Modeling Analog Repeaters in IBIS-AMI

Walter Katz
Michael Steinberger
Todd Westerhoff

SiSoft

DesignCon IBIS Summit
Santa Clara, CA
February 3, 2011

SiSoft™
We Are Signal Integrity

Overview

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

SiSoft™
We Are Signal Integrity

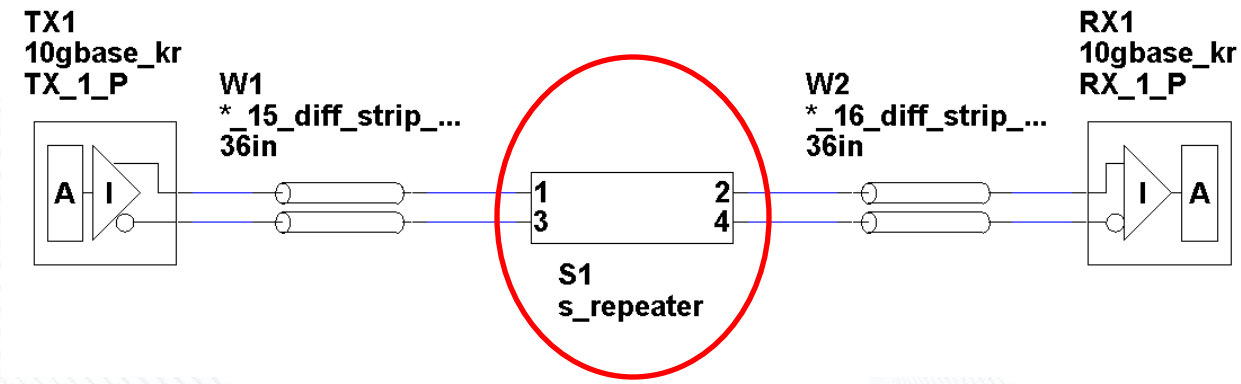
Repeaters 101

- 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

SiSoft™
We Are Signal Integrity

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

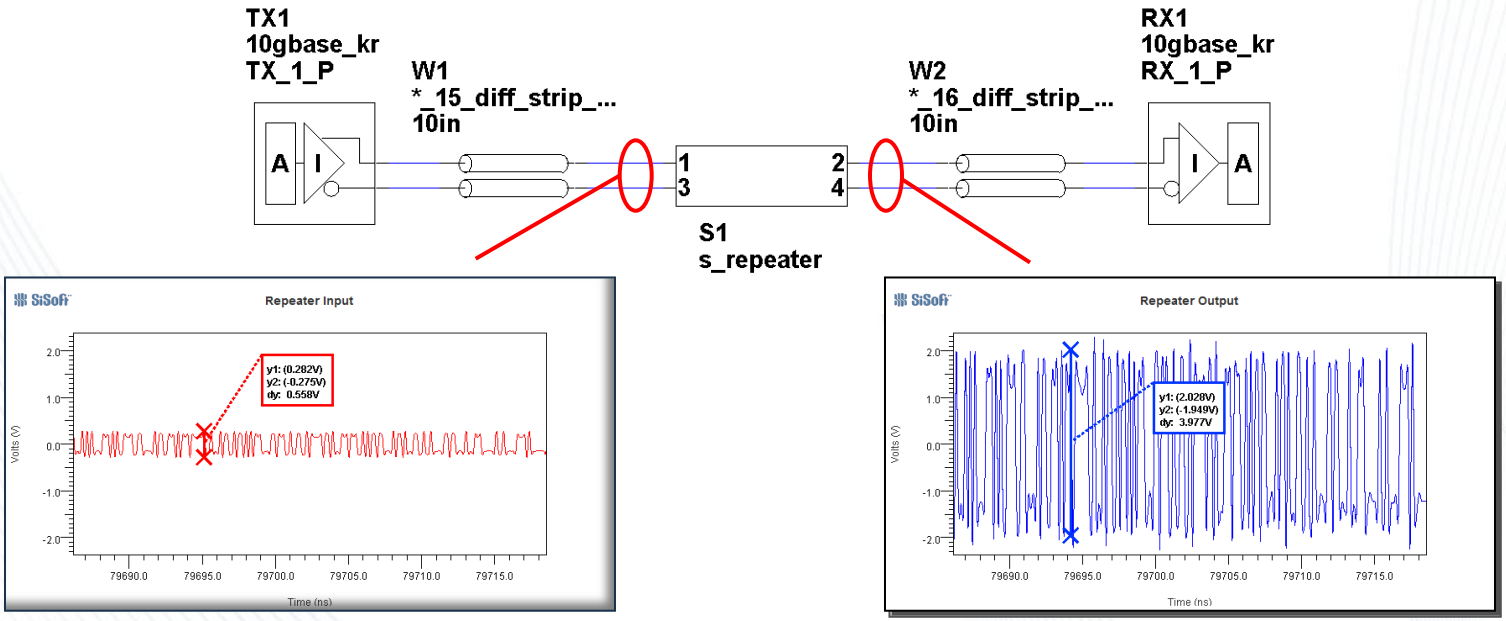
- This method assumes Repeater behavior is both Linear and Time-Invariant (LTI)

SiSoft™
We Are Signal Integrity

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



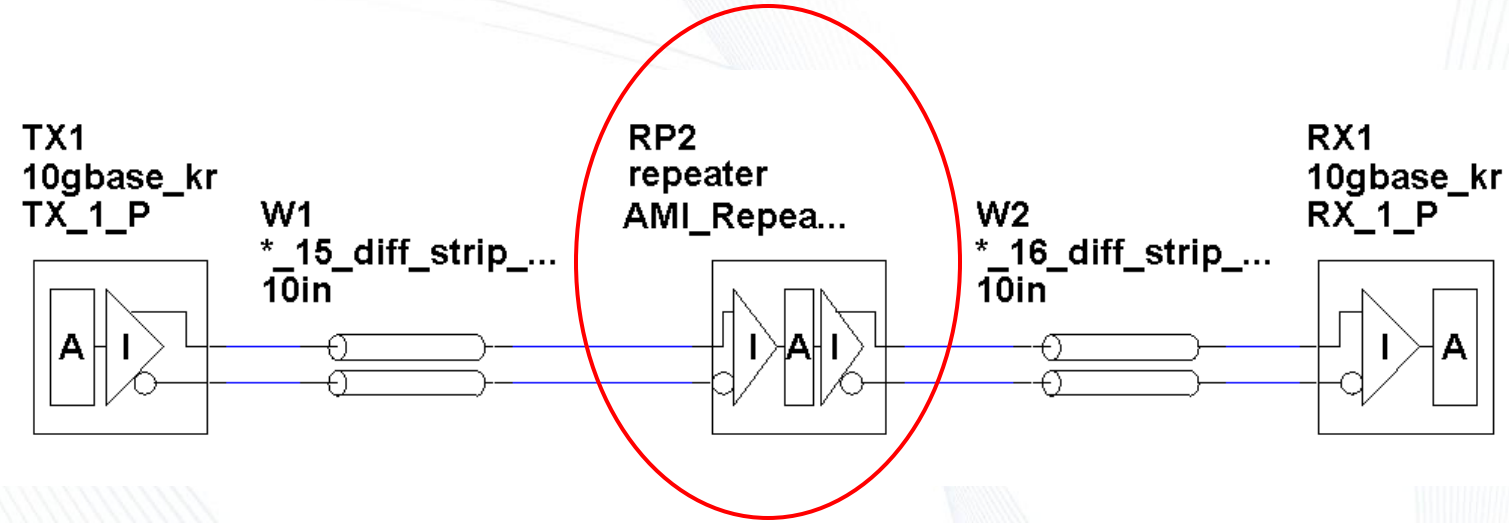
558 mV in

3997 mV out

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

SiSoft™
We Are Signal Integrity

What We Need



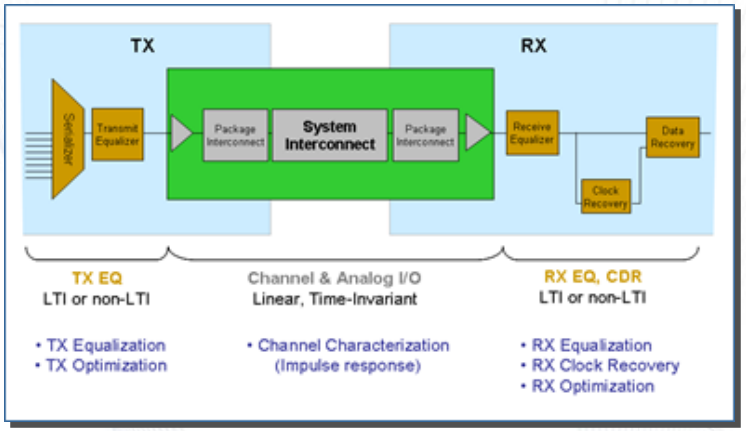
- AMI Repeater model
  - RX analog termination network
  - Algorithmic filtering block
  - TX analog output

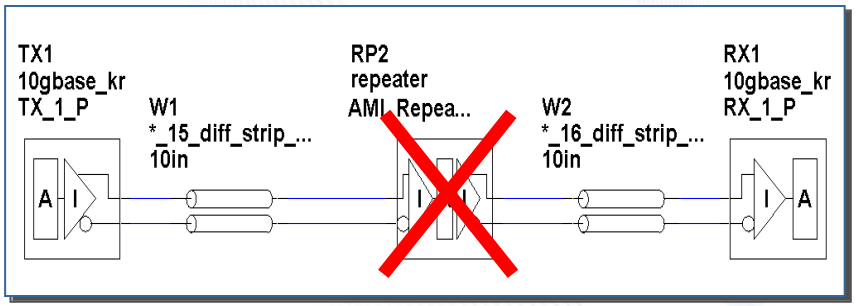
SiSoft™
We Are Signal Integrity

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)

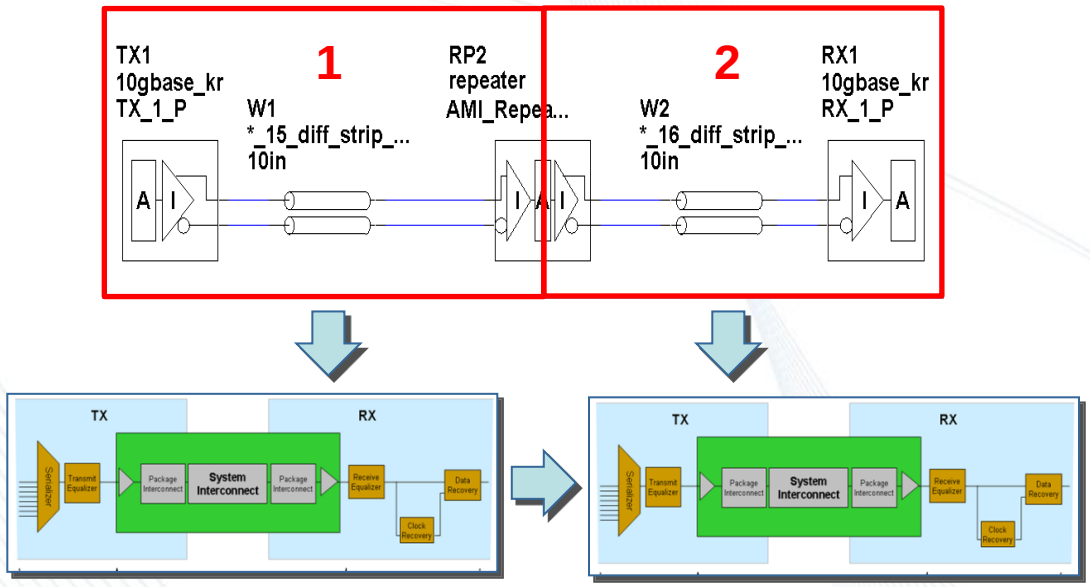
- Modeling a Repeater as part of the channel neglects saturation and noise
- Accurate modeling of saturation and noise requires modeling at least ***three*** active devices.





SiSoft™
We Are Signal Integrity

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

SiSoft™
We Are Signal Integrity

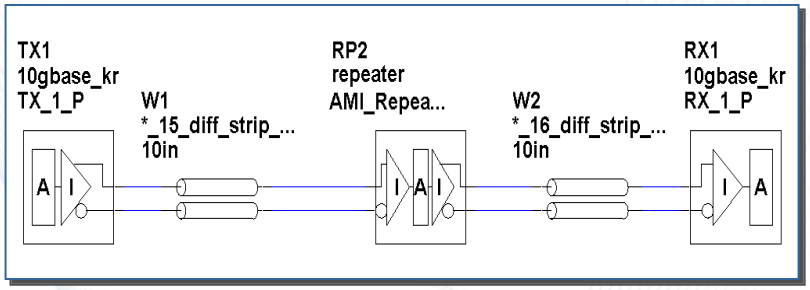
Changes to IBIS / IBIS-AMI

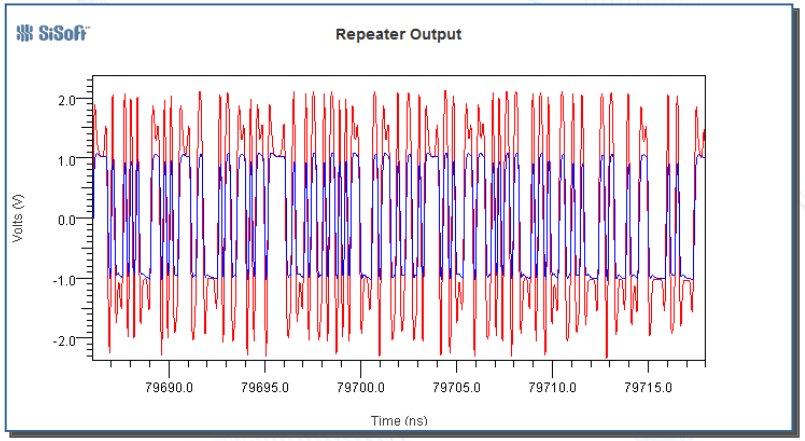
- IBIS (.ibs) updates
  - 4 pin model: Repeater Rx pin linked to Repeater Tx pin
- IBIS-AMI updates
  - Repeater Rx model uses existing Rx IBIS-AMI conventions, but does not return clock ticks.
  - Tx repeater is a regular IBIS-AMI Tx model
    - By convention, all filtering is placed in the Rx algorithmic 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

SiSoft™
We Are Signal Integrity

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

SiSoft™
We Are Signal Integrity

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

SiSoft™
We Are Signal Integrity