Modeling Analog Repeaters in IBIS-AMI

Walter Katz
Michael Steinberger
Todd Westerhoff

SiSoft

DesignCon IBIS Summit
Santa Clara, CA
February 3, 2011
Overview

• What are Repeaters?
• Simulating Repeaters
• Repeaters and IBIS 5.0
• Extending IBIS
• Changes to IBIS-AMI Flows
• Summary
Repeater 101

• What are Repeaters?
  – High speed analog devices that
    • Amplify an incoming signal & boost selected frequencies
    • Do NOT include clock recovery circuits

• Why use Repeaters?
  – Support longer channels / higher data rates
  – Simpler & cheaper than data recovery / retransmission

• Repeaters are here today
  – Found next to backplane or cable connectors
  – Multiple vendors offering parts
  – Expect widespread use at 25 Gb/s and up
Simulating Repeaters

- Simplest way to model repeaters is a S-parameter block with the desired gain and filtering.

Note: These S-parameters are **NOT** passive.

- This method assumes Repeater behavior is both Linear and Time-Invariant (LTI).
Non-Ideal Repeater Behavior

• Saturation
  – Repeaters are active devices that produce gain using a fixed power supply voltage. If the input signal and gain are large enough, the output voltage will become limited by the power supply

• Noise
  – Repeaters are active elements that introduce noise into the signal. This is a key design parameter that needs to be modeled
Life Without Saturation

- S-parameter modeling can cause output voltages to exceed the power supply rail
  - Tough to implement in silicon!
What We Need

- AMI Repeater model
  - RX analog termination network
  - Algorithmic filtering block
  - TX analog output
IBIS 5.0 and Repeaters

- IBIS 5.0 assumes a single driver / receiver per link
- IBIS 5.0 assumes channel behavior is linear and time-invariant (LTI)
- Modeling a Repeater as part of the channel neglects saturation and noise
- Accurate modeling of saturation and noise requires modeling at least three active devices.
Strategy: Divide and Conquer

- The end-to-end channel can be viewed as two serial channels, joined by the active Repeater in the middle
  - Allows modeling of non-linear behavior and noise using existing algorithmic modeling methods

- Multiple channels can be concatenated
Changes to IBIS / IBIS-AMI

- **IBIS (.ibs) updates**
  - 4 pin model: Repeater Rx pin linked to Repeater Tx pin

- **IBIS-AMI updates**
  - Repeater Rx model uses existing Rx IBIS-AMI conventions, but does not return clock ticks.
  - Tx repeater is a regular IBIS-AMI Tx model
    - By convention, all filtering is placed in the Rx algorithmic block and the Tx algorithmic block is a pass-thru
  - Analog noise introduced by the repeater

- **IBIS-AMI Analysis flow**
  - Algorithmic model calls are chained
    - Driver Tx ➔ Repeater Rx ➔ Repeater Tx ➔ Receiver Rx
Repeater Models

- SiSoft has collaborated with semiconductor vendors to create & validate repeater models
- SiSoft will introduce a Repeater BIRD with its semiconductor partners in the weeks after DesignCon

Red = S-parameter model
Blue = IBIS-AMI model
Summary

• IBIS 5.0 has difficulty modeling analog Repeater
  – Saturation
  – Noise

• “Divide and Conquer” strategy leverages existing infrastructure to allow Repeater modeling with minimal changes to IBIS / IBIS-AMI

• Modeling of Repeater saturation and noise has been demonstrated