

Q1) If the system rise time is too high, the result is:

- **Answer: b) Increased signal distortion**
(High rise time means slower system response → more distortion.)
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Q2) Which of the following components contributes to the rise time budget?

- **Answer: d) All of the above**
(Transmitter, fiber, and receiver *all* contribute to total system rise time.)
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Q3) Which type of fiber typically has a lower rise time contribution?

- **Answer: c) Single-mode fiber**
(Single-mode fiber minimizes modal dispersion → lower rise time contribution.)
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Q4) System rise time calculation:

- Given:
Transmitter = 3 ns, Fiber = 2 ns, Receiver = 4 ns

$$\begin{aligned}\text{System rise time} &= \sqrt{3^2 + 2^2 + 4^2} \\ &= \sqrt{9 + 4 + 16} \\ &= \sqrt{29} \\ &\approx 5.39 \text{ ns}\end{aligned}$$

- **Answer: c) 5.39 ns**
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Q5) Modal dispersion is more prominent in:

- **Answer: b) Multimode fibers**
(Multiple modes travel at different speeds → modal dispersion.)
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Q6) To support a higher data rate, the system rise time must be:

- **Answer: b) Reduced**
(Higher data rates require faster system response, so *lower* rise time.)

Q7) What is the primary purpose of a power budget in optical communication?

- **Answer: b) To ensure adequate signal power at the receiver**
(Power budget ensures that the signal is strong enough after losses.)
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Q8) The power budget is defined as:

- **Answer: a) The difference between transmitted power and received power**
(Exactly the definition.)
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Q9) The formula to calculate link margin is:

- **Answer: a) Transmitter power + losses - receiver sensitivity**
(You add losses to be sure receiver still gets enough signal.)
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Q10) Which of the following contributes to power loss in optical fiber links?

- **Answer: d) All of the above**
(Attenuation, dispersion, and connector losses all cause power loss.)

Q11) A larger link margin in an optical system indicates:

- **A larger link margin means the system can tolerate more losses or degradation and still work properly → better system reliability.**
 - **Answer: a) Better system reliability**
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Q12) In a power budget calculation, "link margin" refers to:

- **Link margin is the safety factor added to the power budget to account for uncertainties (like aging, temperature variations, future losses).**
- **Answer: a) The safety factor added to account for uncertainties**

Final smart answers:

Q Answer

1 b

2 d

3 c

4 c

5 b

6 b

7 b

8 a

9 a

10 d

11 a

12 a

Q2) Al- Mamoon University, ask an optical system designer to design an optical link for transmit

112 Mbps. of data coded by NRZ format.

The link has a following parameter:

a. Optical cable

Length = 500 m , Attenuation factor $\alpha = 6 \text{ dB / Km}$, NA = 0.25

Two connectors of 2 dB losses per each,

Rise time of (5 n sec/ Km) and Inter mode of (1 n sec./Km)

b. Optical source (LED), launch power of 0.1 mw and has rise time of 8 n sec.

c. The system work with allowed Margin factor of 4 dB

The designer asked to complete the design by specified the optical receiver parameters
(Minimum - sensitivity and Rise Time)

Solve :

Given:

- Data rate = 112 Mbps (NRZ coding)
- Optical cable:
 - Length $L = 500 \text{ meters} = 0.5 \text{ km}$
 - Attenuation $\alpha = 6 \text{ dB/km}$
 - Numerical Aperture $NA = 0.25$ (not needed here directly)
 - 2 connectors with 2 dB loss each
 - Cable rise time components:
 - Material dispersion = 5 ns/km
 - Intermodal dispersion = 1 ns/km
- Optical source (LED):
 - Launch power $P_{\text{launch}} = 0.1 \text{ mW}$
 - Source rise time = 8 ns
- Margin = 4 dB

(a) Link Power Budget Method

Using the link power budget to calculate total losses and received power:

$$\text{Link Loss (fiber)} = \alpha \times L = 6 \times 0.5 = 3 \text{ dB}$$

Connector loss:

$$\text{Connector Loss} = 2 \times 2 = 4 \text{ dB}$$

Including margin:

$$\text{Total Link Loss} = 3 + 4 + 4 = 11 \text{ dB}$$

Convert launch power from mW to dBm:

$$P_{\text{launch (dBm)}} = 10 \times \log_{10}(0.1) = -10 \text{ dBm}$$

Received power:

$$P_{\text{received}} = -10 \text{ dBm} - 11 \text{ dB} = \boxed{-21 \text{ dBm}}$$

✅ Thus, the receiver minimum sensitivity must be at least -21 dBm .

(b) Bandwidth and Rise Time Budget Method

For NRZ format, the maximum system rise time allowed:

$$t_{\text{sys(max)}} = \frac{0.7}{B}$$

Where $B = 112 \times 10^6 \text{ bps}$.

Thus:

$$t_{\text{sys(max)}} = \frac{0.7}{112 \times 10^6} \approx 6.25 \text{ ns}$$

✅ The system rise time must be $\leq 6.25 \text{ ns}$.

(c) System Rise Time Calculation Method

The system rise time is the root sum square (RSS) of all rise times:

$$t_{\text{sys}} = \sqrt{t_{\text{tx}}^2 + t_{\text{fiber}}^2 + t_{\text{rx}}^2}$$

Where:

- $t_{\text{tx}} = 8 \text{ ns}$ (LED)
- Fiber rise time is calculated from material and intermodal dispersion:

Material dispersion contribution:

$$t_{\text{material}} = 5 \times 0.5 = 2.5 \text{ ns}$$

Intermodal dispersion contribution:

$$t_{\text{intermodal}} = 1 \times 0.5 = 0.5 \text{ ns}$$

Fiber total rise time:

$$t_{\text{fiber}} = \sqrt{(2.5)^2 + (0.5)^2} = \sqrt{6.25 + 0.25} = \sqrt{6.5} \approx 2.55 \text{ ns}$$

Substituting:

$$t_{\text{sys}} = \sqrt{8^2 + 2.55^2 + t_{\text{rx}}^2} = \sqrt{64 + 6.5 + t_{\text{rx}}^2} = \sqrt{70.5 + t_{\text{rx}}^2}$$

We require:

$$t_{\text{sys}} \leq 6.25 \text{ ns}$$

Squaring both sides:

$$(6.25)^2 = 70.5 + t_{\text{rx}}^2$$

$$39.06 = 70.5 + t_{\text{rx}}^2$$

$$t_{\text{rx}}^2 = 39.06 - 70.5 = -31.44$$