COM Simulation and Analysis for 200Gbps/Lane Chip-to-Module
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Outline

- Overview
  - Motivation and methodology
  - Objectives

- COM simulation for 200Gbps/Lane PAM4 C2M

- Channel feasibility: key challenges

- SerDes feasibility: COM sensitivity to key parameters

- Conclusion
Motivation and Methodology

• Straw poll #4 (Feb. 24, ’22) – PAM4 for 200G/L optical PMDs (500m & 2km)
  – Q: Will be PAM4 feasible for 200G/L C2M?

• Exploration of the feasibility of 200G/L chip-to-module AUI PAM4
  – Channel & SerDes requirements?

• Channel requirements analysis – by COM v3.7 simulation
  – All available 200G C2M channels from IEEE & OSFP (total 38x)
  – Based on baseline SerDes

• SerDes feasibility – starting from COM sensitivity by sweeping key SerDes parameters
  – Provide the directions to make good trade-off between performance & power/cost of SerDes
Objectives

• Do
  – Leverage published channel materials to represent potential 200Gbase channel characteristics and evaluate their corresponding performance
  – Analyze 200G/L PAM4 C2M feasibility from the system’s point of view
  – Point out key challenges of channel – reflection (roll-off) & crosstalk
  – Direction of SerDes – COM sensitivity of key parameters

• Don’t
  – Offer the SerDes or channel solutions
C2M Channel Profile

- Channel variations mainly come from
  - Host/Module trace length & impedance
  - BGA breakout topology
  - Connector transition finger connectivity
  - Crosstalk

The objective is to explore diverse channels to assess C2M technology feasibility
- Channel ball2ball IL: 10~23 dB
- FOM_ILD: 0~3 dB

<table>
<thead>
<tr>
<th>CH Index</th>
<th>S-Parameter File</th>
<th>Crosstalk</th>
<th>Contributor</th>
<th>Source</th>
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<tr>
<td>1 ~ 36</td>
<td></td>
<td>1 FEXT, 1 NEXT</td>
<td>C2M model from Amphenol BGA model from Keysight</td>
<td>OSFP200GEL</td>
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<td>37</td>
<td>KEY_C2M_200G_120G_2p5HCB_022422_Thru</td>
<td>1 FEXT, 1 NEXT</td>
<td>Rick Rabinovich</td>
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</tbody>
</table>
COM Simulation Consideration: 200G Baseline

- **Die model**: keep the similar IL as 100G (parameters need further investigation)
- **PKG model**: 25% trace loss improvement from 100G, follows the values proposed in iof2021.596.01 (parameters need further investigation)
- **Equalization length & frequency/Rise time/Jitter/Noise**: scaled with 2x baud rate
- **DER/TX swing/TX SNR/Nonlinearity**: kept the same as 100G
- **COM version**: 3.7
- **Test case 1 (short package)**: \[z_p(TX) \ z_p(RX)] = [15 8] mm
- **Test case 2 (long package)**: \[z_p(TX) \ z_p(RX)] = [31 15] mm

* TX \( C_p = 0 \) fF as it is included in the channel model
COM Simulation for 200G/L PAM4 C2M

• Whole link budget analysis
  – To allow the interoperability among channel components
  – Analyze performance from the system’s point of view
  – Evaluate COM instead of VEC & VEO

• Whether 200G/L PAM4 C2M works?
  – If keep the same bump2bump IL target from 100G to 200G
    - IL target in 100G/L PAM4 C2M: 16 dB ball2ball + PKG loss = ~22 dB bump2bump
  – If make SerDes capability aligned from 100G to 200G

22dB bump2bump still reasonable for 200G/L C2M?
Channel Feasibility: FOM_ILD

- FOM_ILD represents reflection severity
  - Banks of floating taps (FLTs) are needed with increasing FOM_ILD
  - Roll-off in IL profile
    - Can cause severe IL degradation at Nyquist frequency
    - Can cause multiple reflections

- FOM_ILD < 1 feasible?
Channel Feasibility: FOM_ILD & Crosstalk

- Residual ISI caused by reflection may dominate noise budget
- Concerns in crosstalk
  - PAM4 feasibility: crosstalk increases with frequency
  - Particular in BGA & transition via region
200G/L PAM4 C2M Feasibility: Reach

- **Support 22dB bump2bump IL seems possible**
  - If can keep IL at frequency of interest at the close vicinity of that for 100Gb/L
  - If SerDes capability can align with increased baud rate

- **Short channel effect in test case 1 needs further investigation**
  - Will be accentuated by higher Nyquist frequency
Roll-Off in IL Profile

- Impairments in next generation have been discussed in [noujeim_3df_01_220224](#)
  - Including BGA dimensions, connector transition connectivity, and other structures

- Frequency of resonances characterizing impairments affects roll-off characteristics
  - Can cause multiple reflections, especially challenging for short channels

BGA breakout model from *Keysight via OSFP200GEL*  
C2M channel with effective wipe sweep from *Amphenol via OSFP200GEL*
Impact from Roll-Off

• COM results of two channels with different resonance frequencies

<table>
<thead>
<tr>
<th></th>
<th>CH IL (dB)</th>
<th>FOM_ILD</th>
<th>COM (w/o FLT)</th>
<th>COM (wi 3*3 FLT)</th>
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</thead>
<tbody>
<tr>
<td>CH 19</td>
<td>14.04</td>
<td>0.21</td>
<td>3.32</td>
<td>4.88</td>
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<tr>
<td>CH 17</td>
<td>14.17</td>
<td>2.23</td>
<td>1.89</td>
<td>3.43</td>
</tr>
</tbody>
</table>

*Max. UI span for floating taps: 80

• Roll-off in proximity of Nyquist frequency will cause multiple reflections
  – More DFE taps or banks of floating taps (FLTs) are required

• Resonances just beyond Nyquist seems not good enough
  → Required bandwidth?
Sensitivity to Transceiver Capability

- Necessity of delicate balance among performance, power, and area in SerDes design
  - Possibility of increased SerDes performance and functionality (200G baseline shown in P.6)?

- COM sensitivity check of key SerDes parameters
  - SerDes alternatives can be observed from the results of sensitivity analysis
  - For jitter, a stricter A_DD may be a complementary solution for sigma_RJ without sacrificing performance

* Scale factor = 1 → 100G values
* Scale factor = 0.5 → 200G expected values (Baseline)

• Choose critical channels with $2 < \text{COM} < 4$ for analysis
Conclusions of 200G/L PAM4 C2M

• Feasibility of 200G/L PAM4 C2M requires both channel and SerDes technology enablement
  – Keep IL profile at frequency of interest at the close vicinity of that for 100G/L
  – SerDes capability should be enhanced as higher Nyquist frequency

• Channel feasibility is analyzed with
  – Potential reach: bump2bump IL ~22 dB
    - Ball2ball (TP0 to TP1a) IL target for 200G C2M could be derived from 22 dB once the consensus of package model have been reached
  – Resonances characterizing impairments & crosstalk are observed
  – Short channel effects need further investigation

• SerDes feasibility starts with the sensitivity check of key parameters, further investigation will be conducted with the trade-off among performance, power, & area
APPENDIX
Sensitivity to Transceiver Capability

*Each curve represents one channel*