Analytical Investigation of FWM for O-band Multi-Channel Transmission

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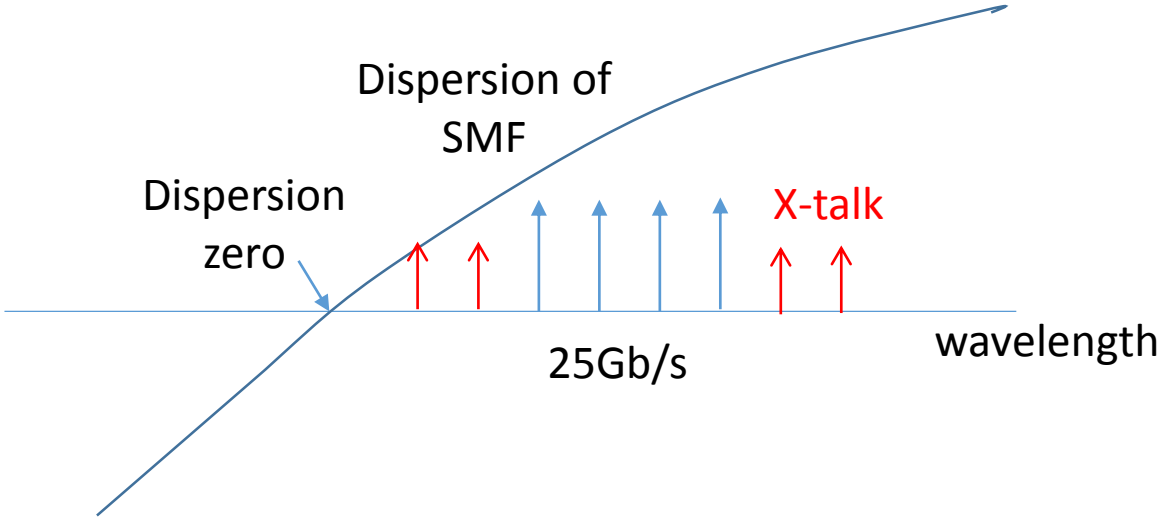
O-band Multi-Channel Transmission

The effects of FWM on system performances should be resolved to use multi-channel transmission at O-band for 100G-EPON.



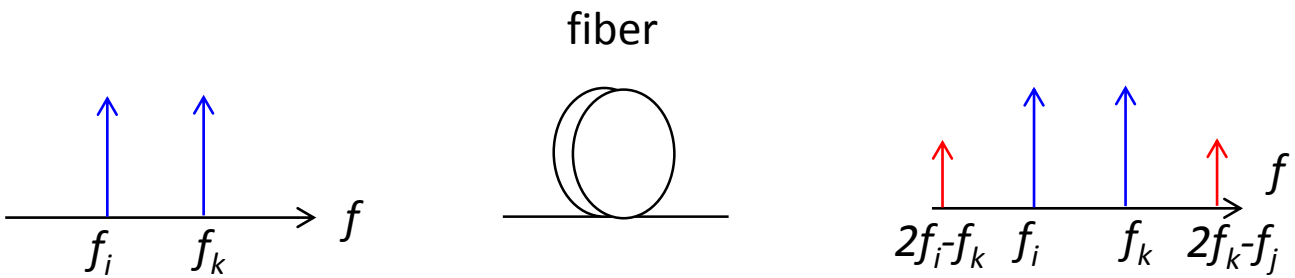
Minimum channel spacing at given dispersion?

Four-Wave Mixing (FWM)

Definition

- Intensity-dependent refractive index of silica generates one or more new channels when three waves at frequencies f_i, f_j, f_k traverse at fiber

$$f_{ijk}=f_i+f_j-f_k$$



FWM Products

FWM induced output power

$$P_{ijk} = \left(\frac{D_{ijk}}{3}\gamma L_e\right) P_i P_j P_k \, e^{-\alpha L}\eta$$

γ: nonlinear coefficient
D_{ijk}: 3 for two tone product, 6 for three tone product
L_e: fiber effective length
P_{ijk}: input peak power of channels

$$\text{efficiency } (\eta) = \frac{\alpha^2}{\alpha^2+\Delta\beta^2}\left(1+\frac{4e^{-\alpha L}sin^2(\Delta\beta/2)}{(1-e^{-\alpha L})^2}\right)$$

α: fiber loss
$\Delta\beta$: difference of propagation constants

$$\Delta\beta \propto \lambda^2/c\,(\Delta f)^2 D(\lambda)$$

FWM

- increases with P^2
- decreases as 4^{th} power of channel spacing
- decreases quadratically with dispersion

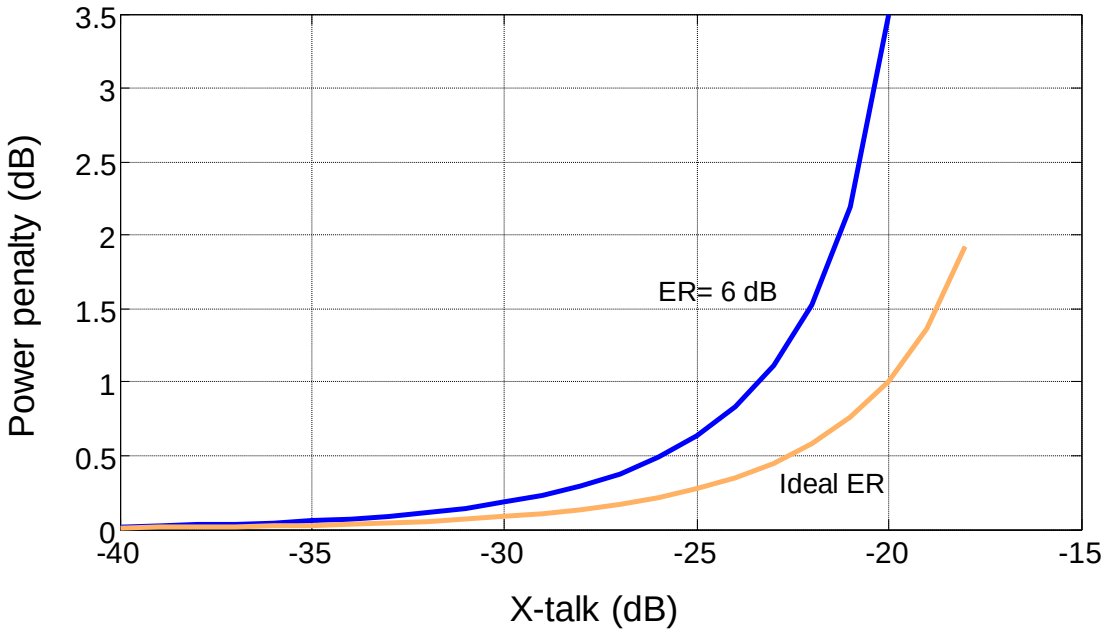
Power Penalty

Homodyne cross-talk power penalty

$$Power\ penalty\ (dB) = -5\log\left(1 - 4 \times 10^{Xtalk/10} Q^2 \frac{1 + 1/r}{(1 - \frac{1}{r})^2}\right)$$

r: extinction ratio of signal
Q: Q-factor (6 for BER of 1e-9, 3.1 for BER of 1e-3)

- ITU-T G.sup.39



Specifications of Conventional SMF (G.652)

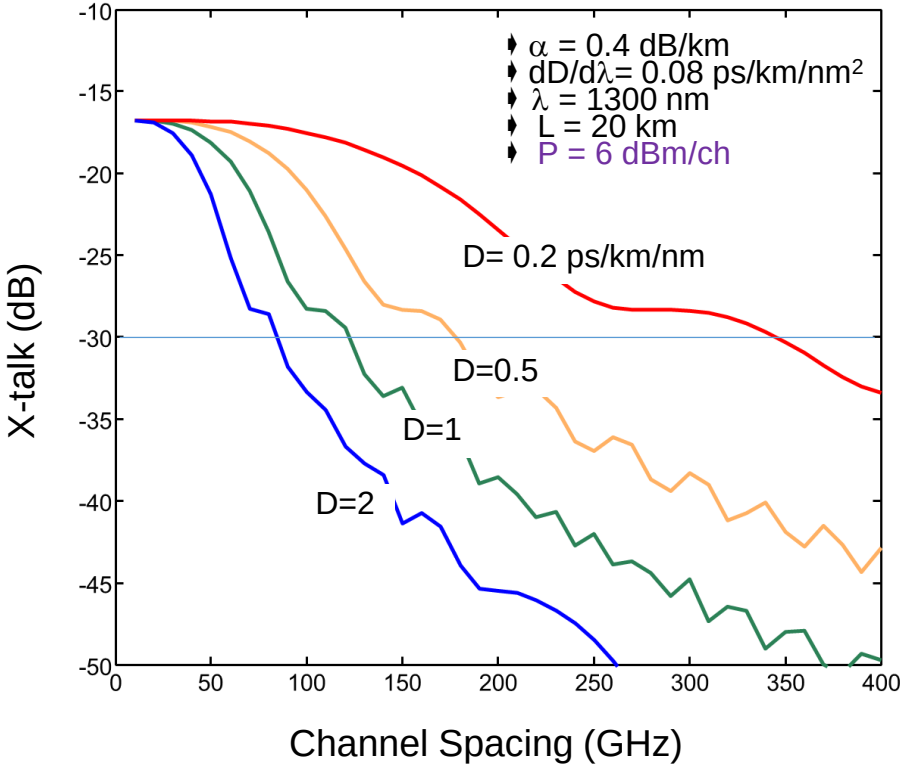
- O-band Characteristics

Attribute	Value
Loss (dB/km)	0.4~0.5
Dispersion zero wavelength (nm)	1300 ~1324
Dispersion slope max (ps/nm^2 x km)	0.092
Mode field diameter (μm)	8.6 ~ 9.5

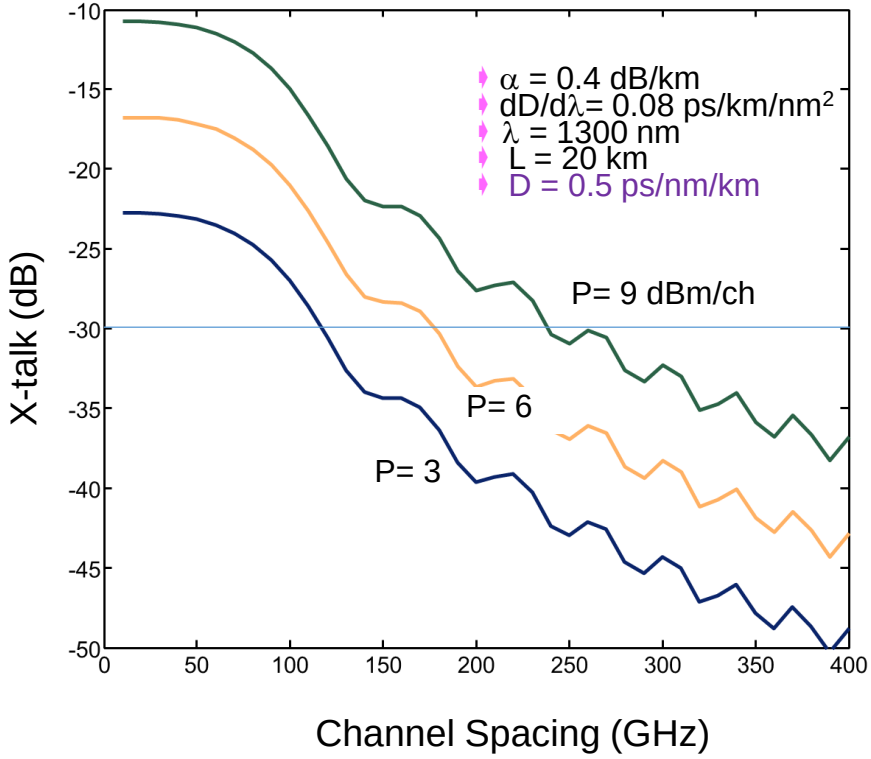
FWM X-talk: O-band

The ratio of mixing product power to output signal power @ O-band

[Dispersion vs. Channel Spacing]



[Launching Power vs. Channel Spacing]



Summary

- The effects of FWM crosstalk on the performances of multi-channel transmission at O-band was investigated analytically.
  - FWM crosstalk decreases rapidly as a function of channel spacing, power, and dispersion.
  - FWM crosstalk was negligible when channel spacing was higher than 400 GHz.
  - FWM would not be a limiting factor for O-band multi-channel transmission.