and P_0 is the reference power level corresponding to 1 mW.

And with some examples:

P			P_{dBm}	
1000	mW	⇒	30	dBm
100	mW	⇒	20	dBm
10	mW	⇒	10	dBm
1	mW	⇒	0	dBm
1	μW	⇒	–30	dBm
1	nW	⇒	–60	dBm

In this way the return loss given in (1) can be also expressed with the power level in dBm, as follow:

$$RL = P_{incident,\,dBm} - P_{reflected,\,dBm} \quad [dB] \qquad (3)$$

In case of two mated connectors, the return loss is generally caused by dissimilar fibre indexes, by impurities or scratches on the fibre surface or by a wrinkled fibre surface.

4. Methods

4.1 Measurement method 1 or OCWR method

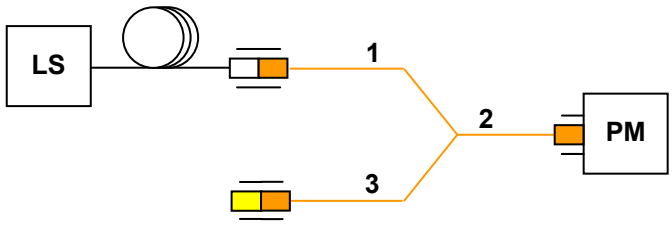
Measurement method 1 is also known as OCWR method and consists in the measurement of the return loss of one or more optical components along a measurement line. The OCWR measurement method requires the use of a coupler.
Due to the fact that this method measures not only the optical return loss of single mated connectors but also the Rayleigh backscattering of the fibre, the use of short patch cords is recommended. Furthermore possible high reflections caused by components along the measurement line, like for example unmated PC polished connectors at the end of the line, that will affect the measurement results, have to be eliminated using so called low reflection terminations, by winding the fibre on a mandrel with a sufficient small radius or by the use of index matching gel boxes.

This method shows some limitations, in particular, it cannot spatially resolve single reflections along the measurement line and the dynamic range is limited by the characteristics of the used devices and by the possibility of suppressing reflections beyond the one caused by the device under test. The dynamic range is generally in the order of 60 dB.

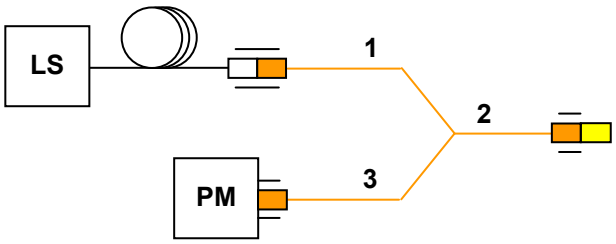
The return loss measurement with the coupler method is performed in three main steps. The first step consists in the measurement of the incoming power level P_{in} at the reference output. The second step consists in the measurement of the back reflected power level of the coupler $P_{back\ coupler}$. The third step consists in the measurement of the back reflected power level of the coupler and the device under test $P_{back\ coupler\ +\ DUT}$. The measurement setups are represented below in a simplified way.

4.1.1 Measurement setup

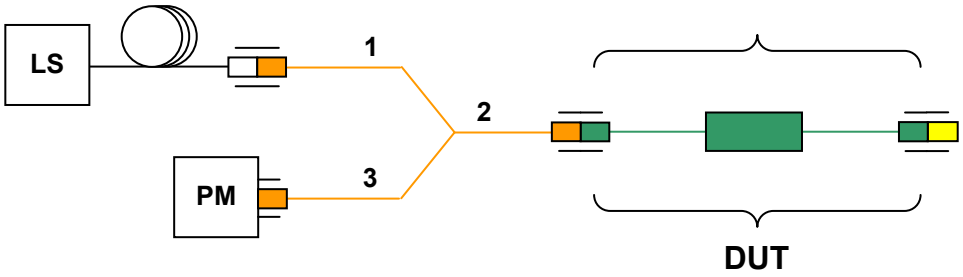
a) Measurement of the incoming power level (P_{in})



b) Measurement of the back reflected power level of coupler ($P_{back\ coupler}$)



c) Measurement of the back reflected power level of coupler and DUT ($P_{back\ coupler\ +\ DUT}$)



4.1.2 Measurement result

For a correct calculation of the return loss RL using the coupler method, the insertion loss of the used coupler in the coupler arm from to 2 to 3, IL_{23}, has to be considered. The corrected return loss RL can therefore be given with following formula:

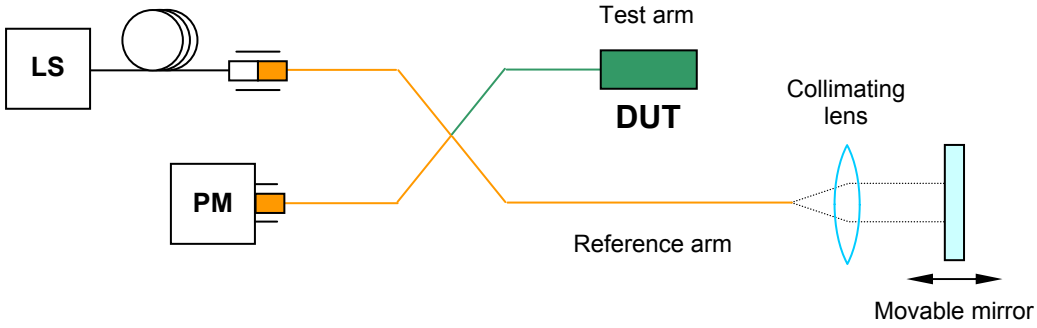
$$RL = -10 \cdot \log\left(\frac{P_{back\ coupler\ +\ DUT} - P_{back\ coupler}}{P_{in}}\right) - IL_{23} \quad [dB] \qquad (4)$$

Some measurement instruments have integrated back reflection measurement modules that perform the return loss measurement with the coupler method, as showed above, in a fully automated way.

4.2 Measurement method 3 or OLCR method

Measurement method 3 is also known as OLCR method, is based on the principle of low coherence interferometry and allows the measurement of the reflection at a defined point by detecting the power of the signal produced by the optical interference between the reflected light and a reference light.
The OLCR interferometry allows the measurement of reflection profiles with micrometre spatial resolution and a high dynamic range in the order of 80 dB and higher.
Furthermore the OLCR interferometry can suppress from the reflected power the fraction of reflected power caused by the Rayleigh backscattering of the fibre.

4.2.1 Measurement setup



4.2.2 Measurement result

The return loss RL of the device under test using the OLCR method is directly given by the data processing device of the OLCR Reflectometer as reflection in function of the measured distance. The measurable distance is directly given by the translation of the mirror, as given in the measurement setup. OLCR Reflectometers have measurement distances from several centimetres up to several meters with a spatial resolution in the range of 0.1 up to 0.01 millimetres.

4.3 Other measurement methods

The standard IEC 61300-3-6 defines two other measurement methods of the return loss. One of them called OTDR method, for Optical Time Domain Reflectometry, and the second one called OFDR method, for Optical Frequency Domain Reflectometry.

The OTDR method is commonly used in field measurements on installed optical lines with a spatial resolution in the metre range and a dynamic range of about 60 dB up to 75 dB depending on the used measurement parameters. The OFDR method is used to measure return loss of optical devices with a spatial resolution in the centimetre range and a dynamic range in the order of 70 dB and higher.

One of the advantages of both methods is the ability to spatially resolve single reflections along the measurement line. In order to have a correct spatial resolution of the measured events, both methods require the exact knowledge of the Rayleigh backscattering indexes of the measured fibre.

For more details about measurement methods refer to the standard IEC 61300-3-6.