**Where are we now?**

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

**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

**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

**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
**PMD**

**Where are we now?**

- A brief history of PMD
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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)

**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

**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 & D (2005) v7 ...

**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
**PMD and System Performance**

ITU recommends:
- max PMD of 0.5ps/√km (G.652.A&C) to support 400km @ 10Gb/s
- max PMD of 0.2ps/√km (G.652.B&D) to support 2500km @ 10Gb/s or 156km @ 40Gb/s

**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

**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

**Polarisition Mode Dispersion**

Acceptance Criteria

<table>
<thead>
<tr>
<th>Data rate</th>
<th>Max. PMD</th>
<th>Distance for 0.5 ps/√km</th>
<th>Distance for 0.1 ps/√km</th>
<th>Distance for 0.05 ps/√km</th>
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<td>2.5Gb/s</td>
<td>40ps</td>
<td>6400km</td>
<td>40,000km</td>
<td>160Mm!</td>
</tr>
<tr>
<td>10Gb/s</td>
<td>10ps</td>
<td>400km</td>
<td>2500km</td>
<td>10,000km</td>
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<tr>
<td>40Gb/s</td>
<td>2.5ps</td>
<td>25km</td>
<td>156km</td>
<td>625km</td>
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<tr>
<td>100Gb/s</td>
<td>1ps</td>
<td>4km</td>
<td>25km</td>
<td>100km</td>
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