Security Level:

Reconsideration of PIN-based Receiver for 25GbE SMF 40Km

Xi Huang (HUAWEI)
Ali Ghiasi (Ghiasi Quantum LLC)

www.huawei.com

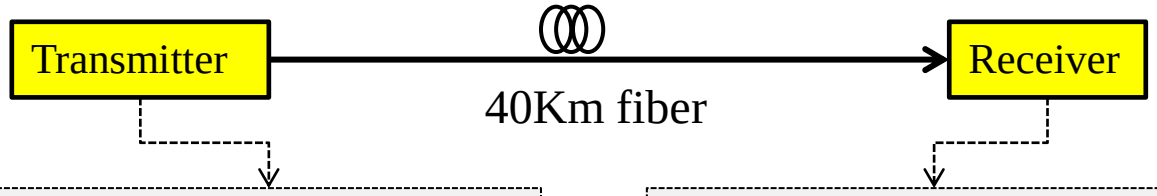
HUAWEI TECHNOLOGIES CO., LTD.

HUAWEI

Content

- 1. Overview
- 2. Experimental results
- 3. Economic analysis
- 4. Conclusions

Overview

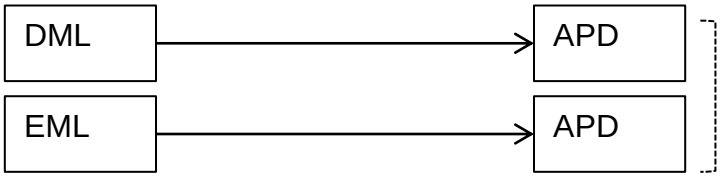


- **Tx side:**

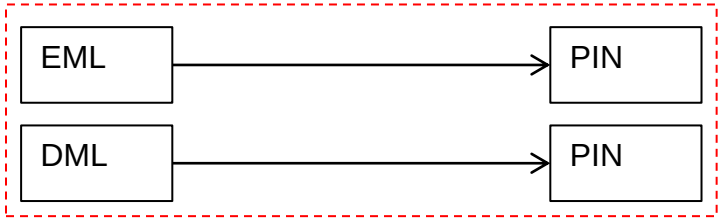
1. DML and EML have been fully evaluated including dispersion penalties and high temperature performance.

- **Rx side:**

1. Only APD-based Rx has been investigated currently .
2. Lack of low cost PIN-based receiver solution



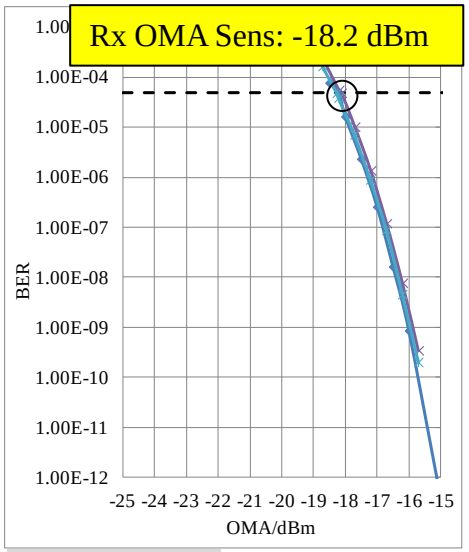
Based on Dr Tamura's proposal, these solutions satisfy link budget of 25G SMF 40Km application.



In this proposal, we will evaluate the BER performance and economic aspect based on PIN-solution.

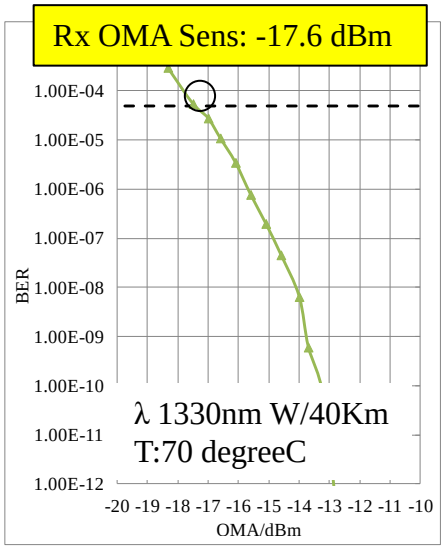
Experimental results

EML+PIN



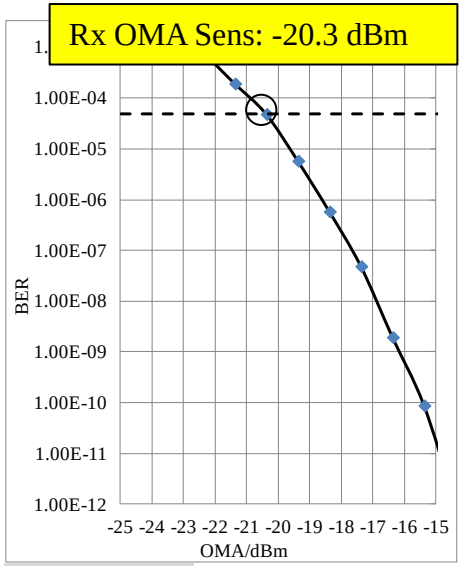
ER≈10dB

DML+PIN



ER≈4dB

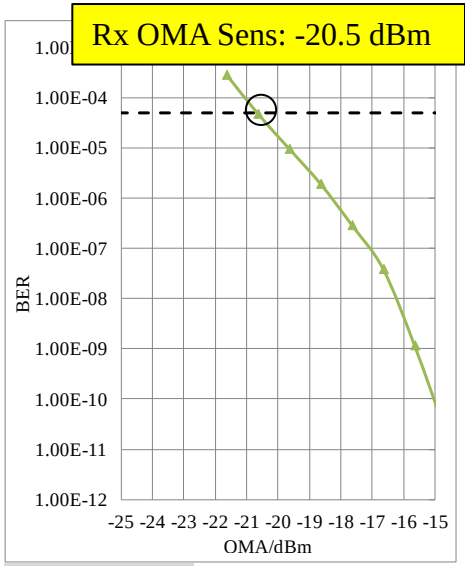
EML+APD



ER≈8dB

Data from Tamura_160314e_40Km_25GSMF.pdf

DML+APD

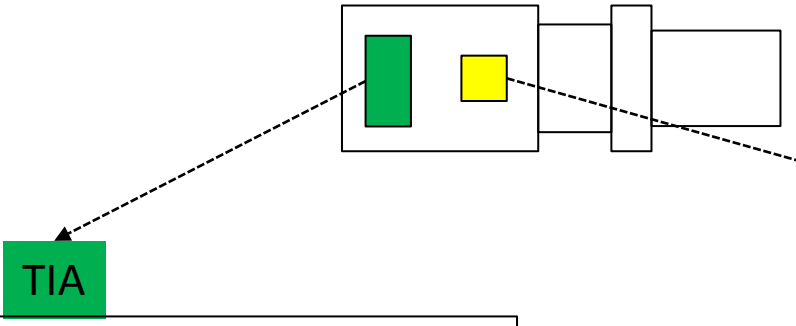


ER≈4dB

Data from Tamura_160314e_40Km_25GSMF.pdf

- 25G EML/DML devices and 25G PIN devices are commercially available.
- Based on our experimental results, the Rx sensitivity of PIN+EML is about -18.2dBm in OMA and DML+PIN is about -17.6dBm in OMA
- For more data on APDs, please refer to tamura_3cc_03_0916.pdf & Huang_3cc_1116.pdf.

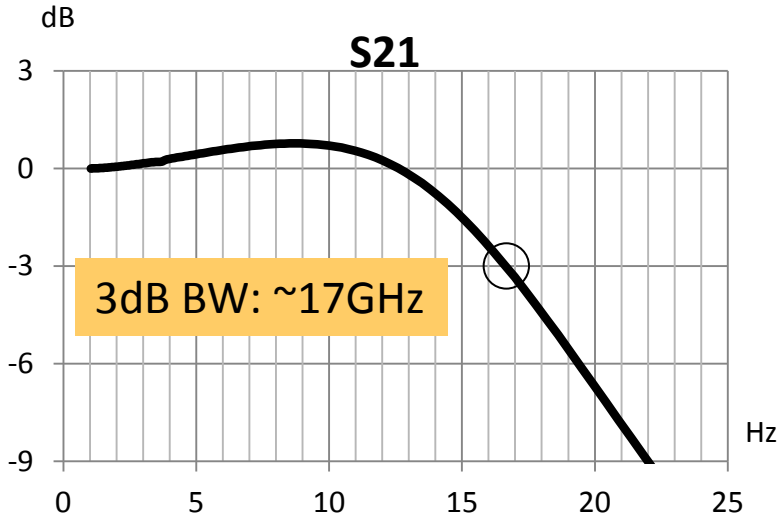
The Key Parameters of Rx



Overload Power（OMA）：>+3dBm

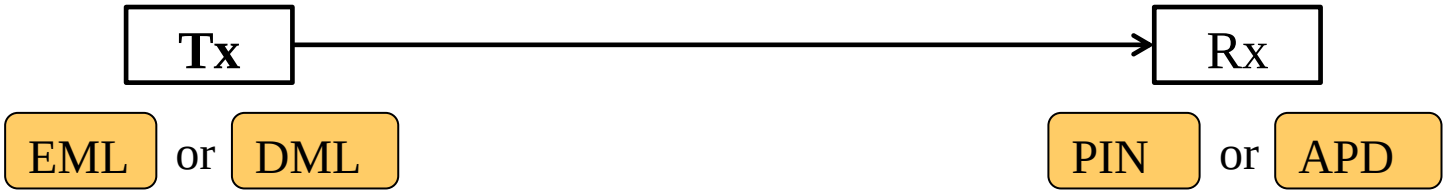
Input Referred Noise Current Density:

min	typical	max	Unit
	9.7	12	pA/√ Hz



Item	Symbol	Typical	Unit	Test condition
Responsivity	R	0.7~0.8	A/W	1310nm,Pi=0mW,Vr=2V
Dark Current	Id	0.2	nA	Vr=5V,Pi=0uW
-3dB BW	BW	25	GHz	Vr=2V,1310nm,Pi=+3dBm

Why should a PIN-based solution be considered (Economic analysis)



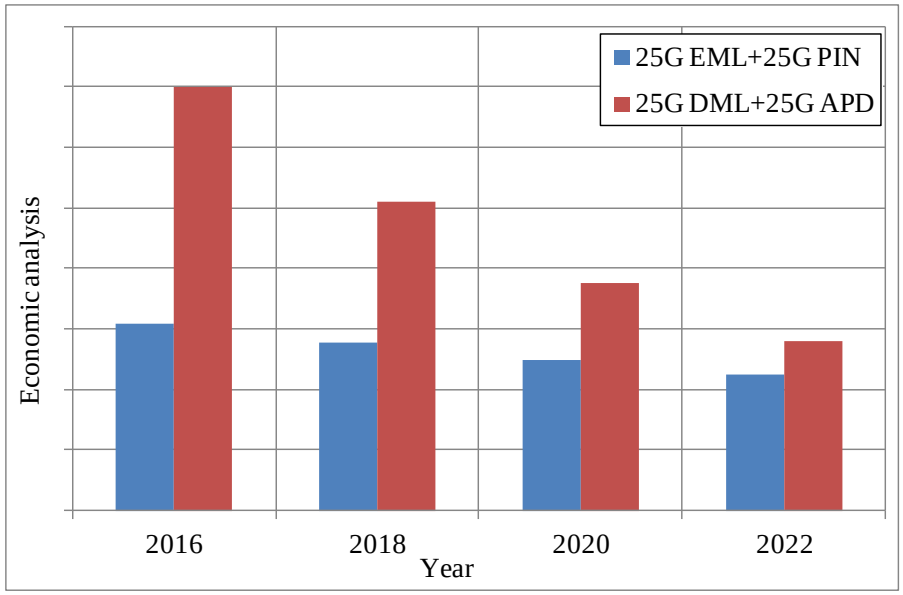
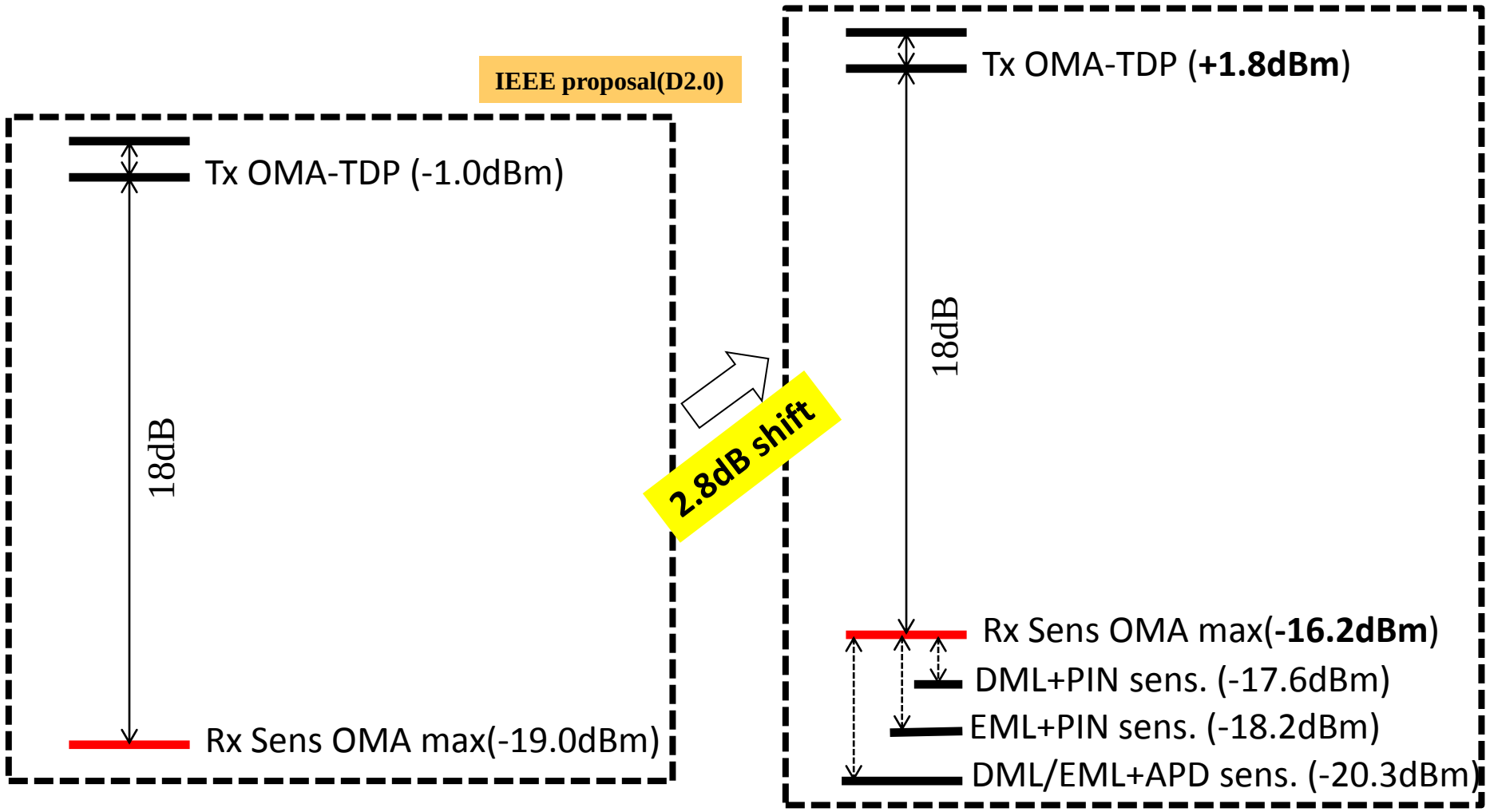


Fig.1 System economic comparison

- For Tx side， two alternatives could be chosen, i.e., EML and DML. EML typically includes TEC usually. So the performance of EML is better than DML under the high-temperature.
- For Rx side, we have also two alternatives, i.e., APD and PIN. Usually, the performance of APD is better than PIN. We should acknowledge that the cost difference between APD and PIN is very large now and likely in the future . It is more economical to use PIN-based solution if possible.
- So, if a PIN-based receiver solution can be shown to meet BER requirements for the 25G SMF 40 Km application, a good balance for TX and RX costs can be achieved.

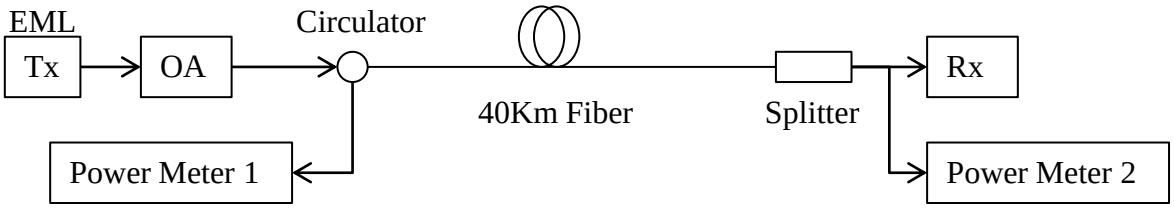
Update of Link budget(25GE SMF 40Km)

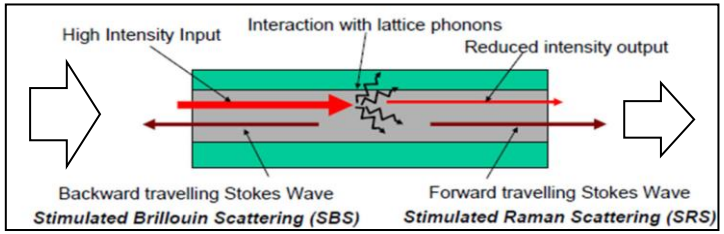


Benefits:

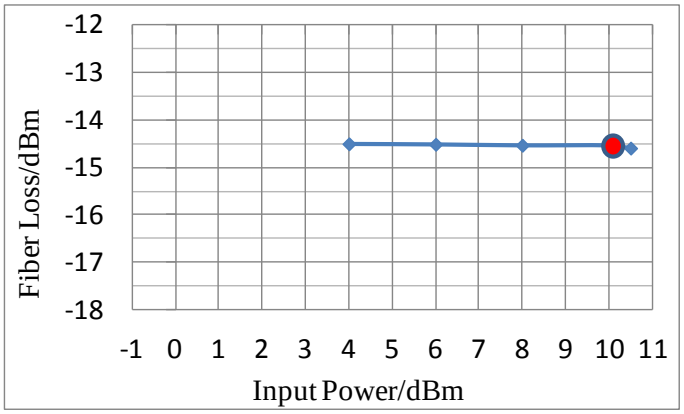
1. If we shift up **2.8dB** in the link budget, both PIN and APD satisfy to achieve 25GE SMF 40Km
2. We then have more options for Tx /Rx side for the 25G SMF 40Km link , i.e, EML+APD/ DML+APD/ EML+PIN even DML+PIN.
3. It is the best choice based on current and future technological state of the art.

Maximum Tx power consideration

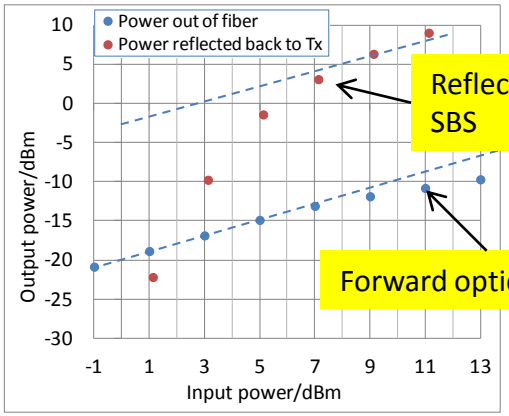




Fiber Loss= PowerMeter2-PowerMeter1.
Reflected Power is measured from PowerMeter1.
Forward Power is measured from PowerMeter2.



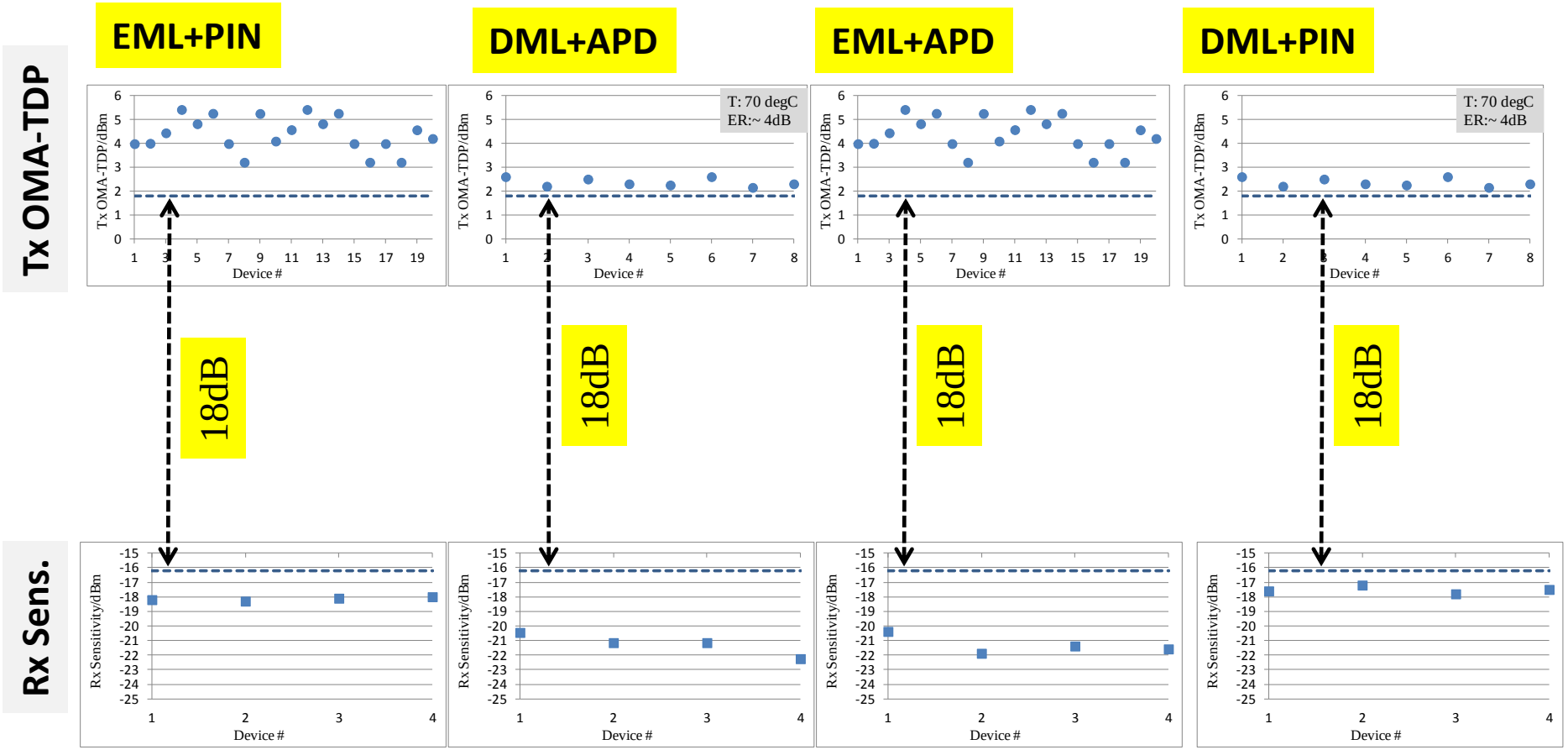
↑ Experimental results



↑ Simulated results

- Base on our simulated and experimental results, the threshold power of SBS is about +10dBm (Fiber loss of 40Km is significantly increased.)
- To avoid potential SBS, the maximum transmitter power should keep to below +10dBm.

System margin analysis



We have investigated the device capability on both Tx side and Rx side. All devices are commercial availably.

1. Based on **EML+PIN** solution, it is at least 1.0dB margin on Tx side and at least 2.0dB margin on Rx side.
2. Based on **DML+APD** solution, the margin on Tx side is limited but the Tx power is large enough for 40Km scenario. Increasing DML optical power may technically feasible.
3. Based on **EML+APD** solution, there are usually many margins on both Tx side and Rx side.
4. Based on **DML+PIN**, the margin is limited, but it still satisfies the 18dB requirement.

Conclusions

- The proposed link budget shifts the 2.8 dB of OMA from the receiver to the transmitter to allow lower cost pin based implementation.
- It offers lower cost more reliable alternative for 25G 40 km SMF PMD based on EML+PIN or DML+PIN.
- The proposed link budget supports all 4 combination of the device type, i.e., EML/DML+PIN and EML/DML+APD.

Transmit characteristics

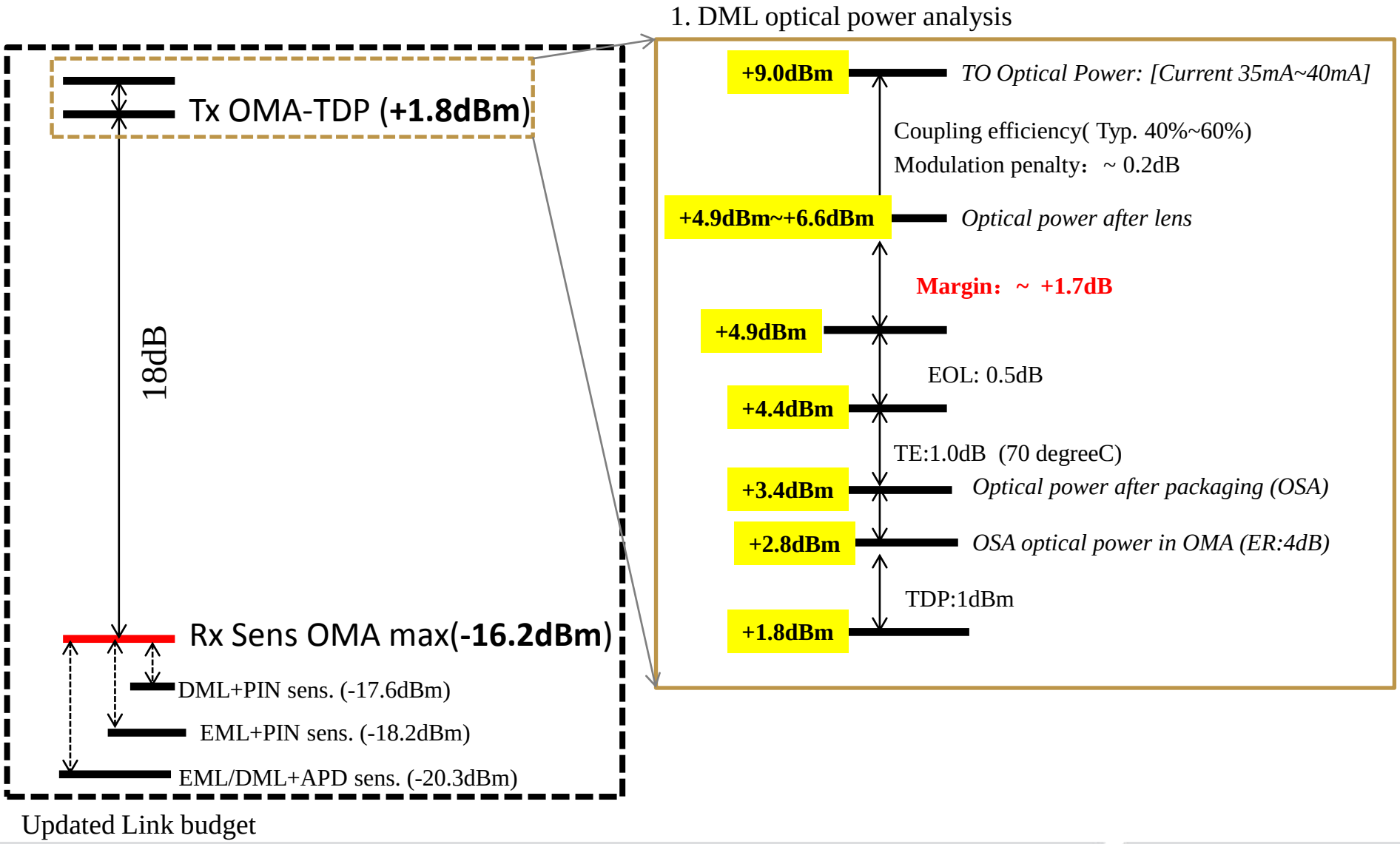
Description	25GBASE-ER (D2.0)	25GBASE-ER (Huawei Proposal)	Unit
Signaling rate (range)	25.78125 ± 100 ppm	25.78125 ± 100 ppm	GBd
Center wavelength (range)	1295 to 1310	1295 to 1310	nm
Side-mode suppression ratio (SMSR), (min)	30	30	dB
Average launch power (max)	6	6	dBm
Average launch powera (min)	-3	-0.2	dBm
Optical Modulation Amplitude (OMA) , (max)	6	6	dBm
Optical Modulation Amplitude (OMA)), (min)	0	2.8	dBm
Launch power in OMA minus TDP (min)	-1	1.8	dBm
Transmitter and dispersion penalty (TDP)), (max)	2.7	2.7	dB
Average launch power of OFF transmitter (max)	-25	-25	dBm
Extinction ratio (min)	4	4	dB
RIN20OMA (max)	-130	-130	dB/Hz
Optical return loss tolerance (max)	20	20	dB
Transmitter reflectancec (max)	-12	-12	dB
Transmitter eye mask definition {X1, X2, X3, Y1, Y2, Y3} Hit ratio 5x10-5 hits per sample.	{0.31, 0.4, 0.45, 0.34, 0.38, 0.4}	{0.31, 0.4, 0.45, 0.34, 0.38, 0.4}	

Receive characteristics

Description	25GBASE-ER (D2.0)	25GBASE-ER (Huawei Proposal)	Unit
Signaling rate (range)	25.78125± 100 ppm	25.78125± 100 ppm	GBd
Center wavelength (range)	1295 to 1325	1295 to 1325	nm
Damage threshold (min)	-3	-3	dBm
Average receive power (max)	-4	-4	dBm
Average receive power (min)	-19.6	-16.8	dBm
Receive power (OMA), (max)	-4	-4	dBm
Receiver reflectance (max)	-26	-26	dBm
Receiver sensitivity (OMA), (max)	-19	~~-16.2~~ -18.2	dBm
Stressed receiver sensitivity (OMA), (max)	-16.5	-13.7	dBm
Conditions of stressed receiver sensitivity test			
Vertical eye closure penalty	1.9	1.9	dB
Stressed eye J2 Jittere	0.27	0.27	UI
Stressed eye J4 Jittere	0.39	0.39	UI
SRS eye mask definition {X1, X2, X3, Y1, Y2, Y3} Hit ratio 5x10-5 hits per sample.	{0.24, 0.5, 0.5, 0.24, 0.24, 0.4}	{0.24, 0.5, 0.5, 0.24, 0.24, 0.4}	

Thank you

The capability of DML



Updated Link budget