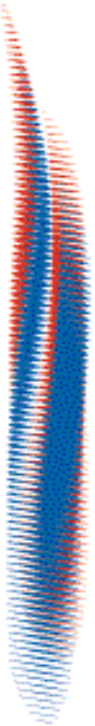

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Proposed Inclusion of Non-Zero Dispersion Shifted Fiber (IEC 60793-2 Type B4)

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Proposed Comment

- Comment to add NZ-DSF(IEC 60793-2 B4) fiber types to standard:
  - Change 52.14.1 Optical fiber and cable – paragraph 1 to read (changes in **bold**)
  - *The fiber optic cable requirements shall meet the requirements of Table 52-27. These requirements are satisfied by IEC 60793-2 for fiber types A1a (50/125 mm multimode), A1b (62.5/125 mm multimode), B1.1 (dispersion un-shifted single mode), B1.3 (low water single mode),* **and B4 (non-zero dispersion shifted single mode),** *with the exceptions noted in Table 52-27.*

Proposed Comment (cont.)

Description	62.5 mm MMF	50 mm MMF	Type B1.1, B1.3 SMF		Type B4 SMF	Unit
Nominal fiber specification wavelength	850	850	1310	1550	1550	nm
Fiber cable attenuation (max)	3.5	3.5	0.4 or 0.5	see footnote 1	see footnote 1	dB/km
Modal Bandwidth (min)	160 or 200	400 or 500 or 2000	N/A		N/A	MHz km
Zero dispersion wavelength (λ_0)	$1320 \le \lambda_0 \le 1365$	$1320 \le \lambda_0 \le 1365$	$1320 \le \lambda_0 \le 1365$		N/A	nm
Dispersion Slope (max) (S_0)	0.11 for $1320 \le \lambda_0 \le 1365$ and $0.001(1458-\lambda_0)$ for $1348 \le \lambda_0 \le 1365$	0.11 for $1300 \le \lambda_0 \le 1320$ and $0.001(\lambda_0-1190)$ for $1295 \le \lambda_0 \le 1300$	0.093		N/A	ps/nm^2 km
Dispersion coefficient	N/A	N/A	N/A	N/A	$1 \le D_{min} \le \lvert D(\lambda)\rvert \le D_{max} \le 10$ (see footnote 2) $D_{max} - D_{min} \le 5$ (see footnote 3) $(1530 \le \lambda_0 \le 1565)$	ps/nm km

Footnotes:

1) Attenuation for 1550 links is based on fiber channel and is specified in 52.14.3.

2) The sign of the dispersion shall not change across a specified band for an individual fiber. However, the sign may change from one fiber to another in a system. Positive or negative dispersion is equally effective in suppressing four-wave mixing. The selection of a fiber with a particular dispersion sign should be made with the knowledge of application related aspects discussed in ITU-T recommendation G.663.

3) The values of D_{min} and D_{max} and their signs shall be agreed between manufacturer and purchaser within these limits.

Motivation for Proposed Comment

- Customers are asking if NZDSF can support 10GigE
- Millions of km of NZDSF already installed
- NZDSF mitigates dispersion tolerance on 1550 nm transmitters
- Provides future upgrade path
  - Higher data rates
  - Multiple channels (DWDM)
  - Longer distance

Definition of NZDSF (by IEC 60793-2)

"This non-zero dispersion-shifted single-mode fibre is optimised for multiple channel transmission in the 1550 nm region with a cutoff wavelength that may be shifted above the 1310 nm region. The dispersion coefficient is required to be non-zero throughout the band from 1530 nm to 1565 nm, but may be either positive or negative. Depending on the dispersion characteristics, multiple channel transmission may be possible at bands either above or below the normal 1550 nm region."

- NZDSF dispersion design intended to reduce four wave mixing penalties in multiple channel transmission in 1550 nm region
- Concurrent reduced dispersion at 1550 nm allows for reduced dispersion penalty compared to dispersion-unshifted fiber

Comparison of Fiber Types - B1 Fibers
From IEC 60793-2/A1 (ed 4)

B1.1 Fibres	Values
Attenuation (dB/km) 1310 nm 1550 nm 16XX nm (XX ≤ 25 nm)	 ≤ 0.40 ≤ 0.30 ≤ 0.40
λ_0 – range (nm)	1300 – 1324
$S_{0\,max}$ (ps/nm^2·km)	0.093
$\lvert D_{max} \rvert$ (ps/nm·km)	b
PMD (uncabled fibre) (ps/km$^{0.5}$)	c
Macrobending (dB) 1550 nm (100 turns; 75mm diameter)	≤ 0.50
Nominal MDF range (μm) at 1310 nm	8.6 – 9.5
MFD tolerance (μm) at 1310 nm	±0.7
Cable cut-off wavelength (nm)	≤ 1260

[b] In the 1550 nm region, the chromatic dispersion can be approximated as a linear function of wavelength. A typical value for the chromatic dispersion at 1550 nm for B1.1 fibres is 17 ps/(nm*km) with a typical slope at 1550 nm of 0.056 ps/(nm^2*km)

[c] An optional maximum PMD coefficient on uncabled fibre may be specified by cable manufacturers to support the primary requirement of cable PMDQ < 0.5 ps/km according to IEC 60794-2, if it has been demonstrated for a particular cable construction.

Comparison of Fiber Types - B4 Fibers
From IEC 60793-2 (ed 4)

B4 Fibres	Values
Attenuation (dB/km) 1550 nm 16XX nm (XX ≤ 25 nm)	 ≤ 0.30 ≤ 0.40
Chromatic dispersion C-Band λ_{min} (nm) λ_{max} (nm) D_{min} (ps/nm·km) D_{max} (ps/nm·km) Sign $D_{max} - D_{min}$ (ps/nm·km)	 1530 1565 ≥ 1.0 ≤ 10.0 Pos/Neg ≤ 5.0
PMD (ps/km$^{0.5}$)	c
Macrobending (dB) 1550 nm (100 turns; 75mm diameter)	≤ 0.50
Nominal MFD range (µm) at 1550 nm	8.0 – 11.0
MFD tolerance (µm) at 1550 nm	± 0.7
Cable cut-off wavelength (nm)	≤ 1480

[c] An optional maximum PMD coefficient on uncabled fibre may be specified by cable manufacturers to support the primary requirement of cable PMDQ < 0.5 ps/km according to IEC 60794-2, if it has been demonstrated for a particular cable construction.

Support of All Proposed Specifications

- IEC 60793-2 B4 (NZ-DSF) is single-mode fiber, compliant with IEEE 802.3ae HSSG objectives
- By IEC 60793-2, all B4 have reduced dispersion at 1550 nm compared to B1.1 (max 10 ps/nm km for B4 versus typ. 17 ps/nm km for B1.1 at 1550 nm)
  - Relaxed dispersion penalty facilitates 40 km reach in 1550 nm serial PMD (D_{max} at 40 km is 400 ps/nm compared to 728 ps/nm for B1.1 in table 52-26)
- Attenuation is equivalent to B1.1

Facilitation of Logically Foreseeable Standardization

- NZDSF mitigates nonlinear effects in multiple channel (DWDM) transmission through reduced dispersion and nonzero dispersion within intended transmission window
- Reduced dispersion at 1550 nm enables relaxed transmitter dispersion tolerance for higher data rate transmission and longer unregenerated reach requirements

Vendors of NZDSF

- Alcatel
- Corning
- Lucent (Furukawa)
- Pirelli
- Sumitomo

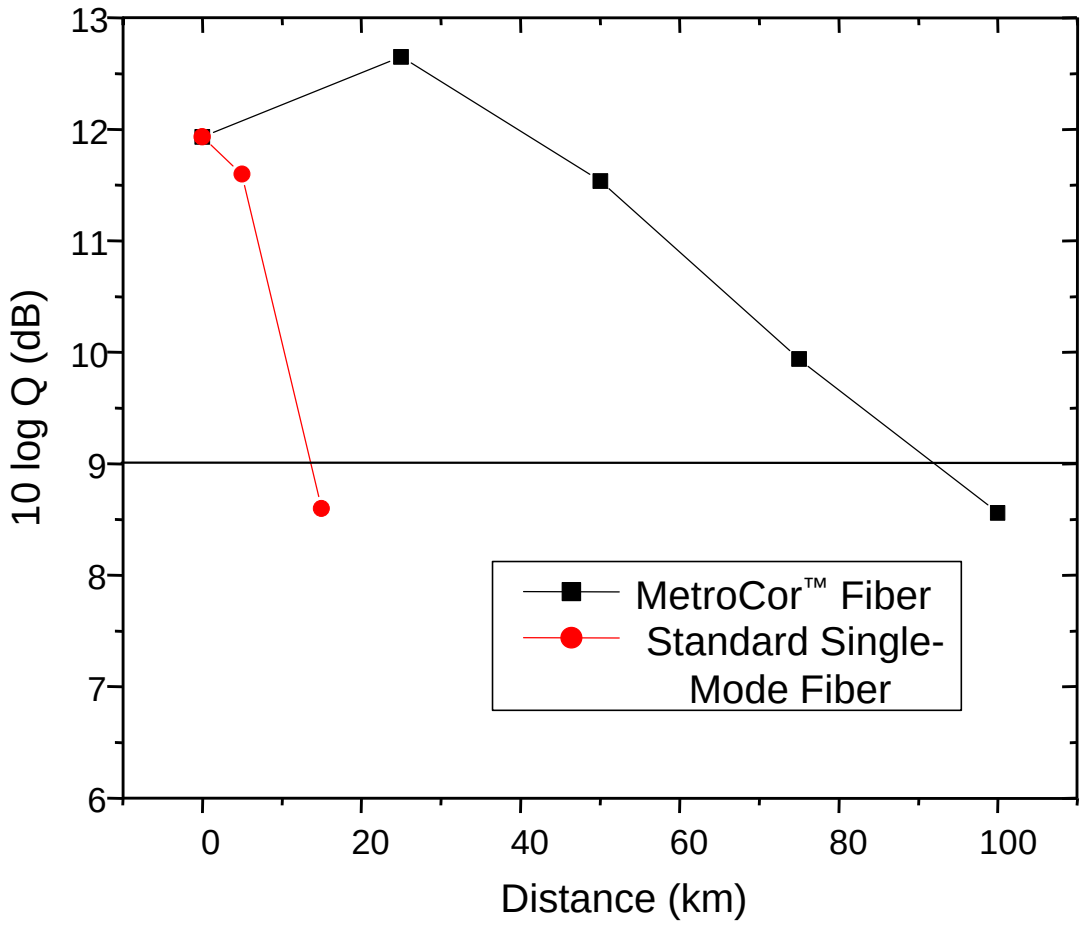
Increased Range of Transmitter Types

- Lower cost directly modulated DFB (and potentially VCSEL) transmitters with reduced dispersion tolerance can support 1550 nm serial PMD in combination with reduced dispersion NZ-DSF
- System manufacturers can have broader range of available transmitter types

Increased Range of Transmitter Types

- Multiple vendors of 10 Gb/s directly modulated (DML) DFB transmitters. DMLs have beneficial features.
  - Small package
  - Reduced drive power requirements
  - High output power
- 10 Gb/s VCSELs in development
- Majority of currently available NZDSF will support 40 km 1550 nm serial PMD specification, comparing dispersion tolerance in SSMF transmission with NZDSF dispersion magnitude

Evaluation of Directly Modulated DFB Transmitter



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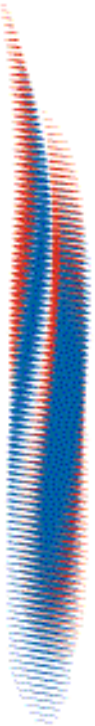
Conclusion

- Inclusion in standard will eliminate explicit exclusion of NZDSF from consideration in 10Gigabit Ethernet based systems
- NZDSF inclusion will anticipate foreseeable future upgrades and associated standardization such as higher data rates, DWDM, and long distance transport
- NZDSF will mitigate dispersion considerations dictating transmitter type



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