

# PMD... Where are we now?

Workshop "40Gb/s networks and the PMD challenge"



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## History of PMD: late 90s

- PMD understood and controlled by most major manufacturers
- Telecoms boom creates incredible demand for fibre = 18 month waiting list!
- shortages suck in fibre from less well-established manufacturers, often with poor PMD
- measurement problems, bad PMD fibre undetected at one US factory – but fibre was not scrapped
- 10Gb/s systems start to be deployed

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## Where are we now?

- A brief history of PMD
- Fibre specifications
- System requirements
- Test Standards
- Measurement techniques & equipment

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## History of PMD: 2000

- Oct 2000 ITU G.652 recommends limits on PMD for some grades – 0.5ps/√km
- PMD compensation hot topic
- 2001: telecoms crash – fibre shortage eases – 40Gb/s goes on ice
- 2003: ITU G.652 recommends limits on all grades:-
  - 0.5ps/√km for 'slower' A&C grades
  - 0.2ps/√km for 'faster' B&D grades
- good fibre from reputable suppliers now routinely < 0.05ps/√km

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## History of PMD

- early years of fibre, PMD not an issue
- early 1990's awareness builds
- mid 1990's PMD was a critical issue for TAT 12/13: Trans-Atlantic Telecoms cable
- used amplifiers instead of repeaters, 6500km @ 5Gb/s
- achieved fibre PMD < 0.175ps/√km by introducing mode coupling (spinning)




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## History of PMD: today

New fibre is very, very good, but...

- lots of old fibre still in use
- Fibre characterisation
- PMD compensation: optical methods still limited and expensive
- PMD tolerance: new coding schemes &/or electronic dispersion compensation

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## Evolution of the Standards

Trends in PMD e.g. ITU G.652

- pre 2000
  - 'under study'
- 2000
  - Not specified (slower grade A)
  - 0.5ps/root km (faster grades B&C)
- 2003 & 2005
  - 0.5ps/root km (slower grades A&C)
  - 0.2ps/root km (faster grades B&D)

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## Optical Fibres for Telecomms

- G.652 (A,B,C,D) (Non-Dispersion Shifted Fibre)
- G.653 (Dispersion Shifted Fibre)
- G.654 (Cut-off Shifted Fibre)
- G.655 (A,B,C,D,E) (Non-zero Dispersion Shifted)
- G.656 (Broadband non-zero Dispersion Shifted Fibre)
- G.657 (A,B) (Bend tolerant fibre for FTTH)


Others...

- Pure Silica Core, high power
- Dispersion Compensating
- Polarisation Maintaining



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## Evolution of the Standards

ITU recommendations

- a process of evolution
- many changes
- important to be specific about version e.g.
  - G.652 (1984) v1
  - G.652 (1988) v2
  - G.652 (1993) v3
  - G.652 (1997) v4
  - G.652 A, B & C (2000) v5
  - G.652 A, B, C & D (2003) v6
  - G.652 A, B, C & D (2005) v7 ...



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## PMD and System Performance

System design 'rule of thumb' states that...

- total PMD for a link should be **less than one tenth of bit period**
- acceptable probability of outage due to DGD
- e.g. STM-64 @ 10Gb/s
  - bit period = 100ps
  - therefore maximum PMD – 10ps

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## PMD and System Performance



ITU recommends:

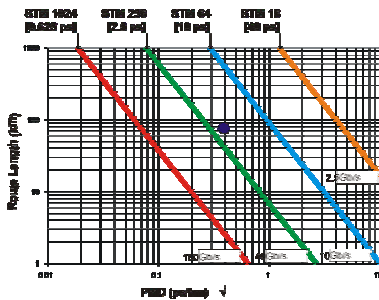
- max PMD of  $0.5\text{ps}/\sqrt{\text{km}}$  (G.652.A&C) to support 400km @ 10Gb/s
- max PMD of  $0.2\text{ps}/\sqrt{\text{km}}$  (G.652.B&D) to support 2500km @ 10Gb/s or 156km @ 40Gb/s



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## PMD and System Performance PMD 'Ready Reckoner'



## PMD measurement standards



IEC International Electro-technical Commission

- Technical Committee 86 fibre optics
- Sub Committee 86C fibre optic systems and active devices
- Working group 1: Fibre optic communications systems and sub-systems

## Polarisation Mode Dispersion

Acceptance Criteria

Data rate	Max. PMD	Distance for $0.5 \text{ ps}/\sqrt{\text{km}}$	Distance for $0.2 \text{ ps}/\sqrt{\text{km}}$	Distance for $0.1 \text{ ps}/\sqrt{\text{km}}$
2.5Gb/s	40ps	6400km	40,000km	160Mm!
10Gb/s	10ps	400km	2500km	10,000km
40Gb/s	2.5ps	25km	156km	625km
100Gb/s	1ps	4km	25km	100km

## PMD measurement standards from the IEC



- 61280-4-4 Fibre optic communication subsystem test procedures  
Part 4-4: Cable plants and links: Polarization mode dispersion measurement for installed links
- 61282-9 Fibre optic communication system design guides  
Part 9: Guidance on polarization mode dispersion measurements and theory