Application Note

Self-calibration of the RL1 Automated Return Loss Meter

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As fiber-optic networks have gotten more sophisticated, the insertion loss (IL) and return loss (RL) requirements of cable assemblies and other passive components have gotten stricter.

In order to meet these new requirements, more accurate instruments have become necessary. Since the manufacturer designed and built the instrument, the most reliable calibration is one performed by them or an approved service center.

The Cost of Calibration

Sending a unit back to the manufacturer is a costly endeavour. Highest of these costs is the absence of the instrument. In a production environment operating close to its capacity, shutting down a line is not an option.

At JGR Optics' ISO17025 calibration lab, we pride ourselves on having lead-times shorter than one week, but time spent in transit is out of our control. From a company's outgoing and incoming internal procedures to government bureaucracies and customs issues, going from point A to point B and back can sometimes be measured in weeks or even months! As a result, some facilities need equipment backups that can be 25% of their inventory or higher.

JGR offers on-site calibration directly or through local service centers which are continuously trained by us to maintain our high standards. This on-site service reduces the aforementioned downtime and alleviates the cost of calibration.

As we set ourselves the target of developing the next generation of IL/RL meter, we asked ourselves what if the instrument was designed in a way that it could be *reliably* calibrated by the customer?

Figure 1: JGR's new RL1 Automated Return Loss Meter

The Importance of Calibration

Regardless of the type of instrument, the goal of any calibration is for the instrument to be performing within the specifications of that unit. The RL1 Automated Return Loss Meter outperforms other meters in its class when it comes to accuracy[1].

In order to meet these specifications, each system, sub-system and component of the meter must be within the established internal specifications. Everything is tested from output power, laser stability, IL stability, RL accuracy, dynamic range, component temperature, etc. Any deviation from the expected values outside the tolerances *could* indicate a problem with the meter and throw into question the test results.

A well-trained technician knows how to properly evaluate the state of the meter and whether a recalibration or repair is warranted.

Conventional RL Calibration

RL calibration has generally been done using an external artifact. Like the RL1, JGR's legacy MS12 uses optical time domain reflectometry (OTDR). The single-mode (SM) model has an internal reflector whose peak is compared to an attenuated glass-to-air artifact, both in the 50-55 dB range. The advantage of having an internal reflector is that it is protected from the outside world. That value will not change unless severe physical damage is done to the unit.

The calibration of the internal reflector is done by a trained technician and the approved calibration procedures include multiple redundancies to eliminate the possibility of a biased calibration. When the SM MS12 initializes, it uses the internal reflector to get a calibration point in the 50-55 dB range. Since modern connector RL specifications are typically between 50 and 65 dB, this optimizes the accuracy of the meter in the actual measurement range.

Some OTDR return loss meters may use an external UPC glass-to-air reflection at 15 dB[2] to get a calibration point. There is now an added variable to consider: the linearity of the APD over a 50+ dB range. Furthermore, if the calibration is done by the operator at the start of a test, what if the artifact is damaged or there is contamination? All the tests performed by that unit may be incorrect and there would be no warning to verify or re-do the calibration.

Multimode RL connector specifications[3] do not require such precision therefore a calibration point at 15 dB is acceptable and more common.

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[1] IL ± 0.03 dB (< 5 dB) and RL ± 1.0 dB (< 70 dB, SM)

[2] Exact value can vary depending on wavelength and core size.

[3] Typically between 20 and 35 dB.

A New RL Calibration Method

In 2020, JGR Optics released a white paper[4] describing how RL can be calibrated instead using an intrinsic property of the fiber: its *backscatter coefficient*.

By generating different pulse widths, one can generate different injection levels. The difference in pulse widths (measured in time) can be converted to length via the speed of light. The backscatter from an optical fiber of that length is equivalent to the height difference of the injection levels.

In Figure 2, a pulse width D_m produces the blue injection level IL_m. A pulse width D_i produces the green injection level IL_i. If a reflection A from a pulse width D_m causes a peak of height H_p, the RL of A is equivalent to the excess backscatter which results in the injection level height difference H_i.

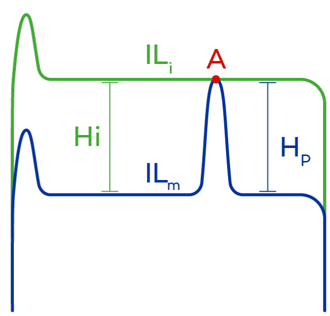

Figure 2: Graphical representation of the principle behind the new calibration method.

This allows for multiple calibration points of the RL meter without the need of an external artifact. There are two major advantages to this method.

Firstly, OTDR meters calibrated using a single RL peak suffer from non-linearity for RL > 60 dB[5]. Using this new method, the RL1 generates six RL calibration points between 55 and 75 dB. The calibration curve significantly improves the meter's accuracy for RL > 70 dB compared to other industry leading RL meters including the legacy MS12 and allows the RL1 to measure up to 85 dB.

Secondly, without the need of an external artifact during RL calibration, all other aspects of the calibration can be incorporated into the design of the RL1. The result is a reliable and user-friendly *self-calibration* of the RL1 that the customer can perform with minimal training. There are built-in self-diagnostics that test every parameter that would normally be verified by a JGR technician.

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[4] G. Paradis, R. Veenkamp, *OTDR calibration method using multiple levels of optical fiber backscatter*, 2020. Patent pending US16.791.574.

[5] A. R. Anderson, L. Johnson, F. G. Bell, *Troubleshooting Optical-fiber Networks*, 2nd Edition, Elsevier Academic Press, 2004.

Performing a Self-calibration

All the instruments used in a return loss meter calibration have been built into the RL1. The only extra equipment needed by the user is a 3m jumper and the appropriate inspection and cleaning tools.

Connect the RL1 to a network via Ethernet then go to the RL1's webpage by entering the IP address displayed on the *Setup* page of its front panel touchscreen. The webpage acts as a portal to show the factory calibration report and other useful instrument information.

Click on the *Self-calibration* tab and a detailed, step-by-step procedure is displayed (Figure 3). Each step requires the user to validate a physical inspection or the RL1 to successfully run a self-diagnostic task before moving on to the next.

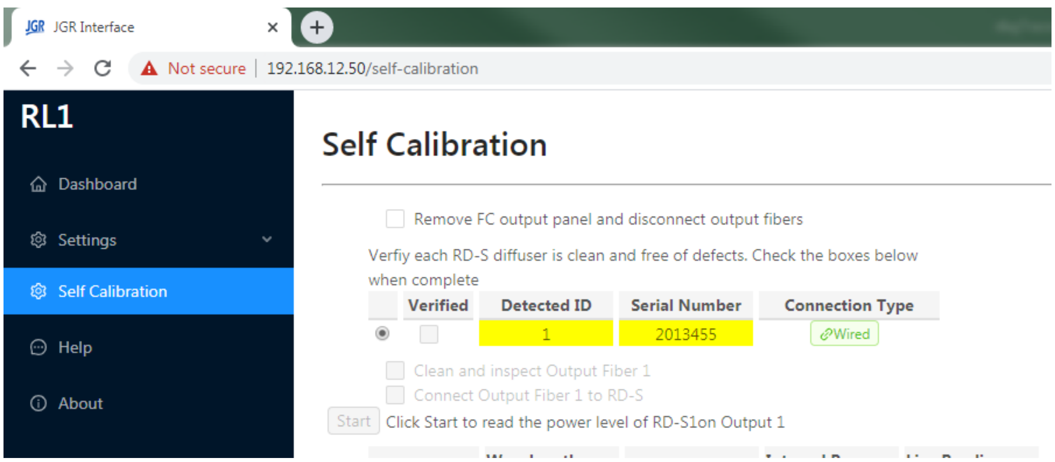

Figure 3: *Self-calibration* tab of the RL1's webpage

If all the steps are successfully completed, the self-calibration report can be saved on the RL1 to be viewed, printed or exported to PDF.

Summary

As we continue striving to improve and develop test equipment based on customer needs, the conventional RL calibration methods were re-examined. Instead of relying on an external artifact, an intrinsic fiber property, the backscatter coefficient, was used. The RL1 Automated Return Loss Meter is the next generation of IL/RL test instruments. Along with improvements to its speed, accuracy and ease of implementation, it features a new concept in its class: self-calibration.

Customers will now benefit from greatly reducing the time and money spent on calibration as well as having the peace of mind of a reliable calibration at their discretion.