PASSIVE OPTICAL NETWORK

POWER BUDGET

OBJECTIVE

- TO REALISE ABOUT THE OPTICAL FIBER LINK WITH POWER
- TO ENSURE THAT THE RECEIVER CAN RECEIVE SUFFICIENT POWER
- TO GURANTEE ON DESIGNED OPTICAL NETWORK WILL WORK WITH MINIMUM TRANSMITTER POWER
- TO DETERMINE A NETWORK WHICH HAVE THE SUCCESSIVE DATA RECEPTION, BEFORE IMPLEMENTING THE OPTICAL NETWORK.

POWER BUDGET

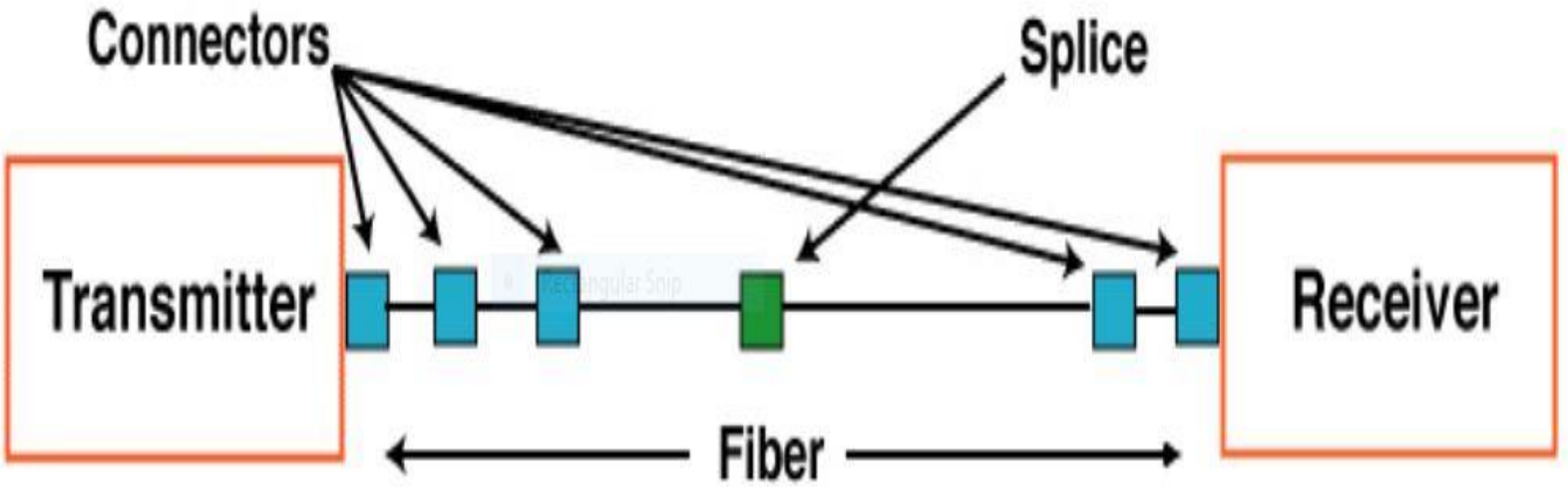
Power budget is the allocation of available optical power among various loss-producing mechanisms in order to ensure that adequate signal strength is available at the receiver.

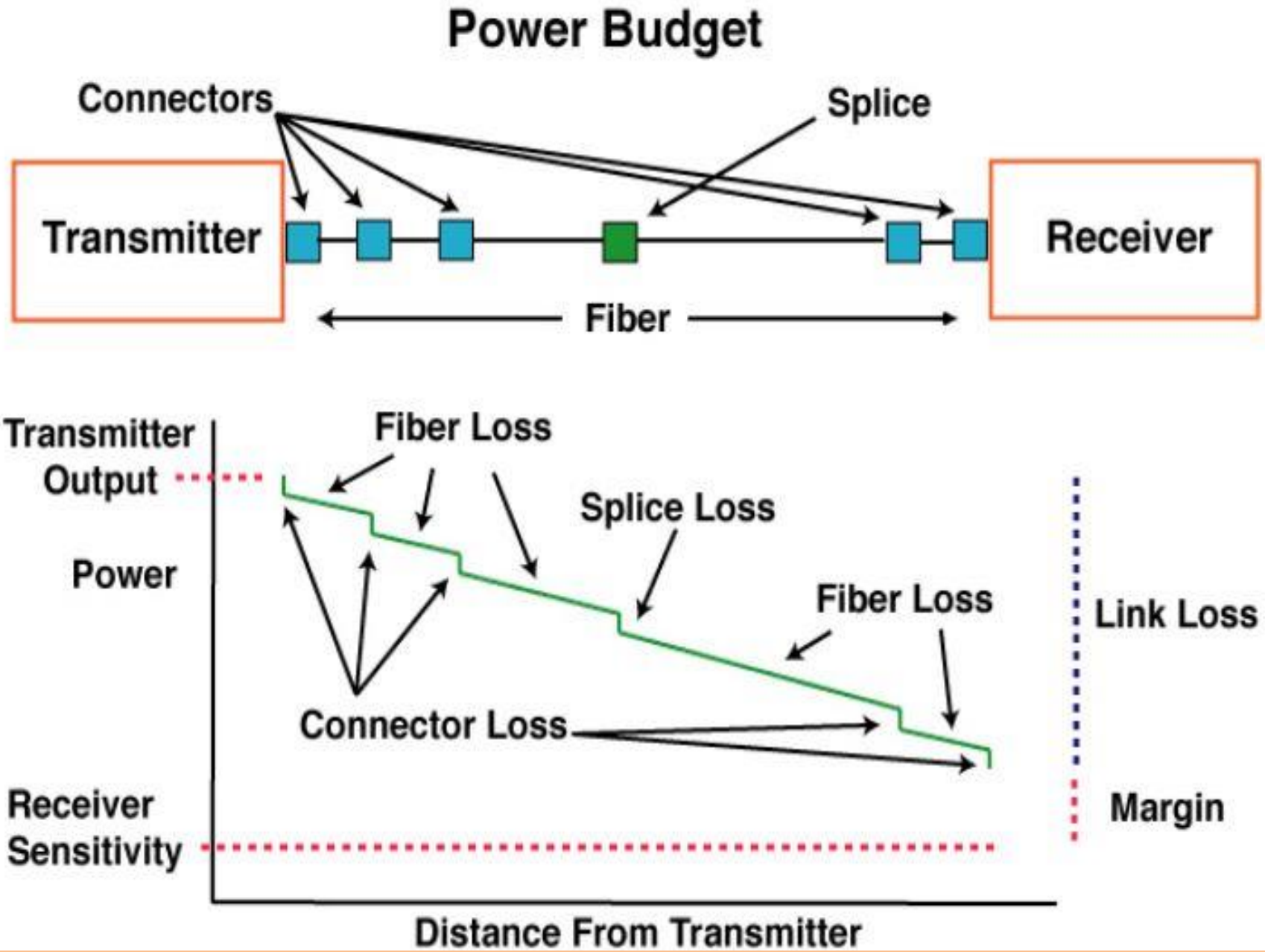
Losses:

- Coupling Loss
- Splice Loss
- Fiber Attenuation
- Connector Loss

PON

EXAMPLE PON LINK:

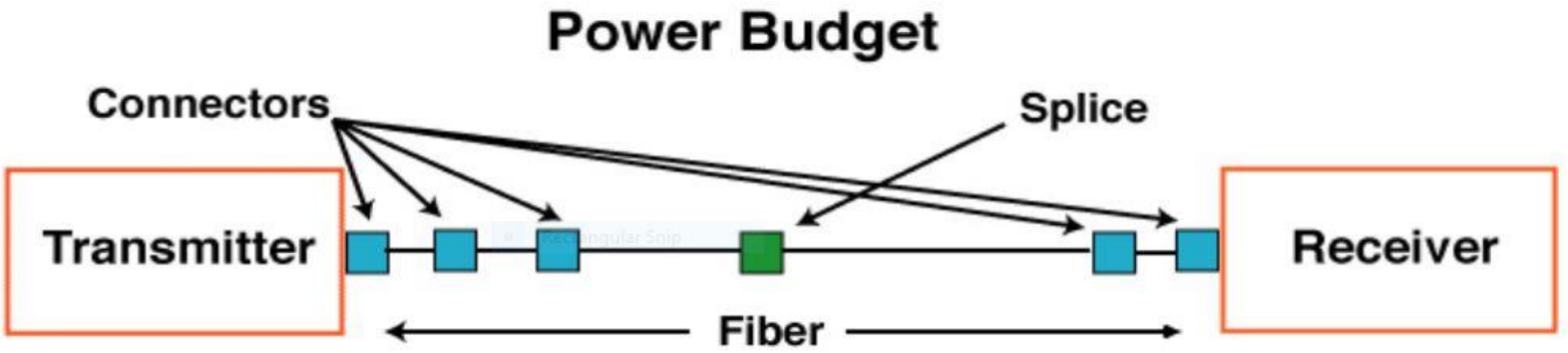



Power Budget
Connectors
Splice
Transmitter
Receiver
Fiber
Transmitter Output
Power
Fiber Loss
Splice Loss
Fiber Loss
Link Loss
Connector Loss
Receiver Sensitivity
Margin
Distance From Transmitter

ESTIMATION TABLE:

Link-Loss Factor	Estimated Link-Loss Value
Higher-order mode losses	Single-mode—None Multimode—0.5 dB
Modal and chromatic dispersion	Single-mode—None Multimode—None, if product of bandwidth and distance is less than 500 MHz-km
Connector	0.5 dB
Splice	0.5 dB
Fiber attenuation	Single-mode—0.5 dB/km Multimode—1 dB/km

TABULATION



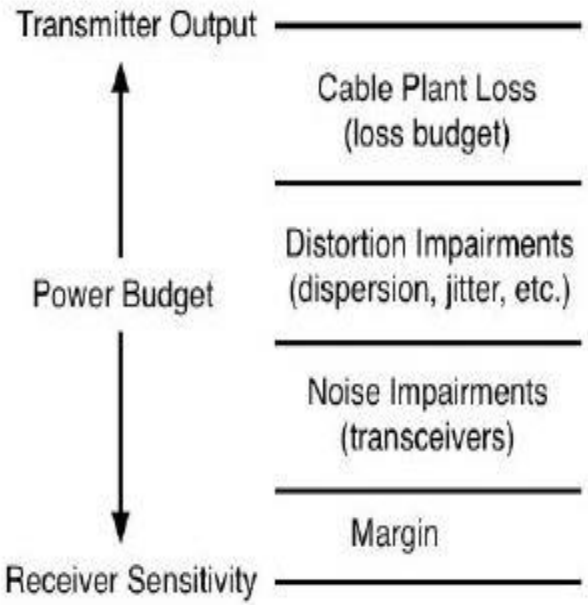
Type	Loss	No. of Components in Total Link	Total Loss
Fiber Loss	2 dB/Km	5 Km	10 dB
Connector Loss	1.5 dB	5	7.5 dB
Splice Loss	0.5 dB	1	0.5 dB

Total Link Loss = **18 dB**

CALCULATION

POWER BUDGET

$$PB = PT - PR$$



Power budget (PB)
Minimum transmitter power (PT)
Minimum receiver sensitivity (PR)
Power Budget Unit should be in **dBm**

EXAMPLE PROBLEM

Quest: Assume that minimum transmitter power is -15dBm and minimum receiver sensitivity is - 28dBm, Find the Power Budget for this optical fiber network?

$$PB = PT - PR$$
$$PB = -15\ dBm - (-28\ dBm)$$
$$PB = 13\ dBm$$

This power is allocated for the link loss of this network.

POWER MARGIN:

The amount of power available after subtracting attenuation or link loss (LL) from the power budget (PB) is the POWER MARGIN (PM).

$$PM = PB - LL$$

PM - POWER MARGIN
PB - POWER BUDGET
LL - LINK LOSS

Note:

If the calculated Power Margin of PON Network is greater than zero (PM > 0), That's indicating the PON link has sufficient power for the successful transmission.

LINK LOSS

Link Loss = [fiber length (km) x fiber attenuation per km] +
[splice loss x # of splices] +
[connector loss x # of connectors] + [safety margin]

EXAMPLE PROBLEM

Quest: Calculate Power Margin(PM) and link loss (LL) of a optical link which has attenuation (2 km @ 1 dB/km, or 2 dB) and loss for five connectors (0.5 dB per connector, or 2.5 dB) and two splices (0.5 dB per splice, or 1 dB) (assume safety margin as 0.5 dB)

Solution:

LL = 2 km (1 dB/km) + 5 (0.5 dB) + 2 (0.5 dB) + 0.5 dB

LL = 2 dB +2.5 dB + 1 dB + 0.5 dB

LL = 6 dB

PM = PB - LL

PM = 13 - 6 = **7 dB**

MAX.LENGTH OF THE FIBER

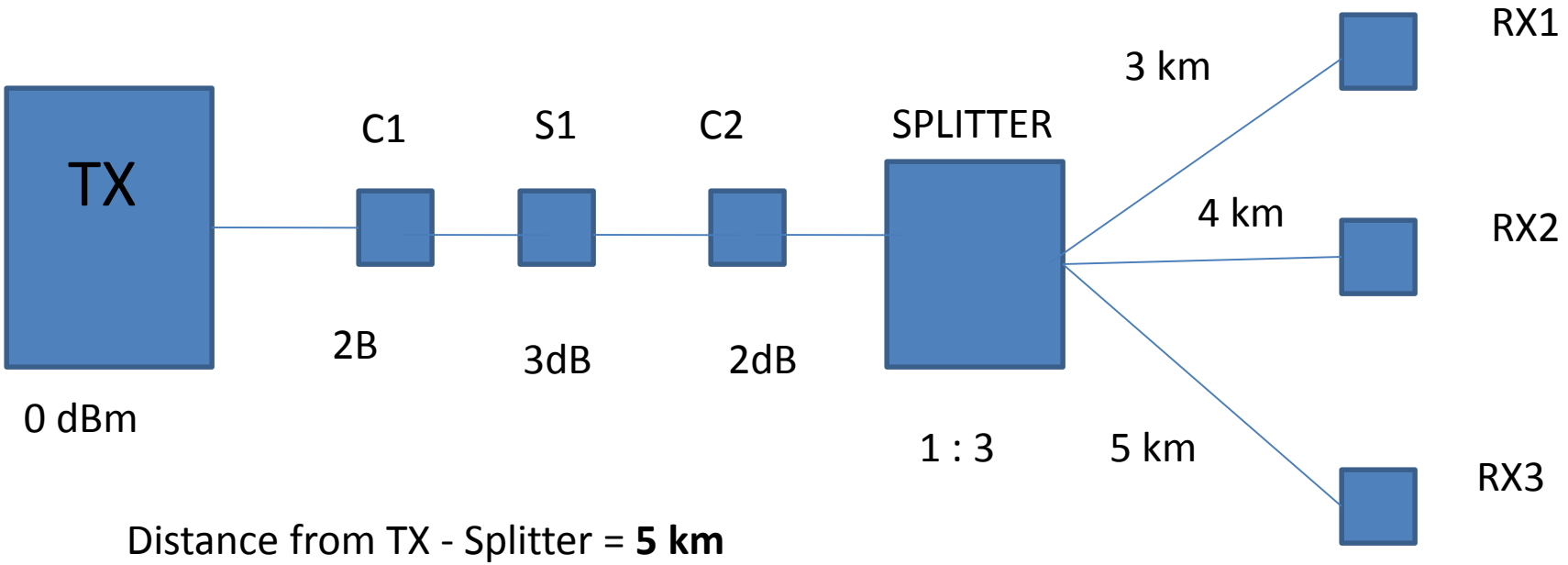
$$\text{Fiber Length} = \frac{[\text{Optical budget}] - [\text{link loss}]}{[\text{fiber loss/km}]}$$

Quest: Find maximum Length of a optical link which has Power Budget (PB) 13dB and attenuation (1 dB/km @ 2 km or 2 dB) and loss for five connectors (0.5 dB per connector, or 2.5 dB) and two splices (0.5 dB per splice or 1 dB) (assume safety margin as 0.5 dB)

Solution:

$$\text{Max. Length of the fiber} = \frac{13 - (2 + 2.5 + 1 + 0.5)}{1} = 7 \text{ Km}$$

DESIGN



Distance from TX - Splitter = **5 km**

FIBER LOSS = 3.5 dB/km

All Receiver Sensitivity = **-42 dBm**

STEP 1: FIND POWER BUDGET

PB = PT - PR = 0 - (-42) = 42 dBm

STEP 2: FIND LINK LOSS

LL = (L*3.5) + (2* 2) + (1*3) + SPLITTER LOSS +1

LL = (5*3.5) + (2* 2) + (1*3) + 4.77 +1 = 30.27 dB

STEP 3: FIND MAX. LENGTH

$$\text{Fiber Length} = \frac{[\text{Optical budget}] - [\text{link loss}]}{[\text{fiber loss/km}]}$$

Max. Length = (42 - 30.27) / 3.5 = 3.35 km

CONCLUSION :

1. RECEIVERS 2 & 3 CAN'T RECEIVE DUE TO DISTANCE

- If we increase the receiver sensitive power, **Power Budget** will increase.
- So High Sensitive receivers (Low power sensitivity) need to be installed long distance link for reliable transmission.

Case 1:

If all receivers sensitivity = -46 dBm
Max. Fiber length = 4.49 km

Case 2:

If all receivers sensitivity = -50 dBm
Max. Fiber length = ? km

FROM THE POWER BUDGET ANALYSIS,