IBIS–AMI Modeling Recommendations

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Agenda

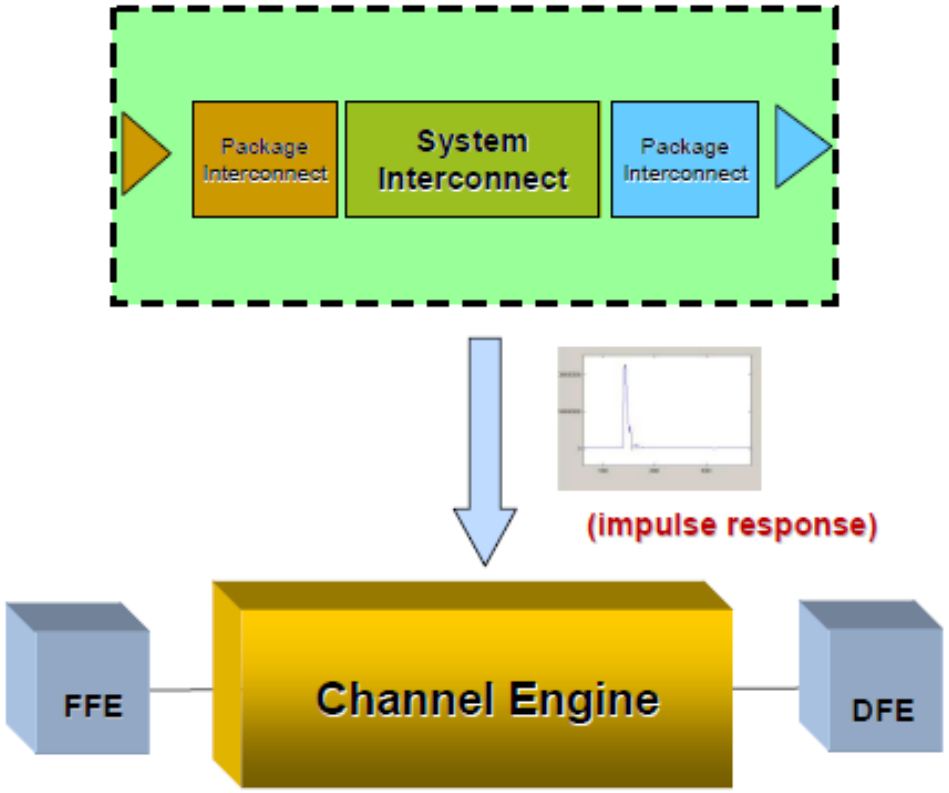
- When is AMI required?
- IBIS-AMI key concepts
- General AMI recommendations
- Real-world AMI examples

When is AMI required?

- AMI is required when ***adaptive filtering*** is done by the Serdes Tx or Rx
- This means that the filtering automatically adjusts to the specific channel, based on its own specific algorithm
- For applications that use “static” filtering (ex. PCI Express Gen 1), the behavior can be represented in a circuit model, and AMI is NOT mandatory

AMI -Required vs. Convenient

- Despite that fact that AMI may not be REQUIRED for static pre-emphasis, it can be CONVENIENT to do so
- Folding the pre-emphasis filtering into an algorithmic model is convenient because filter settings can be modified without requiring additional characterizations to be run for the analog channel



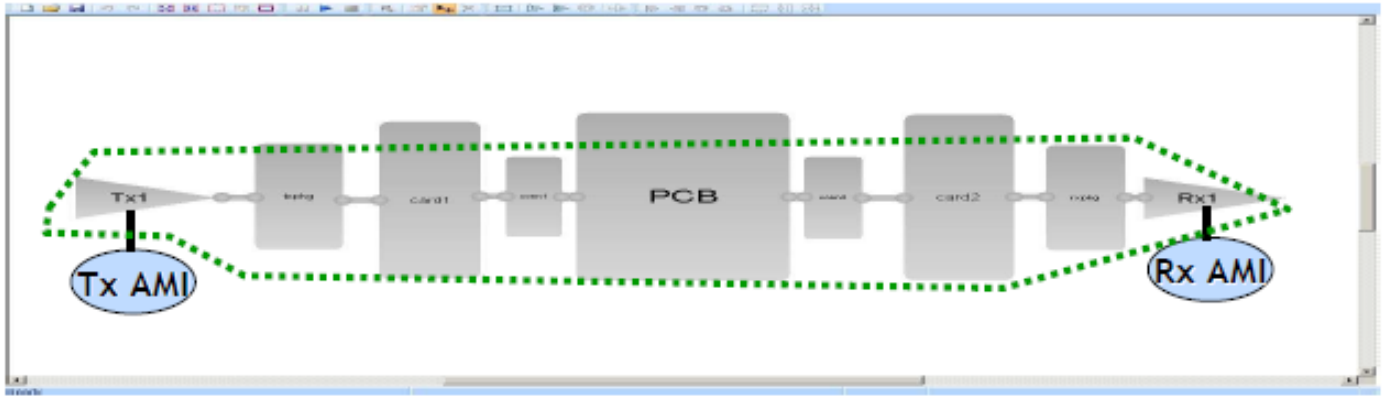
IBIS-AMI Key Concepts

- Circuit and algorithmic models
- “Tap” terminology
- IBIS-AMI data flow and APIs

Circuit Models and Algorithmic Models

- The Tx – to – Rx pathway is composed of 3 separate entities
  - Tx algorithmic part
  - Analog (i.e. “circuit”) channel part
  - Rx algorithmic part

- Three “decoupled” parts can be ***independently*** solved in time domain
  - Underlying assumption is HIGH IMPEDANCE connection between analog and algorithmic elements



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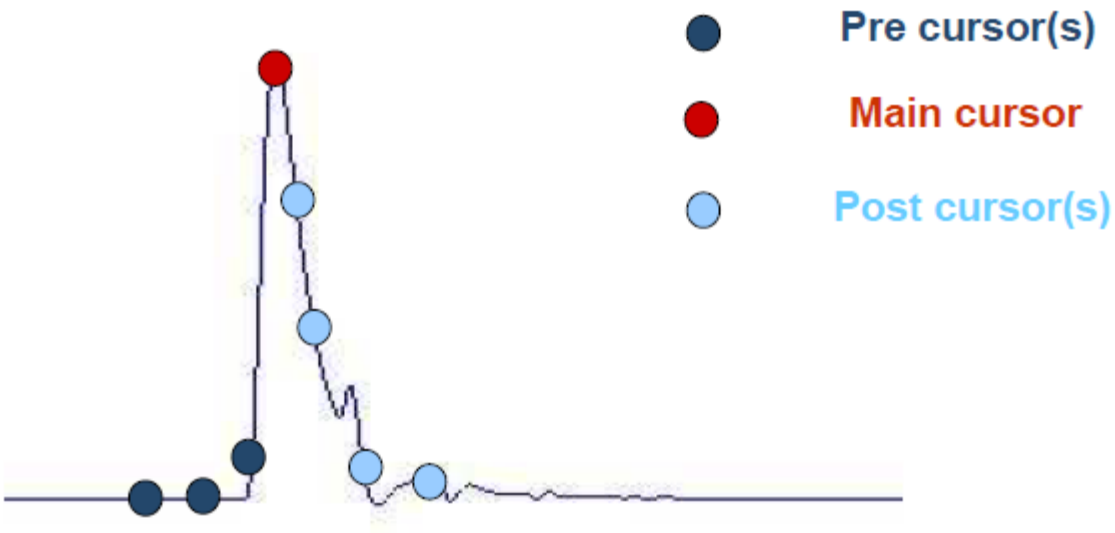
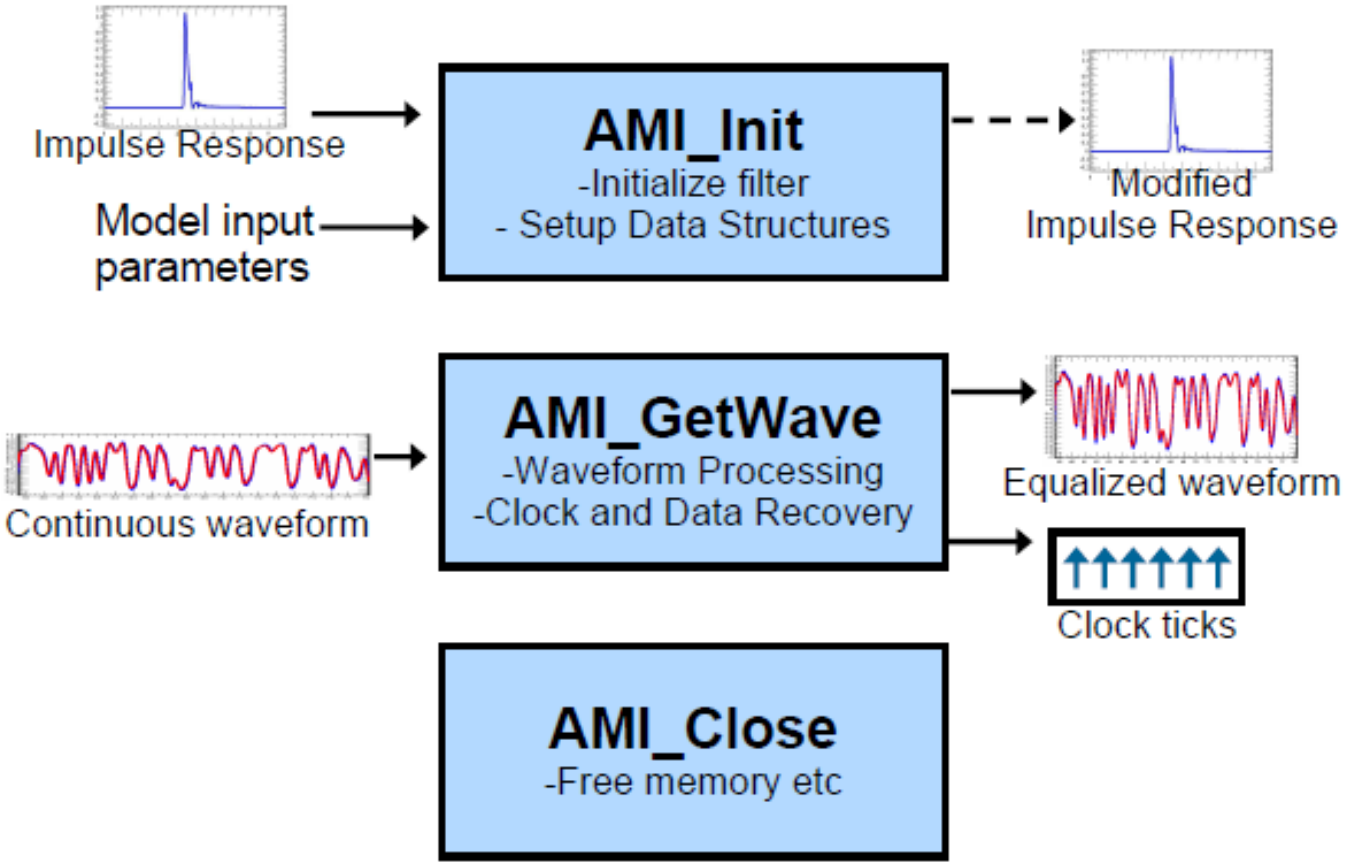
“ Tap” Terminology

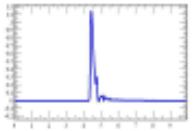
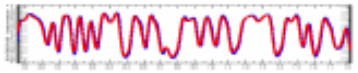


As typically seen in “FFE” implementations

IBIS-AMI Data Flow and APIs



AMI APIs –Impulse Response or Waveforms

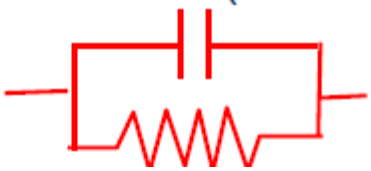
- AMI_Init 
  - Takes in the impulse response of the channel
  - Algorithm in DLL decides how to best filter it
  - The filtered (and hopefully improved) “modified” impulse response is passed back to the tool
- AMI_GetWave 
  - Takes in raw waveforms of the channel
  - Algorithm in DLL decides how to best filter it, “real time”
  - The filtered “modified” waveform is passed back to the tool, along with the clock ticks (sampling information)

General Recommendations

- Circuit vs. algorithmic model content
- When to use AMI_Init vs. AMI_GetWave
- Statistical analysis and AMI_Getwave
- Using ibischk5 for .ibs and .ami files
- IBIS-AMI and vendor-independence

Circuit vs. Algorithmic Model Content

- Don't try to put circuit parasitics into the algorithmic portion of the model
- Leaving out circuit parasitics means you will miss reflections from impedance discontinuities that exist between the Tx output / Rx input and the interconnect channel
- These should get captured in the impulse response
- If you leave these out you will not correlate back to golden data from circuit models (ex. transistor-level IO models)

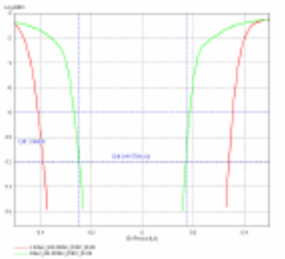


Using AMI_Init vs. AMI_GetWave

- Basic principle – K.I.S.S.
  - "Keep it simple, SI people!"
- AMI_Init > modifies the impulse response
  - If the filtering functionality sets up the coefficients once based on the channel, this API is the simplest implementation
- AMI_GetWave > modifies the raw waveforms
  - If the filtering functionality has real-time, dynamic adaptation of its coefficients based on the incoming waveforms, you need this API
  - If the algorithm includes clock and data recovery (CDR) functionality, this API is needed
- Bottom line > use AMI_Init if it will do the job, otherwise use AMI_GetWave
- Avoid extraneous functionality, and unnecessary complexity

Statistical Analysis and AMI_GetWave

- Pure Statistical Analysis is ***not*** generally compatible with AMI models using AMI_GetWave
- Should not assume anything about inner workings of a "black box" DLL "AMI_GetWave" algorithm
- Could have non-LTI behavior
  - Usually Receiver Models
  - Adaptive DFE
  - Pattern Dependent Equalization
  - Time Domain Clock and Data Recovery



- Only ***limited*** Statistical Analysis is possible
  - Ex. post-processing of time domain data

Using ibischk5 for .ibs and .ami File

- The IBIS5.0 golden parser “ibischk5” can operate on .ibs and .ami files (with –ami switch), ex:
  - ibischk5 <ibis_file.ibs>
  - Ibischk5 –ami <ami_file.ami>
- This should be run on all IBIS-AMI model kits delivered by model developers to users
- Users should run this on incoming models

IBIS-AMI and Vendor Independence

- The purpose of defining a standard is to enable a vendor-neutral format that users can consume with their EDA tool of choice
- Sigrity has seen many “IBIS-AMI models” that are ***full*** of vendor-specific content, and will only run in a specific tool
- This violates the spirit of the IBIS standard

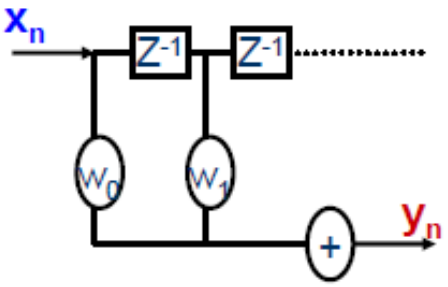
Real- World AMI Examples

- FFE – Feed Forward Equalizer
- DFE – Decision Feedback Equalizer
- Advanced DFE

All can be implemented with existing IBIS 5.0 functionality!

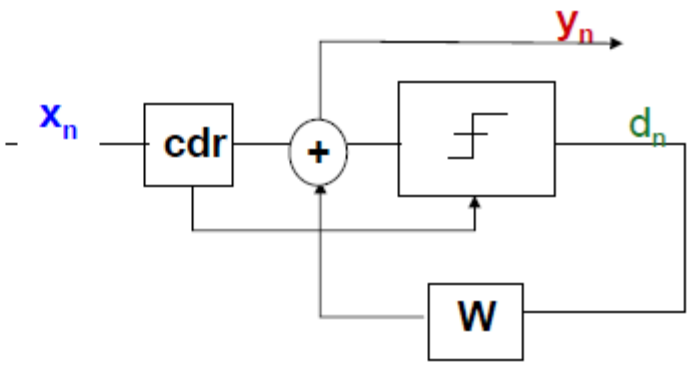
FFE

- FFE stands for *Feed Forward Equalizer*
- Typically used in Tx
- Mathematically
  - $y_n = \Sigma\, w_i * x_i$
  - Xn – input
  - Yn – output



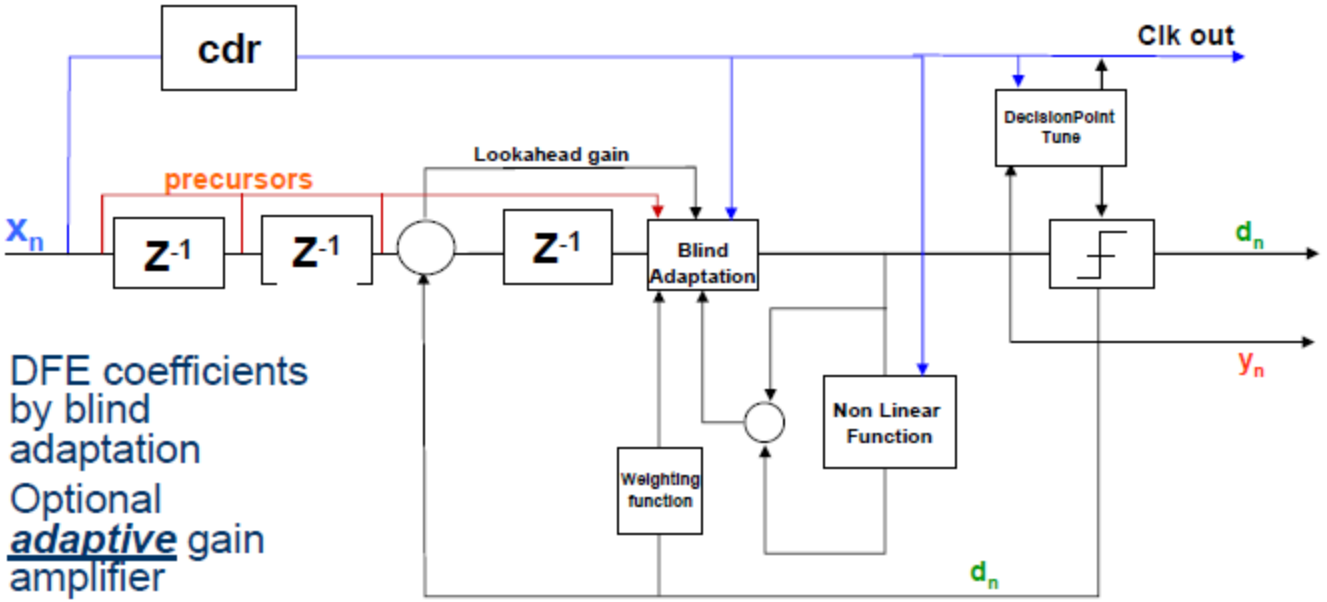
DFE

- DFE stands for *Decision Feedback Equalizer*
- Removes inter-symbol interference (ISI) by adding corrections to the input based on *previous decisions*



- $y_n = x_n + \Sigma\, w_i * d_i$
  - y_n - output
  - x_n - input
  - d_i - previous 'i_{th}' decision
  - w_i - i_{th} tap weight

Advanced DFE



- DFE coefficients by blind adaptation
- Optional ***adaptive*** gain amplifier
- Optional tuning of decision point
- Optionally include precursor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