Understanding Dispersion Testing Requirements in 100G Service Delivery

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All across the world, the number of 100G network deployments is growing. Mostly done in the network service providers' core network, the objective of these deployments is either to add capacity or aggregate multiple existing 10G services. In such scenarios, the lineside uses coherent 100 Gbit/s transmission to reduce the signaling rate while maintaining the 100G data rate. This is achieved using advanced modulation techniques, like DP-QPSK, on channels within the DWDM network.

Thanks to these core deployments, service providers are now starting to offer 100G service to their customers, typically 100 Gbit/s Ethernet to other carriers or datacenter customers. Deploying 100G service using a standardized 100G Ethernet interface presents new challenges that are not always understood and whose impact is not known because CFPs have only been used for short-reach interconnects between different devices in the core network.

The use of multiwavelength CFP interfaces has led to the common misconception that dispersion does not present an issue on fiber infrastructure. This is not the case. When providing service to a CPE location, the use of the LR4 or ER4 CFP will generally depend on the required reach. The LR4 interface operates over 10 km, whereas the ER4 operates over 40 km. Even though both use multiple wavelengths, each individual wavelength has a higher signaling rate than previous service offerings – 28G baud per channel compared to 10G baud on a 10G Ethernet deployment. Since the interface still uses NRZ modulation, the intolerance to PMD is similar to previous generations.

The 100G Base-LR4 and 100G Base-ER4 interfaces are defined as being able to support a bit error rate (BER) better than or equal to 10-12. However, this is only the case when the fiber infrastructure characteristics comply with those defined in the 802.3ba standard.

Description	100GBase-LR4	100GBase-ER4	Unit
Positive dispersion (Max)*	9.5	36	ps/nm
Negative dispersion (Max)*	–28.5	–85	ps/nm
DGD_{max}	8	10.3	ps

Figure 1. Dispersion characteristics of the 10 and 40 km reach interfaces

If the fiber does not meet this specification, then it is not fit to support 100G Ethernet interfaces. Therefore, the transmitter/receiver pair is not required to operate with the specified BER and should not be used for these applications.

Let's take a closer look at dispersion requirements. For chromatic dispersion (CD), a single-mode optical fiber that complies with ITU-T G.652 will satisfy the maximum positive and negative dispersion values over the defined wavelength range. Therefore, care needs to be taken to ensure that the fiber used for transmission is G.652, and not another common fiber type such as G.655 NZDSF, which has very negative dispersion over the same wavelength range.

Comparatively, for the differential group delay (DGD) portion of fibers used in a standard 10G DWDM system, the ITU-T G.691 states that the DGD_{max} must remain below 30 ps. The new 100G interfaces can tolerate approximately one third of the DGD of 10G interfaces.

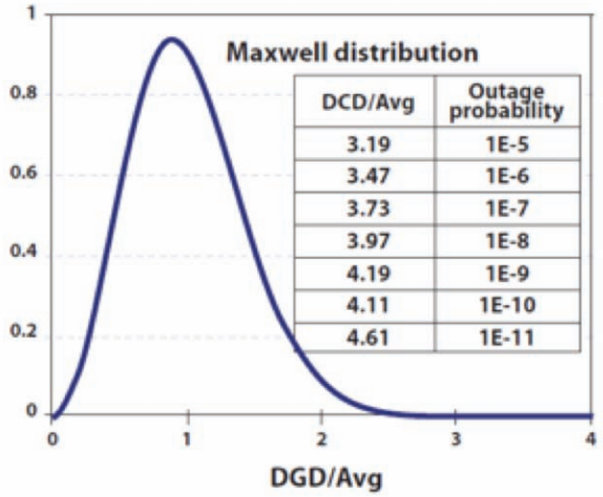

Figure 2. Maxwellian distribution of DGD in a fiber

To understand how this relates to polarization mode dispersion (PMD), which can be measured, it is important to note that DGD in most normal fibers is statistically modeled to a Maxwellian distribution. DGD_{mean} (aka PMD) will be several orders lower than the DGD_{max}. It is generally accepted that to ensure that DGD_{mean} remains below DGD_{max} for 99.999 % of cases, the DGD_{max} value must be divided by 3.19. In this case, this yields a PMD limit of ~2.5 ps and 3.2 ps for the LR4 and ER4 interfaces respectively.

	DGD_{max}	PMD (ps)
LR4	8	2.5
ER4	10.3	3.2
10G	30	9.4

Figure 3. DGD_{max} in terms of PMD

In modern fibers where PMD_{max} coefficients are less than 0.1 ps/km, this limit should be easily met. However, PMD can change during both cabling and installation, so links (ideally fibers) should be tested as part of comprehensive link characterization during construction. In older fibers, testing is a must because there is no way to know what the PMD is.

** Range: 1294.53 nm to 1310.19 nm*

CONCLUSION

In summary, there is a definite requirement to perform dispersion characterization measurements on fiber links prior to deploying 100G Ethernet services over long-reach spans. The fiber characteristics that support 100G speeds are much more stringent than those required to support 10G links over the same distances.

Any fiber that fails to meet the specification described in IEEE 802.3ba should not be used to support 100G Ethernet services as the interface would then not be guaranteed to meet its target 10-12 BER.

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