Optical Fiber Communications

Mid Term 2 Review

What you need to know? (1)

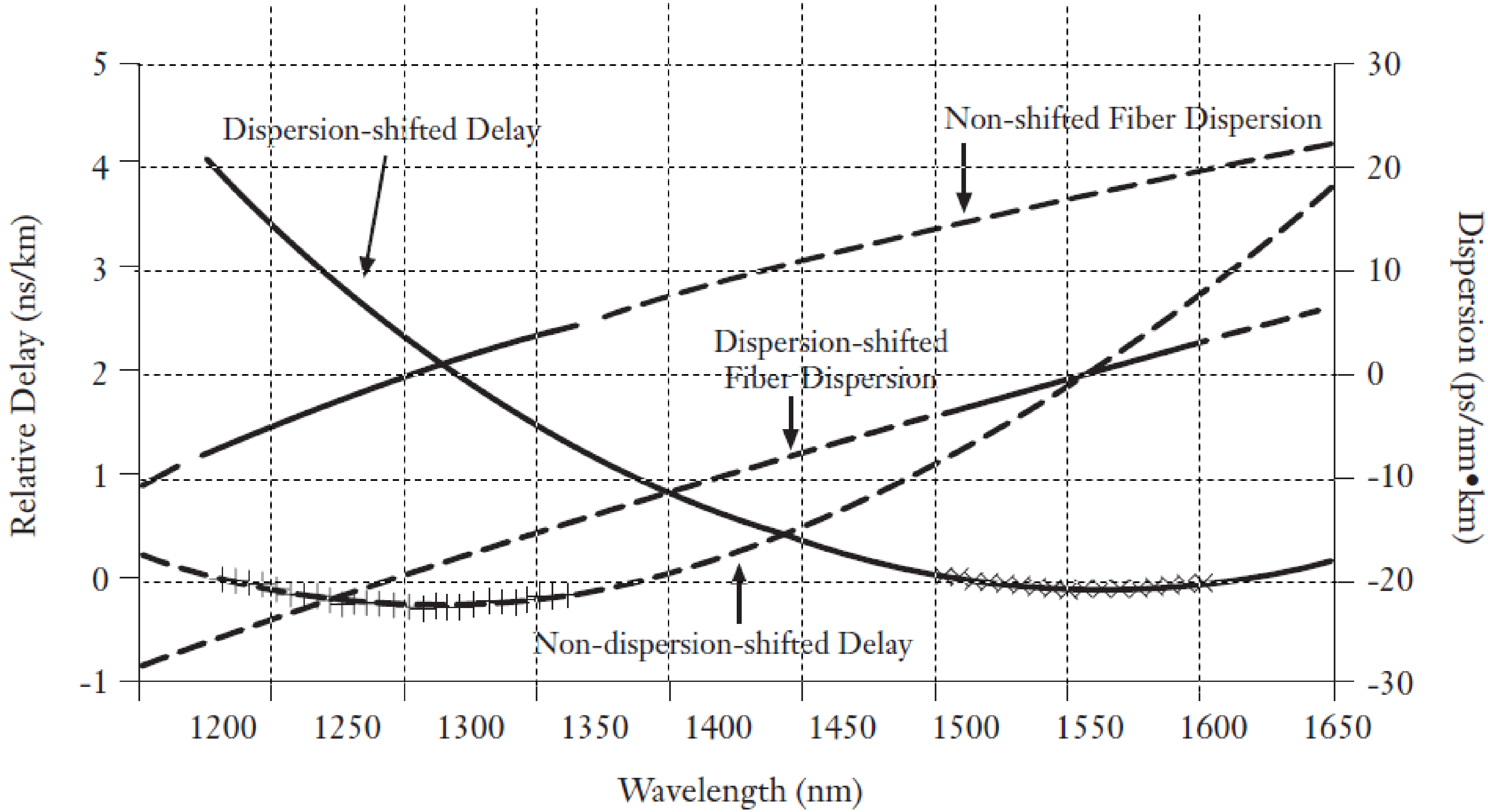
- Know fiber optic transmission wavelength bands, concept of channel spacing, and number of wavelength channels within each bands

- Know how to calculate attenuation, insertion loss, and transmission distances

- Know how to find maximum attenuation limited transmission distances and maximum dispersion limited transmission distances

What you need to know? (2)

- Know how to analyze graphs and extract usable data



What you need to know? (3)

- Know concepts and working principles for
  - Optical Transmitters :
    - FP-LD, DFB-LD, LED
    - Working principle for Tunable Laser Source
  - Optical Receivers :
    - Types of PDs, Responsitivity
    - Receiver blocks and their functions (PD, TIA, Limiting Amp, CDR)
  - Optical Amplifiers :
    - Operating principles, functional blocks
    - Noise Figure and System Link

Tunable Laser Structure

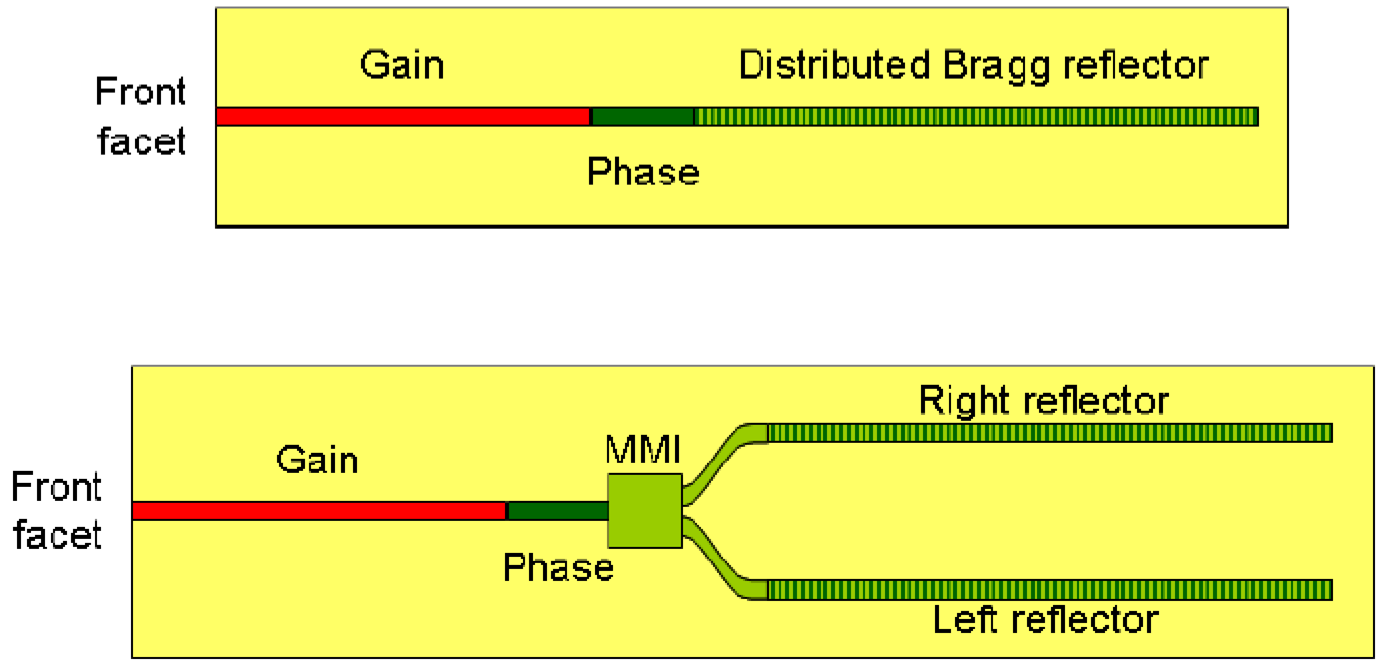


Figure 1 Schematic top view of a conventional distributed Bragg reflector laser and Finisar's modulated grating Y-branch (MG-Y) laser

Operating Principle

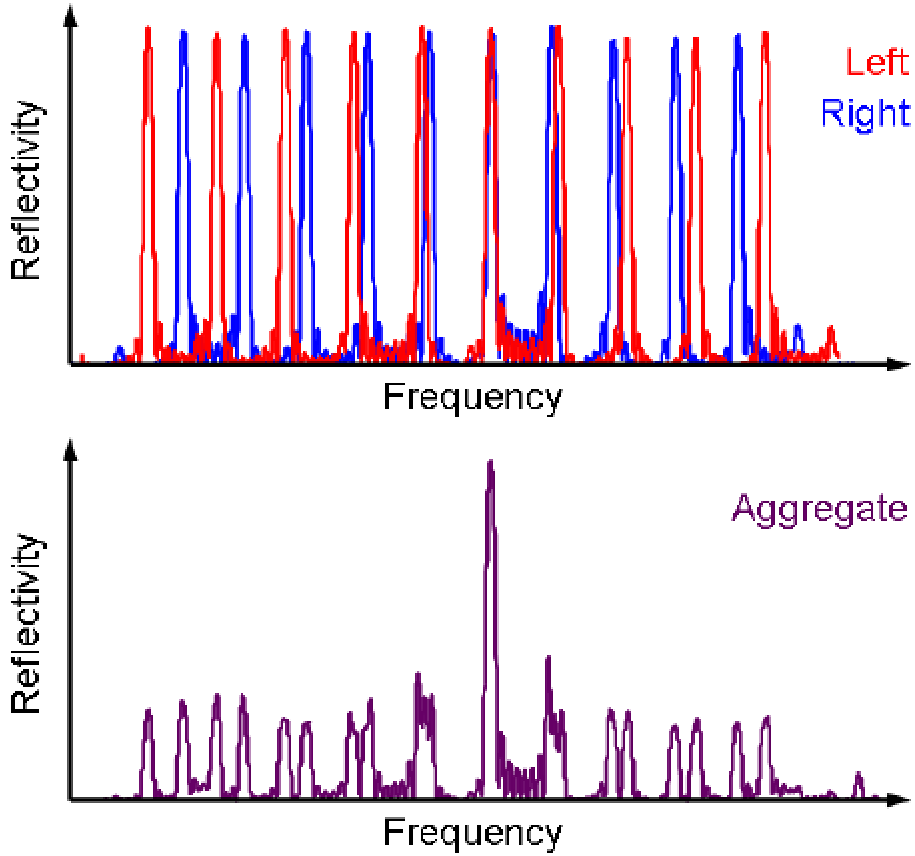
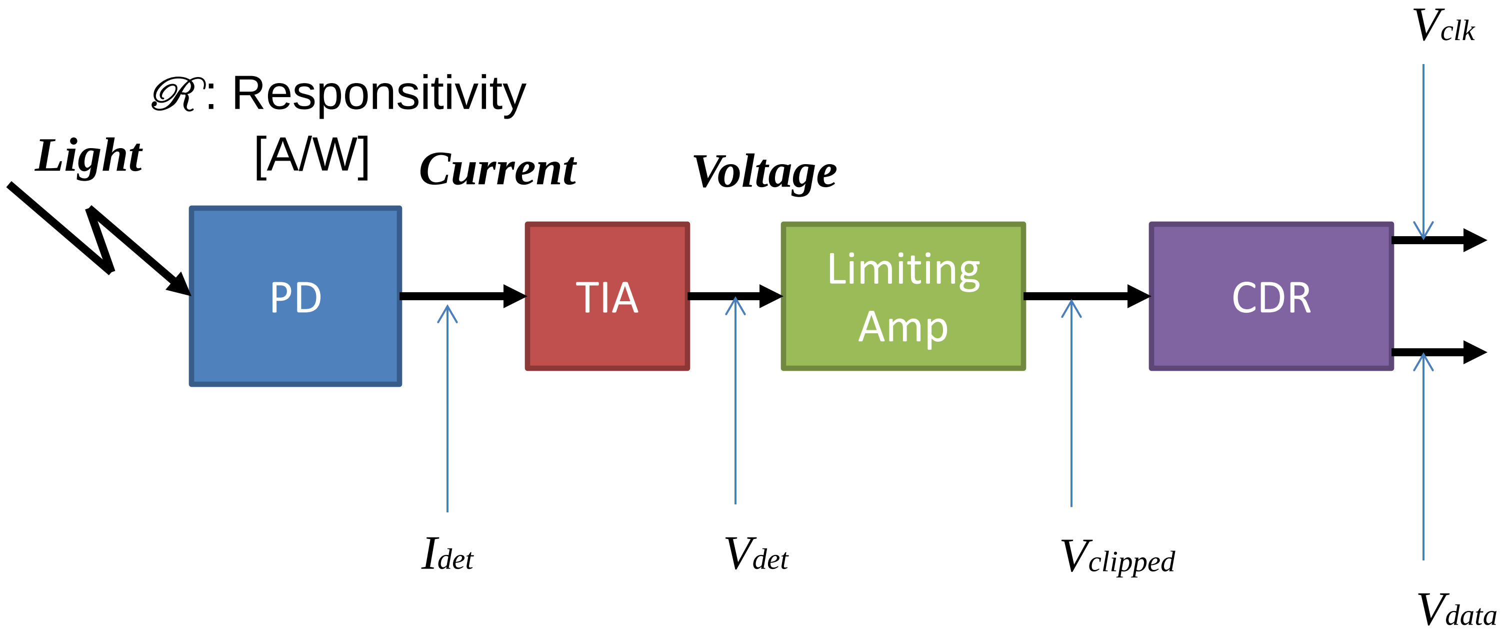
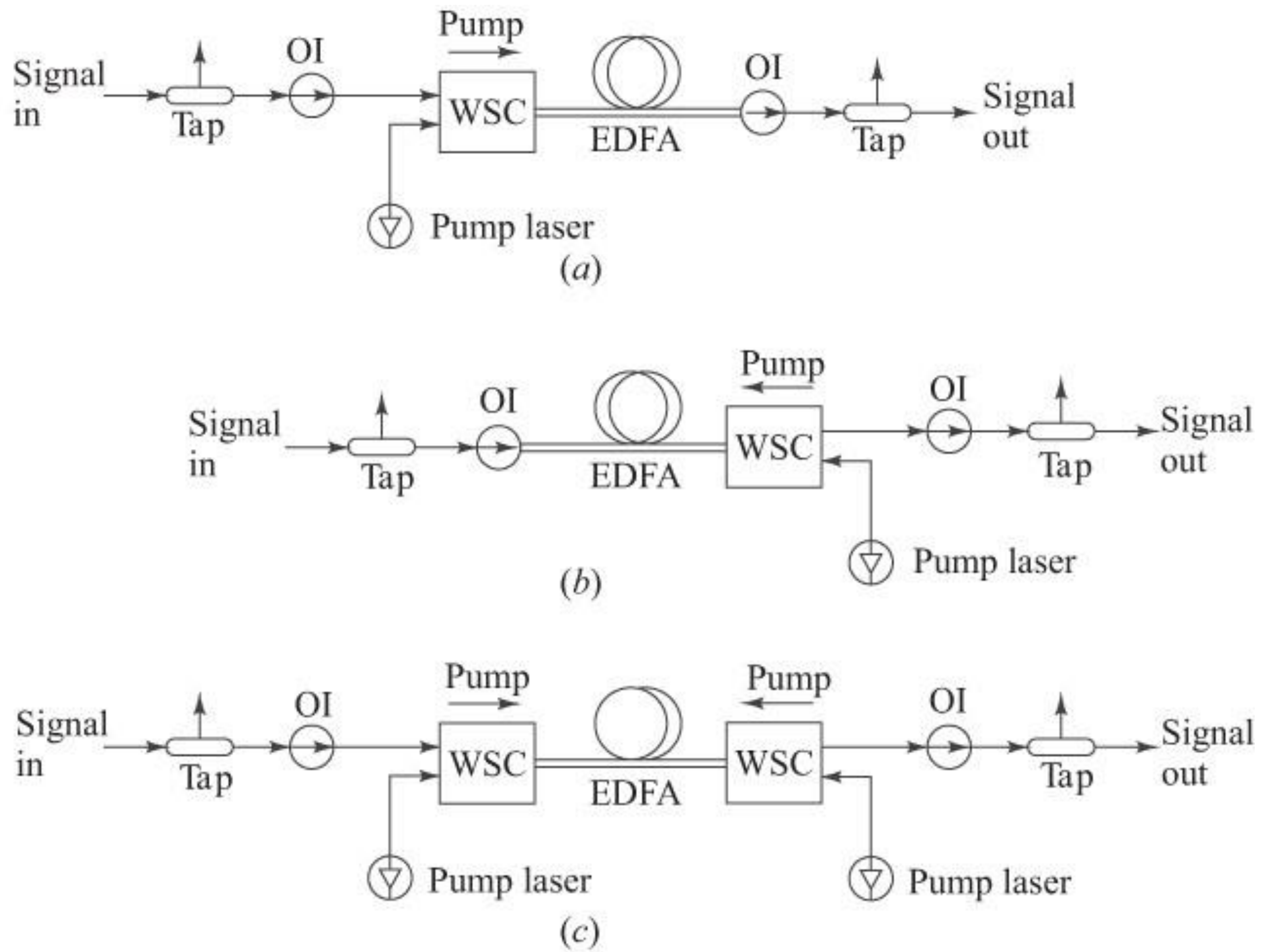


Figure 2 Reflectivity spectra of the left and right modulated grating reflector (top) and the aggregate reflectivity spectrum as seen from the input of the MMI splitter (bottom).

7.1 Fundamental Receiver Operation



Generic Optical Amplifier



OI: Optical isolator
WSC: Wavelength-selective coupler

Optical SNR

- In a transmission link with optical amplifiers, the light signal entering the receiver contains ASE noise from the cascade of optical amplifiers.
- Need to evaluate the *optical signal-to-noise ratio (OSNR)*.
- OSNR is the ratio of the average EDFA optical signal output power P_{ave} to the unpolarized ASE optical noise power P_{ASE}:

$$\text{OSNR} = \frac{P_{\text{ave}}}{P_{\text{ASE}}}$$

or, in decibels

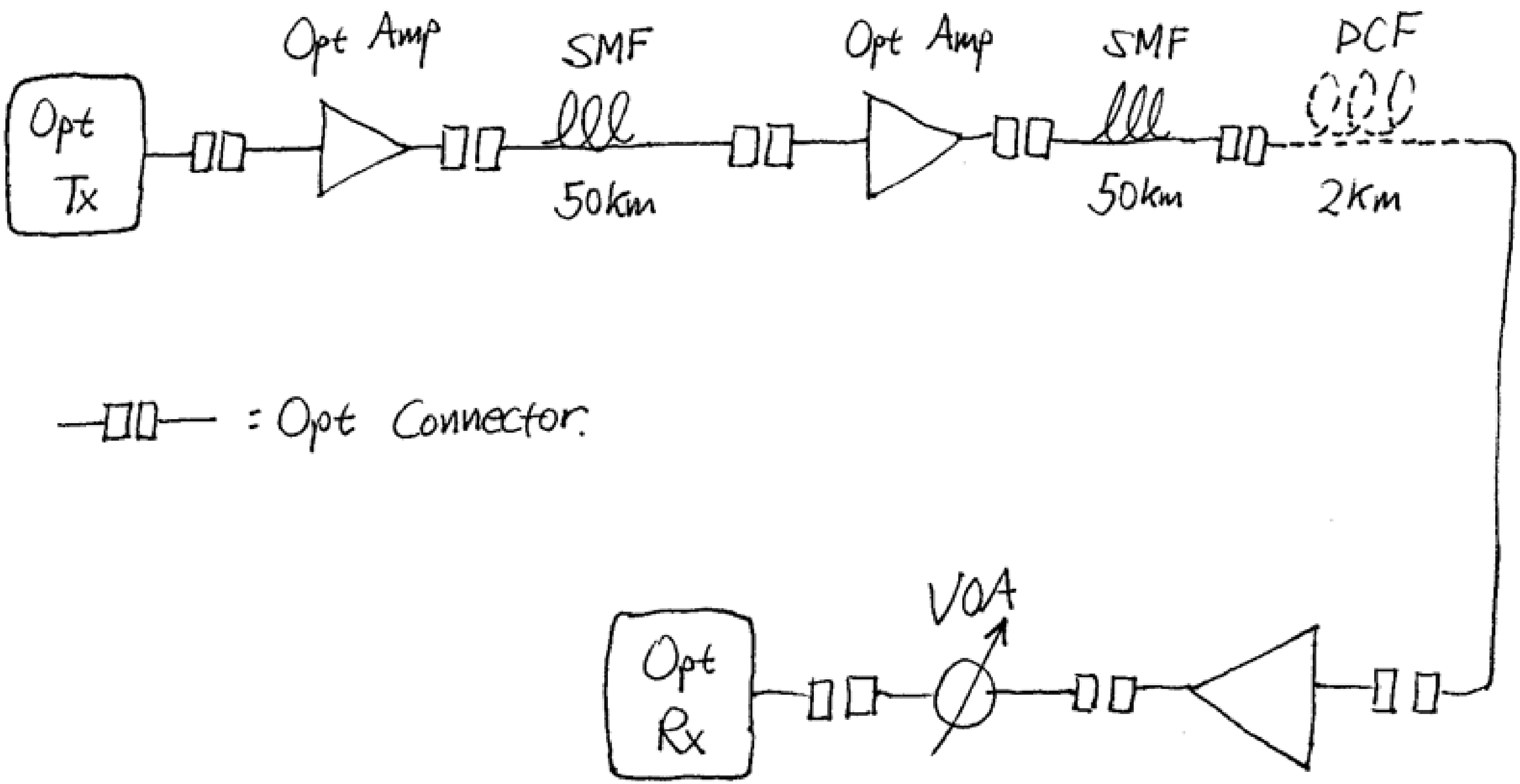
$$\text{OSNR(dB)} = 10 \log \frac{P_{\text{ave}}}{P_{\text{ASE}}}$$

System Designs

Opt Tx	**Optical Transmitter**	**Tx Power = 1 mW**
Opt Conn	Optical Connector	Loss = 0.5 dB
Opt Amp	Optical Amplifier	Gain = 15 dB
SMF	Optical Fiber (Sgl Mode)	Attenuation Parameter = 0.3 dB/km
DCF	Optical Fiber (Disp Comp)	Attenuation Parameter = 8 dB/km
VOA	Variable Optical Attenuator	Loss = Adjustable

See next page for fiber optic system diagram

System Designs

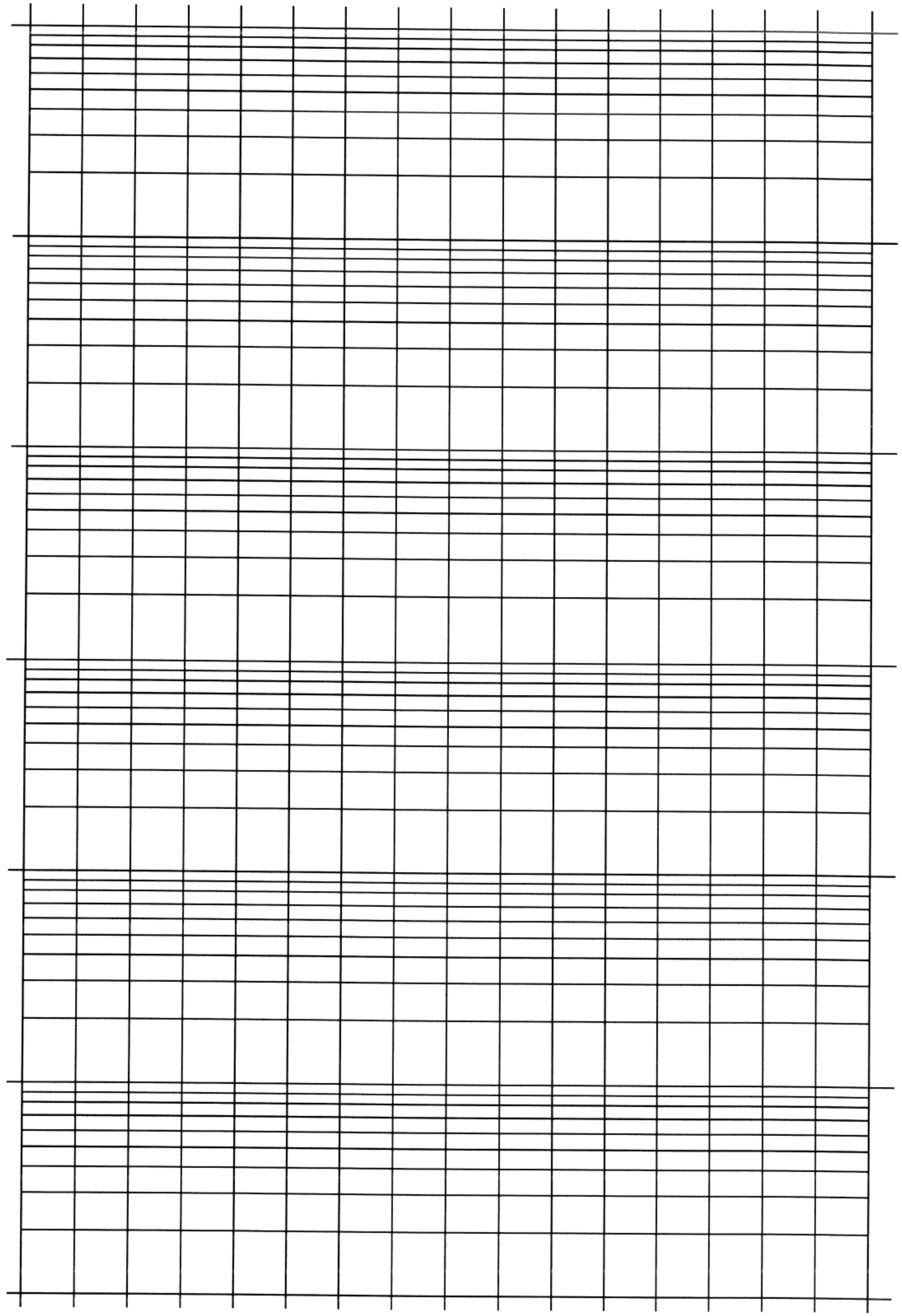


System Designs

- Calculate BER Power Penalty if the fiber optic communication system has below BER performances.
  - Fill in the table below (Fill in "Optical Rx Power")
  - Plot BER curve on a semi-log paper.

System Designs

VOA Attenuation [dB]	Optical Rx Power [dBm]	BER [Error Rate]
13.0		1.0×10^{-4}
12.0		2.0×10^{-5}
11.0		4.0×10^{-6}
10.0		9.0×10^{-7}
9.0		2.0×10^{-7}
8.0		4.0×10^{-8}
7.0		1.0×10^{-8}



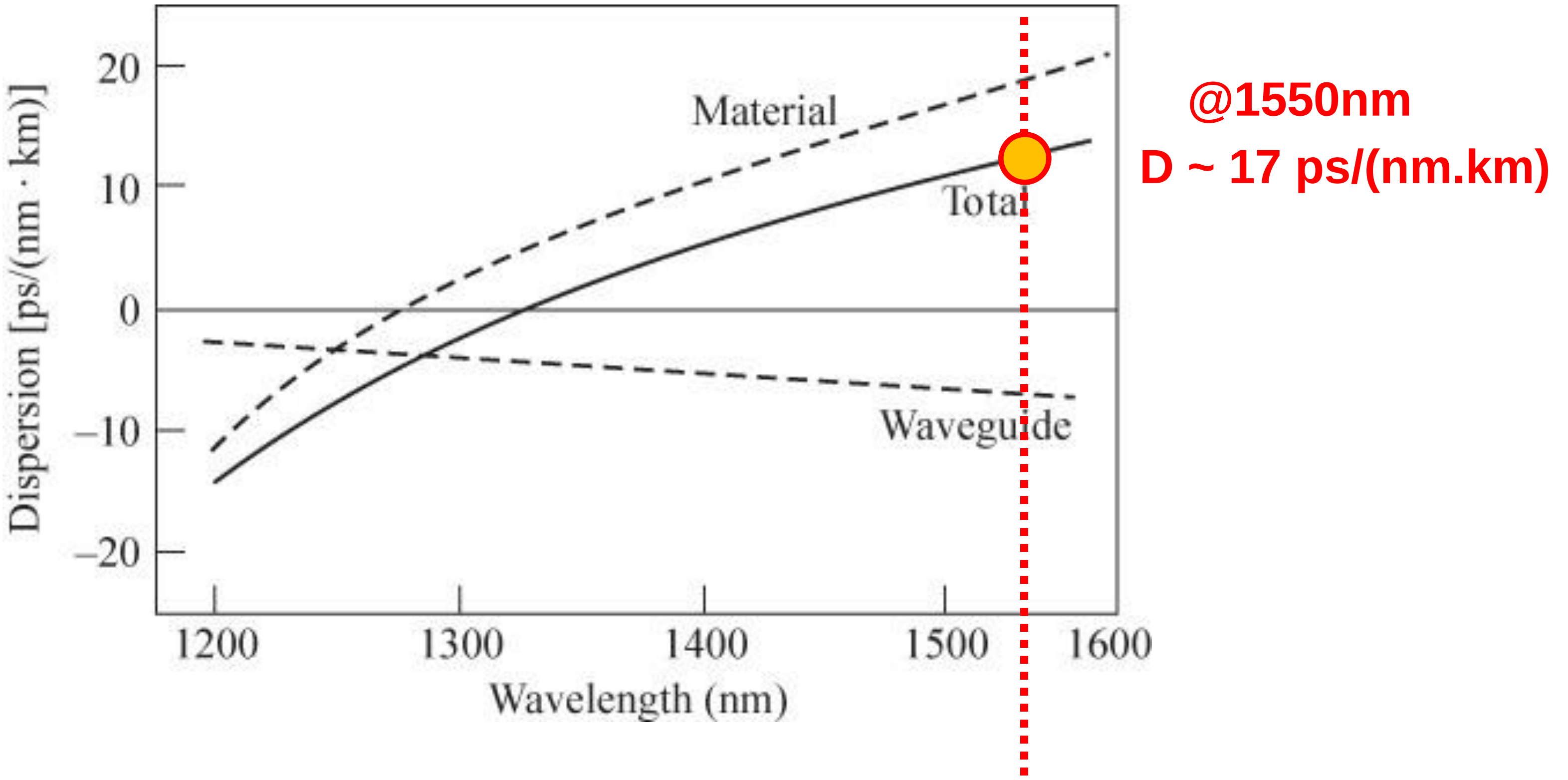
System Designs (2)

Opt Tx		Characteristics
SMF	Optical Fiber (Sgl Mode)	Know how to find dispersion coefficient w.r.t. wavelength D = 17 ps/nm/km @1550nm
DCF	Optical Fiber (Disp Comp)	Know how to find dispersion coefficient w.r.t. wavelength D = -80 ps/nm/km @1550nm
EDFA		Assume EDFA has D = 5 ps/nm @1550nm

See next page for fiber optic system diagram

Dispersion Effects

Dispersion Characteristics for SMF (Single Mode Fiber)



(Chromatic) Dispersion is wavelength dependent.

System Designs