Fiber Optic Communications
Lecture 7

- Optical telecommunication links
- System limitations
Optical Telecommunications: Basic System Components

Input → Optical Transmitter → Communication Channel → Optical Receiver → Output

Driver → Optical Source → Modulator → Channel Coupler

Electrical input
Beyond a certain distance, an amplifier is required to boost the intensity of light. Two types:

- Regenerators – convert light to electrical signal and regenerate
- Optical amplifiers – direct increase strength of input light through input of pump energy

Repeater distance: \( L \)
Optical Telecommunications: Distribution Networks

Commonly used in many-to-one contexts (such as home internet service). Two types:

Hub topology

Bus topology

Central Hub

Hub A

Node A1

Node A2

Hub B

Node B1

Node B2

Node 1

Node 2

Node 3

Hub topology

Bus topology
Optical Telecommunications: Local Area Networks

Commonly used in many-to-many contexts (such as Purdue campus internet service). Two types:

- **Ring topology**
  - Node 1
  - Node 2
  - Node 3
  - Node 4
  - Node 5

- **Star topology**
  - Network 1
  - Network 2
  - Network 3
  - Network 4
  - Central Router
- Optical telecommunication links
- System limitations
Loss and Dispersion Limit Bandwidth

FOR CHIRP-FREE SOURCES @ $\lambda = 1550$ nm

![Graph showing the loss and dispersion limit bandwidth with labels for SSMF, TrueWave\textsuperscript{TM} Fiber, and Dispersion-shifted Fiber.]

Loss Constraints

Loss limits

\[ L = \frac{10}{\alpha_f} \log_{10} \left( \frac{\bar{P}_{tr}}{\bar{P}_{rec}} \right) \]

Power budget

\[ \bar{P}_{tr} = \bar{P}_{rec} + C_L + M_s \]

Table 5.1 Power budget of a 0.85-\(\mu\)m lightwave system

<table>
<thead>
<tr>
<th>Quantity</th>
<th>Symbol</th>
<th>Laser</th>
<th>LED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transmitter power</td>
<td>(\bar{P}_{tr})</td>
<td>0 dBm</td>
<td>−13 dBm</td>
</tr>
<tr>
<td>Receiver sensitivity</td>
<td>(\bar{P}_{rec})</td>
<td>−42 dBm</td>
<td>−42 dBm</td>
</tr>
<tr>
<td>System margin</td>
<td>(M_s)</td>
<td>6 dB</td>
<td>6 dB</td>
</tr>
<tr>
<td>Available channel loss</td>
<td>(C_L)</td>
<td>36 dB</td>
<td>23 dB</td>
</tr>
<tr>
<td>Connector loss</td>
<td>(\alpha_{con})</td>
<td>2 dB</td>
<td>2 dB</td>
</tr>
<tr>
<td>Fiber cable loss</td>
<td>(\alpha_f)</td>
<td>3.5 dB/km</td>
<td>3.5 dB/km</td>
</tr>
<tr>
<td>Maximum fiber length</td>
<td>(L)</td>
<td>9.7 km</td>
<td>6 km</td>
</tr>
</tbody>
</table>
Dispersion Constraints

General dispersion limit:

\[ BL \leq (4|D|\sigma_\lambda)^{-1}, \]

For semiconductor lasers with a single mode, one can reach the ultimate dispersion limit

\[ B^2L < (16|\beta_2|)^{-1}. \]
Rise Time Budget

\[ T_r^2 = T_{tr}^2 + T_{fiber}^2 + T_{rec}^2 \]
Best Recorded Ultra-Long Haul Performance