Feasibility for 10km SMF PMD

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Supporters and Contributors

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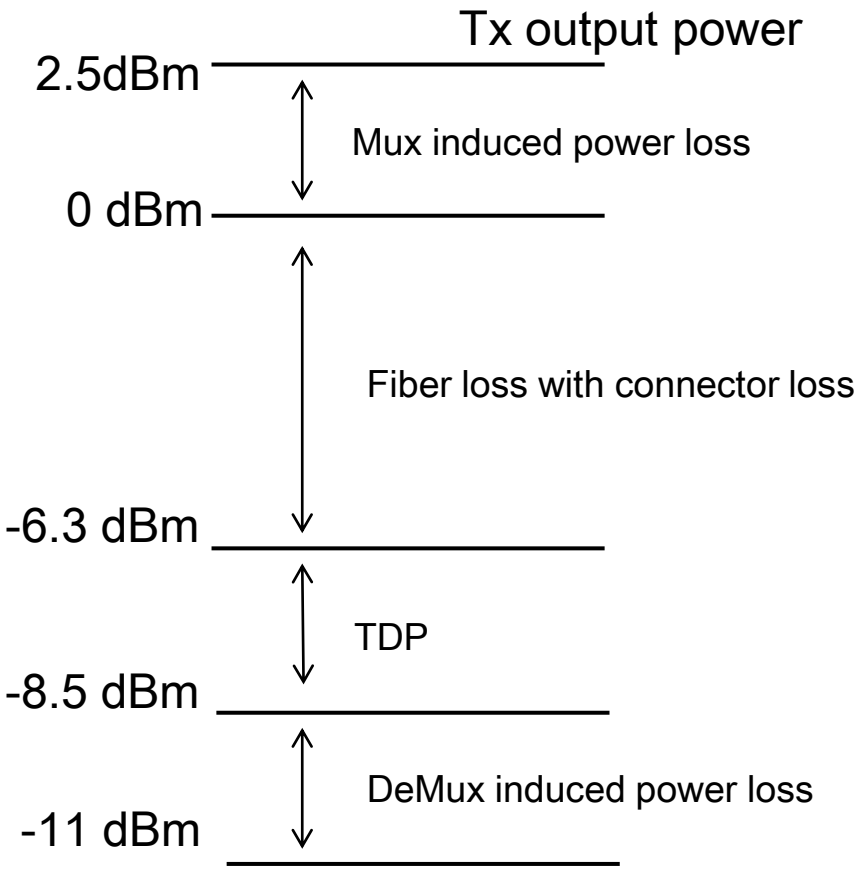
Background

- At the Nov 2013 meeting we have adopted several objectives to provide physical layer specifications which support link distances of :
  - At least 100 m over MMF
  - At least 500 m over SMF
  - At least 2 km over SMF
  - At least 10 km over SMF
- At this meeting some presentations clarified the market potential of the 10km SMF application field.
- This presentation provides some further results from investigations to support the technical feasibility of the 10km SMF objective.

Information

- Several techniques have been mentioned for the 10km SMF application, based on BJ's FEC and the 802.3ba Link Budget for 100GBASE-LR4
- This presentation is focusing on the 8*50G PAM4 configuration
- According to our test results 10km transmission can be achieved even based on state-of-the-art components and techniques.
- There are lot of topics for future study which we will continue to work on.

Power Budget Analysis



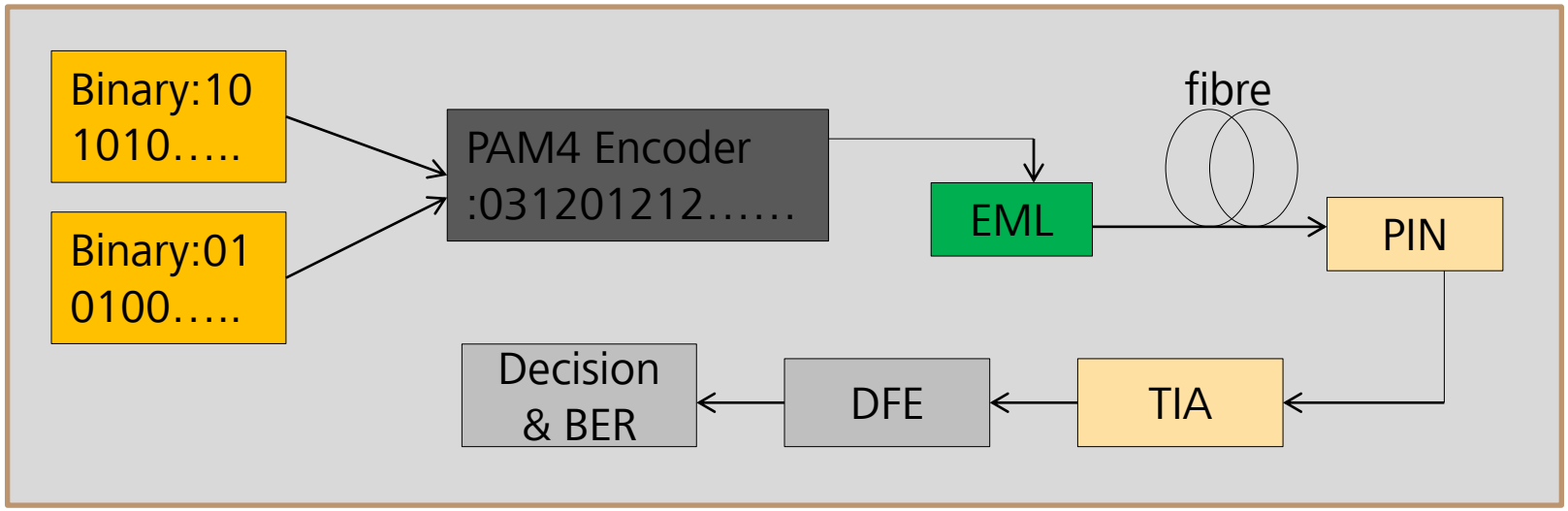
Parameter	100GBASE-LR4	100GBASE-ER4		Unit
Power budget (for maximum TDP)	8.5	—		dB
Power budget	—	21.5		dB
Operating distance	10	30	40[a]	km
Channel insertion loss	6.3[b]	15	18	dB
Maximum discrete reflectance	–26	–26		dB
Allocation for penalties[c] (for maximum TDP)	2.2	—		dB
Allocation for penalties[c]	—	3.5		
Additional insertion loss allowed	0	3	0	dB

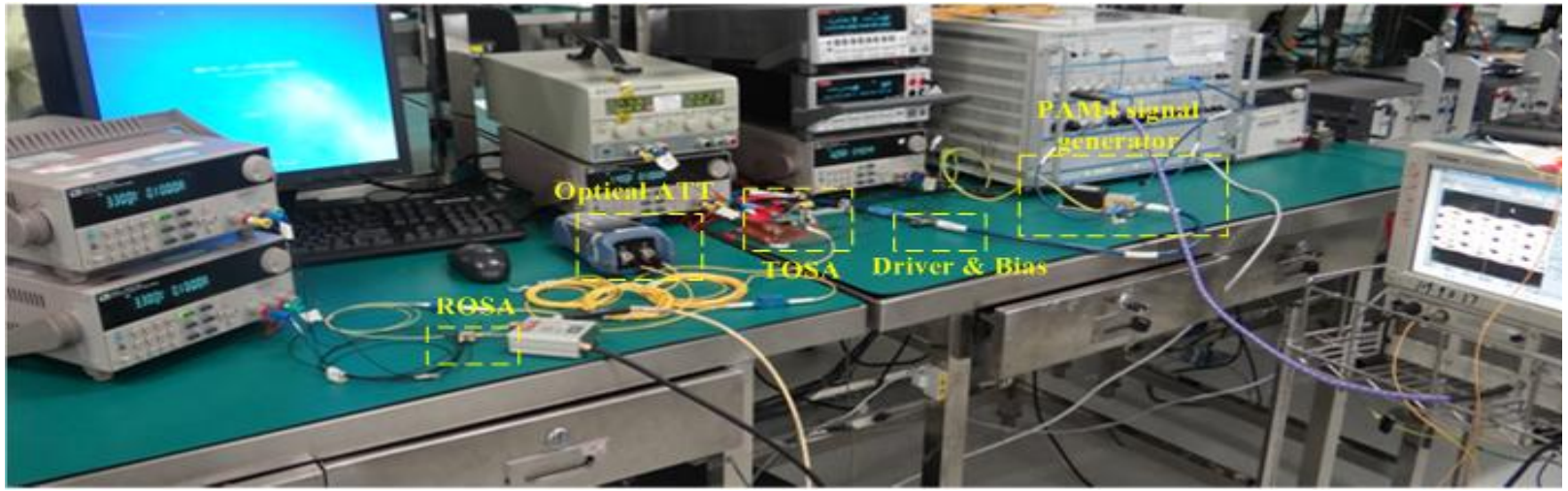
[a]Links longer than 30 km are considered engineered links. Attenuation for such links needs to be less than the worst case for B1.1, B1.3, or B6_A single-mode cabled optical fiber
[b]The channel insertion loss is calculated using the maximum distance specified in Table 88–6 for 100GBASE–LR4 and fiber attenuation of 0.43 dB/km at 1295 nm plus an allocation for connection and splice loss given in 88.11.2.1.
[c]Link penalties are used for link budget calculations. They are not requirements and are not meant to be tested.

Notes:

1. This is a first rough power budget for our FIRST STEP test.
2. We will study an appropriate value for mux/demux loss.

Test Setup

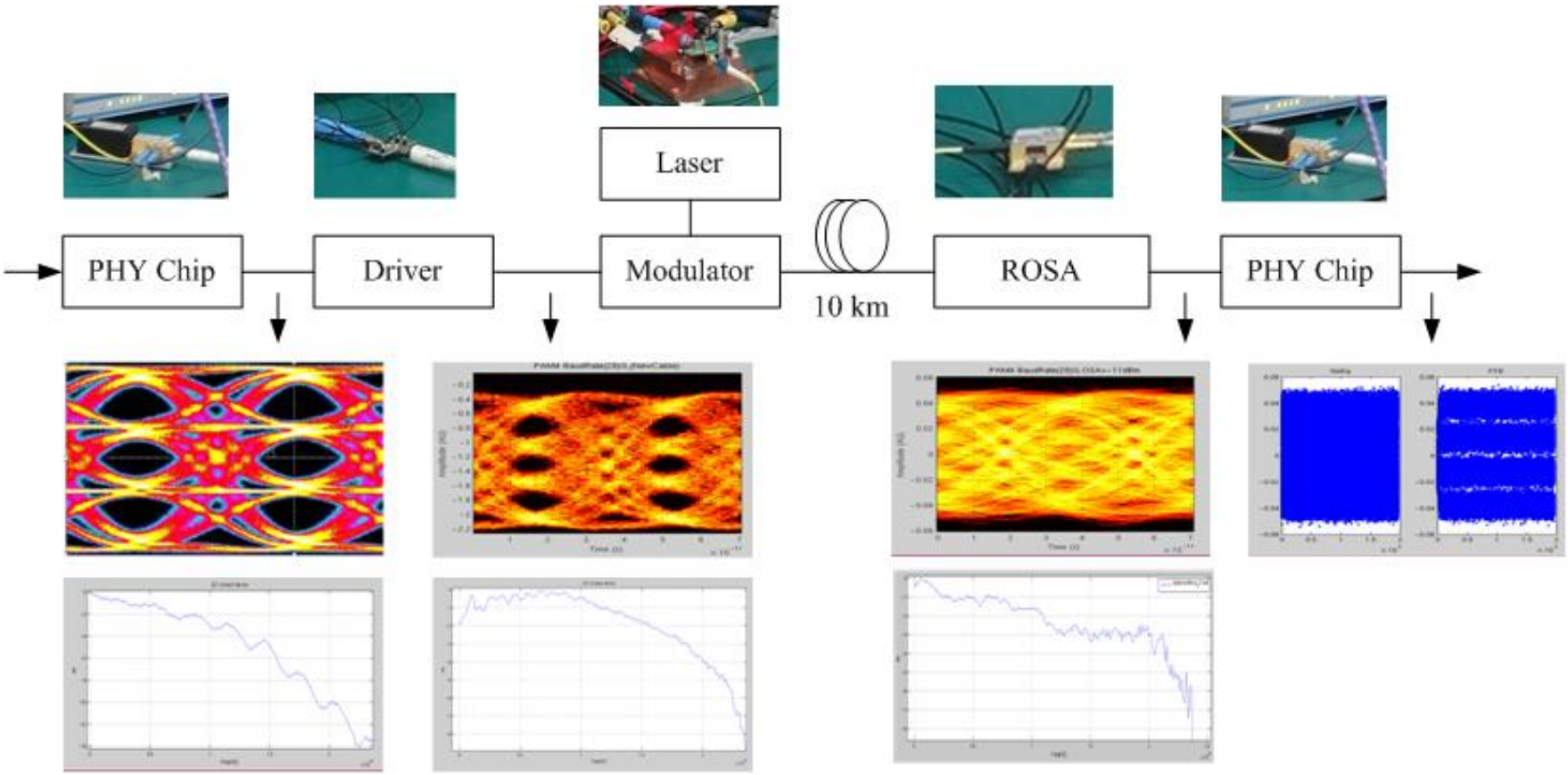

Binary:10
1010…..
Binary:01
0100…..
PAM4 Encoder
:031201212……
EML
fibre
PIN
TIA
DFE
Decision
& BER


PAM4 signal generator
Optical ATT
TOSA
Driver & Bias
ROSA

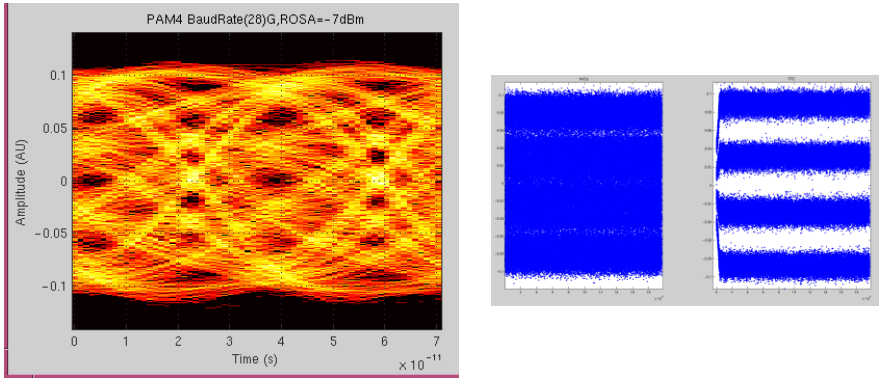
Test Environment

Parameters		Simulation	Test Environment
Rate	Baud rate	28Gbaud/s	28Gbaud/s
TOSA	wavelength	1309.14nm	1304.762nm
	Bandwidth	18.75GHz	17GHz
	TOSA RIN	-141dB	-135dB
	Extinction ratio	10dB	9dB
DAC + Driver	DAC bandwidth	18.75GGHz	13GHz
	DAC output SNR	21~23dB	18dB
	Driver Bandwidth	18.75GHz	18GHz
ROSA	ROSA Bandwidth	18.75GHz	20GHz
	PIN responsibility and noise	0.8A/W，20nA	0.45A/W，10nA
	TIA noise	17.6pA/sqrt(Hz)@20GHz	19pA/sqrt(Hz)@20GHz
	TIA resistance	5000Ω	3550Ω
Fiber	Fiber loss	0.43dB/km	
	Fiber dispersion	1.44ps/nm.km	
8λ optical MUX/DEMUX	Loss and channel spacing	2.5dB, 800GHz/Channel	

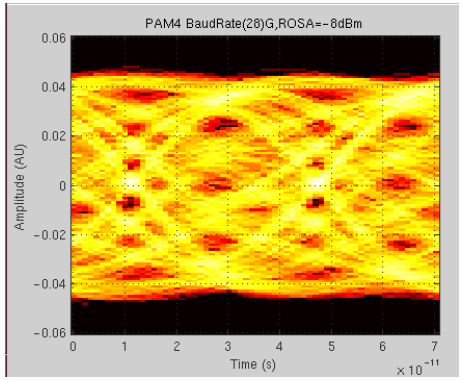
Setup & Eye Diagram

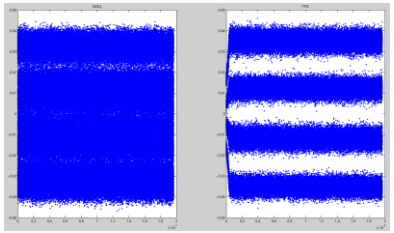


Test Result - Eye Diagram

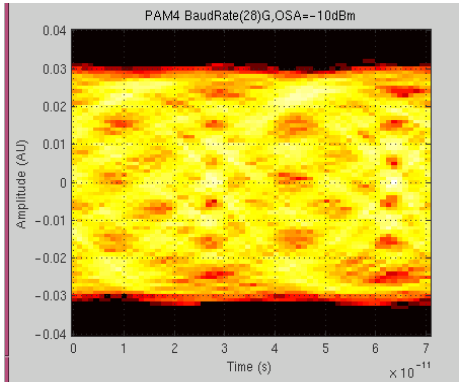


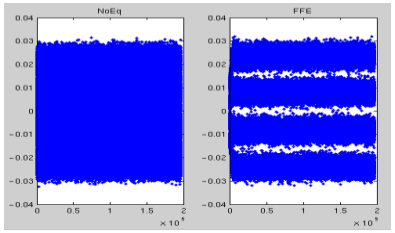
Eye Diagram received and analyzed at ROP -7dBm



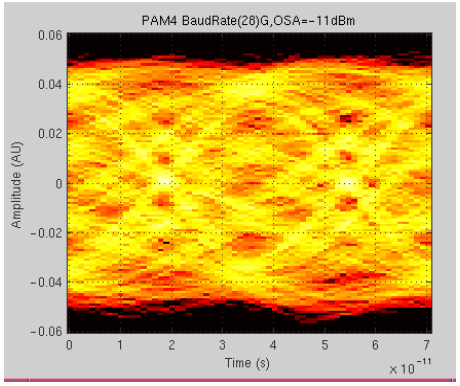


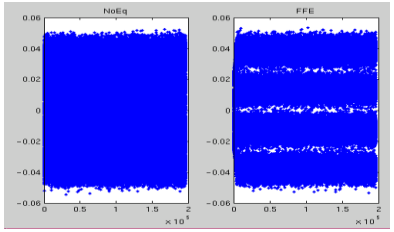
Eye Diagram received and analyzed at ROP -8dBm





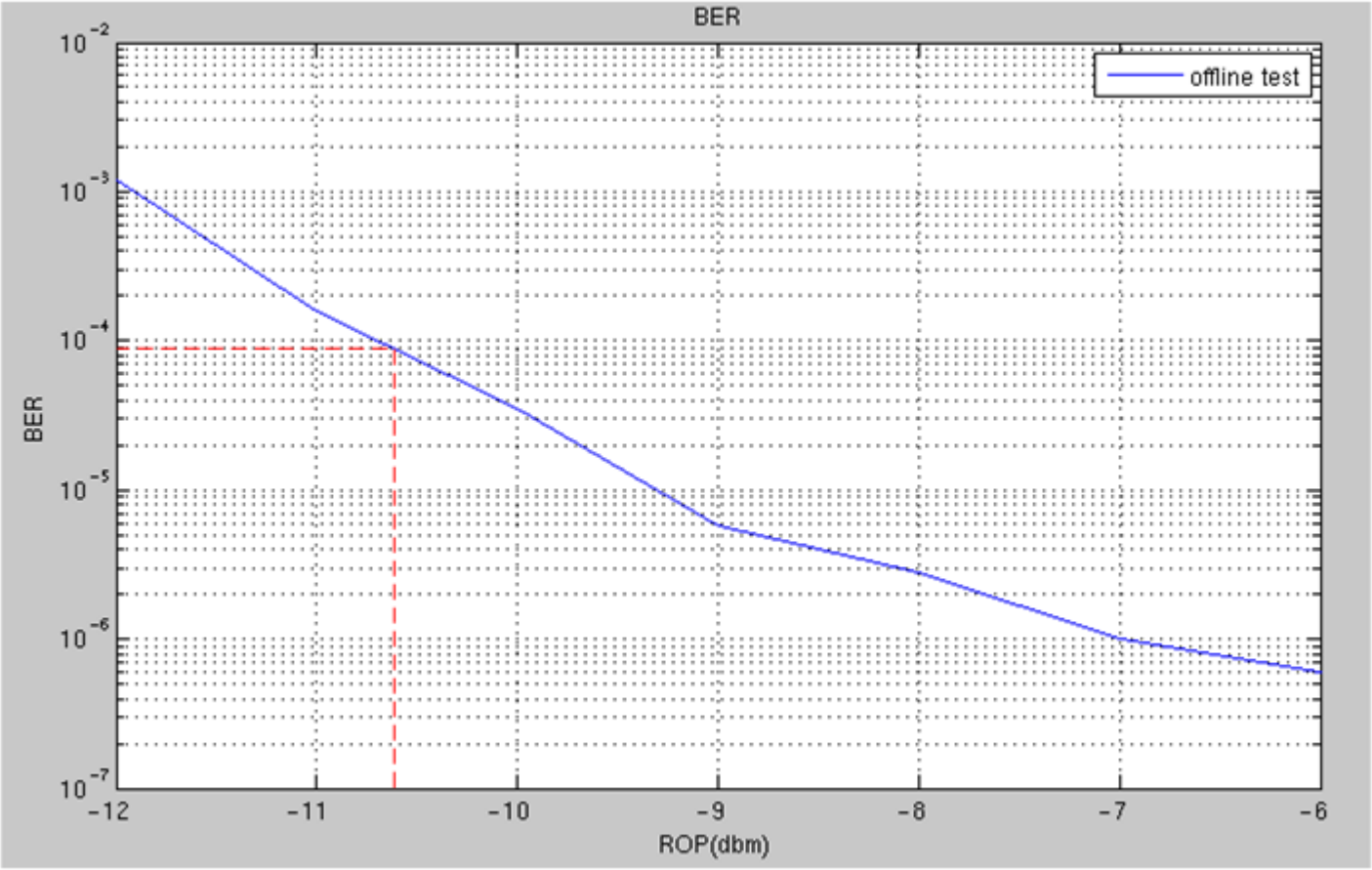
Eye Diagram received and analyzed at ROP -10dBm





Eye Diagram received and analyzed at ROP -11dBm

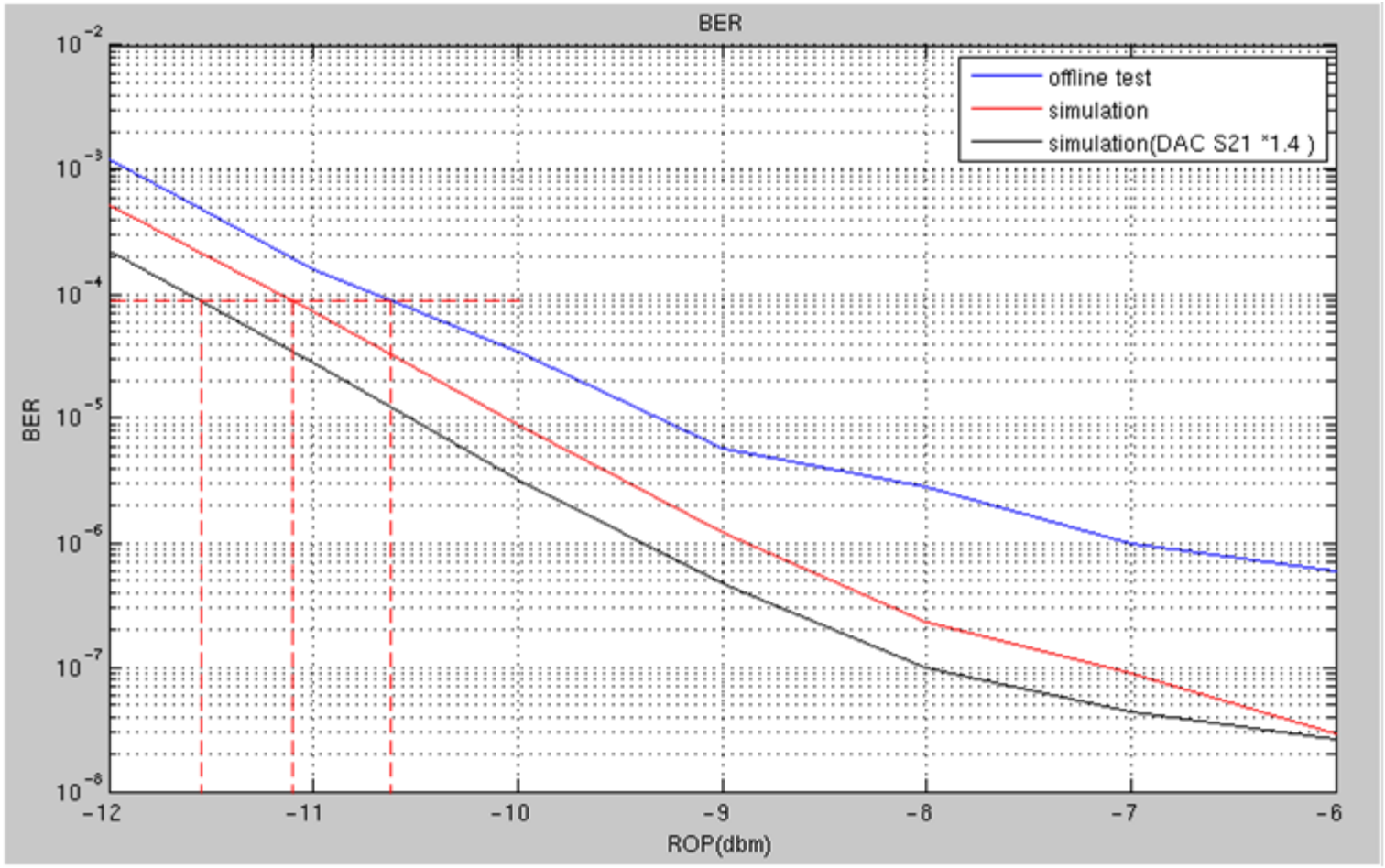
Test Result – BER



- ROP is the optical power received after DeMux.
- At -10.6dBm ROP, BER can achieve to 9e-5; under BJ FEC, will satisfy BER requirement of 10^-13.

Simulation Result

- The performance can be improved by increasing DAC bandwidth to 18GHz.



Summary

- From the test and simulation result, we can see that under current situation, a distance of 10km on SMF is feasible with a 8x50G PAM4 approach.
- We will continue to study this topic and there are several key parameters that should be improved:
  - DAC bandwidth, can be improved from 13GHz to at least 18GHz which will benefit the performance.
  - Use a high speed cable (between PHY chips with driver, driver with modulator, ROSA with PHY chip and so on)
  - Linearity and the bandwidth improvement of the TOSA/receiver
- There are also some effects of the system that should be studied later:
  - MPI Analysis
  - TDP effect and so on
- Except for PAM4, we will also work on the feasibility of other techniques like NRZ and DMT and we would like to invite who ever interested in this topic to share information.

Thank You