



OPTICAL LINK DESIGN

Notes prepared for EE 6310

by

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POINT-TO-POINT LINK DESIGN

- Design is an iterative process involving trade-offs to achieve the desired performance (bit error rate, transmission distance, etc.) at minimal cost
- Design steps for a digital point-to-point link go from the largest to the smallest effects
 - ▷ Link budget for power
 - All power losses, including power penalties for noise, etc.
 - ▷ Rise-time budget
 - Contributions from transmitter, receiver, and dispersion
 - ▷ Optical nonlinearities
 - ▷ Polarization-mode dispersion
- Because of optical nonlinearities, as well as the interdependence of some parameters, the design must be iterated until Q and the link length are in the desired ranges

LINK BUDGET (1)

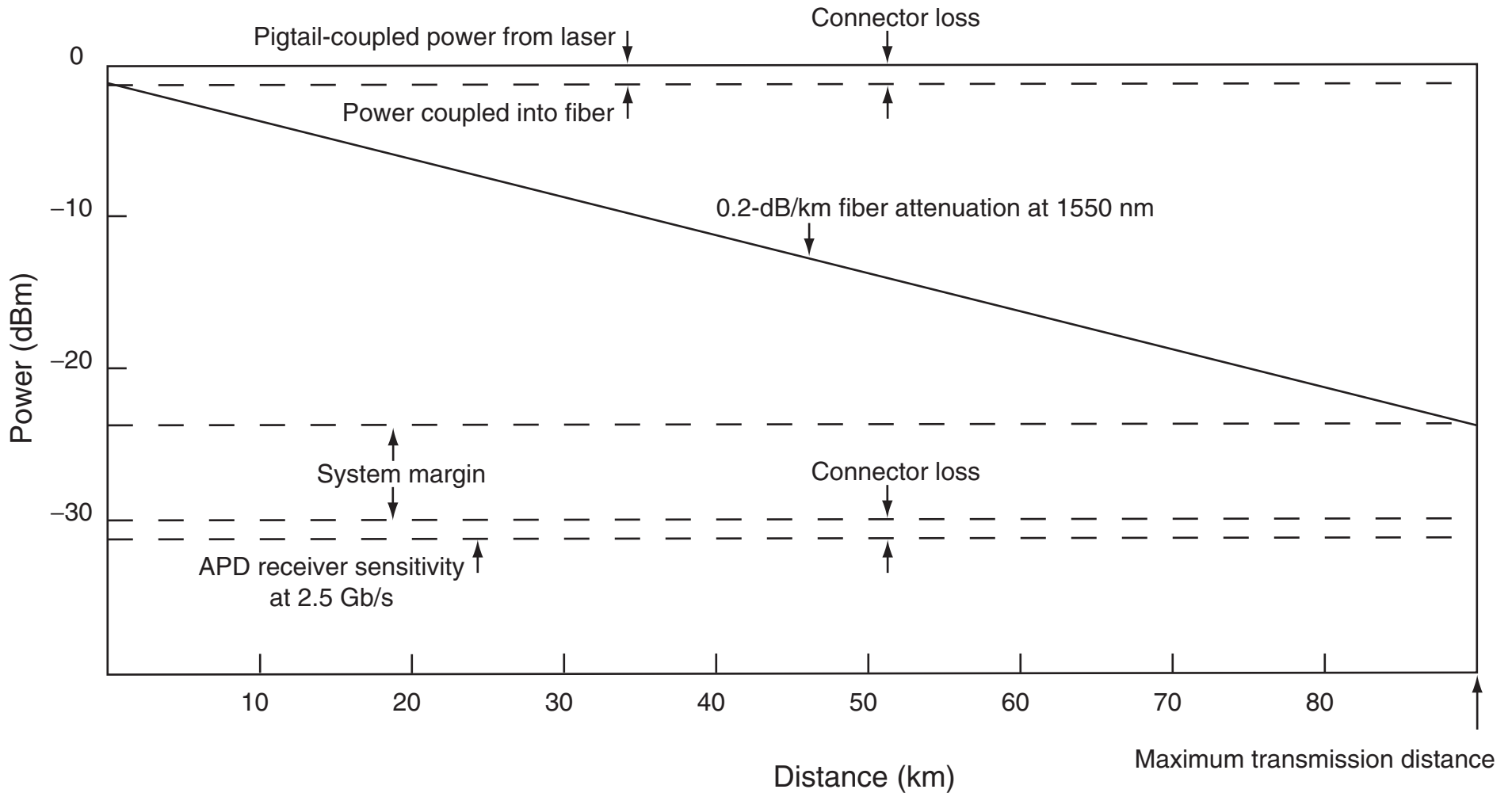
• Loss budget

▷ Power conservation equation for a point-to-point link:

$$P_{\text{out}} = P_{\text{in}} - \text{losses} - \text{link margin}$$

- Usually expressed in dB
 - “Losses” includes power penalties for system impairments such as:
 - ◇ Attenuation
 - ◇ Noise
 - ◇ Inter-symbol interference due to dispersion, etc.
 - ◇ Connectors and splices
 - The link margin is a safety factor to allow for component aging, new splices, etc.
 - ◇ Usually several dB (6 dB is common)
- ▷ Determines the usable link length, modulation format, etc.

LINK-LOSS BUDGET AT 2.5 Gb/s AND 1550 nm



TYPICAL OPTICAL POWER LOSS VALUES

Component	Loss or attenuation
Connectors	
ST type	1.0 dB
FC/PC	0.75 dB
Fiber	
Multimode at 850 nm	3.5 dB/km
Multimode at 1300 nm	1.5 dB/km
Single-mode at 1310 nm	0.6 dB/km
Single-mode at 1550 nm	0.2–0.4 dB/km
Splices	
Butt joint	2.0 dB
Mechanical	0.5 dB
Fusion	0.2 dB
Other	
Patch panel	2.0 dB

LINK BUDGET (2)

- **Power penalties**

- ▷ Fiber
 - Modal noise
 - Dispersion
- ▷ Receiver
 - Quantum noise
 - Thermal noise
- ▷ Transmitter
 - Mode-partition noise
 - Relative intensity noise (RIN)
- ▷ Amplifier
 - Spontaneous-emission noise
 - Relative intensity noise (RIN)

RISETIME BUDGET

- Fiber
 - ▷ Intramodal dispersion
 - ▷ Group-velocity dispersion
- Receiver
 - ▷ Determined by receiver bandwidth for chosen modulation format (RZ, NRZ, etc.)
- Transmitter
 - ▷ Determined by transmitter bandwidth