

Optical fiber loss testing

There is general agreement in the industry on a test procedure that can be relied on for accurate and repeatable optical loss measurements.

Optical fiber loss testing is not as simple as it seems. Providing an accurate method for optical loss testing is becoming a lot more important for higher data rate applications that place more stringent requirements on the maximum allowable loss for a channel between an optical transmitter and an optical receiver.

For example, the maximum allowable loss for a 10Gb/s Ethernet channel over OM3 multimode fiber is 2.6 dB. The maximum allowable loss for a 40 Gb/s and a 100 Gb/s Ethernet channel is 1.9 dB over OM3 fiber and 1.5 dB over OM4 fiber.

What I wanted to do for this month's column is to provide some information on how the method of testing can affect the accuracy of optical loss measurements. Some major factors include 1) the characteristics of light source and how light is coupled into the fiber, 2) the mode conditioning filter that is used, 3) the type and quality of the "test reference cord" and 4) fiber mismatch between the test reference cords and the link under test.

The channel under test can include regular graded-index multimode fibers (MMFs) as well as the newer bend-insensitive multimode fibers (BI-MMFs). There is a task group in TIA TR 42.12 that is currently looking at the performance of newer bend-insensitive multimode fibers compared to regular multimode fibers.

The effective core diameter and the numerical aperture of BI-MMFs can vary as a function of link length because of the propagation of higher order leaky modes.

Leaky modes, which do not propagate in a conventional multimode fiber, can propagate several hundred meters in a BI-MMF.

This can have an affect on the connection loss depending on the distribution of light that is launched into the fiber.

This work is still in progress and the recommendations of the task group have not yet been published. However, a number of contributions have pointed to Encircled Flux (EF) as the best test method to use for loss measurements of MMF and BI-MMF optical fiber channels.

What is Encircled Flux or EF? It is a new method of controlling the power distribution of light that is launched from the end of a test reference cord (TRC) when performing optical loss measurements.

The lower and upper boundaries of the light power distribution are specified as a function of the core radius and for each wavelength at 850 nm and 1300 nm.

EF was developed by optical experts to reduce variability in link-loss measurements compared to other optical loss test methods that use an overfilled launch light source and mode conditioning filters (e.g., mandrel wrap).

The Encircled Flux test method is specified in TIA TIA-526-14-B, "Optical Power Loss Measurements of Installed Multimode Fiber Cable." This standard is "back adopted" and harmonized with

IEC 61280-1-4. Encircled Flux is also the test method that is specified in the IEEE 802.3ba Standard for 40 Gb/s Ethernet (40GBSE-SR4) and 100 Gb/s Ethernet (100GBASE-SR10).

The most common method for performing optical loss measurements in the field is to use an Optical Loss Test Set (OLTS) with an overfilled, Category 1, light source (typically an LED) and a test reference cord that is wrapped with five non-overlapping turns around a mandrel.

The mandrel wrap serves as a "high-order mode filter." The size of the mandrel is specified in the TIA 568-C.0 standard and is selected to meet the launch conditions of ANSI/TIA-455-78B.

The problem with the mandrel wrap method, from our own experience, is that the optical loss measurements can vary significantly when tested using different test equipment. For example, we measured the optical loss of a 20 meter, 2-connector, permanent link using two different OLTS test instruments.

The same test reference cords and mandrel wrap were used for both tests. We found that there was a difference in loss measurements by as much as 0.5 dB between the two different test instruments. We repeated the same tests using the Encircled Flux test method and the results were in agreement within 0.1 dB.

The difference in loss measurements can be attributed to how much light is coupled into the multimode fiber between the different test equipment, in particular the higher order modes.

Although both light sources are specified as Category 1, the specifications are not sufficient to ensure that a consistent mode-power distribution is launched from the end of a reference test cord when using a mandrel wrap. A difference of 0.5 dB in loss measurements can mean a difference between a Passing link and a Failing link when working with a loss budgets that are as small as 1.5 dB to 2.6 dB. The good news is that there is general agreement in the industry on a test procedure that can be relied on for accurate and repeatable optical loss measurements.

The Encircled Flux test method reduces loss measurement variation to a goal of +/- 10% for link attenuation measurements greater than 1dB.

EF compliance can be achieved through the use of a modal controller device that is either integrated into the test equipment or an external device that is inserted between the light source and the fiber under test. The EF modal controller device is a passive device that ensures that launch conditions meet the IEC 61280-4-1 requirements regardless of the light source used (LED or laser).

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