

Production feasibility study on 400GbE PMD for SMF objectives

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- The comparison of relative cost and power consumption was made for 2km and 10km SMF candidates below.

8X 50G NRZ, 8X 50G PAM4, 4X 100G PAM4, 4X 100G DMT

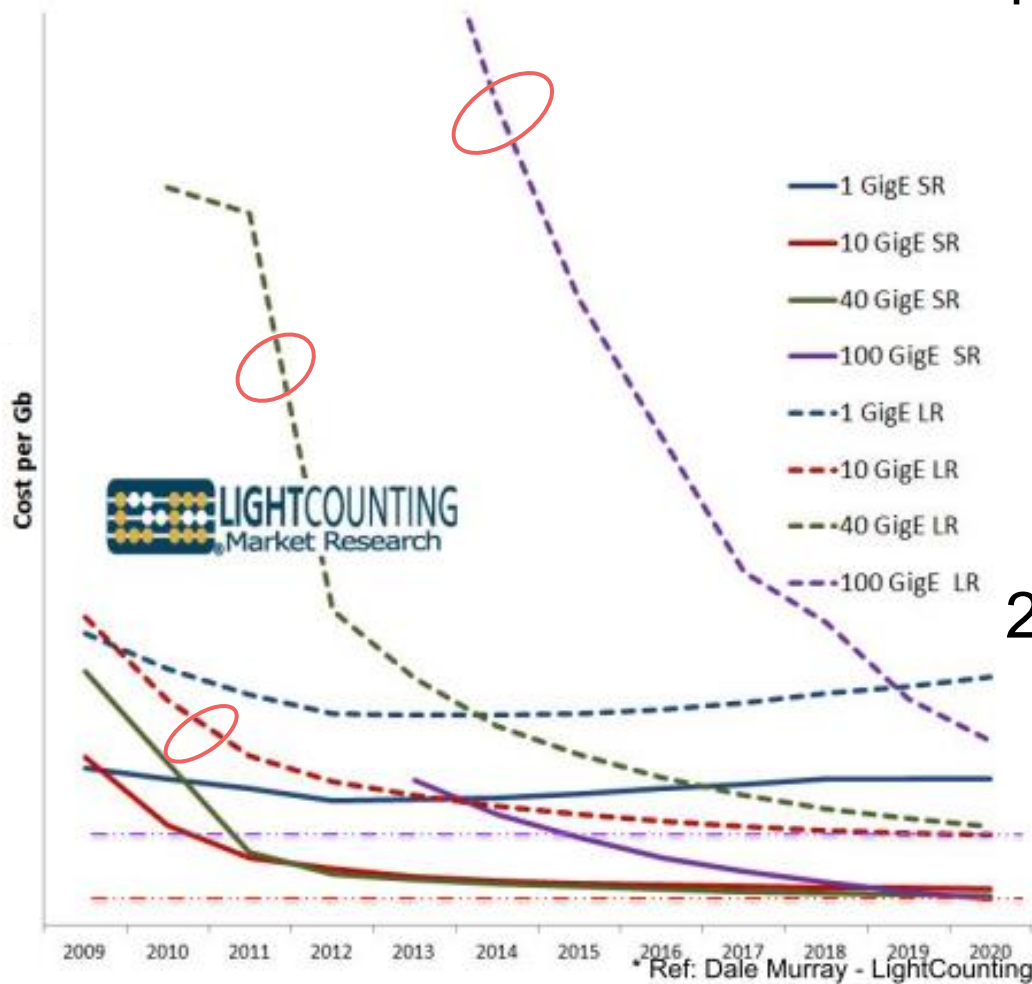
- Relative cost estimation method

- General cost trend was reviewed and the relative cost of 50G components (TOSA/ROSA) was estimated.
- The cost of transceivers strongly depend on the cost of optical components (TOSA/ ROSA). The relationship between the cost of optical component and its bandwidth is reviewed. Current optical component for 100G application (25G base components) is used as a reference of the relative cost.

- Power consumption estimation method

- Pc of TOSA/ROSA is estimated for laser type and its bandwidth.
- Pc of signal processing IC is estimated for the same chip process.

General cost trend of ether transceivers



- 1) From SR observation
 - Cost is drastically reduced after the initial production installation.
 - New bit rate products reached “the same cost per bit value” with product matureness.

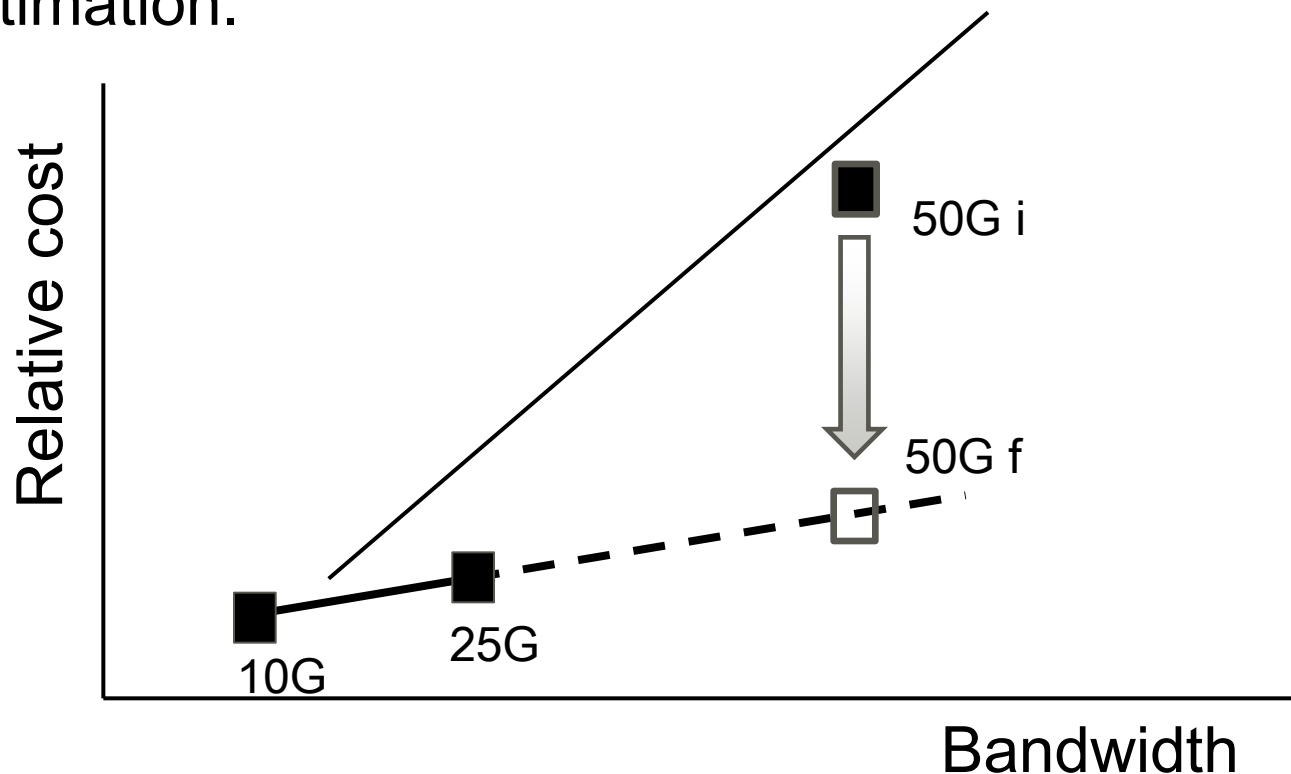
- 2) From LR observation
 - The same tendency is confirmed.
 - X-point in LR case is as follow.

Recap of dove 400 01a 0114
(quoted from Light Counting)

10G \leftrightarrow 40G: 2020
40G \leftrightarrow 100G: >2020

General cost trend of optical components

- For optical components, the same trend is observed from the analysis of 10G/25G behavior.
- Initial estimated cost for 50G will reach the asymptote during several years after installation. (>2020)
- For 50G, this bottom cost is used for transceiver cost estimation.



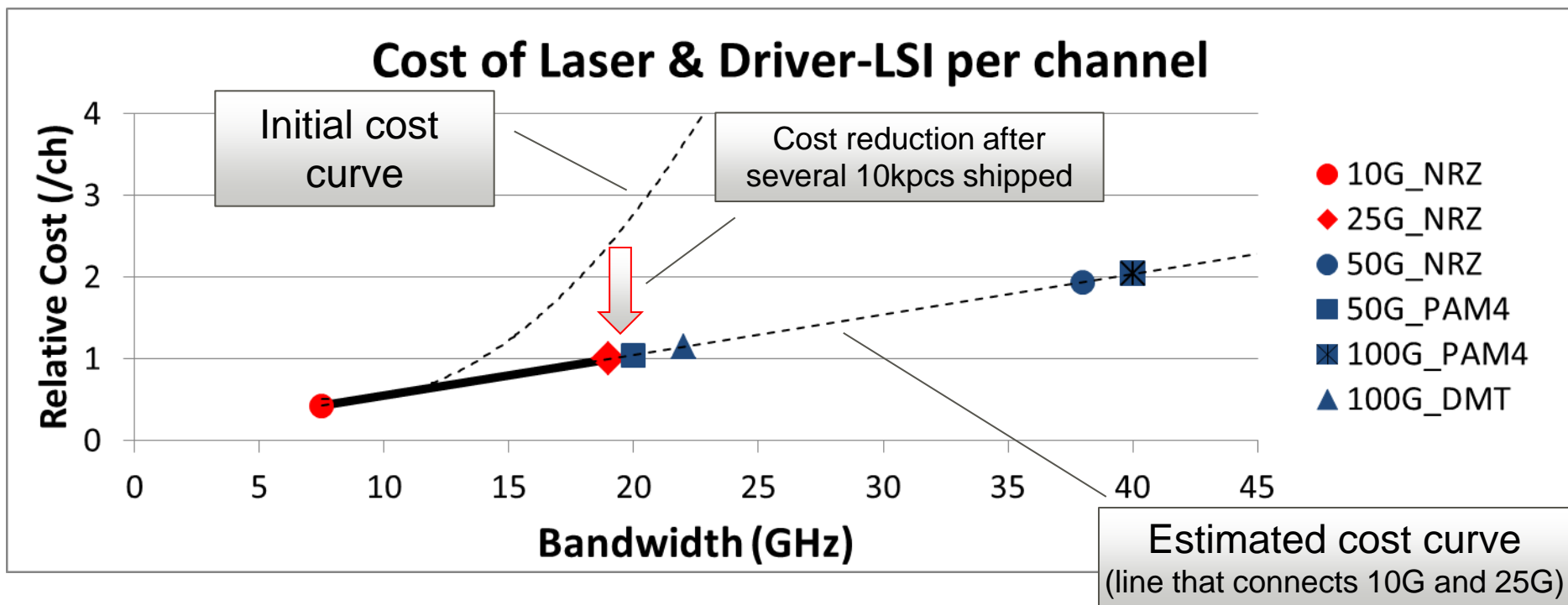
Transceiver components assumptions

- Following components and performance are assumed for transceiver estimation.

	Ref	8x 50G NRZ	8X 50G PAM4	4X 100G PAM4	4X 100G DMT
Q' ty		8	8	4	4
TOSA (BW)	EML (25G)	EML (50G)	EML (25G*)	EML (50G*)	DML (25G**)
ROSA (BW)	PIN+TIA (25G)	PIN+TIA (50G)	PIN+TIA (25G*)	PIN+TIA (50G*)	PIN+TIA (25G**)

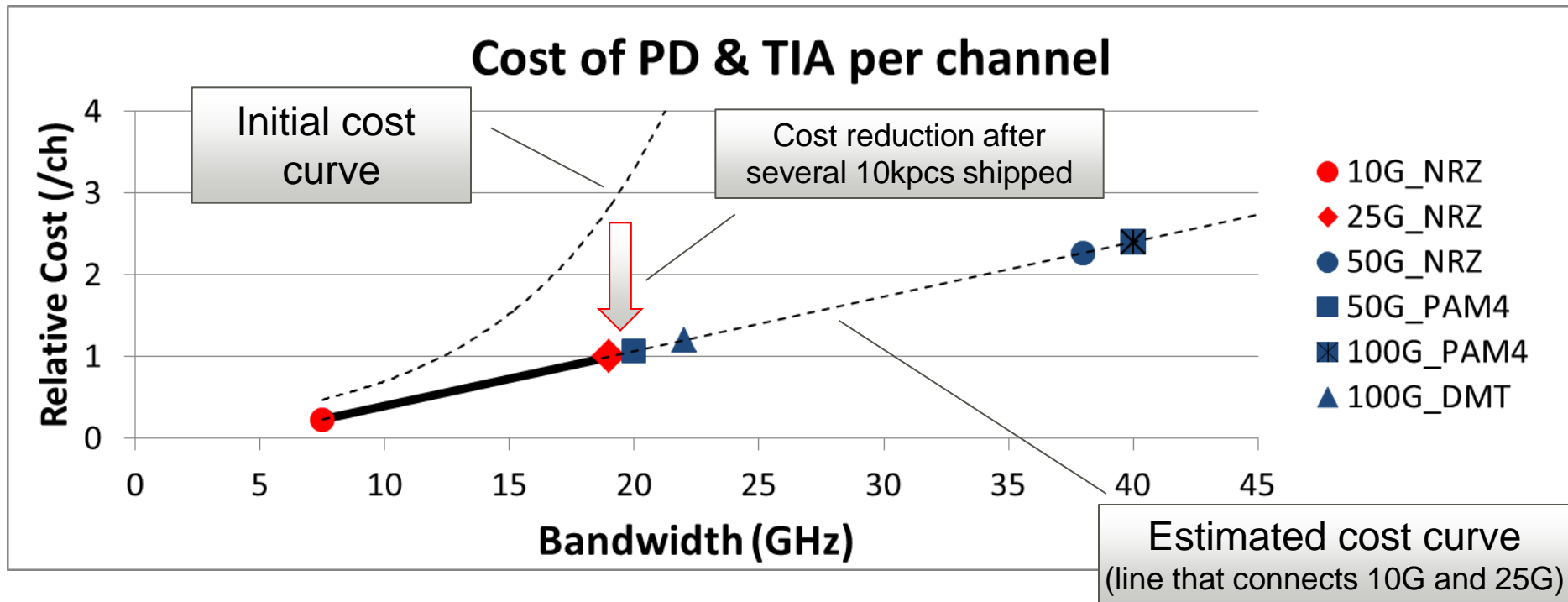
* There is not sufficient information so far.

** Current actual target is TOSA(18GHz) and ROSA(21GHz)



➤ Relative cost = Relative cost (/ch) x number of channel

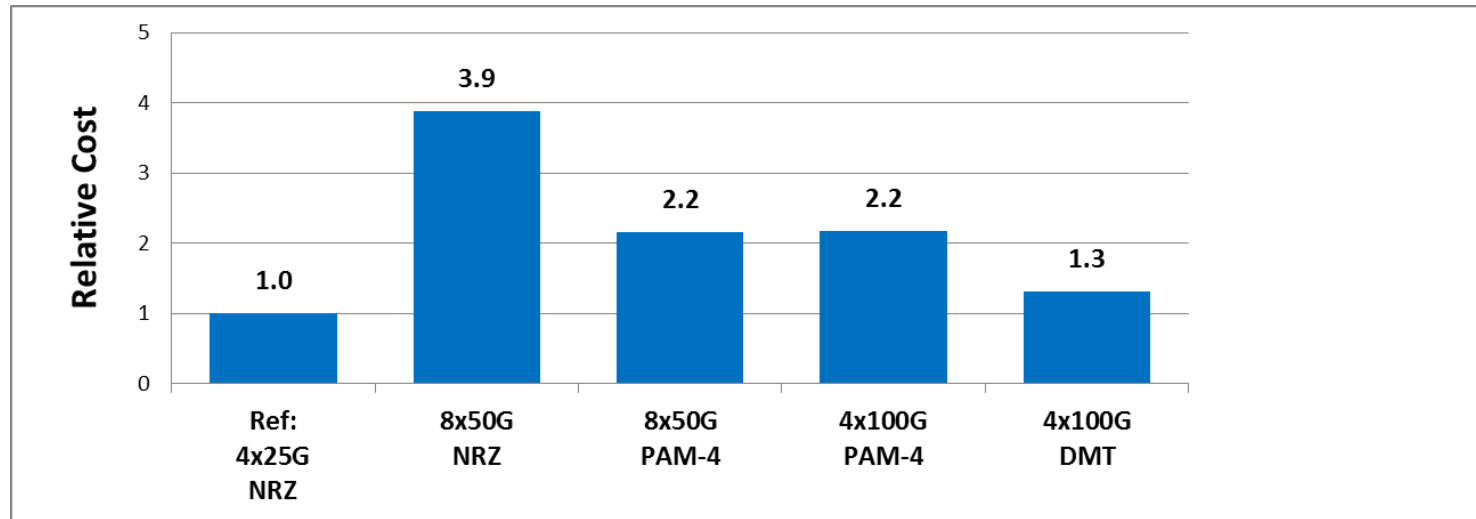
Modulation	Ref: 4x25G NRZ	8x50G NRZ	8x50G PAM-4	4x100G PAM-4	4x100G DMT
Relative Cost of TOSA	1	3.9	2.1	2.0	1.1



➤ Relative cost = Relative cost (/ch) x number of channel

Modulation	Ref: 4x25G NRZ	8x50G NRZ	8x50G PAM-4	4x100G PAM-4	4x100G DMT
Relative Cost of ROSA	1	4.5	2.1	2.4	1.2

Relative Cost comparison



Modulation	Ref: 4x25G NRZ	8x50G NRZ	8x50G PAM-4	4x100G PAM-4	4x100G DMT
Relative Total Cost	1	3.9	2.2	2.2	1.3

➤ DMT position (compared with other options)

- TOSA/ROSA portion is the smallest, because of the smallest quantity of components (4) and the narrowest required bandwidth (25G base).
- Signal processing IC portion is competitive, because of chip size estimation.

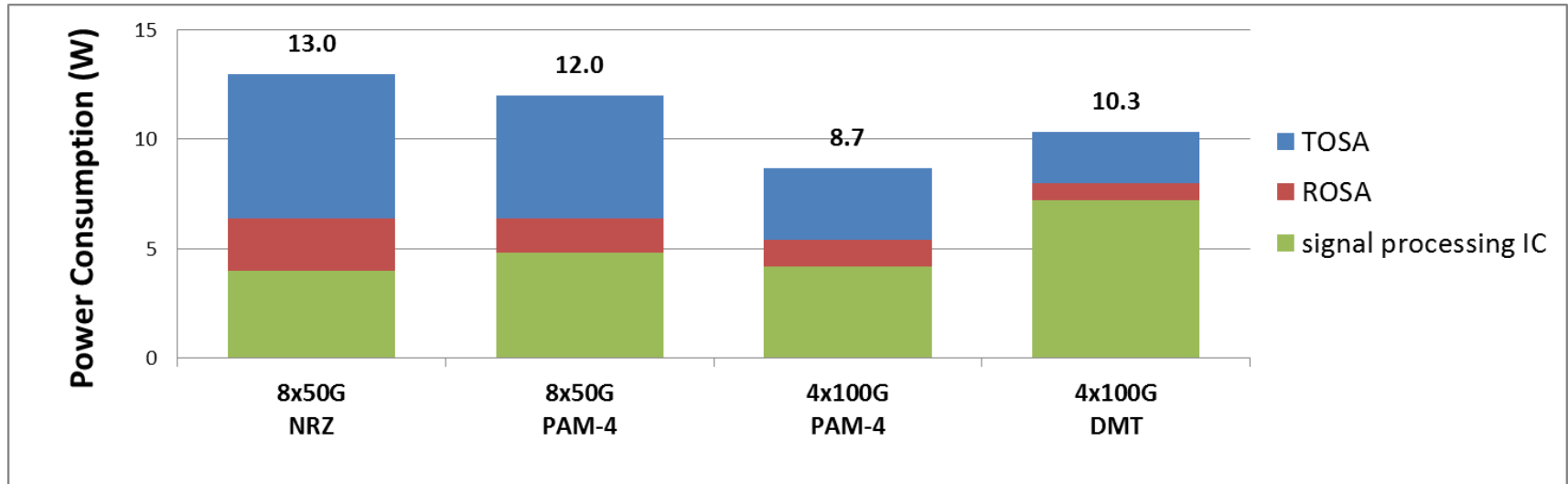
Power consumption comparison

➤ Power consumption is estimated as followings

- TOSA : (EML/DML bias current + Laser DRV + Temp. control) x number of ch
- ROSA : (TIA) x number of ch.

	Modulation format				Note
	8x50G NRZ	8x50G PAM-4	4x100G PAM-4	4x100G DMT	
Laser type	EML	EML	EML	DML	
TOSA	6.6	5.6	3.3	2.3	25G EML+DRV: 0.45W/ch 25G DML+DRV: 0.33W/ch 50G EML+DRV: 0.57W/ch + Temp. cont. 0.25W/ch
ROSA	2.4	1.6	1.2	0.8	25G TIA: 0.2W/ch 50G TIA: 0.3W/ch
Signal processing IC	4.0	4.8	4.2	7.2*	Target
Total	13.0	12.0	8.7	10.3	

* Reference: Ethernet Alliance 100GbE per Lamda for Data Center Workshop- June, 2014



➤ DMT position (compared with other options)

- TOSA/ROSA portion is the smallest, because of the smallest quantity of components (4) and the narrowest required bandwidth (25G base).
- Signal processing IC portion is the largest.
- Totally, it is smaller than 8x50G NRZ / 8x50G PAM-4, but larger than 4x100G PAM-4.
- Signal processing IC portion will be decreasing during the future CMOS process migration.

The estimation of Cost/ Pc is made for 100G SMF 2km/10km candidate options.

DMT capability is positioned as follows.

■ Relative cost

The smallest option among candidates, because of

TOSA/ROSA Q' ty is the smallest.(4)

TOSA/ROSA required bandwidth is the smallest.(25G) .

■ Power consumption

The second smallest option among candidates.

The dominant part of Pc is signal processing IC in case of DMT option, however this portion will be decreasing under future CMOS process migration.

Thank you