The Application of IBIS-AMI Model Cascaded Simulation for 10 Gigabit Repeater Serial Link Analysis

Asian IBIS Summit, Shanghai China, November 15, 2011
Zhengrong Xu, Huawei
Luyu Ma, Huawei
Ken Willis, Sigrity
Haisan Wang, Sigrity
Lee Sledjeski, TI
Nate Unger, TI
Agenda

• Where repeaters might be applied
• The application of repeater in 10G channel
• Needs for repeater simulation
• Repeater topology
• IBIS-AMI data flow and APIs
• Test and simulation correlation
• How to select the repeater parameter
• Summary
Where repeaters might be Applied

Note: All these devices are referred as "repeaters" in this presentation
The application of repeater in 10G channel

- Insertion loss increase with data rate up to 10G at the same channel
- Need repeater to enhance the transmission distance for 10G-SR SerDes IP
The application of repeater in 10G channel (cont.)

- SFF 8431 defines 10G SFP+ module electrical interface specification
- Hardly meet the channel spec. if FR4 trace is longer than 5 inch
- Repeater reduce ISI jitter to meet the eye mask requirement when trace length is longer than 5 inch

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Symbol</th>
<th>Conditions</th>
<th>Min</th>
<th>Max</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>Channel Transfer Including Connector measured with Host Compliance Board (see Appendix C)</td>
<td>SDD21</td>
<td>at 5.5 GHz, see 1</td>
<td>-6.5</td>
<td>-2.25</td>
<td>dB</td>
</tr>
</tbody>
</table>

Table 25 SFI Host Interconnect Budget

![Graph of channel transfer](image)

**Figure 13 Host Compliance Board**

* C' equivalent is located about 1 inch past the SFP+ connector on the host board.

**Figure 19 Transmitter Differential Output Compliance Mask at B and B'**

HUAWEI TECHNOLOGIES CO., LTD.
Needs for repeater simulation

- Industry high speed specification just for point to point application, not suitable for repeater channel
- Jitter transfer in the whole channel and need simulation to estimate
- Parameter setting and combination for the whole channel become more complicated. Simulation is a good assistance to select parameter
Repeater topology

- There’s four IBIS-AMI model in the whole channel
- Model repeater by adding intermediate Rx and Tx models between channels “A” and “B”
- Need EDA tools to support cascaded “N” channels simulation together
IBIS-AMI data flow and APIs

- **AMI_Init** for "one-time adaptive EQs"
- **AMI_GetWave** for "real-time" adaptive EQs

**AMI_Init**
- Initialize filter
- Setup Data Structures

**AMI_GetWave**
- Waveform Processing
- Clock and Data Recovery

**AMI_Close**
- Free memory etc

- Impulse Response
- Model input parameters
- Continuous waveform
- Modified Impulse Response
- Equalized waveform
- Clock ticks
Channel "A" simulation

Channel A

Package Interconnect  System Interconnect  Package Interconnect

FFE

Channel Simulator

Eye @ RX_RPTR

Input waveform is synthesized by EDA tool
Channel “B” simulation

Input waveform is from RX_RPTR of channel “A”
Test and simulation correlation

Eye diagram after EQ and limiter

- \( T_j = 0.31 \text{UI} \)
- Height = 696 mV

- \( T_j = 0.33 \text{UI} \)
- Height = 719 mV
How to select repeater parameter

- Sweeping all parameter in simulation is still a time-consuming work for large number of combinations
- Methods need to simplify the combinations
- Retimer can be treated as an independent receiver
- Repeater: limiting mode vs. non-limiting mode
  - Limiting mode cut the relationship between channel “A” and “B” just compensating for the loss of channel “A”
  - Non-limiting mode still connect “A” and “B”, so setting depends on the whole channel loss budget

<table>
<thead>
<tr>
<th>No. of setting</th>
<th>VOD</th>
<th>PFE</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8</td>
<td>8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rx_main</th>
<th>EQ</th>
<th>DE</th>
<th>VOD</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of setting</td>
<td>adaptive or 16</td>
<td>adaptive or more than 3 tap</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram of Repeater](image)
Summary

• Repeater is a good solution for 10G over-spec. application

• Standard IBIS-AMI models can be used for modeling repeaters. No additional change in IBIS-AMI expression

• The IBIS-AMI models must contain all repeater functionally like EQ, linear/limiting, DE, VOD, DFE, CDR and so on. Accurate IBIS-AMI models are important for analysis results

• EDA tools can handle the cascading of multiple channels during simulation

• Knowledge about repeater help select parameters more efficiently. Simulation is a good assistance
Thank you!