Precision Field Optical Loss Testing

Recent fiber installation test situations may require loss testing with a total loss of only a dB or two, with very tight uncertainty limits compared to previous practice, along with a very high fiber count. This is very challenging for field staff, and this paper attempts to provide some practical clarity and guidance on how to improve field test repeatability and accuracy.

A Typical Situation:

A 40G/100G LAN installation is planned with MPO connectors and ribbon fiber with a maximum loss budget of 2 dB, for a cloud data centre. The loss test uncertainty is 0.5 dB, therefore the acceptable test limit is reduced to 1.5 dB to ensure budget compliance. The installation crew have trouble meeting this, and the situation would be easier if the uncertainty could be reduced to say 0.3 dB, allowing the acceptable test limit to be increased to 1.7 dB.

Test Lead Issues

If excellent test equipment and procedures are used, the accuracy and repeatability of field loss testing is limited by variability between different test leads, particularly if multi-lead reference methods are used. In other words, if the same test is performed on the same system with the same test equipment, but with different test leads, then significant differences in results will be observed. This is usually the limiting factor, beyond which it is impossible to improve. So the required reference lead method needs selecting with care, and test leads should be of superior grade.

Test Lead Maintenance

Test lead maintenance is essential. This implies routine replacement of both leads and through connectors after 1,000 insertions. It also implies a visual and process check at the start of each measurement situation, to ensure that the leads are up to standard.

Cleanliness and Inspection is Key

Precision testing requires that connector ends are properly cleaned and inspected before *every* mating. The speed at which systems can be tested depends on the rate at which each connector can be cleaned and inspected, so the test cycle usually around half a minute per connection. An inspection scope with good image quality and at least 200x magnification is needed.

General Test Uncertainty

Measurement Uncertainty is traditionally calculated by using an RMS method to add up the expected uncertainties (other methods are more complex, so are ignored for this discussion) , so uncertainties don't just add up, eg three uncertainties of 5% don't add up to 15%, they add up to 8.7%. Logarithmic uncertainties should be converted to linear uncertainties before using the RMS method, or inaccurate results can be obtained. For example three 0.2 dB uncertainties correctly add up to 0.33 dB using linear maths, or incorrectly add up to 0.35 dB using a logarithmic calculation. Also, the largest uncertainty dominates, so 3 uncertainties of 0.2, 0.1 and 0.05 dB can be reasonably approximated to 0.2 dB without even bothering with calculations. The implication of this is that typically, once the major sources of uncertainty have been identified, the others can be ignored. Failure to understand this often leads to unnecessary complication.

Light Source Drift

Light sources can drift. Lasers usually drift more than LEDs. A power meter reference should be made at the start of the test, and then re-checked for drift at the end. If the source drift is too much, then the testing must be repeated. The drift limit forms part of the uncertainty calculation. If singlemode testing is only required at 1310 nm, then a 1310 nm LED source may be preferable to a laser source.

Singlemode Testing

With excellent equipment and procedures, uncertainty with single mode field testing is usually defined by test leads.

For singlemode wavelengths, a power meter with an InGaAs detector will always give better results compared to a germanium detector.

Multimode Testing

When testing multimode fiber, source modal fill significantly affects loss test results, so the source must have an identified modal fill pattern, or the results will not be repeatable when other test equipment (eg another light source) is used to check the result. Help is at hand here with the recently introduced Encircled Flux (EF) standard. It has been identified that light source equipment meeting this standard does indeed provide improved consistency. Contrary to popular myth, on modern fibers, a mandrel wrap does not create a consistent modal fill, it merely removes unstable edge modes, so it provides some secondary help, but is not a substitute for an EF compliant source.

For multimode testing at both 850 and 1300 nm, a power meter with a Ge detector is used. Alternatively, for testing is at 850 nm only, a silicon detector will give better results.
At 850 nm, an InGaAs power meter tends to be excessively wavelength sensitive so it is not very suitable.

Is the test equipment fit for purpose?

Quite simply, is the test equipment adequately stable? This is quite easily determined by just turning it on, setting a reference, and then seeing if the reference reading remains adequately stable as the equipment is moved around and subjected to typical knocks (particularly on the optical connectors). Warm-up characteristics and ambient temperature sensitivity can be checked by sensible use of air conditioning, fridge, daily outside temperature variations etc. Particular attention should be given to source stability: try knocking a finger on the attached connector and see what happens. For multimode testing, is the source Encircled Flux compliant?

Local or Remote Referencing & bi-directional testing

Referencing and testing methods need choosing with care. The generally preferred method for any installation is two-way (Bi-directional) testing using remote referencing. The bi-directional method has three distinct advantages: it will always identify wrongly installed fiber types (eg wrong core size), it minimizes the cycle time between referencing and subsequent reference checking, and it automatically compensates for power meter calibration errors. The most accurate bi-directional method is either with a light source and power meter, or an automated bi-directional tester using local (side by side) referencing. When an automated bi-directional loss tester is used with remote referencing, additional errors are introduced which may affect precision testing. If such a procedure is planned, the equipment should be tested for this specific error.

Speed up ribbon fiber testing

The simplest way to simplify and speed up loss testing of ribbon fiber / MPO connectors when using a source and meter, is to use a power meter with a specially designed detector head, so that the meter connection doesn't need shifting each time the source connection is moved. The meter just reads the power from any of the fibers. This also avoids the added inaccuracy caused by having a tail break-out lead for the power meter: the MPO connector is plugged directly into the meter.

Don't Forget Reporting

Typically, the process of manipulating test data to fit a customer's acceptance report template can amount to half of the testing labor effort. It's also risky since mistakes occur. This effort and risk can be eliminated by use of test software that lets the test technician click live test data directly into the customer report, with no intermediate steps.

What's currently achievable in practice?

We have demonstrated a practical test uncertainty of 0.23 dB on an MPO multimode ribbon fiber using a modified single patch lead reference method, a Kingfisher KI9812 LED source, and KI9600XL-Si5 power meter with an MPO connector adaptor. Inspection was performed with a KI6610 microscope fitted with an MPO connector adaptor.

Alternatively, for high speed testing of large fiber arrays, we have demonstrated a test cycle directly into a customer test report, of two wavelengths in about 6 seconds. This is with either a Kingfisher Autotest power meter or Two-Way tester, linked to KITS reporting software.

We believe that both of these results represent current best practice.

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May 2012