

Real-world CATV system design

FO 102 WORKBOOK

Optical link budgets

Linear bus and long-haul design exercises

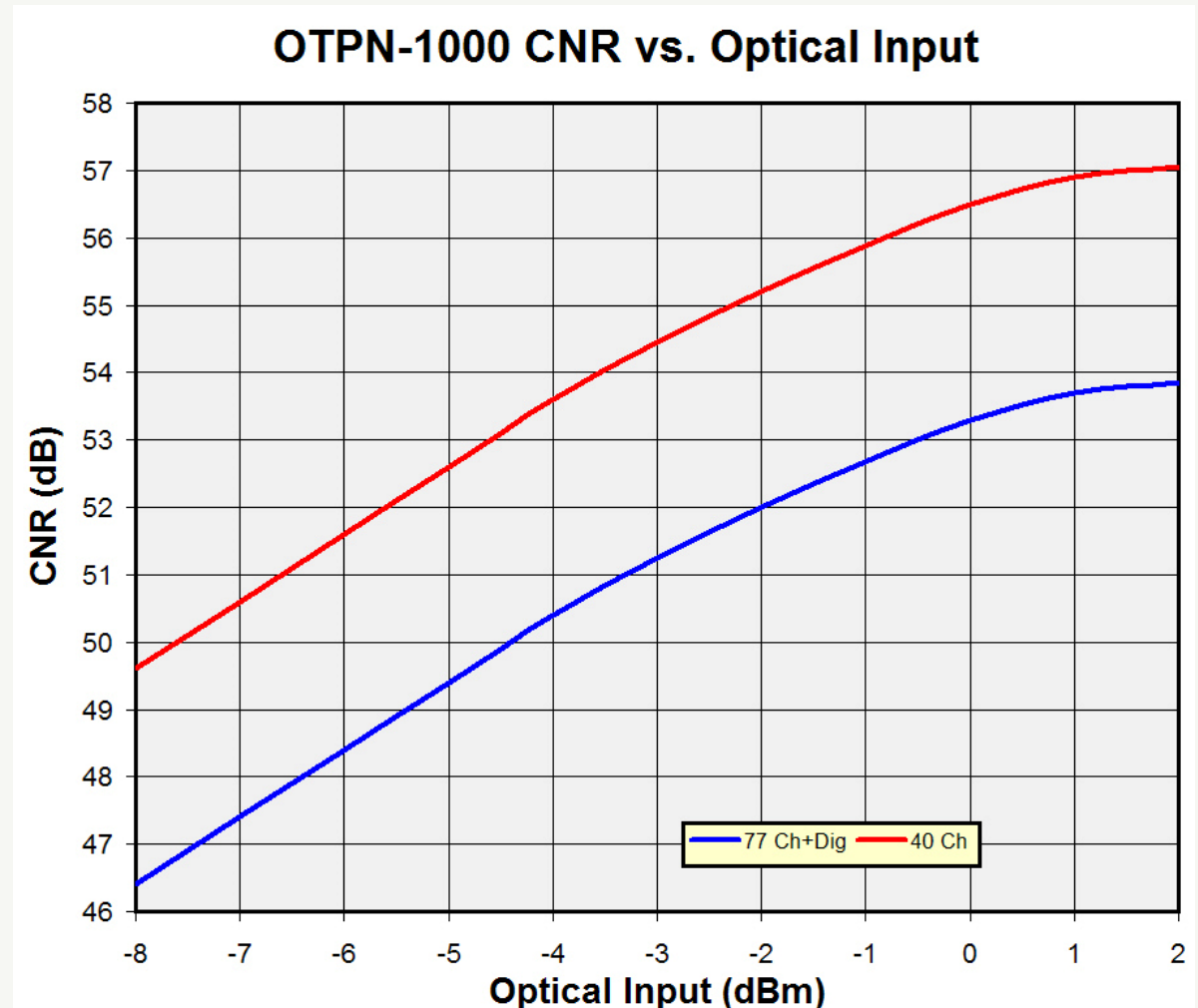
Two systems. Receiver requirements, coupler ratios, and transmitter power.

OTPN-1000 CNR vs. optical input

Receiver power comes first

- 1 Select the channel-loading curve.
- 2 Locate the required CNR.
- 3 Read the optical input in dBm.

Red: 40 analog channels
Blue: 77 channels + digital



Fiber optic coupler losses: 1% to 25%

Leg 1	Leg 2	Loss 1	Loss 2	Delta
1%	99%	23.3	0.4	22.9
2%	98%	18.7	0.4	18.3
3%	97%	16.5	0.5	16.0
4%	96%	15.0	0.5	14.5
5%	95%	14.0	0.6	13.4
6%	94%	13.1	0.6	12.5
7%	93%	12.4	0.7	11.7
8%	92%	11.8	0.7	11.1
9%	91%	11.2	0.8	10.5
10%	90%	10.7	0.8	9.9
11%	89%	10.3	0.9	9.4
12%	88%	9.9	0.9	9.0
13%	87%	9.5	1.0	8.6

Leg 1	Leg 2	Loss 1	Loss 2	Delta
14%	86%	9.2	1.0	8.2
15%	85%	8.8	1.1	7.8
16%	84%	8.5	1.1	7.4
17%	83%	8.3	1.2	7.1
18%	82%	8.0	1.2	6.8
19%	81%	7.7	1.3	6.5
20%	80%	7.5	1.3	6.2
21%	79%	7.3	1.4	5.9
22%	78%	7.1	1.4	5.6
23%	77%	6.9	1.5	5.4
24%	76%	6.7	1.5	5.1
25%	75%	6.5	1.6	4.9

Loss 1, Loss 2, and output delta are in dB. Leg percentages sum to 100%.

Fiber optic coupler losses: 26% to 50%

Leg 1	Leg 2	Loss 1	Loss 2	Delta
26%	74%	6.3	1.7	4.7
27%	73%	6.2	1.7	4.4
28%	72%	6.0	1.8	4.2
29%	71%	5.8	1.8	4.0
30%	70%	5.7	1.9	3.8
31%	69%	5.5	2.0	3.6
32%	68%	5.4	2.0	3.3
33%	67%	5.2	2.1	3.1
34%	66%	5.1	2.2	2.9
35%	65%	5.0	2.2	2.7
36%	64%	4.9	2.3	2.6
37%	63%	4.7	2.4	2.4
38%	62%	4.6	2.4	2.2

Leg 1	Leg 2	Loss 1	Loss 2	Delta
39%	61%	4.5	2.5	2.0
40%	60%	4.4	2.6	1.8
41%	59%	4.3	2.7	1.6
42%	58%	4.2	2.7	1.4
43%	57%	4.1	2.8	1.2
44%	56%	4.0	2.9	1.1
45%	55%	3.9	3.0	0.9
46%	54%	3.8	3.0	0.7
47%	53%	3.7	3.1	0.5
48%	52%	3.6	3.2	0.4
49%	51%	3.5	3.3	0.2
50%	50%	3.4	3.4	0.0

Loss 1, Loss 2, and output delta are in dB. Leg percentages sum to 100%.

Design 1: linear bus with three drops

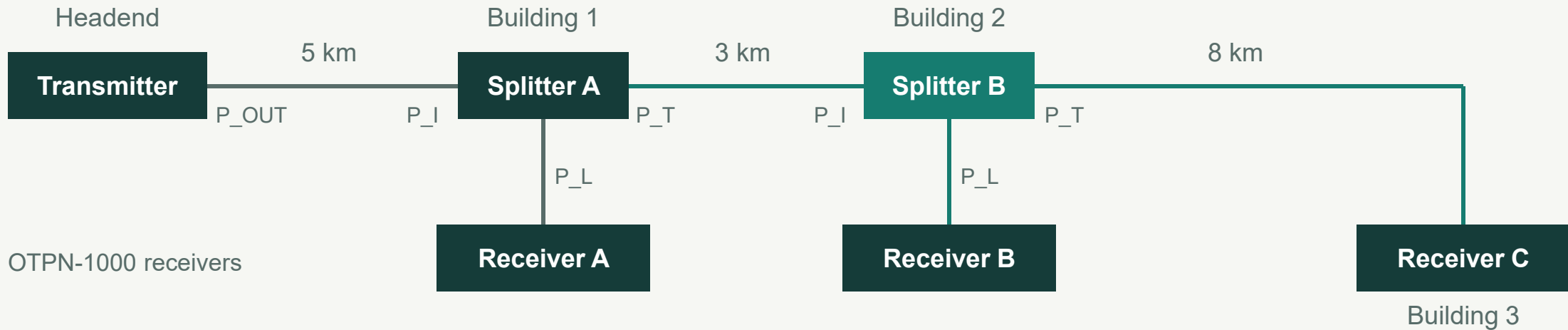
Customer requirements

Analog channels	40
Minimum CNR	51 dB
Wavelength	1310 nm
Fiber attenuation	0.4 dB/km
Connectors	SC/APC

Design sequence

- 01 Receiver input from the OTPN-1000 CNR curve
- 02 Fiber span losses
- 03 Required coupler split ratios
- 04 Total transmitter output power

Design 1: splitter B



Receiver optical input P_{IN} = ____ dBm Splitter B local output P_L = ____ dBm

Through output P_T = ____ dBm + (8 km $\times$ 0.4 dB/km) = ____ dBm

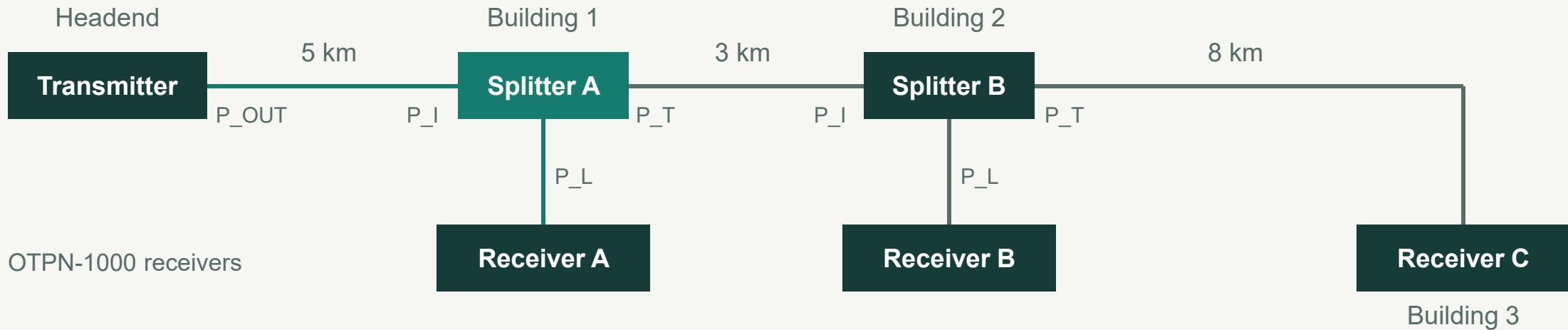
Output delta = ____ dB Selected coupler = ____ / ____ %

Splitter B input, using the first leg: ____ dBm + ____ dB = ____ dBm

Splitter B input, using the second leg: ____ dBm + ____ dB = ____ dBm

Required splitter B input P_I = larger branch value = ____ dBm

Design 1: splitter A



Splitter B input from previous slide = ____ dBm

Splitter A through output P_T = ____ dBm + (3 km $\times$ 0.4 dB/km) = ____ dBm

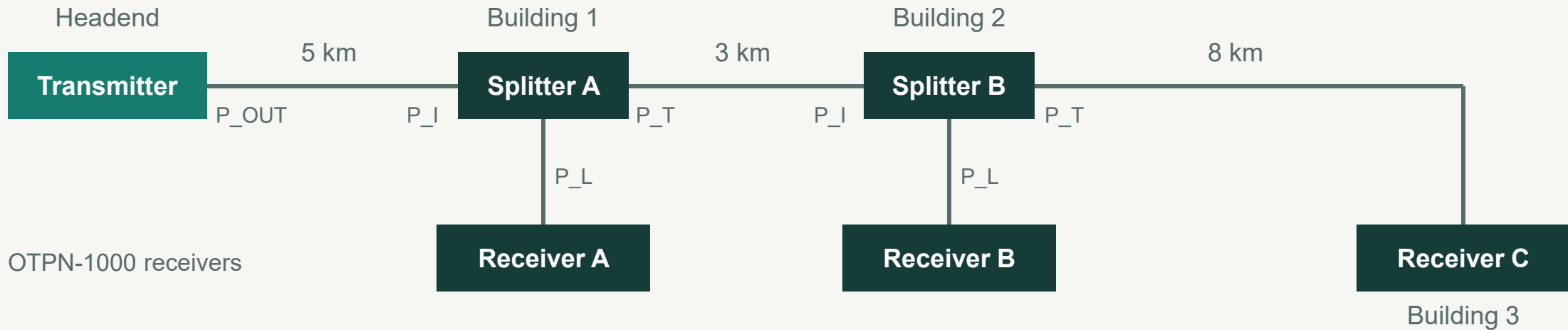
Local P_L = ____ dBm Delta = ____ dB Selected coupler = ____ / ____ %

Splitter A input, using the first leg: ____ dBm + ____ dB = ____ dBm

Splitter A input, using the second leg: ____ dBm + ____ dB = ____ dBm

Required splitter A input P_I = larger branch value = ____ dBm

Design 1: transmitter output power



Required splitter A input from previous slide = ____ dBm

5 km fiber loss = $5 \text{ km} \times 0.4 \text{ dB/km}$ = ____ dB

Transmitter P_{OUT} = ____ dBm + ____ dB = ____ dBm

Selected transmitter output: ____ dBm minimum

Design 2: long haul and local receivers

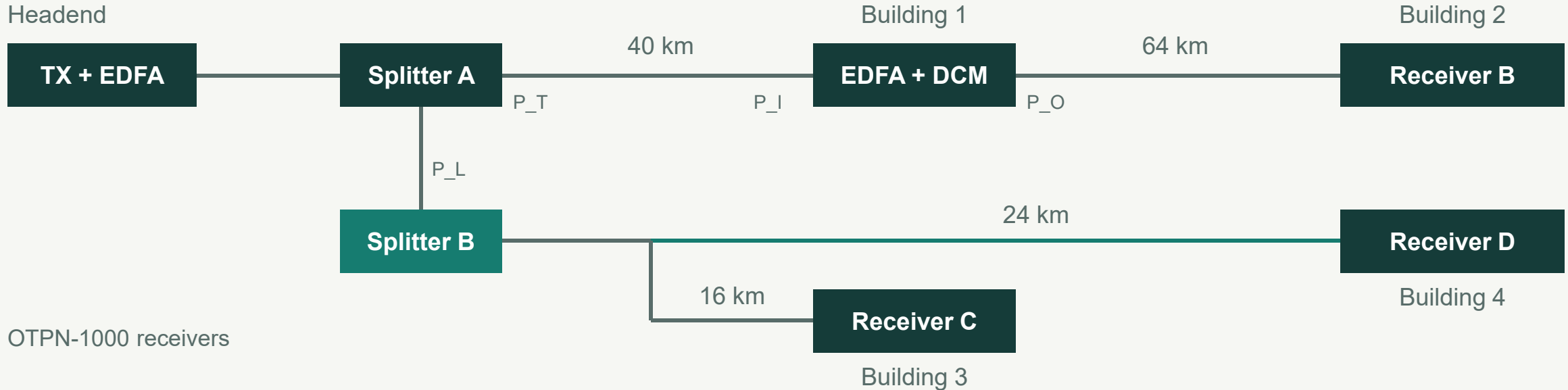
Customer requirements

Channel loading	77 + digital
Building 2 minimum CNR	53.5 dB
Buildings 3 & 4 minimum CNR	53 dB
Optimum EDFA input	+3.0 dBm
Wavelength / attenuation	1550 nm / 0.25 dB/km
Connectors	SC/APC

Design sequence

- 01** Receiver inputs from the OTPN-1000 CNR curve
- 02** Fiber span losses
- 03** Required coupler split ratios
- 04** Total transmitter output power

Design 2: local splitter B



Buildings 3 & 4 receiver input $P_{IN} = \underline{\hspace{1cm}}$ dBm

$P_L = \underline{\hspace{1cm}} + (16 \times 0.25) = \underline{\hspace{1cm}}$ dBm $P_T = \underline{\hspace{1cm}} + (24 \times 0.25) = \underline{\hspace{1cm}}$ dBm

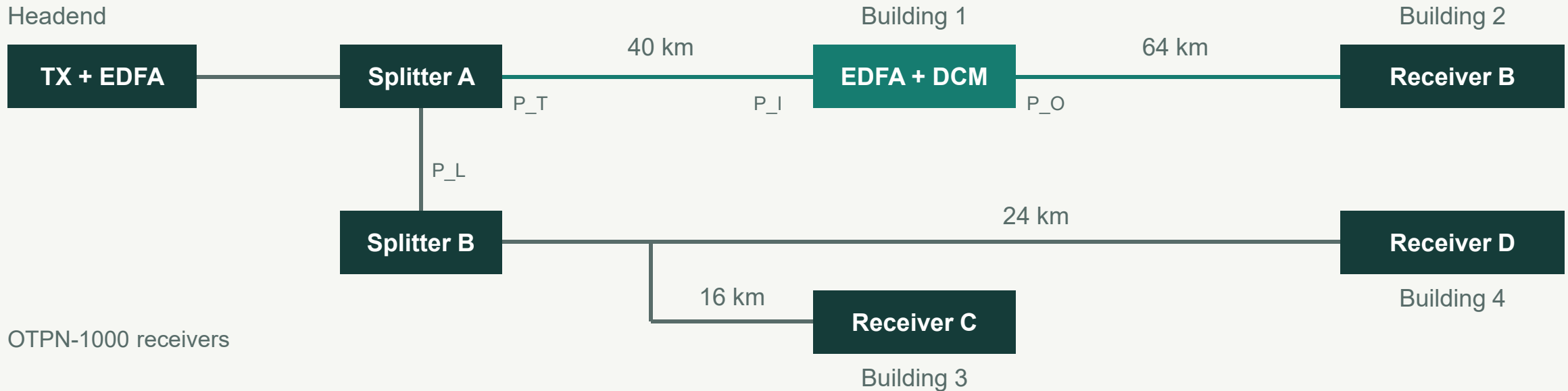
Output delta = $\underline{\hspace{1cm}}$ dB Selected coupler = $\underline{\hspace{1cm}} / \underline{\hspace{1cm}} \%$

Splitter B input, using the first leg: $\underline{\hspace{1cm}}$ dBm + $\underline{\hspace{1cm}}$ dB = $\underline{\hspace{1cm}}$ dBm

Splitter B input, using the second leg: $\underline{\hspace{1cm}}$ dBm + $\underline{\hspace{1cm}}$ dB = $\underline{\hspace{1cm}}$ dBm

Required splitter B input $P_I = \text{larger branch value} = \underline{\hspace{1cm}}$ dBm

Design 2: EDFA and long-haul branch



Building 2 receiver P_{IN} = ____ dBm = ____ mW

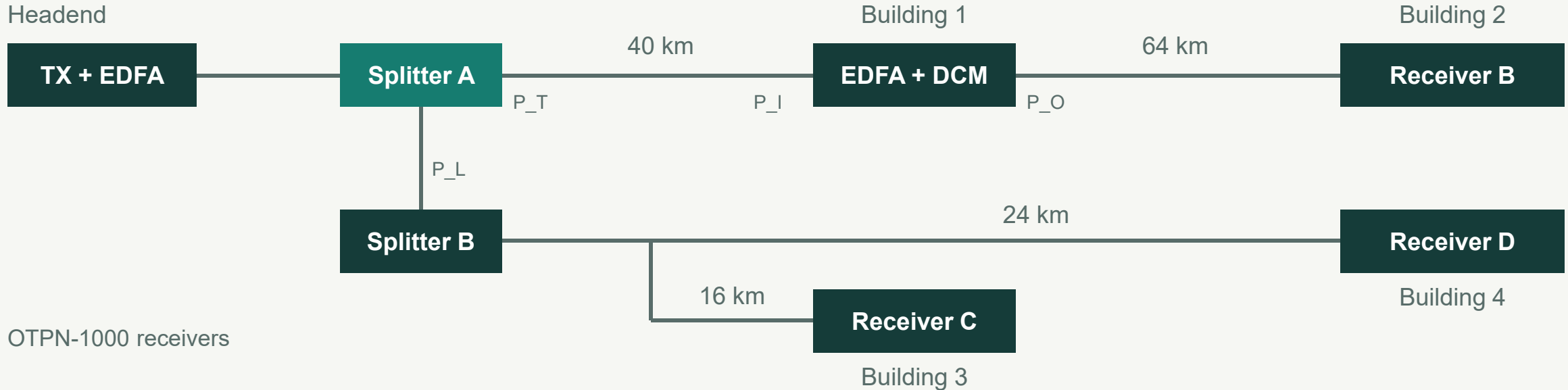
Building 1 EDFA P_O = ____ dBm + (64×0.25) = ____ dBm = ____ mW

Selected EDFA output = ____ dBm

Optimum EDFA input = +3.0 dBm = ____ mW

Splitter A long-haul output P_T = ____ + (40×0.25) = ____ dBm = ____ mW

Design 2: splitter A and headend output



Long-haul branch target = ____ dBm Local branch = splitter B input + 4 km loss

Local branch target = ____ dBm + (4×0.25) = ____ dBm

Output delta = ____ dB Selected coupler = ____ / ____ %

Splitter A input, using the first leg: ____ dBm + ____ dB = ____ dBm

Splitter A input, using the second leg: ____ dBm + ____ dB = ____ dBm

Required P_I = larger value = ____ dBm Headend output $\geq$ ____ dBm