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Effect Analysis of IL Resonance between 0.5~1 Normalized Frequency Bandwidth

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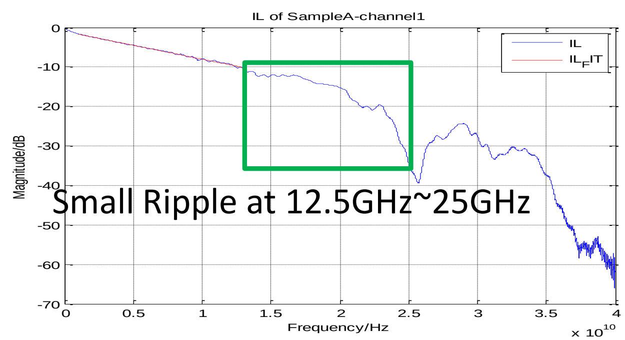
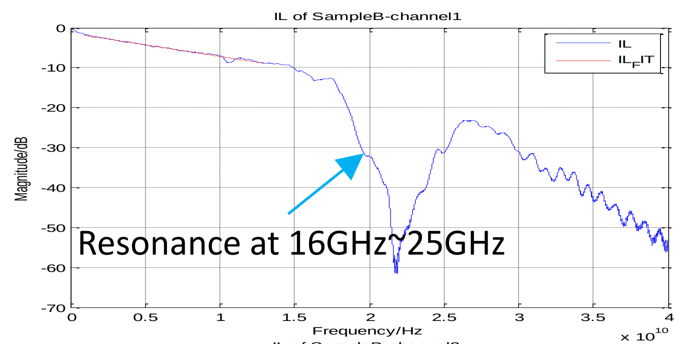
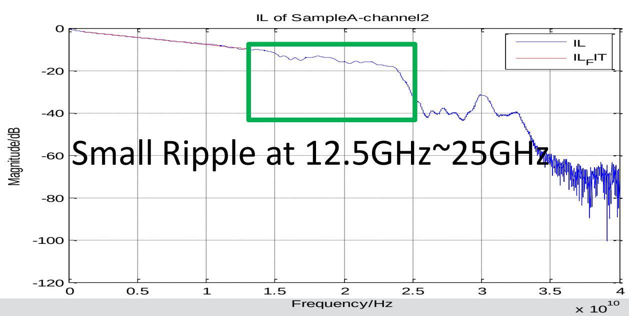
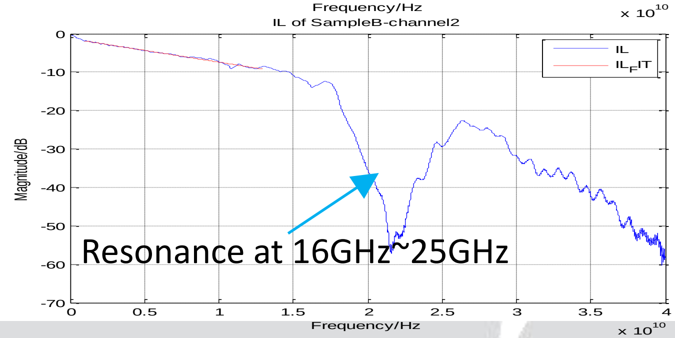
Backgrounds

- When data rate moves to 25Gbps, it is difficult to control stub length within an acceptable range. Resonance is likely to appear in insertion loss(IL) between half Baud-rate and Baud-rate frequencies;
- Two types of IL curves are shown in following four figures. Channel1 and channel2 of sample A have small IL ripples at 12.5GHz~25GHz frequencies, and other two channels of Sample B have big resonance at 16GHz.



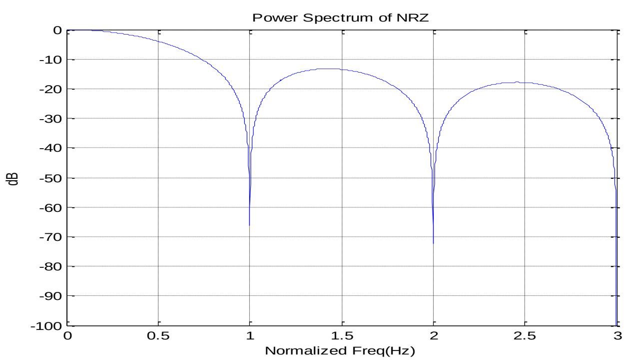


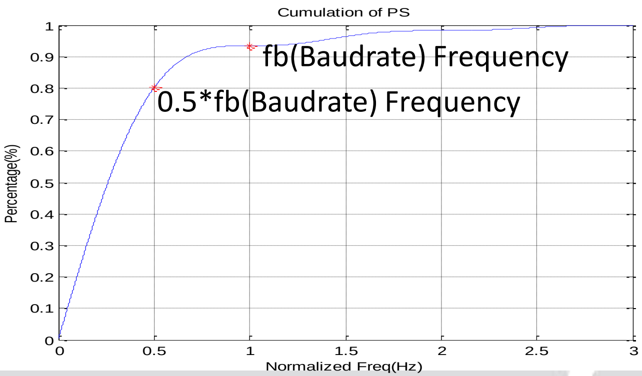




Backgrounds-"Rule of Thumb"

- Four channels of sample A and Sample B shows similar fitted IL performance at 1GHz~12.5GHz frequencies. The question is, will these four channels behave similarly when running 25Gbps data?
- Traditionally, it is a "rule of thumb" that the IL characters at frequencies higher than half baud-rate do have little effects on system performance:
  - Only 13% power are distributed at 0.5~1 baud-rate frequencies and nearly 80% percent power are distributed at 0~0.5 baud-rate frequencies.
- It seems like that IL resonance at 0.5~1 normalized frequencies has little or minor effects on system performance and the system performance of four channels should be very close to each other.





Backgrounds-Resonance effects

- Is the viewpoint true that IL resonance at 0.5~1 normalized frequencies has small effects on system performance?
  - The energy percentage can not fully represent time domain channel transfer function;
  - IL characteristics at 0.5~1 normalized frequencies also contribute to the output signal quality.
  - DFE and CDR may work differently under different distorted input signal.

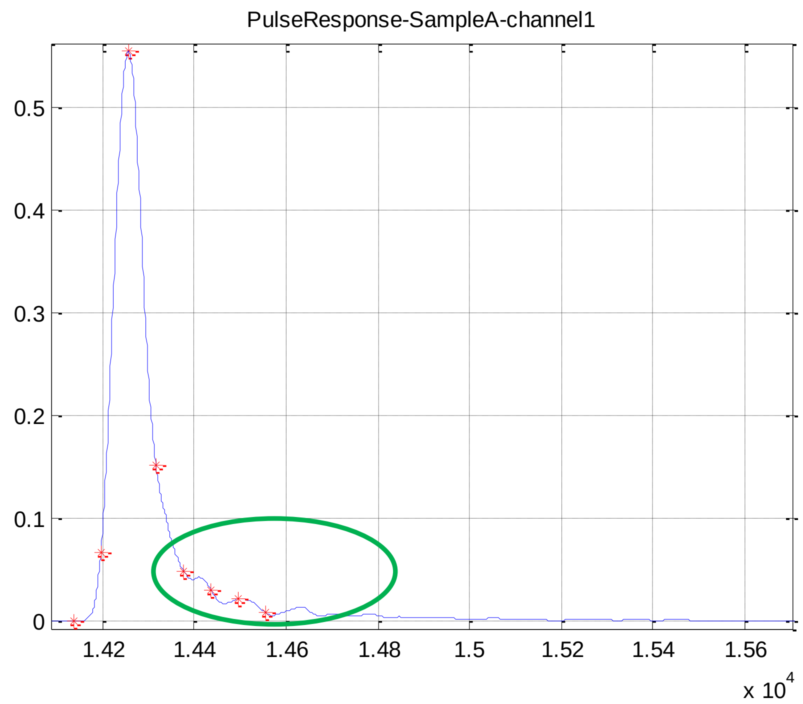
- Further analysis should be done by checking performance of these two types of four channel from pulse response and full channel simulation.

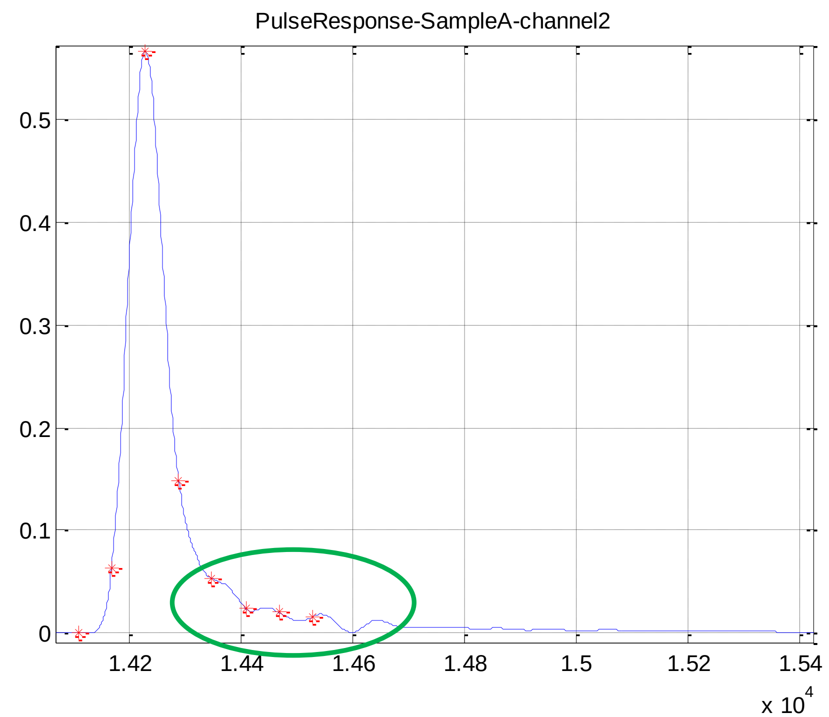
Channel Pulse Response Analysis

- Channel pulse response represents transfer characteristics stimulated by a pulse.
- Pulse response of the passive channel could be used to identify time-domain performance impacted by passive channel only.
- Pulse response is a very useful way to quantify channel transfer function from time-domain, including the detailed information of main cursor, post-cursors and pre-cursors.

Pulse Response Analysis-Sample A

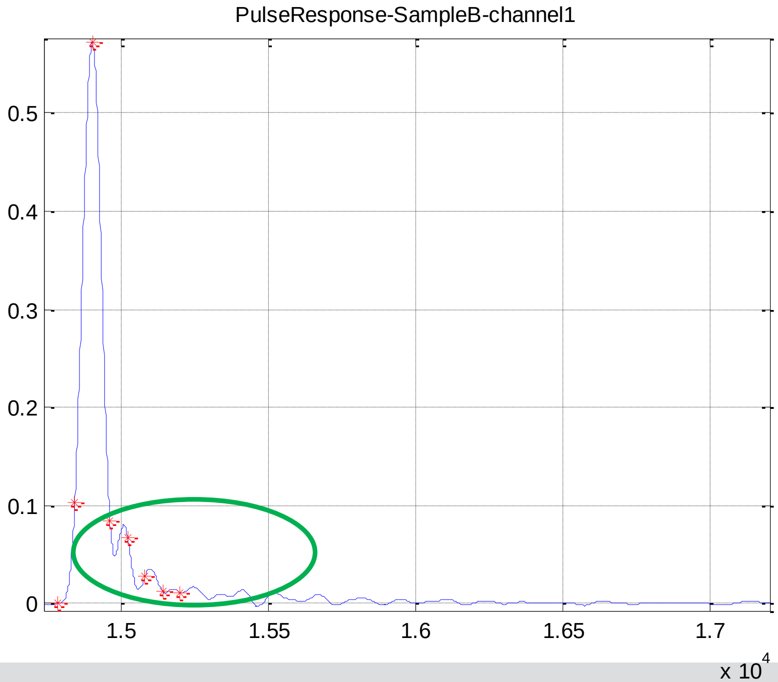
- Pulse Responses of the two channels from sample A roll down very smoothly and only some small ripples occur at post-cursors.
- It indicates that channel ISI is easy to be compensated by equalization. SerDes RX could see a clean eye.

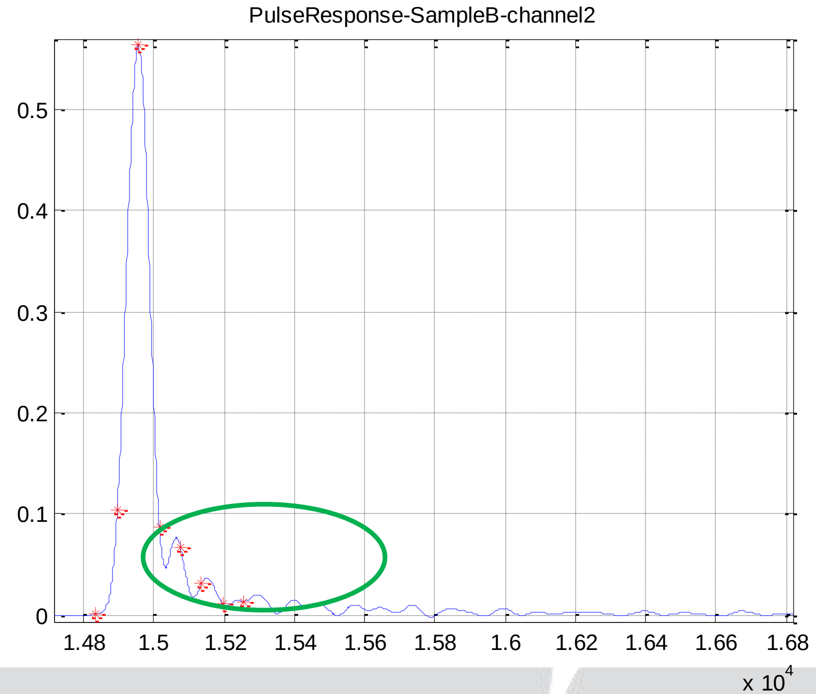




Pulse Response Analysis-Sample B

- Pulse Responses of two channels from sample B are much different from that of sample A, and big resonances occur at post-cursors(2,3,4,5).
- It indicates that channel ISI is hard to be compensated by equalization. SerDes RX could see a relatively blurred eye and CDR will be more sensitive to this kind of signal due to increased jitter.





Full Channel Simulation Validation

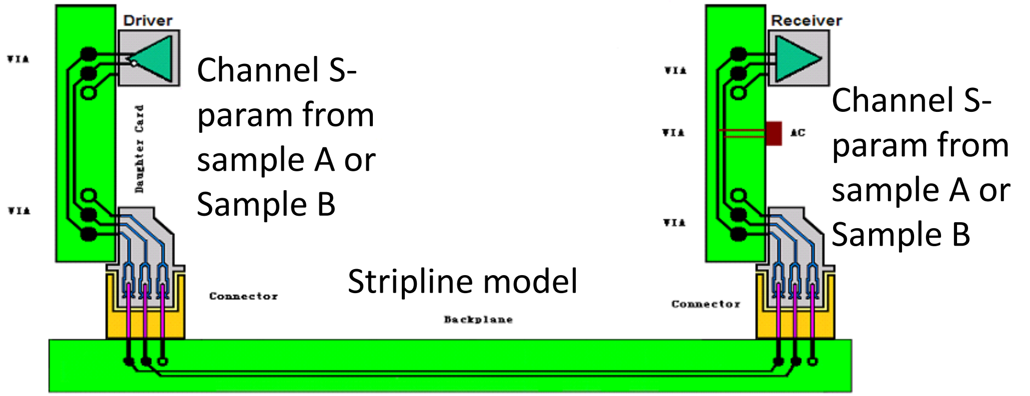
- Channel pulse response analysis proves that transfer characteristics of sample A and sample B is indeed different.
  - Pulse responses of sample A roll down very smoothly and the resultant ISI is easy to be compensated;
  - Due to big resonances at pulse response post-cursors of sample B, channel ISI is hard to be compensated and CDR performance degrades a lot.

- Based on pulse response analysis result, sample B channels may degrade system BER performance more than sample A channels do. It is required to get SerDes maximum driving capability by performing full channel simulation.

Simulation condition

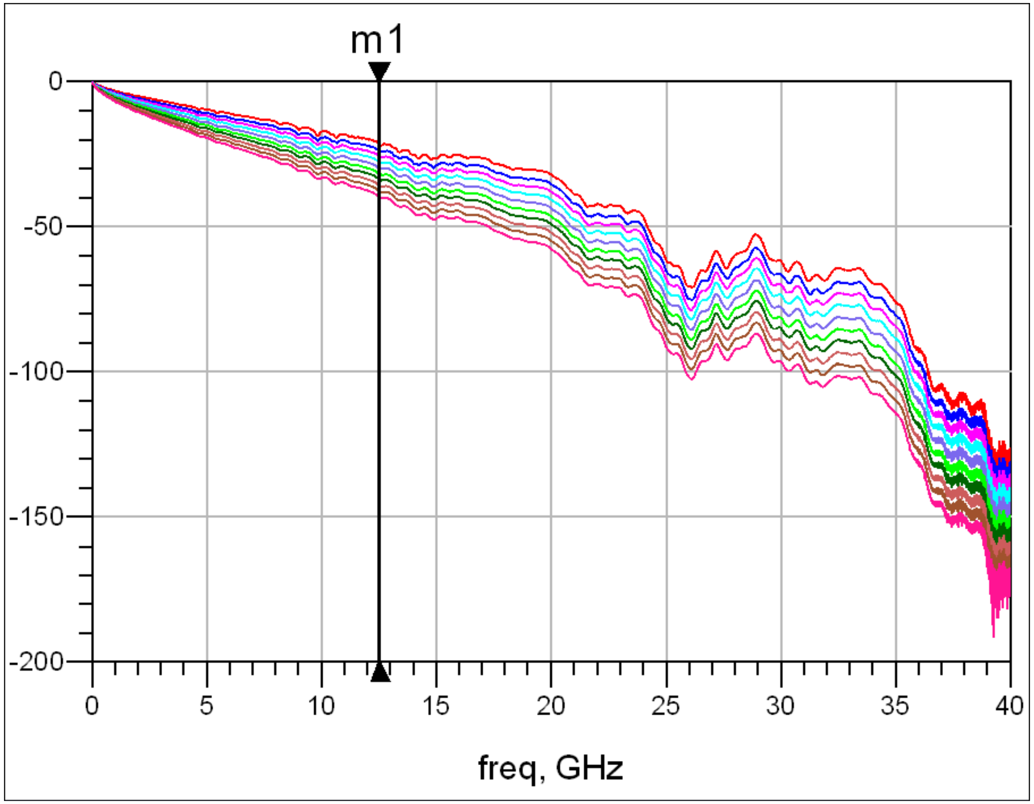
IBM HSS Link Simulator 2.4.5						
Transmitter		Channel	IL:	18~40dB@12.5GHz	Receiver	
Core:	HSS28		XTL:	/	Core:	HSS28
Options:	NA	Data Pattern:		PRBS31	Options:	NA
Technology:	cu032	Frequency Offset:		0ppm	Technology:	cu032
Corner:	nominal	Data Rate:		25Gb/s	Corner:	nominal
Package:	fcpbga_21mm_100ohm	Number of Bits:		2Mbits	Package:	fcpbga_21mm_100ohm

Channel S-parameter are constructed based on channels from sample A or sample B.



Sample A Channels

- Channel S-parameters of IL from 22dB to 40dB are constructed with 2dB increment, and these channels are used to do full channel simulation.

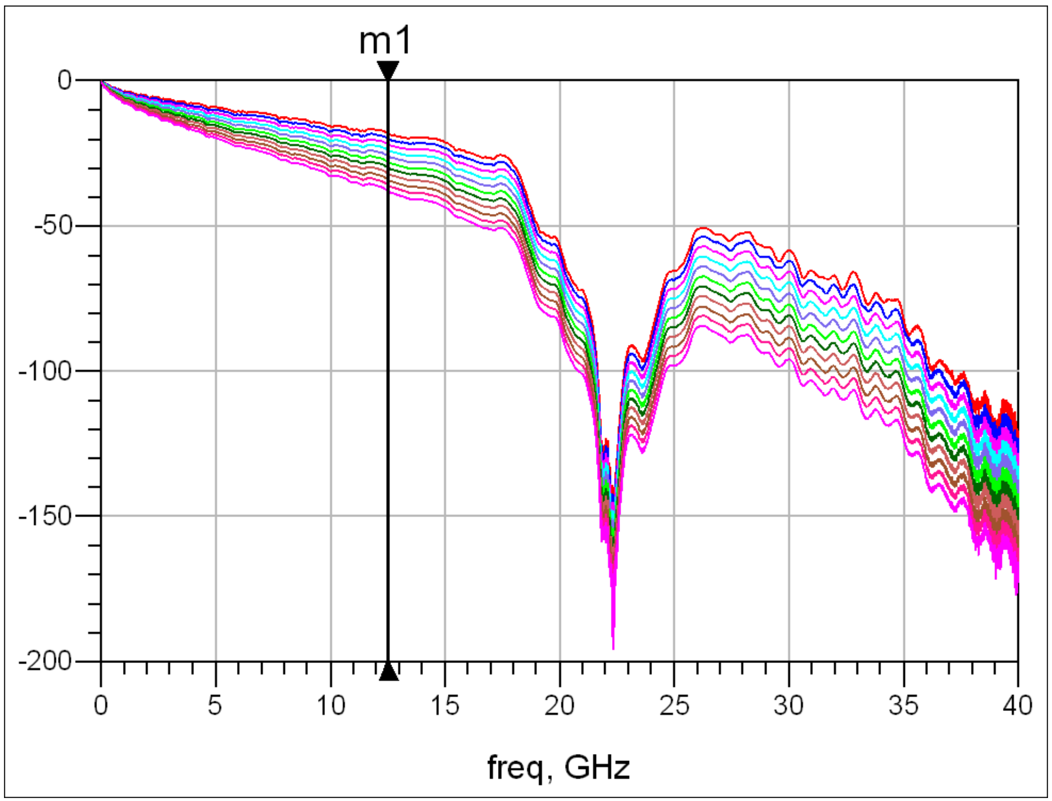


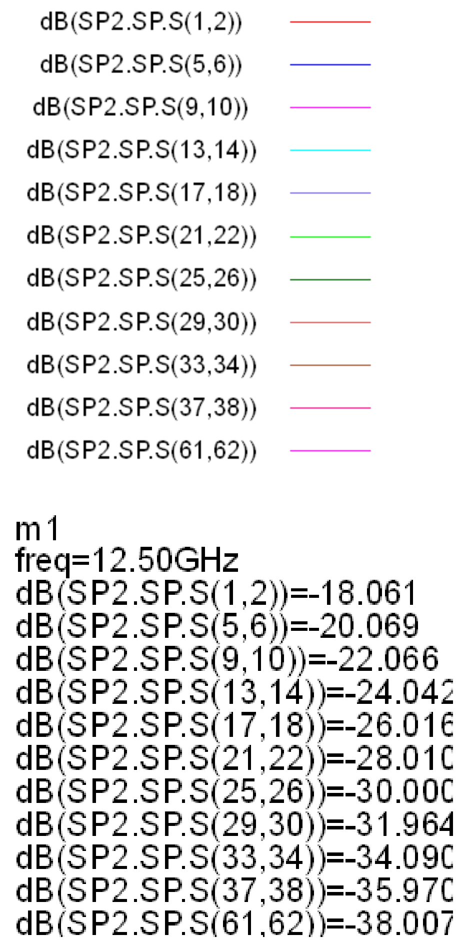
dB(SP2.SP.S(1,2))
dB(SP2.SP.S(5,6))
dB(SP2.SP.S(9,10))
dB(SP2.SP.S(13,14))
dB(SP2.SP.S(17,18))
dB(SP2.SP.S(21,22))
dB(SP2.SP.S(25,26))
dB(SP2.SP.S(29,30))
dB(SP2.SP.S(33,34))
dB(SP2.SP.S(37,38))

m1
freq=12.50GHz
dB(SP2.SP.S(1,2))=-21.965
dB(SP2.SP.S(5,6))=-24.096
dB(SP2.SP.S(9,10))=-26.003
dB(SP2.SP.S(13,14))=-27.942
dB(SP2.SP.S(17,18))=-29.989
dB(SP2.SP.S(21,22))=-32.021
dB(SP2.SP.S(25,26))=-33.897
dB(SP2.SP.S(29,30))=-35.950
dB(SP2.SP.S(33,34))=-37.966
dB(SP2.SP.S(37,38))=-39.976

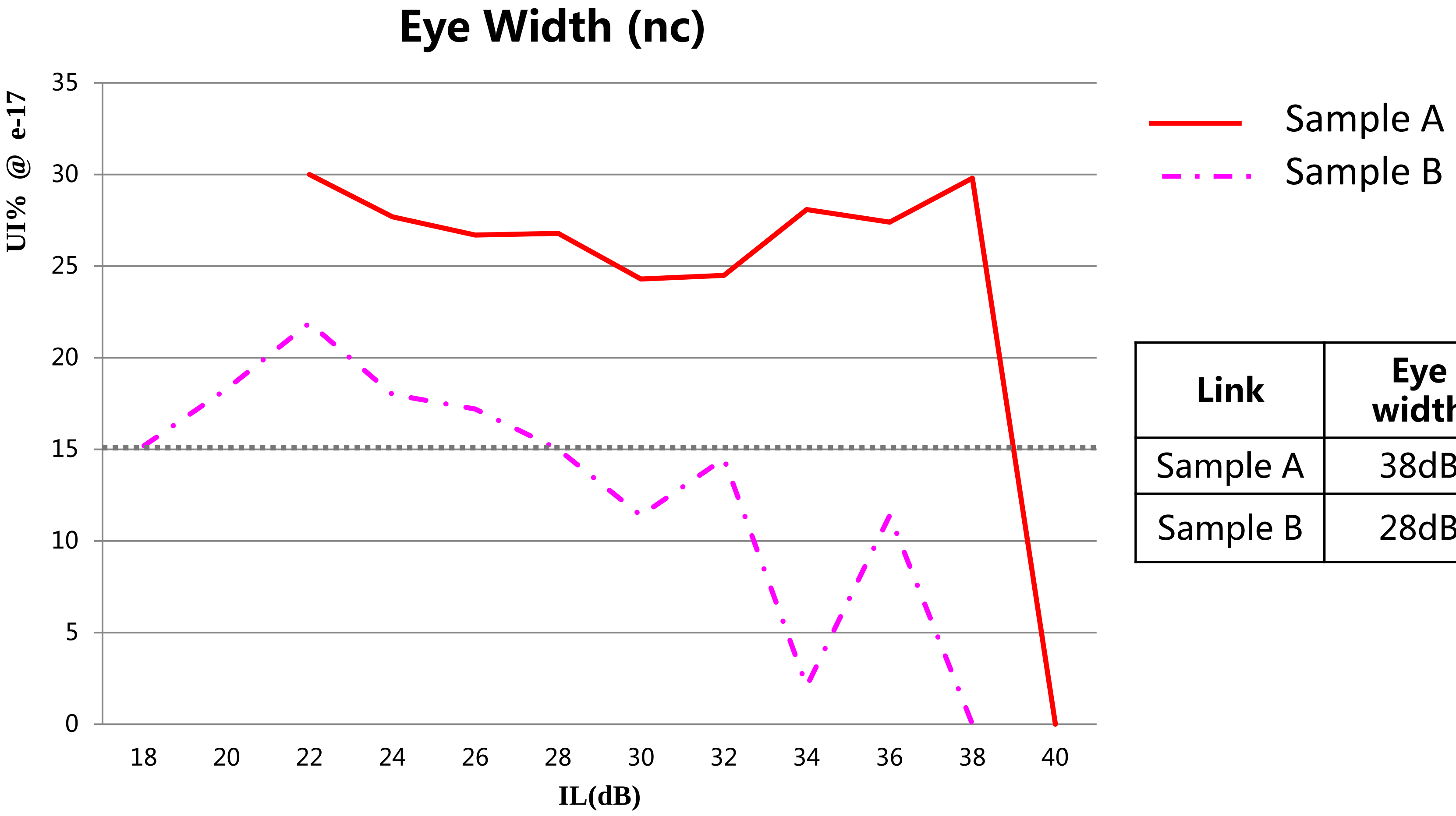
Sample B Channels

- Channel S-parameters of IL from 18dB to 38dB are constructed with 2dB increment, and these channels is used to do full channel simulation.



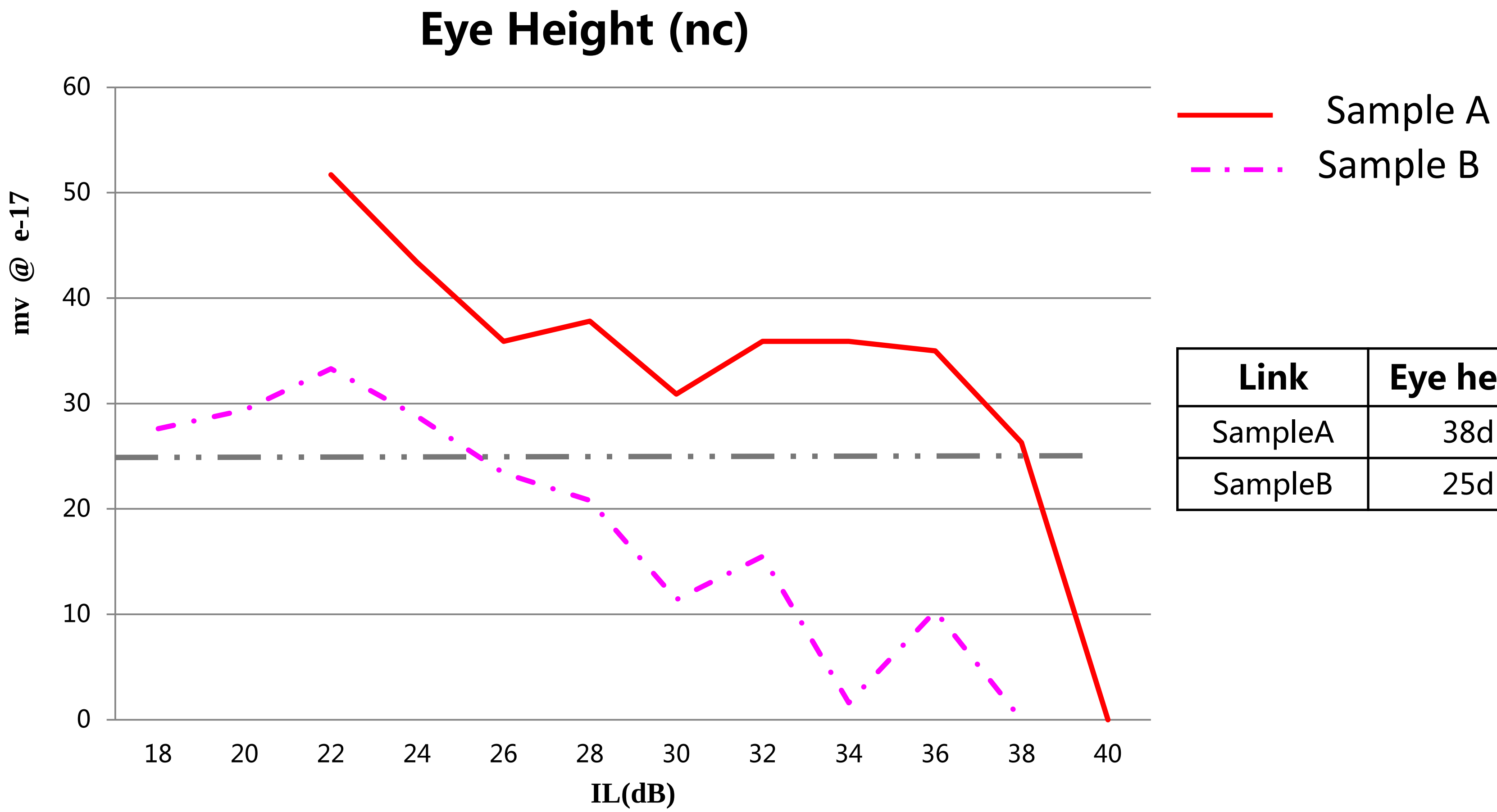


Simulation result : Eye Width (nominal case)



Link	Eye width
Sample A	38dB
Sample B	28dB

Simulation result : Eye Height (nominal case)



Link	Eye height
SampleA	38dB
SampleB	25dB

Conclusions

- The SerDes’ s maximum driving capability under sample A and sample B channels shows very different results. When running at channels of Sample A, SerDes driving capability reaches 38dB but degrades to 25dB when running at Sample B channels.

SerDes core Driving capability--25Gbps, Nominal case，NO XTK			
Link	Bandwidth(GHz)	Driving Ability(dB)	Eye Mask:
Sample A	40(Measurement)	~38	EyeH: 25mv EyeV: 0.15UI
Sample B	40(Measurement)	~25	

Conclusions:

- The viewpoint that IL resonance at 0.5~1 normalized frequencies has small effects on system performance is not true.
- Take care to remove IL resonance between 0.5~1 normalized frequencies when designing 25Gbps system passive link. It helps SerDes reach its maximum link driving capability from the perspective of passive link optimization.

Thank you

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