1300 and 1550 nm single mode serial PMDs

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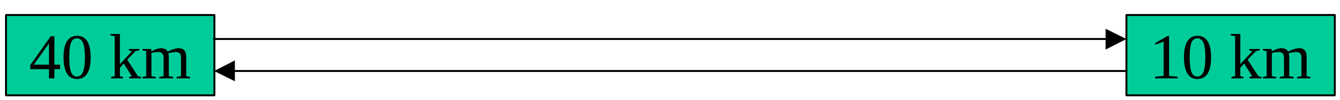
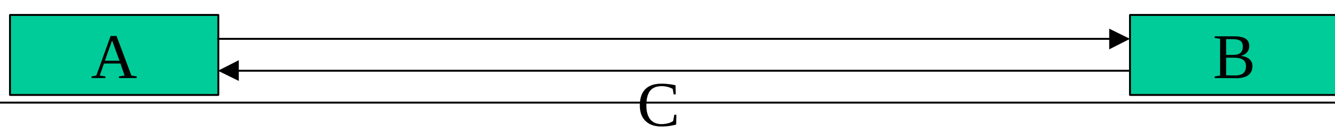
Single mode serial PMDs

- Reduce cost and increase flexibility:
  - Allow both 1300 nm and 1550 nm for 2, 10 and 40 km
  - Reduce demand on extinction ratio to 3dB.
- Ensure interoperability between 2, 10 and 40 km devices:
  - Specify all receivers at both 1300 and 1550



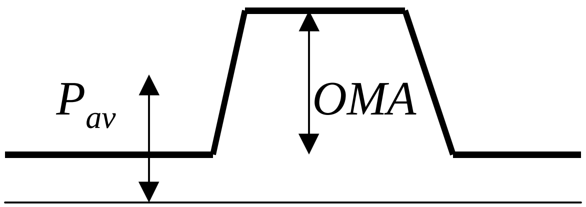
Transmitter-receiver pair function

- Transmitter together with receiver should cope with attenuation and dispersion of fiber.
- Standard single mode fiber (attenuation values are conservative):
  - Dispersion 1310 nm:-3 to 3 ps/km/nm
    attenuation <0.5 dB/km (ITU G.652)
  - Dispersion 1550 nm: 15-19 ps/km/nm
    attenuation <0.4 dB/km (ITU G.652)
- With specifications we want to make sure that tranceiver A works with tranceiver B over link C.



OMA, ER and P_{av}

$$ER = \frac{2P_{av} + OMA}{2P_{av} - OMA}$$



- *OMA* (optical modulated amplitude) sets receiver sensitivity
- *ER* (Extinction Ratio) ≥3 dB to avoid shot noise limitation of receiver sensitivity
- P_{av} (average power) sets eye safety
- High *ER* costs money and dispersion penalty
- No reason to copy costly ITU *ER* requirements.

Receivers

- Normally work for both 1300 and 1550 nm with about the same sensitivity (< 1dB difference).
- Filtering but normally no dispersion compensation
- Sensitivity can be improved (~5 dB) with avalanche photo diode but at high cost.
- We want to have (vendor, 1300/1550 nm and 2/10/40 km) interoperability by defining minimum sensitivity and filtering.

Transmitters

- Should cope with loss and dispersion
- Trade off between high extinction ratio and dispersion handling
- More complex laser chip may reduce packaging and driving costs
- Cooling is expensive but increases performance and reliability
- We want interoperability by defining optical modulated amplitude and dispersion handling at 1300 nm and 1550 nm.

1300 nm direct-modulated DFB

+Simple processing of chip

+High output power (compensates for higher attenuation at 1300 nm)

+Possible to achieve 10 Gbit/s speed at low ER

-Difficult to combine high speed with high ER, due to laser dynamics. A reduction of ER from 6 dB to 3 dB increases speed with 70%

-Need high modulation current

-Eye safety for 40 km device?

$$F_r = D\sqrt{I - I_{th}}$$

Relaxation frequency

1550 nm DFB-EA

+Available today for SDH/SONET 10 Gbit/s system with multiple vendors

+Easy to achieve modulation speed (40 GHz shown)

+With moderate ER, low driving swing or higher power is possible.

+Compatible with Er-amplifiers and future DWDM

-Low power (however sufficient for 40 km)

-Complex processing of laser chip

-Needs high performance AR and cooling

Direct-modulated 1550 nm DFB

+Easier to make high speed lasers at 1550 nm compared to 1300 nm

+Compatible with Er-amplifier

+Simple process

+High power compared to DFB-EA

-Cannot cope with dispersion for 40 km (maybe for 10 km).

-Low ER needed for dispersion handling

Direct-modulated 1550 nm DBR

+Can cope and compensate dispersion at 1550 nm, 115 km transmission at 10G and 4 dB ER shown

+High speed modulation possible

-Low ER

-Moderately complex chip

1300 nm DFB-EA

+Easily cope with dispersion

+Easy driving

-Low output power (attenuation problem for 40 km)

≈1300 nm VCSEL

+Good fiber coupling and simple packaging

+Simple driving

-Speed not reached

-For short wavelength <1280 nm fiber performance not specified (cut-off wavelength could be a problem)

-Not available today but research is promising and should not be excluded by the standard.

Why both 1300 and 1550 nm?

- Specify receiver sensitivity at both wavelengths to allow market to find the most cost efficient solution and to ensure interoperability.
- Run both 1300 nm and 1550 nm on a single fiber using cheap multiplexors. Create bidirectional single fiber solutions or upgrade to two channels.
- 1550 nm is needed if Er-amplifier is present on link or dispersion shifted fiber is used.
- 1550 nm gives a path to future DWDM solutions

2 km PMD

- Can probably be made uncooled and without expensive isolator. Much lower cost.
- Should be interoperable with 10 and 40 km transceivers
- Allow both 1300 and 1550 nm transmitters.
- What is gained by removing 2 km serial PMD if interoperability is ensured?

My message

- Low requirement on extinction ratio, 3 dB. Use optical modulated power for transmitter power to remove extinction ratio dependence in linkbudget
- Specify both 1300 nm and 1550 nm in standard (preferably for 2,10 and 40 km) and specify receiver for both wavelengths.
- Ensure interoperability between PMDs.
- Keep 2 km distance. Allows low-cost transmitters without costly isolators.
- Include fiber link specification in standard. To handle each and every 40 km link will be costly.

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