Bit Error Rate (BER) Functionality Testing of Laser-Optimized Multimode Fibre: DMD-mask or minEMBc?

White Paper

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Russell Ellis, Corning Incorporated
Sharon Bois, Corning Incorporated

The minEMBc (minimum calculated effective modal bandwidth) measurement method is used to certify the laser bandwidth of all Corning 50 micron InfiniCor® multimode fibres. Corning has extensively studied minEMBc and other laser bandwidth techniques and has reported the superiority of the minEMBc laser bandwidth technique in several published articles and white papers[1]. Accurate characterisation of multimode fibre bandwidth for high speed applications (10G and beyond) is far from a trivial undertaking. It is important to realize that one-off measurements or collaborative studies, while technically interesting, are no substitute for 100% full-time, accurate and reliable measurements which Corning performs on every reel of laser-optimized 50µm multimode fibre.

Since the advent of laser-optimized 50µm multimode fibres, it has been clear to Corning, the original architects of both the Differential Mode Delay (DMD) measurement tools and minEMBc, that minEMBc is the most precise, accurate, and robust bandwidth measurement technique for multimode fibre. This is largely due to the fact that the contribution of VCSEL transceivers on overall system bandwidth (and therefore installed system performance) is incorporated into the minEMBc measurement technique. The encircled flux (EF) pattern or modal power distribution of the light emitted by each and every VCSEL is fundamental to the system performance capability of a multimode fibre. This is due to the fact that the power distribution of a group of VCSELs can vary widely resulting in significant performance differences over a given fibre. The link length obtained with a large-spot (hot outside) laser can be very different than that obtained with a small-spot (hot inside) laser. The minEMBc method ensures that the stated performance will be obtained when the fibre is used with any standards-compliant VCSEL.

In some recently published articles, attempts have been made to compare the relative accuracy of the DMD-mask and minEMBc through a series of functionality tests using a small sample set of multimode fibres and one or two 10GBASE-SR 850nm transceivers. Most often, minEMBc is reported as the more accurate and reliable measurement method. However, some incomplete studies have tried to claim that DMD-mask tests are equally sufficient. In such studies with relatively few fibre samples, where only a small number of transceivers are used and when often many transmission properties are either simplified or not considered, there is a danger that the results will only tell half of the story and the true system performance will be misrepresented.

Any testing or research pertaining to DMD-mask and minEMBc bandwidth measurement accuracy through a system test using BER testing can be misleading and erroneous unless the tests are performed with a wide variety of fibre-transceiver combinations and unless the work fully characterises the transceivers that are used in such tests. From Corning's 30+ years of experience testing literally

[1] A few examples of published white papers and articles highlighting the superiority of the minEMBc laser bandwidth technique are listed below. Additional resources can be found at http://www.corning.com/opticalfiber/products/infinicor_fibers.aspx

"Refined multimode fibre supports high-rate data", Autumn 2007 issue of Fibresystems Europe. http://www.corning.com/WorkArea/showcontent.aspx?id=11533
" The importance of minEMBc Laser Bandwidth Measured Multimode Fiber for High Performance Premises Networks" http://www.corning.com/WorkArea/showcontent.aspx?id=7881

thousands of multimode fibre-transceiver combinations (including transceiver EF properties) in both system bandwidth studies and in functionality BER tests, overall system performance can vary greatly due to differences in available transceiver characteristics. Remember: system bandwidth is a function of both fibre AND transceiver performance.

One example of the rigor of Corning's multimode testing program is the functionality testing Corning performed to validate the minEMBc bandwidth metric of InfiniCor® eSX+ multimode fibre (OM3+). Corning used over 1500 fibre-transceiver combinations for this testing. Corning also employed very stringent criteria for the selected pseudo-random bit sequence (2^{31}-1) and BER capture time (300 seconds) for its testing, providing 95% detection capability. Using values that are more relaxed can have a significant impact on the accuracy and reliability of the test results and often such parameters are either not specified in the study reports or are selected to improve the results.

When conducted correctly, Corning has found that BER testing is a useful tool to verify functional performance of an actual transmission link. During Corning's own testing programs, good correlation between BER link performance and minEMBc has been achieved through rigorous and accurate characterisation of both the multimode fibre and the VCSELS that are used in real world applications. However, this technique is unsuitable for production-scale measurements during fibre manufacturing since multimode spool lengths of up to 17.6 km require higher power lasers and not 850nm VCSELs that typically operate in maximum 300 – 600 meter link lengths and feature transmission properties (EF, wavelength, line width etc.) that vary greatly between devices.

minEMBc vs. DMD-mask; The facts…

- minEMBc was developed by Corning and accepted into the IEC 60793-1-49 and TIA-455-220-A standards in 2004. It was developed to address some of the limitations of the already standardized DMD-mask.

- The minEMBc measurement provides a system measurement – effectively combining the effects of the fibre properties (i.e. mode delays) and the 10G VCSEL properties (i.e. the flux distribution). The DMD-mask is a fibre characterization only. The minEMBc measurement integrates the launch characteristics of 10G 850nm VCSEL sources with the fibre modal delay to provide a calculated system bandwidth.

- The DMD-mask method as currently defined by international and TIA standards provides a pass/fail result only while minEMBc provides an actual bandwidth value.

- minEMBc is a scalable metric while the DMD-masks were intended to verify 10GbE over 300 meters of OM3 only. There is currently no international or domestic standard DMD mask-set for guaranteeing an OM3+/OM4 category fibre with 4700 MHz.km EMB and it is believed that the existing DMD-mask method is unable to screen 4700 MHz.km bandwidth fibres as accurately or robustly.

- For future, higher speed applications such as 40/100GbE, minEMBc certified fibres offer greater bandwidth measurement reliability compared to DMD-mask tested fibres.

- Corning's measurement equipment is state-of-the-art. Corning developed its own minEMBc measurement benches by using very precise Ti-Sapphire laser source technology both in its production facilities and at its Center for Fiber Optic Testing (CFT). The measurement benches have been qualified through internal functionality testing and certified by extensive tests between Corning's test labs and production benches. Corning Optical Fiber (including manufacturing facilities, business and management systems and development operations) is certified to ISO 9001/TL9000 and Corning performs internal audits to ensure compliance to industry standards.

- Corning is the first and only fibre manufacturer to perform the minEMBc measurement in a production environment. Corning provides minEMBc bandwidth measurement data for every reel (100%) of 50 µm laser-optimized fibre*.

- Corning InfiniCor fibres, whose bandwidth often exceeds minimum requirements, may be used to engineer links employing additional connectors or requiring extended lengths.**

- To-date Corning has supplied more than 0.7 Million km of minEMBc certified InfiniCor multimode fibre around the world.

- Corning has never had a multimode fibre field return due to bandwidth. Ever.

*minEMBc laser bandwidth data is provided for all InfiniCor® 600, InfiniCor® SX*i*, InfiniCor® SX+ and InfiniCor eSX+ fibres. Corning uses the RML bandwidth method for all 62.5 µm InfiniCor® 300 and InfiniCor® CL™1000 fibre types.

**Multimode fibres exhibiting higher EMB (via the minEMBc measurement) than minimum requirements offer increased system margin and enable network engineers the use of additional interconnecting passive hardware (i.e. increased reach or additional connectors). For such interconnects all link designs should confirm to the IEEE 802.3ae model and components should be of sufficient OM3/OM3+ quality, including connectors.

For further information or access to technical papers describing bandwidth fibre functionality testing of multimode fibres please visit our web site: www.corning.com/opticalfiber/products.

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