Scaling 64GFC to 256GFC

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Overview: Scaling 64GFC → 256GFC

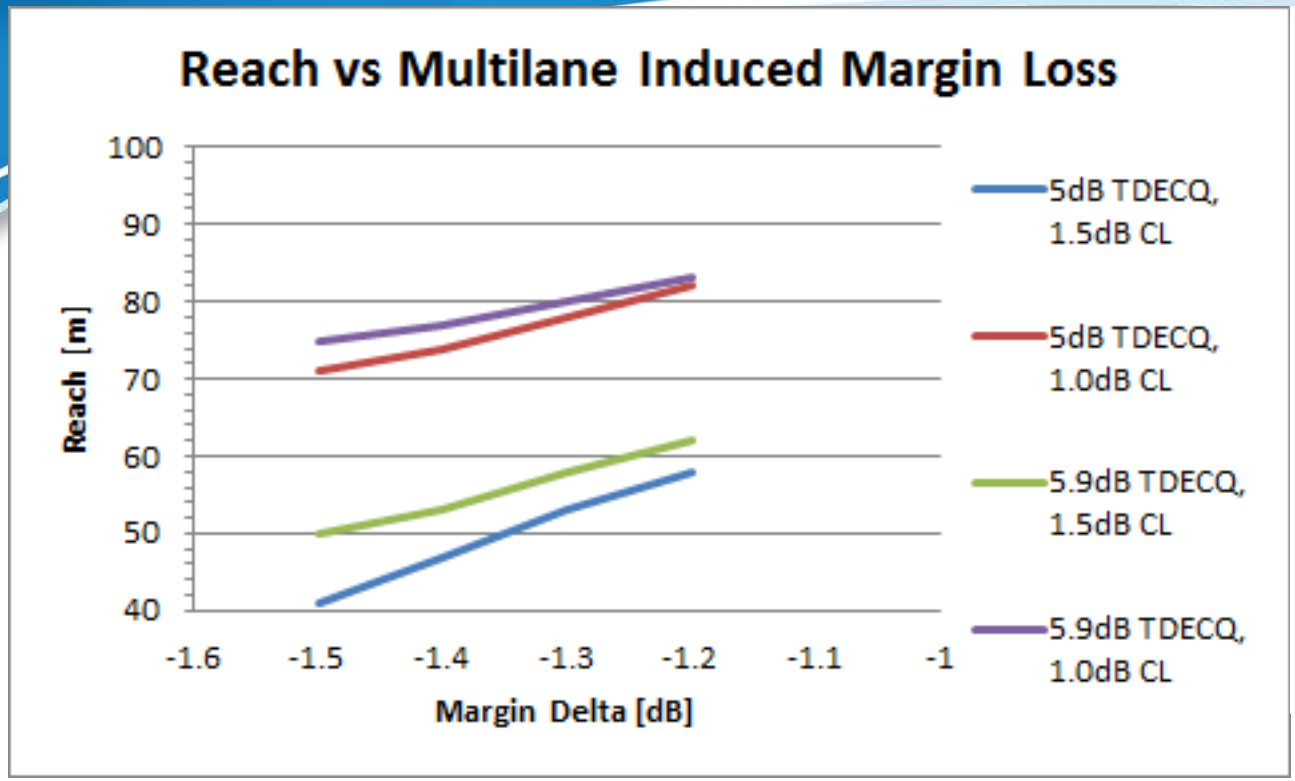
- This presentation considers the viability of using reach to compensate for multilane or crosstalk (hereafter multilane) induced impairments in the definition 256GFC links when scaling from 64GFC links.
- 32GFC and 128GFC link budget model attributes are compared to find where link margin was generated and where it was spent.
- Since a link model was not available for a link using PAM4 modulation and a 5-tap reference equalizer, the analysis is based on the example link model prepared for 128GFC.
- Applicability of scaling 32GFC-to-128GFC links to scaling 64GFC-to-256GFC links relies on the following assumptions :
  - Multilane impairment mechanisms are essentially the same for 256GFC as for 128GFC
  - Power penalties from multilane impairments are essentially the same for 256GFC as for 128GFC

Summary of prior scaling: 32GFC → 128GFC

Link Model Attributes	32GFC	128GFC	32GFC to 128GFC Cum Margin Delta
Link Margin, dB	-0.04	0.00	
Max BER	$1x10^{-6}$	$1x10^{-5}$	0.68
Connector Loss, dB	1.5	1.0	1.27
Min Tx OMA at max VECPq or TDEC, dBm	-3.2	-3.0	1.47
Rx BW, GHz	20.00	18.80	1.63
Tx output transition time, ps	20.8	20	1.89
RINoma, dB/Hz	129	130	2.01
Rx Sensitivity, dBm	-10.2	-10.8	1.87
Modal Noise Penalty, dB	0.14	0.064	1.85
TP4 DJ, UI	0.193	0.319	0.84
Fiber Effective Modal BW	4500	4400	0.83
DCD, %	0	5	0.38
Tx output Spectral Width, nm	0.57	0.60	0.23
TP4 TJ, UI	0.800	0.780	0.00

The above table lists the 32GFC and 128GFC link model attributes where their differences affected the link margin. The first set of attributes, without shading, shows where margin was generated. The second set shows where margin was spent.

Reach Compensated Margin Loss



- A 128GFC link model was extended to the 256GFC signal rate and BER with a ~ 5 dB Rx sensitivity loss to approximate operation with PAM4. Two versions were prepared, one for attributes in FC-PI-7 Rev 0.00, e.g. TDECQ = 5.0 dB and another for TDECQ = 5.9 dB.
- The models were used to estimate the reach lost due to non-mitigated multilane induced impairments

- The above chart shows results from two link modules; one for a link with a TDECQ of 5.0 dB and Rx bandwidth ~ 0.65 of the signal rate and the other for a link with a TDECQ of 5.9 dB and Rx bandwidth ~ 0.50 of the signal rate. For both, two cases of connector loss, 1.0 dB and 1.5 dB, were included. As expected a lower connector loss allocation yields longer reaches.
- The PAM4 reference receiver and TDECQ limit has recently changed at 802.3 cd.

Summary

- The ‘Summary of prior scaling: 32GFC → 128GFC’ table shows that link margin was first enhanced by about 2 dB after which about 1.2 dB was spend on impairments expected from multilane operation. The link models used for this analysis are essentially those used in the 32GFC and 128GFC projects. Both are based on NRZ modulation
- The Reach Compensated Margin Loss chart shows estimates of reach lost for a 1.2 dB to 1.5 dB range of margin loss. The link model used for this analysis is an extension of that from the 128GFC project. Since the model is based on NRZ modulation, an approximate 5 dB Rx sensitivity loss was included to account for the effects of PAM4 modulation. Since the 5 dB Rx sensitivity loss only accounts for the division of a single eye into three eyes, it seems reasonable to increase the 1.2 dB of multilane impairments from the NRZ case for the PAM4 case. An increase to 1.5 dB is proposed.
- It appears that using reach to compensate for multilane induced impairments is a viable option to consider.
- The exact amount of mitigation can be determined after more experience with 64GFC and 256GFC links is acquired.

Summary of prior scaling: 32GFC → 128GFC

Attribute	32GFC	128GFC	32GFC to 128GFC Cum Margin Delta
Link Margin, dB	-0.04	0.00	
Max BER	$1x10^{-6}$	$1x10^{-5}$	0.68
Connector Loss, dB	1.5	1.0	1.27
Min Tx OMA at max VECPq or TDEC, dBm	-3.2	-3.0	1.47
Rx BW, GHz	20.00	18.80	1.63
Tx output transition time, ps	20.8	20	1.89
RINoma, dB/Hz	129	130	2.01
Rx Sensitivity, dBm	-10.2	-10.8	1.87
Fiber Effective Modal BW	4500	4400	1.85
DCD, %	0	5	1.43
Modal Noise Penalty, dB	0.14	0.064	1.42
Tx output Spectral Width, nm	0.57	0.60	1.28
TP4 DJ, UI	0.193	0.319	0.23
TP4 TJ, UI	0.800	0.780	0.00

NF = Not Defined (TDECQ calculation yields infinity for a closed eye)

Summary of prior analysis: 50G-SR → 64GFC

Case	Symbol Rate	Reach	BER	Fiber BWm	Fiber BW	Rx BW	TP4 TJ	Tc	Pisi c	Ptot c	Margin
	GBd	m		MHzkm	GHz	GHz	UI	UI	dB	dB	dB
128GFC OM4	28.05	100	1.00E-5	4400	24.07	18.80	0.780	1.131	3.60	6.44	0.00
32GFC OM4	28.05	100	1.00E-6	4500	25.11	20.00	0.840	1.133	3.16	5.18	-0.04
128GFC for 32GFC Ptot c	28.05	56	1.00E-5	4400	42.80	18.80	0.780	1.032	2.81	5.22	1.38

Blue font indicates changes moving from 50GBASE-SR to 64GFC

Transition Time = Longest of rise or fall times between 20% and 80% of the signal amplitude; measured at γT (aka TP2)

NF = Not Defined (TDECQ calculation yields infinity for a closed eye)