SerDes Modeling: IBIS-AMI Correlation

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Agenda

• IBIS-AMI milestones
• IBIS-AMI simulation correlation
• SPICE-based correlation
• IBIS-AMI simulator correlation
• Dedicated SerDes tool correlation
• Closing Thoughts
IBIS-AMI Milestones

- Feb 2007 – IBIS-AMI BIRD development begins
- June 2007 – Draft BIRD approved for prototyping
- Aug 2007 – SiSoft toolkit released
- Sep 2007 – Cadence toolkit released
- Nov 2007 – BIRD 104.1 approved
- Feb 2008 – Interoperability documented
- Mar 2008 – Vendor IBIS-AMI models released
- May 2008 – BIRD 107.2 approved
IBIS-AMI Simulation Correlation

• What does “correlation” mean?
  – Nominally, reproducing time-domain waveform behavior
  – Ideally, reproducing Bit Error Rate (BER) & other metrics

• What types of simulations need to be correlated?
  – IBIS-AMI to SPICE-based analysis
  – IBIS-AMI to IBIS-AMI
  – IBIS-AMI to dedicated SerDes tools

• How is correlation measured?
  – Visually, with waveform overlay
  – Analytically, comparing dynamic and steady-state voltage matches
IBIS-AMI to SPICE-based Correlation

- Technologies with simple TX equalization and no/simple RX equalization
  - PCI Gen 1
  - PCI Gen 2
  - XAUI
  - SATA
- SPICE-based analysis of these technologies is common since SPICE TX equalization models are possible along with simulations of 1000’s of bits
- These are ideal “crossover” applications for IBIS-AMI, since simulations using either method are possible
SPICE Correlation (Algorithmic Model)

- Algorithmic (communications) analysis requires the analog channel impulse response as an input
- The analog channel impulse response can be derived from either:
  - Analog simulation of the unequalized TX / channel / RX using a conventional analog IBIS model
  - Analog simulation of the unequalized TX / channel / RX using the SPICE transmitter and receiver model
  - We’ll start with the latter, as it allows the simulation and correlation to be performed only using the published IBIS-AMI toolkit and SPICE
SPICE/Toolkit Correlation Process

**Step Input**

- TX Model with EQ = OFF
- Channel Model
- RX Model

**SPICE Analysis**

**Step Response / Impulse Response**

- dV/dt

**SPICE Analysis**

- TX Model with EQ = ON
- Channel Model
- RX Model

**SiSoft IBIS-AMI Toolkit**

**IBIS-AMI Waveform**

**Reference Waveform**
PCIe Gen 1 / Gen 2 / XAUI Results

Green = SPICE, Blue = IBIS-AMI
Where waveform is green, simulations match

IBIS-AMI and SPICE models provided by IBM

PCI Gen 1

PCI Gen 2

XAUI
SPICE/EDA Tool Correlation Process

IBIS Analog, IBIS-AMI Models

EDA Tool

Test Pattern

TX Model with EQ = ON
Channel Model
RX Model

SPICE Analysis

IBIS-AMI Waveform

Reference Waveform

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PCIe Gen 1 Results

Green = SPICE results, Blue = IBIS-AMI results
Where waveform is green, results are identical
PCIe Gen 1 Simulation Performance

- **SPICE** – 2ps timestep, 200 ps data unit interval
  - 10,000 bits, 500 sec: 1.2K bits/min

- **IBIS-AMI**
  - Time-Domain Analysis – 1M bits
    - Single run, 150 sec: 400K bits / min
    - Dual run / dual core, 160 sec: 750K bits / min

- **Relative performance**: ~ 300 – 600X

- **Relative performance will typically be higher**:
  - SPICE models optimized for simulation performance
  - S-parameter fit not included in run-time
IBIS-AMI to IBIS-AMI Correlation

• Work done with IBIS-AMI toolkits and IBM models to test consistency between EDA vendors
• EDA vendors responsible for consistency between toolkits and their commercial tools
• This effort drove clarifications to the IBIS-AMI spec
  – BIRD 107.2 / IBIS-AMI reference flow
  – IBIS-AMI terminology
• Resulted in updates to existing toolkits and models
  – SiSoft toolkit 2.10
  – Updates to Cadence kit
IBIS-AMI to IBIS-AMI Correlation

SiSoft IBIS-AMI Toolkit

Analog Channel Impulse Response

Cadence IBIS-AMI Toolkit

SiSoft Waveform

Cadence Waveform
PCIe Gen 1 / Gen 2 / XAUI Results

PCI Gen 1

PCI Gen 2

XAUI

Green = SPICE, Blue = SiSoft, Red = Cadence

Where waveform is green, all 3 simulations match
IBIS-AMI to SerDes Tool Correlation

• Many semiconductor vendors have dedicated simulation environments for their SerDes IP
• Simulation functionality and outputs vary from vendor to vendor, so correlation plans must be built around the specific models and simulation capabilities
• Most tools allow customers to input their own channel models via S-parameters
• These results show current correlation results for IBM’s HSS6G technology simulated in HSSCDR with a realistic channel model
HSSCDR Correlation Methodology

HSSCDR

Translator

S-Parameter Channel Models
Settings
IBIS Analog, IBIS-AMI Models

EDA Tool

IBIS-AMI Model Correlation - DAC IBIS Summit – June 10, 2008

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HSSCDR Correlation Results

Green = HSSCDR results, Blue = EDA Tool results using IBIS-AMI models
Where waveform is green, results are identical
Closing Thoughts

• This stuff really works!
• We expect to see continued correlation activity as more users and vendors adopt IBIS-AMI modeling
• Three common IBIS-AMI correlation activities
  – IBIS-AMI vs. SPICE
  – Between IBIS-AMI tools
  – IBIS-AMI vs. SerDes vendor tools
• Levels of correlation
  – (1st level) Time-domain waveforms
  – (2nd level) Metrics (BER, etc.) for single channels
  – (3rd level) Metrics (BER, etc.) for coupled channels