



# IBIS-AMI, industry adoption, and current challenges

**Fluid Dynamics** 

Structural Mechanics

Electromagnetics

Systems and Multiphysics

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# **ANSYS** AMI Challenges Today

AMI models are compiled libraries and text files

No graphical representation

Package model standard not finalized

- User needs to manually add IC/package parasitics to channel model
- Large S-parameter issue

#### Each IC vendor has different parameter set

- No standards set
- Each vendor must document their models

AMI simulations depend on accurate channel modeling

Passivity and causality problem

No standard way to sweep parameters and channel corner effect

- Need to create multiple .AMI files
- EDA tools need to parse arbitrary .AMI parameters
- Six-Sigma design at one flow

## **ANSYS** SI Challenges Today

High Speed Serial channels are pushing the current limits of simulation. Models/Simulator need to handle current challenges:

- Need to accurately handle very high data rates
- Simulate large number of bits to achieve low BER
- Non-linear ,Time Variant Systems
- TX/RX equalization and vendor specific device settings
- Specific Data patterns and coding schemes
- All types of jitter: RJ, DJ, UJ, PJ, etc.
- XTLK
- Clock Data Recovery circuits
- TX and RX may come from different vendors
- Corner and Manufacturing Variations



#### **AMI stands for Algorithmic Modeling Interface**

#### It allows users to specify their own transmitter and receiver models as Cinterface compiled libraries

- EDA tool supports Matlab as well as compiled DLLs
- faster signal processing algorithms
- intellectual property protection

#### Mainly used in convolution (fast) transient engines for channel simulation

• Designed to be used with fixed time step data

#### **Introduced in IBIS 5.0 specs**

- http://eda.org/pub/ibis/ver5.0/ver5\_0.txt
- IBIS stand for "I/O Buffer Information Specification"; high-level buffer specification for circuit modeling
- In these specs the library is specified inside the IBIS wrapper and the interface is called IBIS-AMI
- In fact, AMI concept is independent of IBIS

#### AMI Circuit Example, time domain **ANSYS**<sup>®</sup>





#### **Impulse responses**

- Before and after AMI initialization
- frequency domain is also available •

#### **Transient data**

#### **Eye diagrams**

- **Bathtub plots**
- **Contour plots**
- **Bit-error-rate** •



1.00



# **ANSYS** Comparison of Simulation Types

Method	Analysis	Advantages	Disadvantages
Traditional IBIS	Transient	Fast	Not accurate
Transistor Level	Transient	Potentially Accurate Handles Non-Linear	Very Slow No Rx Eq IP Liability Not interoperable
Fast Convolution	Quickeye	Very Fast Handles EQ Includes Bit Patterns	Not Silicon Specific LTI Assumption
Statistical	Verifeye	Very Fast Handles EQ	Not Silicon Specific No Bit Patterns LTI Assumption
IBIS-AMI	AMI	Fast Handles Vendor EQ Includes Bit Patterns Not LTI limited	Implementations vary

# ANSYS AMI simulations depend on accurate channel modeling

## What can we do about non-passive, non-causal models?

**Bypass them** 

• Connect inputs to outputs directly and leave S-parameter model out of the simulation

Leave them as-is

• The source S-parameter data is non-passive, but the circuit simulation model is sufficiently passive to simulate without problems

**Enforce passivity and causality** 

• Built-in enforcement algorithms to generate passive and causal models

# ANSYS AMI simulations depend on accurate channel modeling



### Channel ? passivity ? causality ?



## **ANSYS** Corner and Manufacturing Variations

- Usually SI engineers extract only the package or the pcb due to the trade-offs between capacity and simulation time
- For high speed channels, it is important to combine the package and pcb to capture the transitions in 3D
- Merging multi-layer package and pcb in 3D can be cumbersome

## **ANSYS** Corner effect information

Design Data Co	orner Cases Zo-Attn Parametric	Statistical T	abular Queue	e Utility: NMF	Packer							
Degrees of O 3-Level C	f Freedom [Cases] Corner [5] O 5-Level Corn	er [9] 💿 7-L	.evel Corner	r [13]				Load Settin Save Settin	ngs Default ngs Settings	Generate Tabular Cases		
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	Loss Tangent	0.70	0.80	0.90	1.00	1.10	1.20	1.30			Impedance	ľ
	RMS Copper Roughness	0.25	0.50	0.75	1.00	1.25	1.50	1.75		Low	┩┐ ┌┡,	J Hig
	Copper Conductivity	0.80	0.84	0.87	0.90	0.93	0.96	1.00		Attenuation	Atte	nu
Stack-up											<b>⊢</b> ∳−	
	Copper Thickness	0.85	0.90	0.95	1.00	1.05	1.10	1.15				
	Dielectric Thickness	0.85	0.90	0.95	1.00	1.05	1.10	1.15				
Geometry											Low Impedance	
	Trace Width	0.85	0.90	0.95	1.00	1.05	1.10	1.15				

# **ANSYS** Assigning Variables – Layout Approach

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# **ANSYS** Assigning Variables

# • Etching Factor

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#### • Trace Width

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#### **CSV Import for Parametric Analysis**



#### **Parametric Batch Mode**



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75	2pf	25	3ns	60	1.5pf



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## Handle all of geometric project and tune for Prbs31 at Tool and Design of Experiments analysis

#### PRBS31



## **ANSYS** Channel "V" Design for AMI solution



## **ANSYS** Simulation Approaches :DOE way

 we showed how we can use DOE way to investigate surface responses of a channel design with hundreds parametric variations. But we still had to break down the 3D component designs to small chunks of the board or package to keep simulation times reasonable



## **ANSYS** AMI Analysis flow

- (1) Compute impulse response of the channel (as well of aggressor impulse responses)
- Regular transient analysis
- (2) Initialize AMI libraries with the channel response
- Libraries can modify impulse responses

In a loop:

- Generate a block of transmitted bits
- Convert a list of bits into a piecewise-linear rise-fall signal
- Push the signal through the transmitter
- Convolve the signal with the channel
- Push the signal through the receiver
- Post-process the results (eye and bit-error-rate plots)



- (3) Add FFE weight parameter
- (4) Add Corner and Manufacturing Variations
- (5)Uses the final impulse response from AMI analysis to run VerifEye (statistical eye) analysis
- (6) Use DOE way to investigate surface responses of a channel design with hundreds parametric variations and find root cause with min-eye

(7) Six-Sigma Report



Today, It is not easy for SI engineer to take care AMI parameters and

high Speed Serial channels manufacturing variations. We need to

enforce passive and causal models for channel .By using channel V

design, we can do large capacity simulation, and get the best solution

for AMI Channel model.