Proposal for Some Baseline Specification of Bidirectional 10&40km Optical PHY for 50GbE

Jialong Shuai, Yu Xu, Xinyuan Wang
Huawei Technologies
Dechao Zhang, Dong Wang
China Mobile

IEEE P802.3cp Task Force, Indianapolis, September 2019

Revisit CFI for Bidirectional 50Gb/s Optical Access PHYs

- During IEEE 802 July plenary meeting , "Bidirectional 50Gb/s optical access PHYs call for interest" is discussed from 5G Mobile network application perspective as:
  - In the past, the IEEE 802.3 Ethernet Working Group has standardized bidirectional optical PHYs running at 100Mb/s and 1Gb/s over one single mode fiber, that are intended for optical access applications. Presently, the bidirectional 10 Gb/s and 25 Gb/s Optical Access PHYs Study Group has started. In the near future, due to the high bandwidth requirement of 5G mobile networks, bidirectional links running at 50 Gb/s will be needed. This Call for Interest is to assess the support for the formation of a study group to explore the development of 50Gb/s bidirectional optical access PHYs.
- This application and technical requirement is supported by several Carriers, Telefonica, China Mobile, China Telecom, etc at Application and Technical Feasibility to Support Bidirectional 10&40 km Optical PHY for 50GbE on Spokane meeting at 2018.

Fiber Reach in 5G Mobile Network for 50GbE BiDi PHYs

- **For Fronthaul,** latency from REC to RE limit the acceptable fiber length, 10km to 20km is observed in centralized RAN (C-RAN).See: https://www.exfo.com/en/resources/blog/preparing-transport-network-for-5g/

- As potential relaxed latency requirement for fronthaul, extend reach is possible as for large scale Geographical area:

Table 1A Split E and splits I_D, II_D, I_U Latency classes for CoS 'High'

Latency Class	Maximum One-way Frame Delay Performance (see section Error! Reference source not found.)	Use case
High25	25 µs	Ultra-low latency performance
High100	100 µs	For full E-UTRA or NR performance
High200	200 µs	For installations where the lengths of fiber links are in the 40 km range
High500	500 µs	Large latency installations

http://www.ieee802.org/1/files/public/docs2018/cm-mustala-eCPRI-update-0718.pdf

- **For Backhaul**, from huang_ecdc_01_0716 of China Mobile, 10GbE with 10km and 40km reach is most popular deployed

Present status and forecast

• According to our survey, long distance module is a mandatory requirement for us

Statistics for 10GE & 100GE Modules used in PTN, as of June, 2016				
Transmission Distance	**<2km**	**10km**	**40km**	**80km**
10GE distribution	0.28%	44.46%	44.05%	11.20%
100GE distribution (more than 15K modules)	0	56.43%	34.59%	8.97%

Reference of Duplex Fiber Link Loss for Mobile Network Application

- Reference to Clause 139: for 50GBASE-LR(Ratified), for 50GBASE-ER(D3.1):

Table 139–12—Fiber optic cabling (channel) characteristics

Description	50GBASE-FR	50GBASE-LR	50GBASE-ER		Unit
Operating distance (max)	2	10	30	40	km
Channel insertion loss[a, b] (max)	4	6.3	18	18	dB
Channel insertion loss (min)	0	0	10[c]		dB
Positive dispersion[b] (max)	3.2	16	48	64	ps/nm
Negative dispersion[b] (min)	–3.7	–18.6	–56	–74	ps/nm
DGD_max[d]	3	8	10.3		ps
Optical return loss (min)	25	22	19		dB

[a]These channel insertion loss values include cable, connectors, and splices.
[b]Over the wavelength range 1304.5 nm to 1317.5 nm for 50GBASE-FR, ~~and~~ 50GBASE-LR, and 50GBASE-ER.
[c]Channel insertion loss (min) may be implemented with an optical attenuator.
[d]Differential Group Delay (DGD) is the time difference at reception between the fractions of a pulse that were transmitted in the two principal states of polarization of an optical signal. DGD_max is the maximum differential group delay that the system must tolerate.

Further Information on Wavelength Choice Needed

- 50GBIDI baseline Proposal including wavelength plans have been presented on January in Long Beach.
- Except operating wavelength and TDECQ, the optical transmitter and receiver characteristics of 50GBASE-BLR (50Gb/s over 10km) and 50GBASE-BER (50Gb/s over 40km) using the existing 50GBASE-LR and 50GBASE-ER specs have been adopted on May in Salt Lake City.

Motion on 50Gb/s BIDI over 10km

Motion # 3
Move to use the existing 10GBASE-LR, 25GBASE-LR, and 50GBASE-LR optical Tx and Rx characteristics for the 10GBASE-BLR, 25GBASE-BLR, and 50GBASE-BLR optical Tx and Rx characteristics (tables 158-12, -13; 159-6, -7; 160-6, -7) with the exception of operating wavelength, and with the caveat that TDP/TDEC(Q) will need to be re-evaluated.
Moved: Frank Effenberger Second: Vince Ferretti
For: 8 Against: 0 Abstain: 0
Technical (≥ 75%) Motion Passed

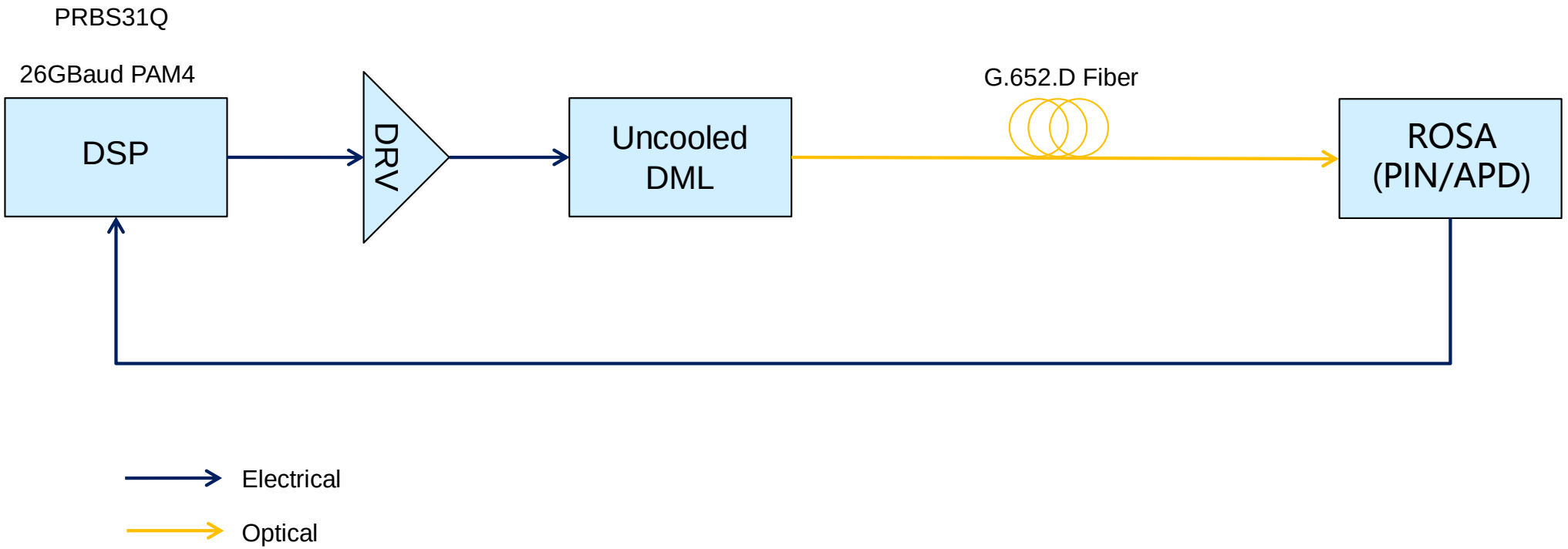
Motion on 50Gb/s BIDI over 40km

Motion # 4
Move to use the existing 10GBASE-ER, 25GBASE-ER, and 50GBASE-ER optical Tx and Rx characteristics for the 10GBASE-BER, 25GBASE-BER, and 50GBASE-BER optical Tx and Rx characteristics (tables 158-12, -13; 159-6, -7; 160-6, -7) with the exception of operating wavelength, and with the caveat that TDP/TDEC(Q) will need to be re-evaluated.
Moved: Frank Effenberger Second: Han Hyub Lee
For: 8 Against: 0 Abstain: 0
Technical (≥ 75%) Motion Passed

- The wavelength choices for 50Gbps BIDI PHY need further information by simulation and measurement results.

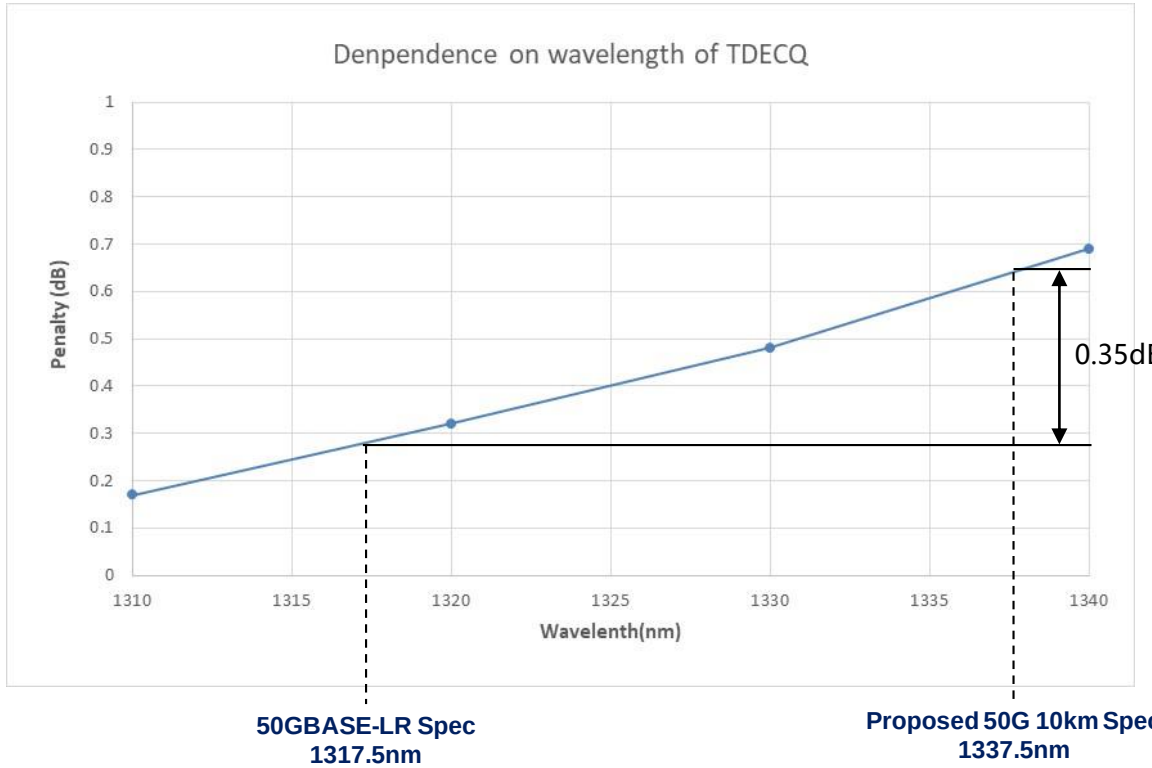
Test Setup for Wavelength Investigation

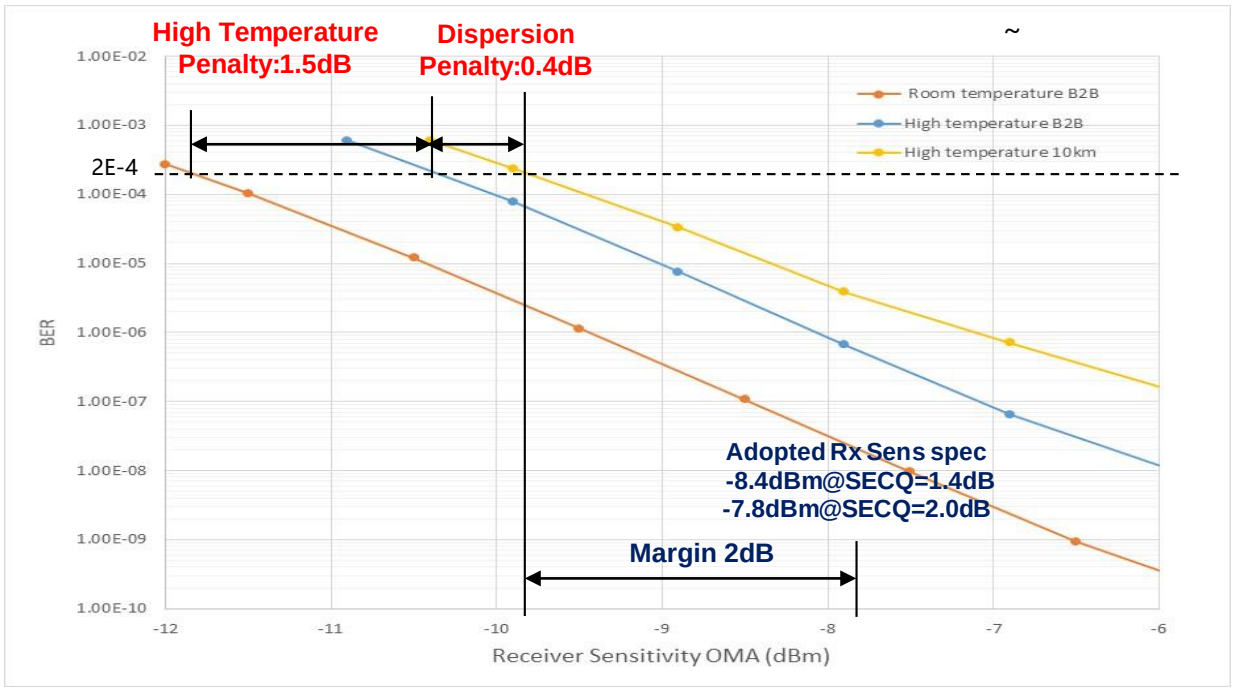
- The BER online tests were done in room and high temperature.



Test Result of 50Gb/s PAM4 over 10km

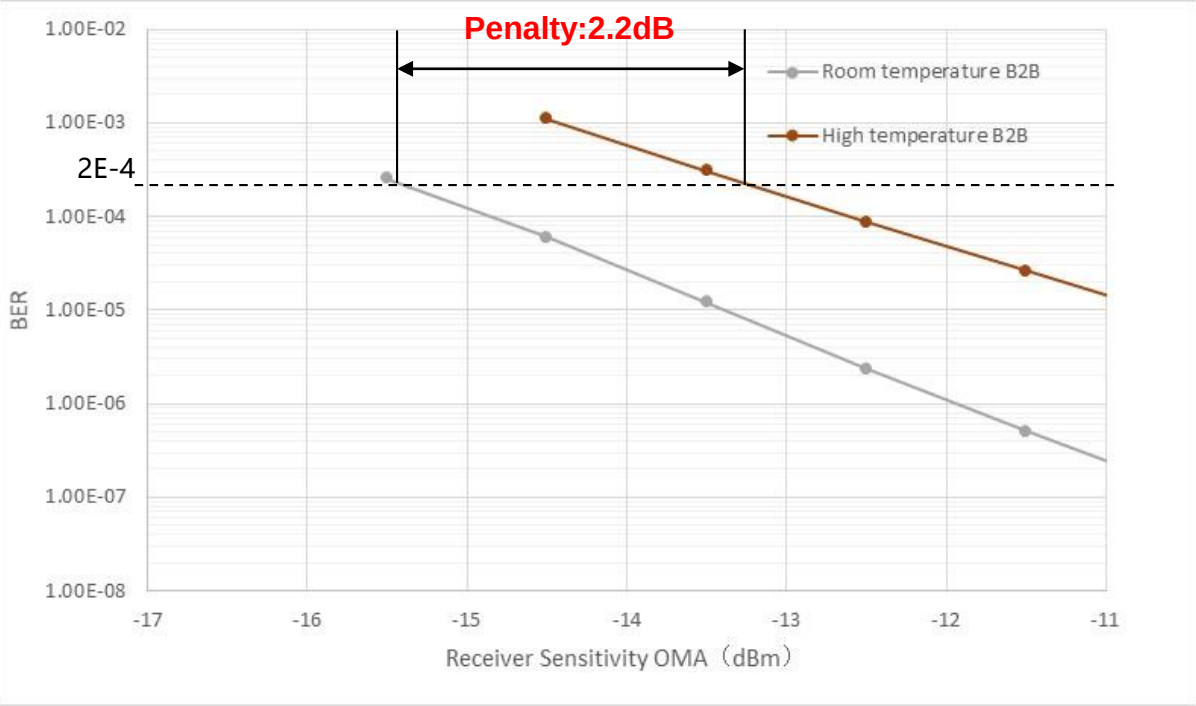
- With the measured chirp, it was found that the simulated dispersion penalty of 50Gb/s PAM4 over 10km based on DML is increased by 0.35dB when the wavelength is expanded from 1317.5nm to 1337.5nm,
- Given the adopted 50GBASE-BLR baseline spec, receiver sensitivity measurements show that there have 2dB margin by using 1330nm DML over 10km positive dispersion fiber.
  - The measured dispersion penalty is about 0.4dB, which is similar with simulation result.
  - The measured penalty introduced by high temperature is about 1.5dB.

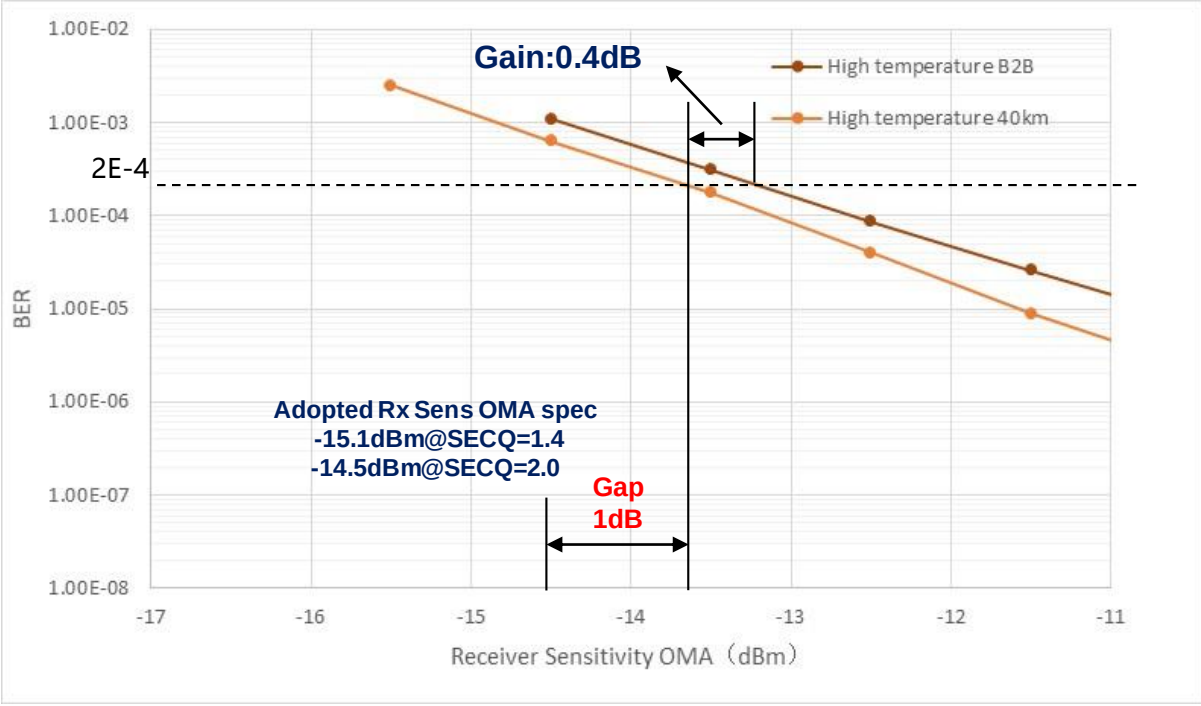




Test Result of 50Gb/s PAM4 over 40km

- The measurement results show that the link budget of 50Gb/s PAM4 over 40km can not be closed by using 1270nm DML and APD.
  - The penalty introduced by high temperature is about 2.2dB.
  - The benefit brought by positive chirp is around 0.4dB.





Recommendation on Wavelength Choice

- Based on the test result, the following wavelength would be suggested for 50Gb/s BIDI PHY application.

	Reach	Up Stream	Down Stream
50GBASE-BLR	10km	1270*	1330*
50GBASE-BER	40km	1295*	1309*

*nominal

Transmitter Characteristics of 50Gb/s BIDI PHY

Description	Proposal		Unit
	10km	40km	
Signaling rate	26.5625	26.5625	GBd
Wavelengths (range)	Up: 1264.5 to 1277.5 Down: 1324.5 to 1337.5	Up: 1292.21 to 1296.59 Down:1306.29 to 1310.19	nm
Side-mode suppression ration (SMSR), (min)	30	30	dB
Average launch power (max)	4.2	6.63	dBm
Average launch power (min)	-4.5	0.4	dBm
OMA_{outer} (max)	4	7.4	dBm
OMA_{outer} (min)	-1.5	3.4	dBm
Launch power in OMA_{outer} − TDECQ (min)	-2.9	2	dBm
TDECQ (max)	3.2	3.2	dB
TDECQ – $10log_{10}(C_{eq})$ (max)	3.2	3.2	dB
Average launch power of Off transmitter, each lane (max)	-16	-15	dBm
Extinction ratio (ER) (min)	3.5	6	dB
Transmitter transition time (max)	34	34	ps
RIN OMA (max)	-132	TBD	dB
Optical return loss tolerance (max)	15.6	TBD	dB
Transmitter reflectance (max)	–26	–26	dB

Receiver Characteristics of 50Gb/s BIDI PHY

Description	Proposal		Unit
	10km	40km	
Signaling rate	26.5625	26.5625	GBd
Wavelengths (range)	Up: 1324.5 to 1337.5 Down: 1264.5 to 1277.5	Up: 1306.29 to 1310.19 Down: 1292.21 to 1296.59	nm
Damage threshold	5.2	-2.37	dBm
Average receive power (max)	4.2	-3.37	dBm
Average receive power (min)	−10.8	−17.6	dBm
Receive power (OMA_{outer}) (max)	4	-2.6	dBm
Receiver reflectance (max)	−26	−26	dB
Receiver sensitivity (OMA_{outer}) (max)	max(−8.4, SECQ − 9.8)	max(−15.1, SECQ − 16.5)	dBm
Stressed receiver sensitivity (OMA_{outer}) (max)	-6.6	−13.3	dBm
Conditions of stressed receiver sensitivity test			
Stressed eye closure for PAM4 (SECQ)	3.2	3.2	dB
SECQ – $10\log_{10}(C_{eq})$ (max)	3.2	3.2	dB

Illustrative Link Power Budget of 50Gb/s BIDI PHY

Description	Proposal		Unit
	10km	40km	
Power budget (for maximum TDECQ)	10.1	21.7	dB
Operating distance	10	40	km
Channel insertion loss	6.3	18	dB
Maximum discrete reflectance	TBD	TBD	dB
Allocation for penalties (for maximum TDECQ)	3.8	3.7	dB
Additional insertion loss allowed	0	0	dB

Summary

- According to the 5G network requirement, the 10km application link loss would be 6.3dB and the 40km application link Loss would be 18dB.
- Regarding 50Gb/s PAM4 over 10km, 1330nm would be a reasonable choice
  - The dispersion penalty is acceptable when the wavelength is expanded from 1317.5nm to 1337.5nm.
- Regarding 50Gb/s PAM4 over 40km, LWDM would be a better choice:
  - It would be too difficult to use 1270nm DML because of the significant penalty introduced by high temperature.
  - LWDM wavelength choice would allow to share the same optics with 100GBASE-LR4, 100GBASE-ER4, 200GBASE-LR4, 200GBASE-ER4


thank you
danke
謝謝
ngiyabonga
teşekkür ederim
gracias
go raibh maith agat
mochchakkeram
merci
obrigado
dziękuję
bedankt
спасибо
Баярлалаа
рахмат
sukriya
kop khun krap
terima kasih
grazie
arigatō
dakujem
мерси
takk
taiku
감사합니다
ありがとう
ευχαριστώ
tapadh leat
hvala
mauruuru
dank je
mersi
tack
blagodaram
matondo
paldies
хвала
asante
enkosi
sagolun
dekuji
mesi
rahmet
tanemirt
diolch
xiexie
shukriya
trugarez
sulpay
gracies
chnorakaloutioun
najis tuke
kam sah hamnida
welalin
barka
vinaka
kiitos
dankie
faafetai lava
misaotra
mahalo
manana
murakoze
dhanyavadagalu
spas
mamnun
djiere dieuf
koszonom
bayarlalaa
grazie
nandri
tanki