Security Level:

Experimental/Simulated results of PIN-based for 25GbE SMF 40Km

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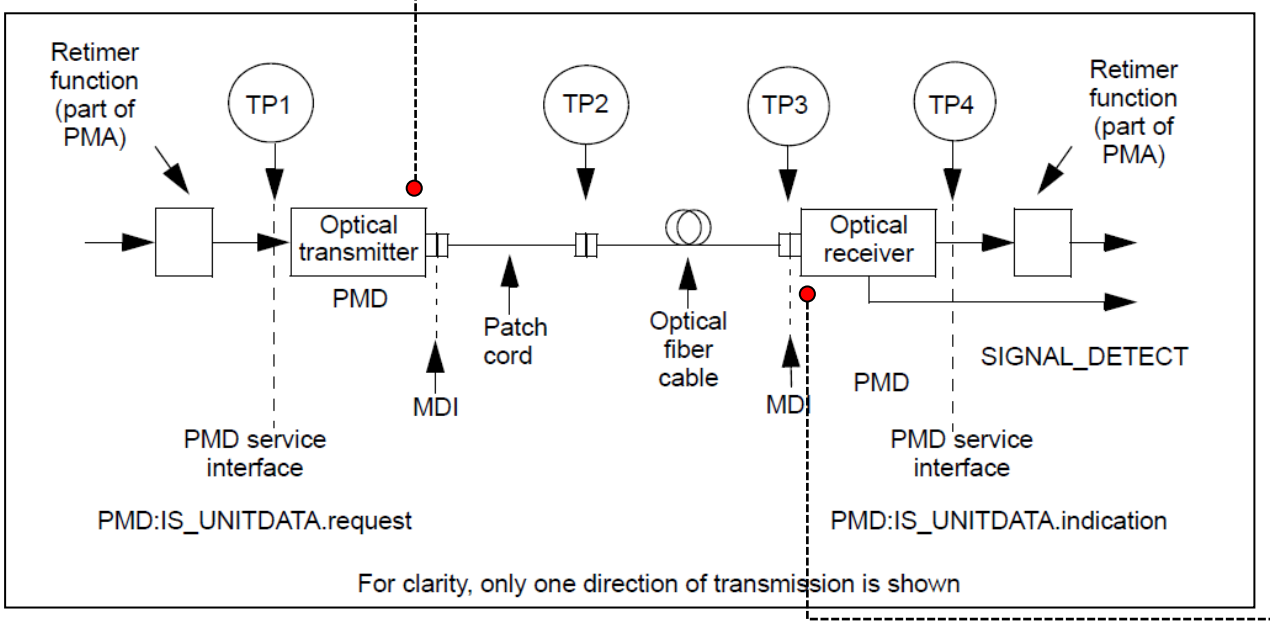
Content

Overview



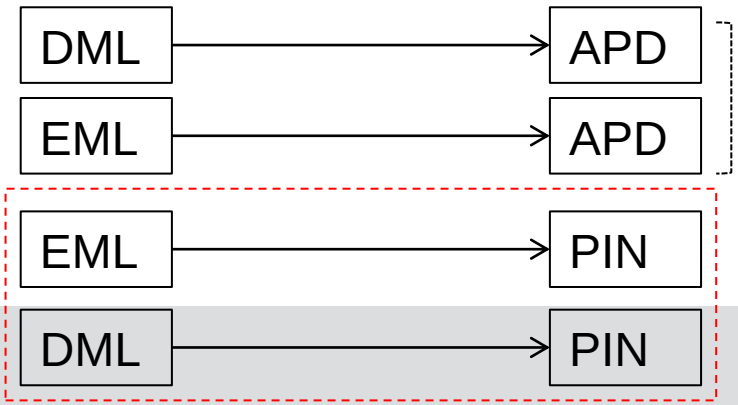
P802.p3cc_D1p1.pdf

- **Tx side:**

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

- **Rx side:**

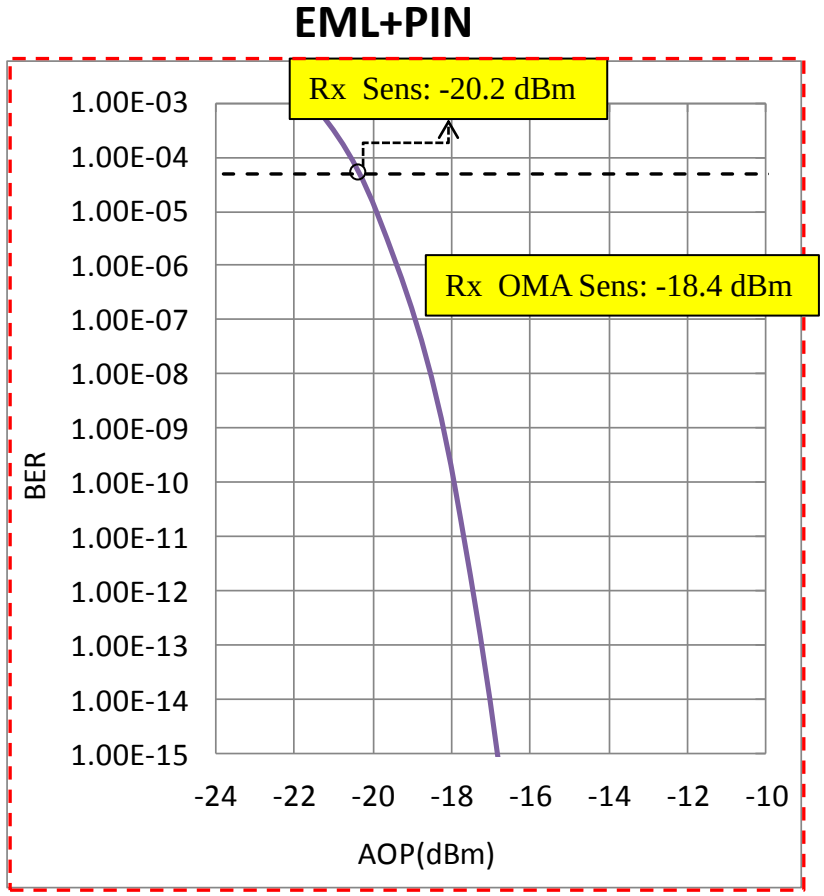
1. Only APD-based Rx has been investigated currently .
2. Lack of experimental results based on PIN

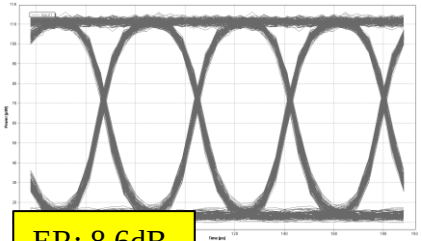


Based on Dr Tamura's proposal, these solutions satisfy link budget of 25G SMF 40Km application.

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

Simulated results of EML+PIN





Key parameters in VPI simulation model

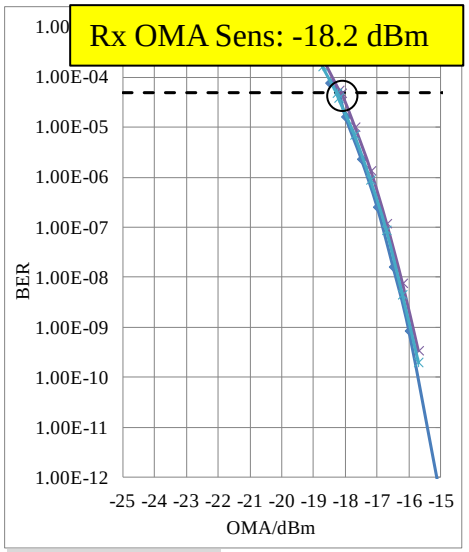
Parameters	Value	Unit
Responsitivity	0.85~0.9	A/W
PhotodiodeModel	PIN	--
DarkCurrent	10~20	nA
Transimpedance	3500	Ohms
Rx Cutoff Frequency	17	GHz

Results from VPI simulation

- We simulated the EML+PIN solution based on VPI.
- The key parameters are from the real devices which are commercially available.
- Based on our simulated results, the Rx AOP sensitivity of PIN+EML is about -20.2dBm (ER:8.6dB).

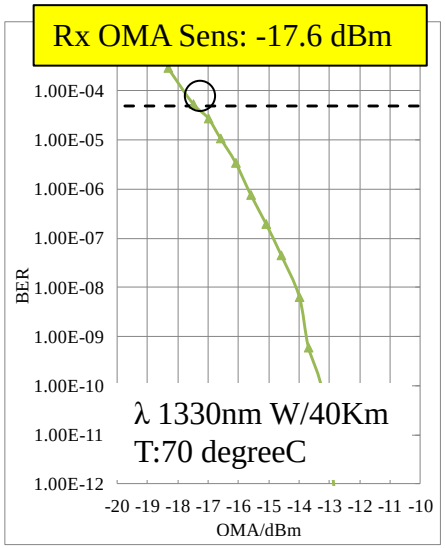
Experimental results

EML+PIN



ER≈10dB

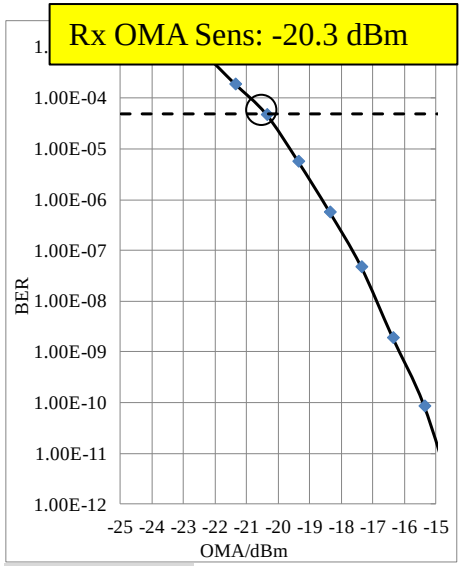
DML+PIN



ER≈4dB

Results from HUAWEI

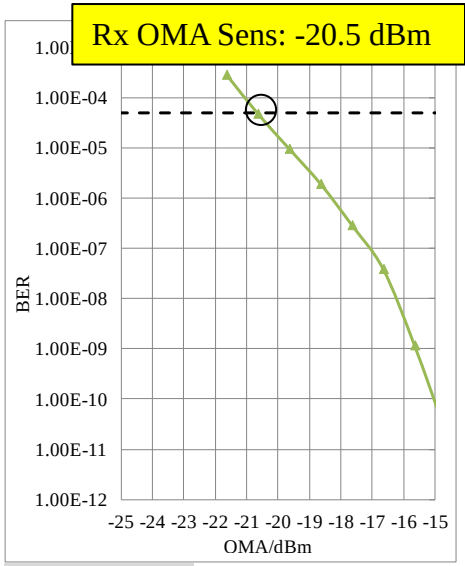
EML+APD



ER≈8dB

Data from Tamura_160314e_40Km_25GSMF.pdf

DML+APD

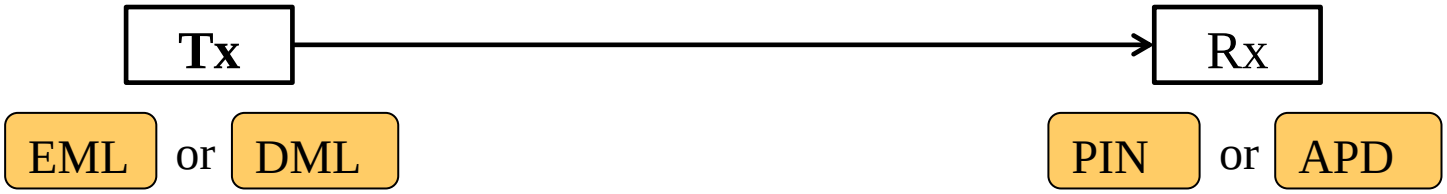


ER≈4dB

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.

Why does PIN-based solution need to be considered (economic analysis)



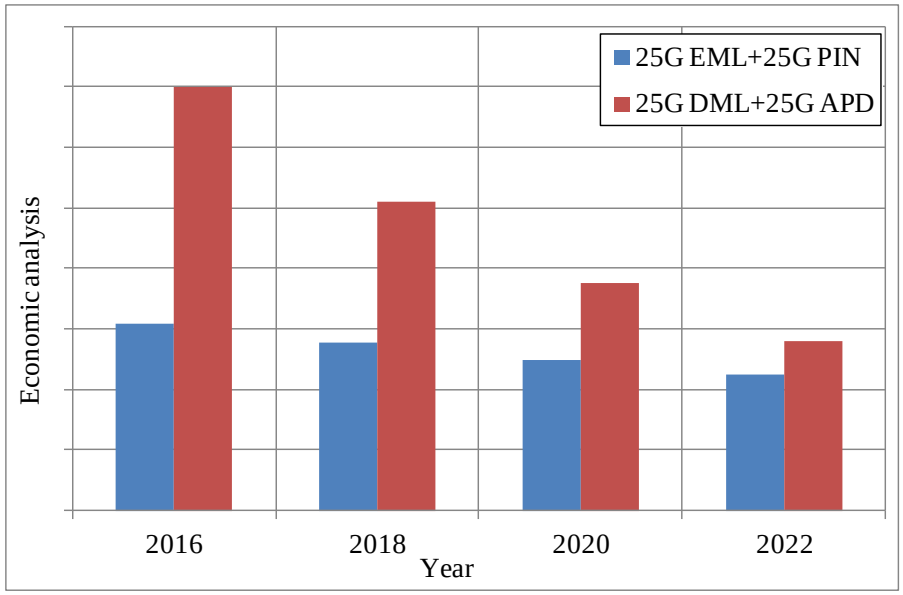
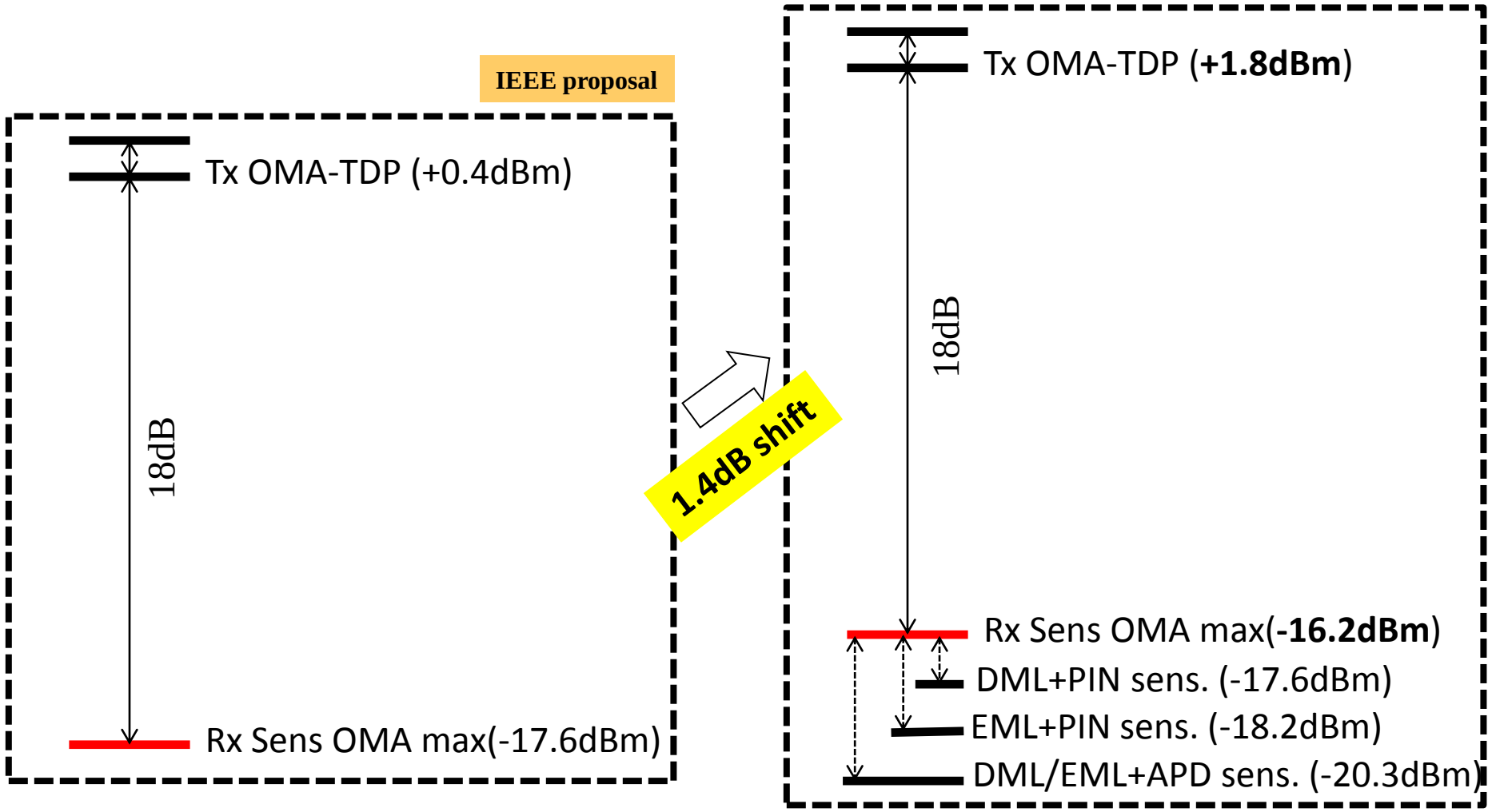


Fig.1 System economic comparison

- For Tx side， two alternatives could be chosen, i.e., EML and DML. EML has 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 aware the cost difference between APD and PIN is very large currently or even in the future . It is more economical to use PIN-based solution if possible.
- To balance cost between Tx side and Rx side which is shown in the left figure, it is better to give priority to select PIN-based solution if the BER performance of PIN satisfies 25G SMF 40Km application.

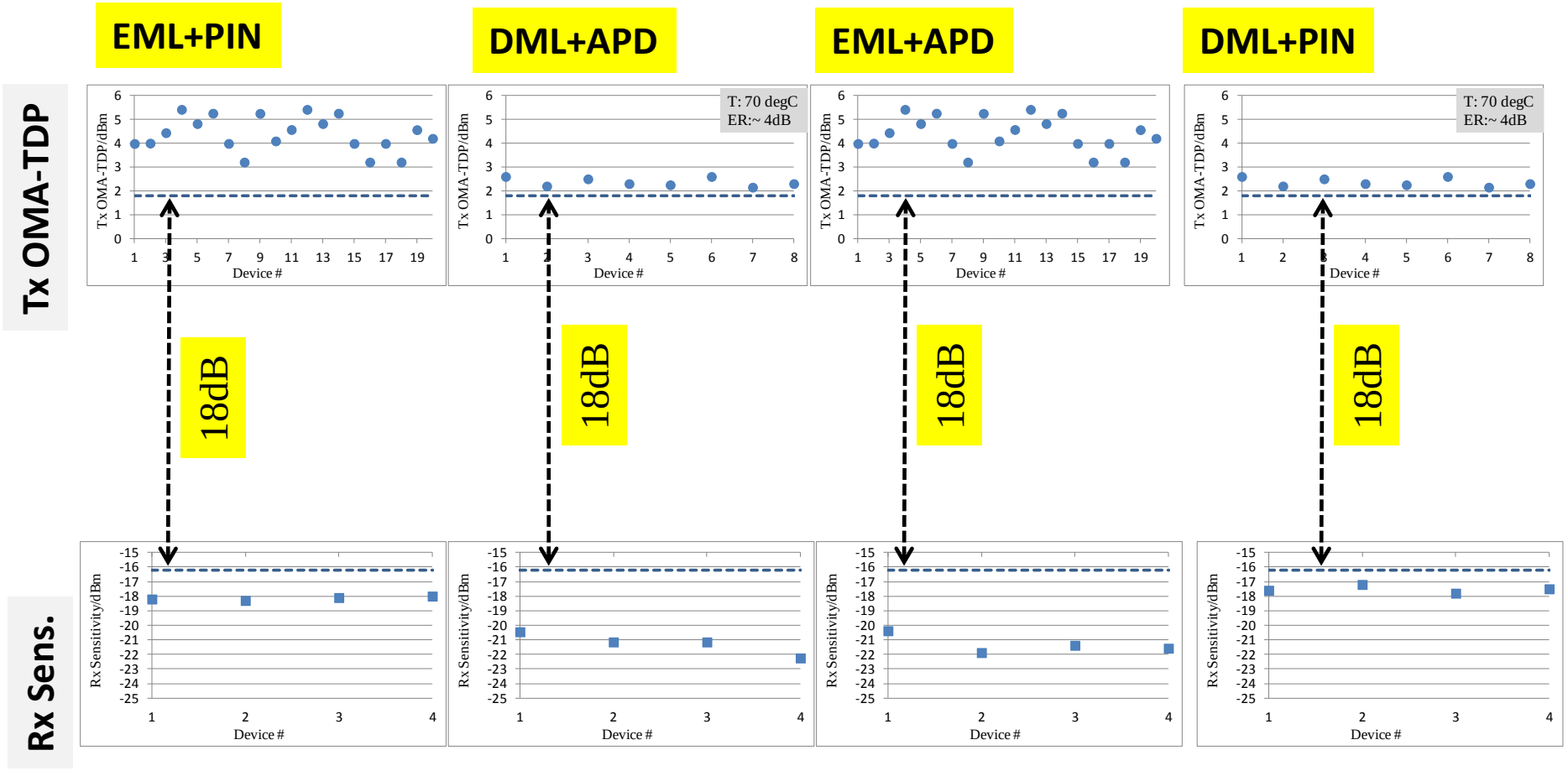
Update of Link budget(25GE SMF 40Km)



Benefits:

1. If we shift up **1.4dB** in the link budget, both PIN and APD have the opportunity to achieve 25GE SMF 40Km
2. We have more selections for both Tx side and Rx side, i.e, EML+APD/ DML+APD/ EML+PIN even DML+PIN could be used for 25G SMF 40Km.
3. It is the best choice based on current and future technological state of the art.

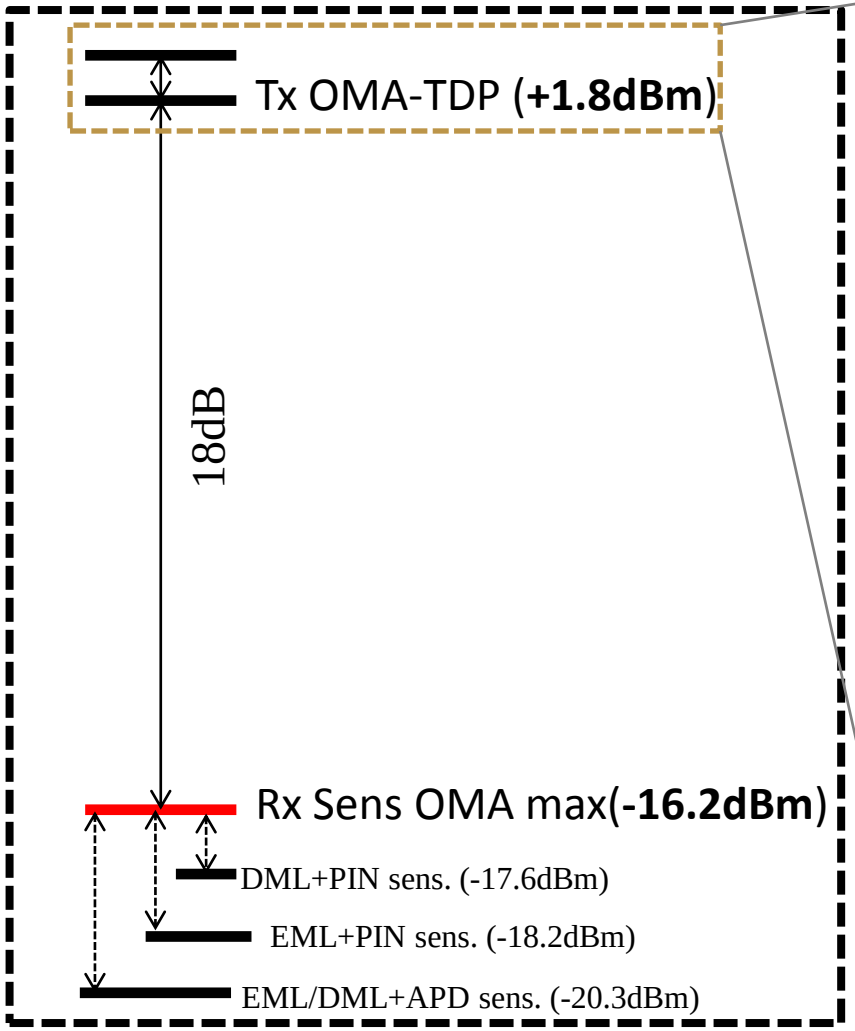
System Reliability



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

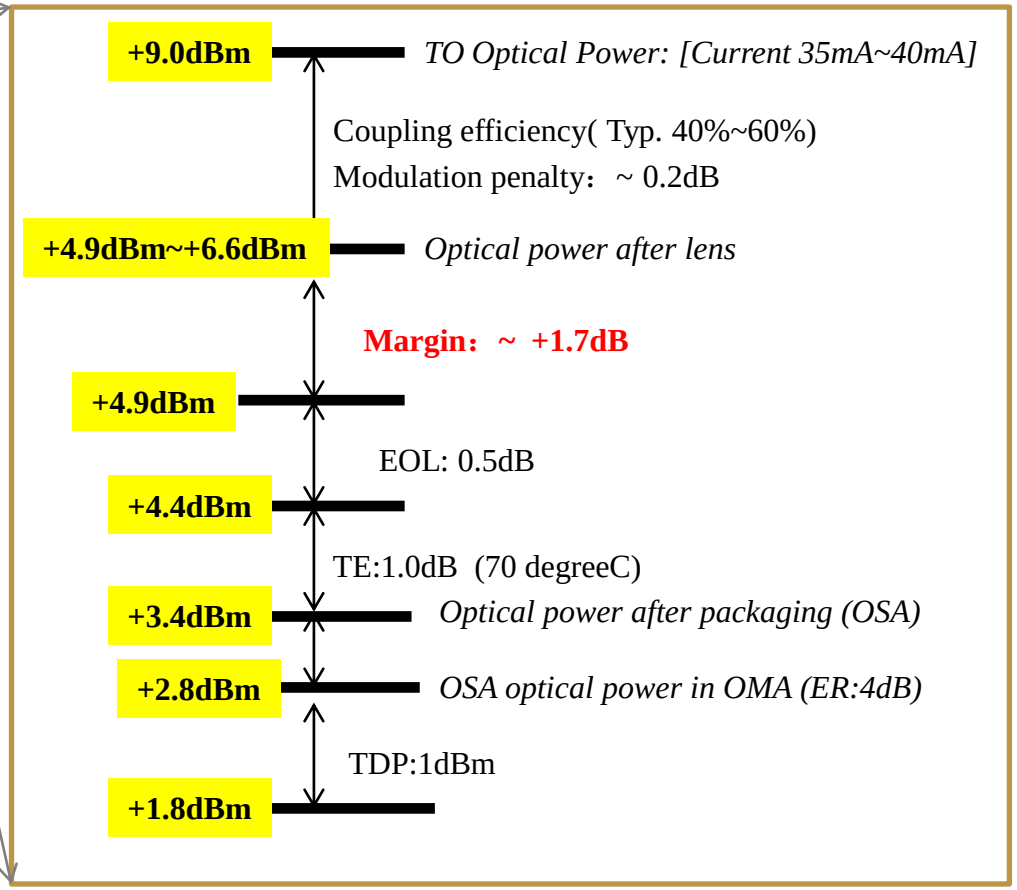
1. Based on **EML+PIN** solution, it is at least 1.0dB margin on Tx side and at least 2.0dB margin on Rx side.
2. Based on **DML+APD** solution, the margin on Tx side is limited but the Tx power is large enough for 40Km scenario. And the DML optical power can be increased by many technological methods.
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 also satisfies the 18dB requirement.

The capability of DML



Updated Link budget

1. DML optical power analysis



2. For EML devices, there are very large margin for optical power, which is shown before.

Conclusions

- In this proposal, we have experimentally demonstrated that EML+PIN and DML+PIN are reliable for 25G SMF 40Km;
- To obtain economic solution, we suggest to add PIN solution as a alternative in Rx side for 25G SMF 40Km;
- We suggest that link budget of SMF 40Km is slightly changed, i.e. shift up 1.4dB and suitable for all the four solutions, i.e. EML/DML+PIN, EML/DML+APD.

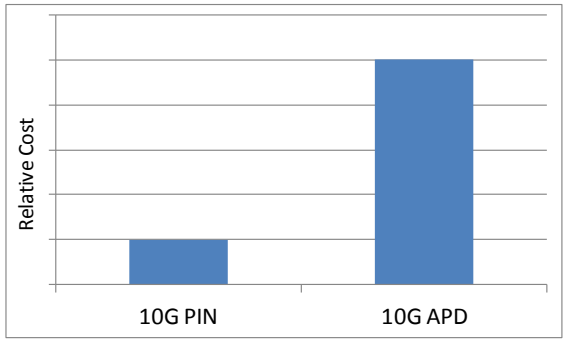
Thank you

Reference: 10GBASE-E solution selection

Table 52–17—10GBASE-E receive characteristics

Description	10GBASE-E	Unit
Signaling speed (nominal) 10GBASE-ER 10GBASE-EW	 10.3125 9.95328	GBd
Signaling speed variation from nominal (max)	± 100	ppm
Center wavelength (range)	1530 to 1565	nm
Average receive power (max)	–1.0	dBm
Average receive power[a] (min)	–15.8	dBm
Maximum receive power (for damage)	4.0	dBm
Receiver sensitivity (max) in OMA[b]	0.039 (–14.1)	mW (dBm)
Receiver Reflectance (max)	–26	dB
Stressed receiver sensitivity (max) in OMA[c,d]	0.074 (-11.3)	mW (dBm)
Vertical eye closure penalty[e] (min)	2.7	dB
Stressed eye jitter (min)[f]	0.3	UI pk-pk
Receive electrical 3 dB upper cutoff frequency (max)	12.3	GHz

Rx Sens OMA is -14.1dBm.



Economic consideration

EML → **PIN** Rx Sens. : ~ -17.0dBm

DML → **APD** Rx Sens. : ~ -23.0dBm

1. For 10G BASE-E, the receiver sensitivity is set to -14.1dBm in Std
2. Test result: DML+APD-based is -23.dBm, EML+PIN is -17dBm， DML+PIN is -13dBm).
3. Economic consideration: 10G PIN is more mature than 10G APD. The mass production is more economic.
4. EML+PIN solution is selected as the only solution for 10GBASE-E.

25GBASE-LR and 25GBASE-ER transmit characteristics

Description	25GBASE-LR	25GBASE-ER	Unit
Signaling rate (range)	25.78125 ± 100 ppm		GBd
Center wavelength (range)	1295 to 1325	1295 to 1310	nm
Side-mode suppression ratio (SMSR), (min)	30		dB
Average launch power (max)	2	6	dBm
Average launch powera (min)	-7	-0.2	dBm
Optical Modulation Amplitude (OMA)), (max)	2.2	6	dBm
Optical Modulation Amplitude (OMA)), (min)	-4	2.8	dBm
Launch power in OMA minus TDP (min)	-5	1.8	dBm
Transmitter and dispersion penalty (TDP)), (max)	2.7	2.7	dB
Average launch power of OFF transmitter (max)	-30		dBm
Extinction ratio (min)	3.5	4	dB
RIN20OMA (max)	-130		dB/Hz
Optical return loss tolerance (max)	20		dB
Transmitter reflectancec (max)	-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}		

25GBASE-LR and 25GBASE-ER receive characteristics

Description	25GBASE-LR	25GBASE-ER	Unit
Signaling rate (range)	25.78125 ± 100 ppm		GBd
Center wavelength (range)	1295 to 1325 nm		nm
Damage thresholda (min)	5.5	TBD	dBm
Average receive power (max)	2	-5	dBm
Average receive power (min)	-13.3	-18.2	dBm
Receive power (OMA)), (max)	2.2	-5	dBm
Receiver reflectance (max) –26 dB	-26		dB
Receiver sensitivity (OMA)), (max)	-11.3	-16.2	dBm
Stressed receiver sensitivity (OMA)), (max)	-8.8	TBD	dBm
Vertical eye closure penaltye	-1.9	TBD	dB
Stressed eye J2 Jittere	0.27	TBD	UI
Stressed eye J4 Jittere	0.39	TBD	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}	TBD	