Return loss referencing using the CTP10 test platform

app note

EXFO

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1. Introduction

This application note complements the *Insertion loss referencing procedure* and discusses more specifically the reference procedure for swept return loss (RL) measurements performed using the IL RL OPM2 module on the CTP10 test platform.

The standard configuration for swept IL-RL measurement is shown in Figure 1.

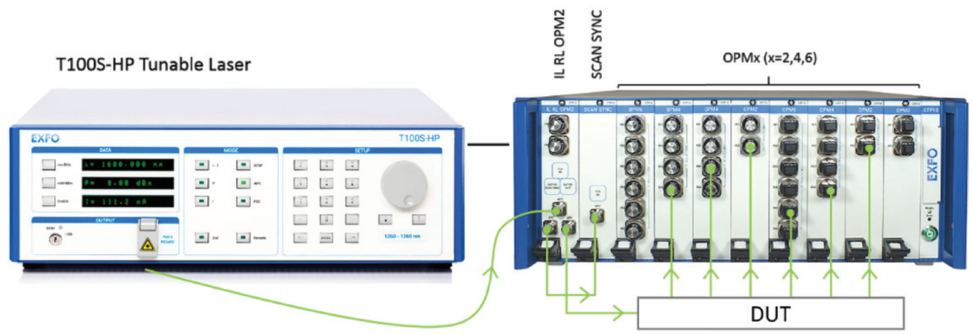

Figure 1. Configuration for swept IL-RL measurement using the CTP10 platform and T100S-HP laser.

As in the case of insertion loss (IL), performing new reference measurements regularly is critical to achieving best performance and compensates for deviations that can appear over time. In addition, return loss tends to be more sensitive to measurement conditions than insertion loss, and certain best practices should be followed to ensure optimal performance:

- Opt for APC connectors instead of PC connectors to minimize parasitic sources of return loss in the optical path.
- Minimize sources of return loss in the optical path before and after the device under test (DUT).

2. CTP10 approach to RL referencing

Return loss measurements are performed by the IL RL OPM2 module, which integrates two calibrated detectors to provide a real-time measurement of the optical power sent to the DUT (OUT to DUT port) and of the light travelling backwards from the DUT.

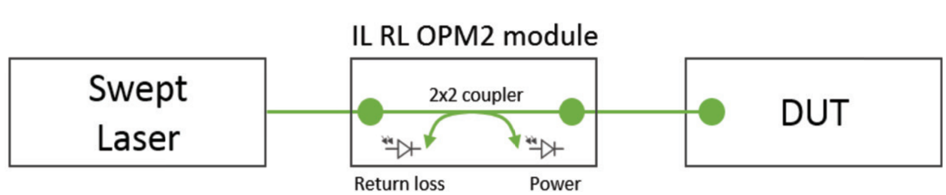

Figure 2. Schematic representation of the return loss measurement principle.

Assuming there is no optical loss between the IL RL OPM2 module and the DUT, the return loss of the DUT can be easily calculated as:

$$RL_{dB} = P_{sent\ to\ DUT} - P_{from\ DUT}$$

where power values are expressed in dBm

Using this definition, RL_{dB} is always positive and components with a strong return loss result in a low (close to 0 dB) return loss. To avoid any confusion, the CTP10 displays back reflection (BR) values, simply defined as $BR_{dB} = -RL_{dB}$. Using back reflection, a component with a stronger return loss would yield a higher back reflection.

It should be noted that any optical loss along the path between the IL RL OPM2 module and the DUT changes the optical power reaching the DUT and therefore the reflected power. Since light travels twice through this optical path, any loss introduces an error of twice that value on the measured return loss, as illustrated in Figure 3 below.

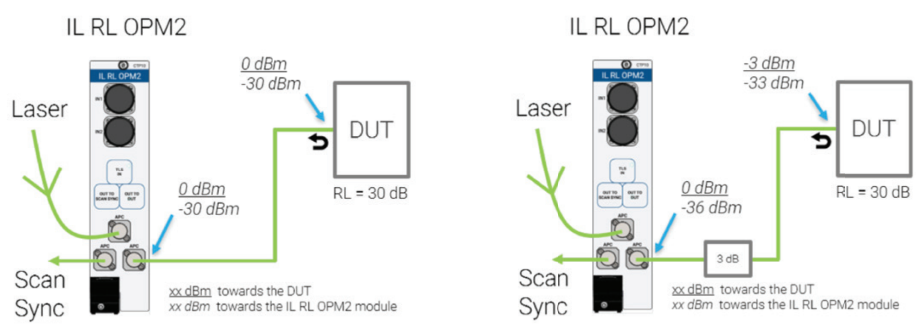

Figure 3. Left: the 30 dB return loss of the DUT is correctly measured. Right: The 3 dB loss between the IL RL OPM2 module and the DUT will result in a 6 dB error on the measured return loss if not accounted for.

Failing to reference the loss in the optical path to the DUT results in the measurement of a weaker optical signal, which is erroneously interpreted as a weaker return loss, therefore underestimating the actual return loss of the DUT. In a manufacturing environment, this may lead to passing components with return loss values that do not meet specifications. Consequently, the loss of the optical path must be referenced to achieve the best RL performance, similarly to insertion loss.

The CTP10 uses an innovative approach that seamlessly references return loss measurements during the standard IL reference procedure, removing the need for a separate RL reference and simplifying the overall reference procedure. The image below shows the reference menu of the CTP10 GUI used to reference the system for both IL and RL measurements.

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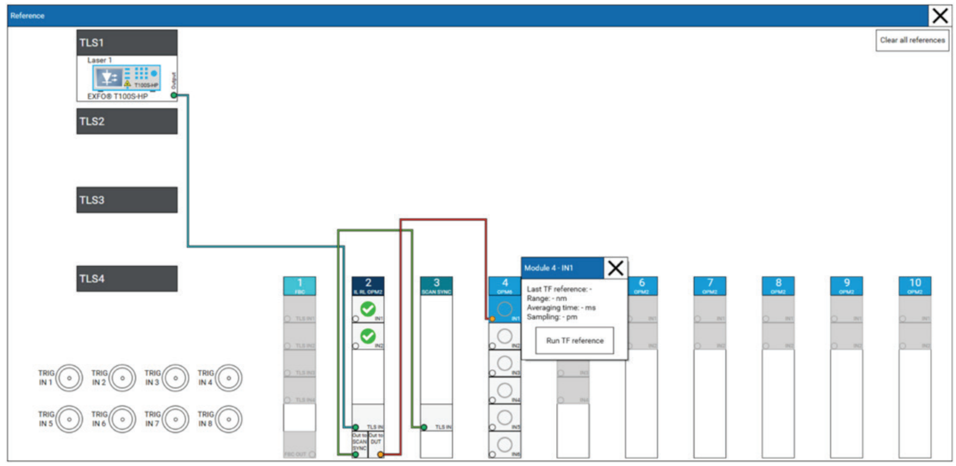


Figure 4. Reference menu of the CTP10 GUI used to reference the system for IL and RL measurements.

2.1 RL reference

To take a return loss measurement, you need to account for the loss between the IL RL OPM2 module and the DUT. This loss can be conveniently measured while performing the mandatory IL reference measurements, as shown in Figure 5.

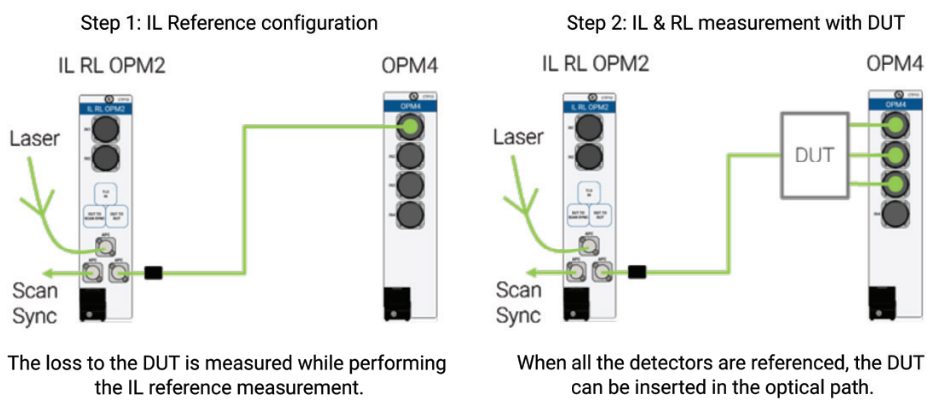


Figure 5. Left: reference configuration. Right: measurement configuration after inserting the DUT.

If a lossy component (e.g., coupler) is placed before the DUT, its loss will be measured during the IL reference measurement and accounted for in subsequent IL and RL measurements.

While every OPM detector must be individually referenced to perform IL measurements, referencing the return loss only requires a single measurement to determine the loss between the IL RL OPM2 module and the DUT. This can be done during any of the IL reference measurements, and the system's first detector (top-left detector) is arbitrarily chosen to serve for both the IL and RL references. Looking at the reference menu shown in Figure 4, the detector in module 2 and channel 1 corresponds to the first detector of the subsystem (top-left detector) and serves both for the IL and RL references.

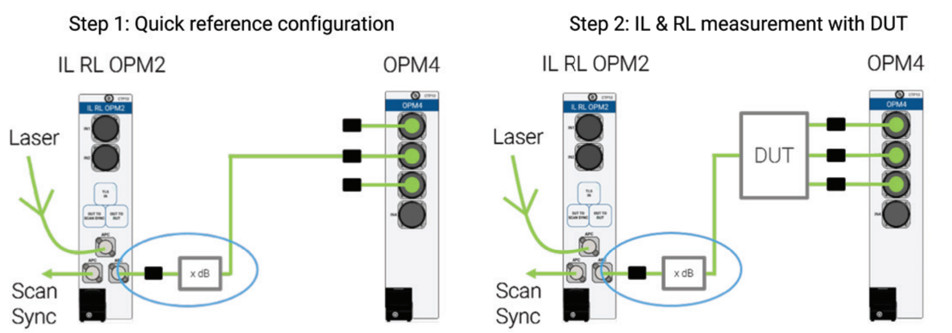
This reference procedure works if the DUT is connected directly to the IL RL OPM2 module or if one or several components are placed between the IL RL OPM2 module and the DUT.

“ The quick reference provides a convenient way to account for variations in the optical path before the DUT.

2.2 Quick reference and RL

As with insertion loss measurements, any change or drift in the loss along the optical path between the IL RL OPM2 module and the DUT will affect the measured return loss. For example, changing the master test jumper or adding a tap coupler will modify the characteristics of the optical path to the DUT and change the measured return loss. Similarly, drifts that can appear over time or because of varying environmental conditions will also affect the measured return loss.

The quick reference provides a convenient way to account for variations in the optical path before the DUT. Although it is possible to use the standard reference procedure to re-reference all the detectors in use, this approach is tedious when dozens of optical detectors are involved, for example when testing high-port-count components such as wavelength division multiplexers (WDMs) or wavelength selective switches (WSSs). In contrast, the quick reference compares the loss along the optical path between the initial reference measurement and the quick reference measurement, providing a convenient way to account for variations or drifts in optical path characteristics. The quick reference can be used on any of the system's detectors to update the IL and RL references with a single measurement.



Any change or drift in the optical path before the DUT (circled in blue) can be compensated for by using the quick reference.

After the quick reference, the DUT can be inserted in the optical path.

Figure 6. The quick reference can be used to account for changes in the optical path before the DUT.

2.3 Full RL reference

If the optical path to the DUT contains non-negligible sources of return loss, referencing these undesired contributions can help improve measurement accuracy at low BR levels. If the DUT is directly connected to the IL RL OPM2 module (as shown in Figure 1), there is no significant source of return loss in the optical path and referencing these small contributions will provide little to no improvement compared to the referencing method available in the CTP10 GUI.

The full referencing procedure described below is not available directly via the CTP10 GUI, but can be done by performing the reference measurements manually and post-processing the raw data from the CTP10. The images below summarize the different steps to reference an undesired source of return loss in the optical path before the DUT.

Steps 1 and 2: Determine the return loss and insertion loss of the component placed before the DUT.

1. Reference the loss of the optical path to the component of undesired return loss.
2. The return loss and insertion loss of the component can be measured by performing a regular IL-RL measurement.

Steps 3 and 4: Reference the loss of the component to the DUT and insert the DUT

3. A new reference measurement should be performed with the component to take its insertion loss into account.
4. The DUT can be inserted and another measurement started.

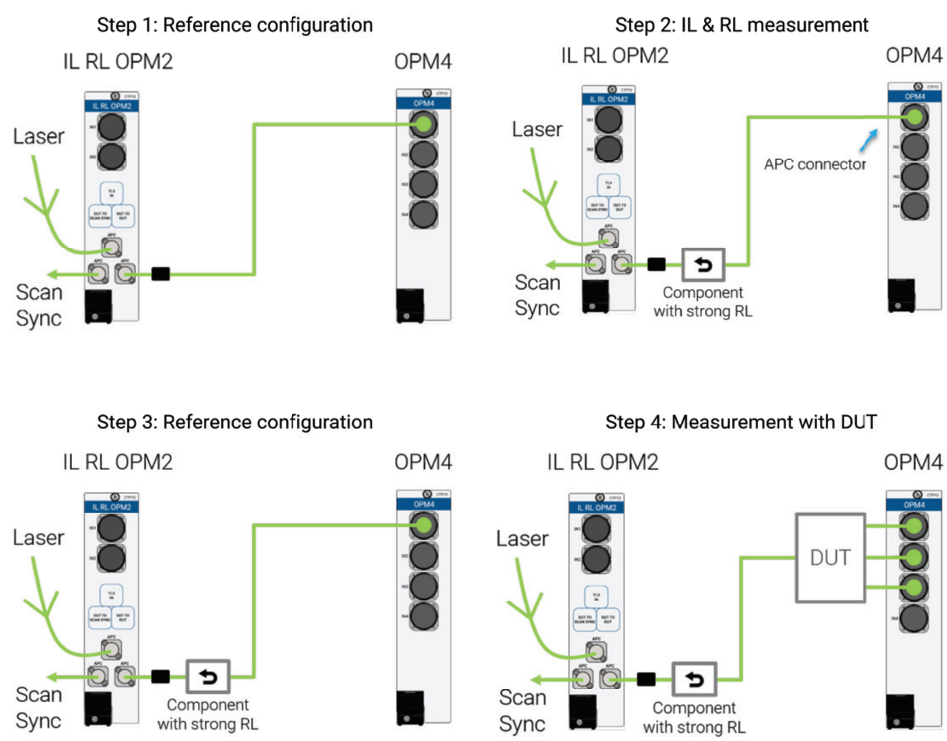


Figure 7. Steps to account for an undesired source of return loss before the DUT.

The transfer function and back reflection measured in step 2 are referred to as *TF and BR* respectively, whereas the back reflection measured with the DUT in step 4 is referred to as BR_{meas}. The back reflection of the DUT can then be calculated as:

$$BR_{DUT} = 10.log_{10}\left[10^{\frac{BR\,meas}{10}} - 10^{\frac{BR-2TF}{10}}\right]$$

Although the contribution of an undesired source or return loss can be measured and compensated for, accurately measuring a DUT that has a much weaker return loss than the parasitic contribution is challenging. Assuming a lossless component with a parasitic return loss of 45 dB, the table below shows the return loss of the DUT for different values of measured return loss.

BR = –45 dB, TF = 0 dB	
BR_{meas} (dB)	BR_{DUT} (dB)
–44.5	–54.14
–44	–50.87
–40	–41.65
–35	–35.46
–30	–30.14

The first line of the table shows that a DUT with a back reflection of -54.14 dB would yield a measured back reflection of -44.5 dB. In other words, measuring a DUT with a back reflection of 9 dB below the parasitic source of return loss requires you to measure a 0.5 dB difference. This can be challenging in practice considering the low power levels, measurement noise and repeatability of the system, as well as interference effects.

This last line of the table also confirms that in cases where the return loss of the DUT is significantly stronger than the parasitic return loss (respectively 30 and 45 dB), the full RL reference only provides a negligible improvement and the back reflection of the DUT can be simply assumed to be equal to the measured back reflection: $BR_{DUT} = BR_{meas}$.

The GUI of the CTP10 provides a built-in reference menu to easily manage and perform reference measurements.

3. Conclusion

This application note discussed the reference procedure for return loss measurements using the CTP10 test platform. The GUI of the CTP10 provides a built-in reference menu to easily manage and perform reference measurements.

The CTP10 also uses an innovative approach to reference the loss to the DUT required for the RL measurement during the standard IL reference procedure, eliminating the need for one or more dedicated RL reference measurements. This reduces the number of reference measurements, greatly simplifies the reference procedure and saves time.

In addition, more advanced reference procedures can be followed if undesired sources of return loss in the optical path need to be considered. While it is theoretically possible to compensate for the contribution of an undesired source of return loss, accurately measuring a DUT with a weaker return loss is challenging in practice. Measuring a weak return loss signal requires special attention to minimize undesired sources of return loss, coming for example from connectors or optical components in the optical path.