SerDes System Design and Simulation

Tools, Technologies and Training for High Speed Digital SerDes System Designers

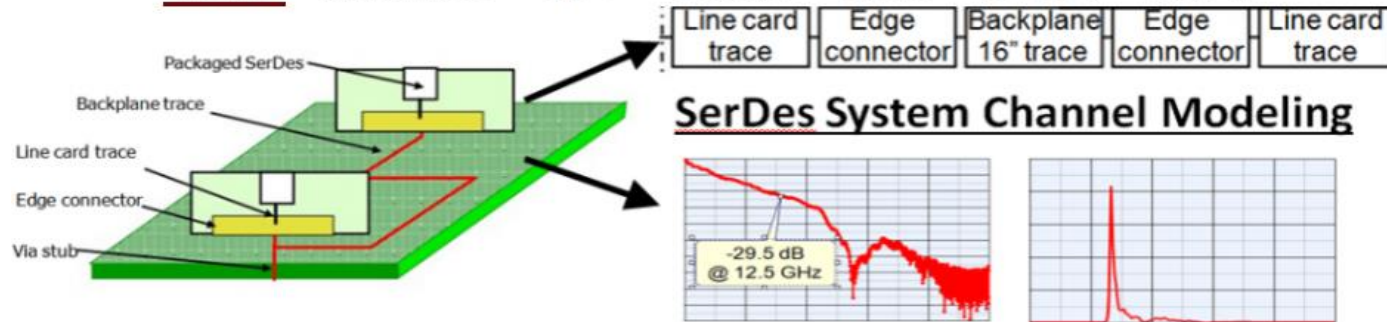HOME REFERENCES BLOG CONTACT STORE LOGOUT SIGN UP

| Line card trace | Edge connector | Backplane 16" trace | Edge connector | Line card trace |

Packaged SerDes
Backplane trace
Line card trace
Edge connector
Via stub

SerDes System Channel Modeling

-29.5 dB @ 12.5 GHz

Tools
Click here

Models
Click here

Systems
Click here

COACHING TEACHING KNOWLEDGE
TRAINING
SKILLS Click here LEARN
EXPERIENCE DEVELOPMENT

JOHN BAPRAWSKI, FOUNDER

Introduction to SerDesDesign.com

About SerDesDesign.com

- Focused on behavioral modeling and simulation of multi-gigabit high speed digital (HSD) integrated circuits (ICs) used in serializer/deserializer (SerDes) channels/systems.

- Features:
  - Free and subscription-use of on-line and Windows tools.
  - Tools for creating custom SerDes system IBIS-AMI models and SystemVue models.
    - IBIS-AMI models are portable for use in any standards compliant SerDes system channel simulator.
  - Consulting and training for custom IBIS-AMI models.

- SerDesDesign.com provides quick, efficient, accurate and cost-effective modeling for SerDes systems.

Free IBIS-AMI Model Generation Tools

- Downloadable and installable on your Windows PC.
- Free time-based node-locked license.
- Contains built-in behavioral models.
- Supports NRZ and PAM4.
- Supports data exported from SerDes circuit simulations.
- Delivered as an IBIS-AMI model useable in any channel simulator.
- Generate IBIS-AMI models from your channel simulations.
- These tools are available:
    - Free Tx/Rx FFE IBIS-AMI Model Generator
    - Free Tx/Rx CTLE IBIS-AMI Model Generator
    - Free Rx CTLE, Nonlinearity, CDR, DFE IBIS-AMI Model Generator
    - Free Repeater IBIS-AMI Model Generator
    - Free Electrical-Optical-Electrical IBIS-AMI Model Generator.
- The generated IBIS-AMI models include an option for delivery of source code and build environment.

Typical SerDes System Block Diagrams

- ## **Single channel SerDes system**
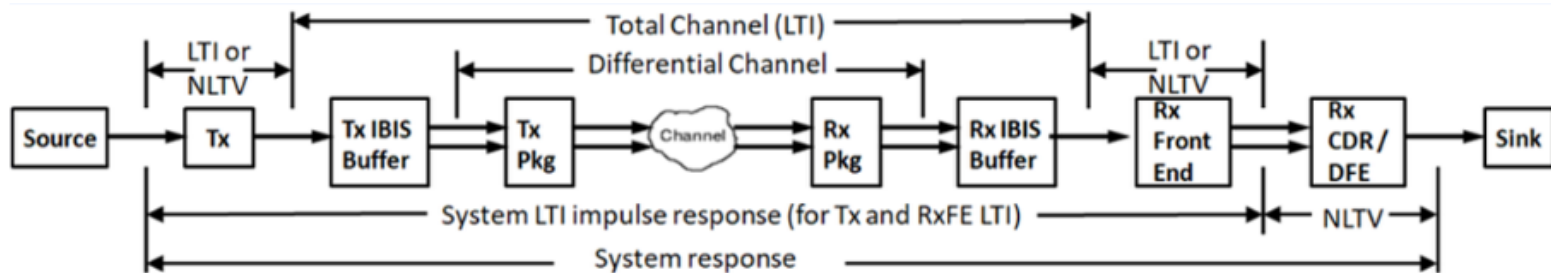
- Source: NRZ or PAM4 data source

- Tx: Transmiter equalization; typically an FFE; see **Note** below.

- Tx/Rx IBIS Buffers: IBIS buffer to the differential channel; defines the on-die impedance; see **Note** below.

- Tx/Rx Pkg: Package characteristic defined in a S4P file.

- Channel: SerDes channel defined in a S4P file.

- Rx Front End: Receiver equalization; typically a CTLE; see **Note** below.

- Rx CDR/DFE: Receiver timing/eq; typically a CDR and DFE; see **Note** below.

- **Note**: Can be a built-in model or a user defined IBIS-AMI model.

Typical SerDes System Block Diagrams

- **<u>Single Repeater SerDes system</u>**
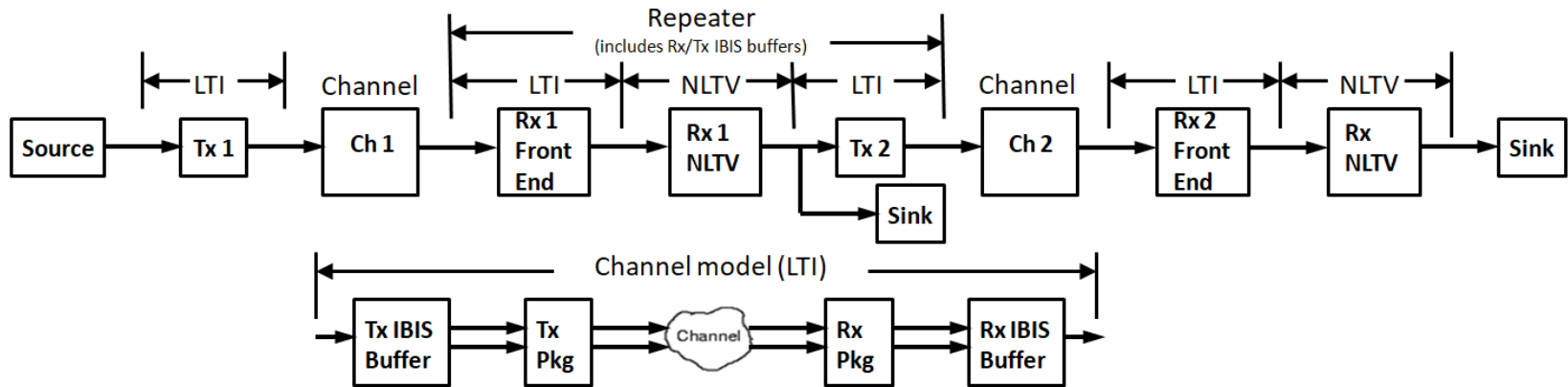
- Source/Tx/Rx/IBIS Buffers/Pkg/Channel are as defined in the prior slide.
- The Repeater cascaseds two single channel systems.
- The Rx1 Front End (including Rx IBIS buffer), Rx1 NLTV and Tx2 (including Tx IBIS buffer) are combined to form the Repeater.
- The Repeater can be a Redriver (no symbol regeneration before Tx2) or a Retimer (with symbol regeneration before Tx2).

SerDes System Design Flow Tools

- [Channel Analysis Tool](#)

- Use this tool to analyze a differential channel for its causal impulse, frequency domain characteristics, eye diagram, BER response and more.

- Total channel includes transmit IBIS output buffer, transmit packaging, transmit-to-receive path channel, receive packaging and receive IBIS input buffer.

- You may download the resultant causal total channel impulse response file.

- Use a SerDes System tool after using the Channel Analysis Tool to setup and observe details for the SerDes system.

SerDes System Design Flow Tools

- [SerDes System Single Channel Tool](#)

- This is a Channel Simulator with a single channel.

- Use this tool to analyze a SerDes system with a single differential channel for the channel impulse and frequency domain characteristics, and the system for its eye diagram, BER response and more.

- Include NRZ or PAM4 source, transmitter model, channel impulse response or 4-port S-parameters, receiver front end model and receiver CDR/DFE model.

- Use the Eye Analysis Tool after using the SerDes System Single Channel Tool to observe eye analysis details for the SerDes system.

SerDes System Design Flow Tools

- [SerDes System Single Repeater Tool](#)

- [SerDes System Electrical-Optical-Electrical Repeater Tool](#)

- This is a Channel Simulator with two cascaded channels.

- Use this tool to analyze a SerDes system with a single repeater stage between two differential channels for Ch1/Ch2 impulse and frequency domain characteristics, and System1/System2 eye diagram, BER response and more.

- The repeater may be of the "redriver" or "retimer" type per the IBIS-AMI standard.

- Include NRZ or PAM4 source, transmitter model, first channel impulse response or 4-port S-parameters, repeater receiver model, repeater transmitter model, second channel impulse response or 4-port S-parameters, receiver front end model and receiver CDR/DFE model.

- Use the Eye Analysis Tool after using a SerDes System tool to observe eye analysis details for the SerDes system.

SerDes System Design Flow Tools

- [Eye Analysis Tool](#)

- Use this tool to perform detail eye analysis for a SerDes system that was previously analyzed using a SerDes System tool.

- Include any additional timing jitter: Gaussian, Deterministic, Duty-Cycle-Distortion, Periodic jitter.

- Change eye slicing levels in amplitude and time.

- Observe eye diagram, BER response and more.

S-Parameter Tools

- [View S-Parameters Tool](#)
- Use this tool to simply view S-Parameters defined in a file.
- [Compare S-Parameters Tool](#)
- Use this tool to compare the S-Parameters defined in two files.
- [Generate Causal S-Parameters Tool](#)
- Use this tool to convert S-parameters (Touchstone 1.0 format) into S-parameters that are causal.
  - Inherently, S-parameters are non-continuous, bandlimited in frequency, possibly distorted with noise, and possibly in violation of requirements for passivity, reciprocity and physical realizability.
  - Such S-parameters may give inconsistent performance in time domain tools including various SerDes Channel Simulators.
  - Converting such S-parameters to causal S-parameters ensures consistent causal behavior in various time domain tools.
  - You may download the generated causal S-parameters and impulse data.

Tools for Transmitter/Receiver Analysis

- [FFE + LPF Analysis Tool](#)
- Use this tool to view the time and frequency domain characteristics of a feed-forward equalizer defined with pre-cursor and post cursor taps.

- [CTLE Analysis Tool](#)
- Use this tool to view the time and frequency domain characteristics of a continuous-time linear equalizer defined with 1) poles and zeros, 2) peaking frequency and peaking gain, 3) set of step responses, or 4) set of spectrum responses.

Models

- SerDesDesign.com provides many template based IBIS-AMI Tx and Rx models, many of which can be delivered for as low a $2000/model, and can be ordered directly from the web site.

- See details at Portable_IBIS_AMI_Models.pdf

- SerDesDesign.com also provides custom IBIS-AMI Tx and Rx models per your specifications.
  - Please contact us to discuss your requirements and for an estimate on the consulting fee for creating your custom IBIS-AMI models.

- All IBIS-AMI models are based on the IBIS-AMI standard and can be used in any Channel Simulator that is compliant with this standard.

Models

- Each IBIS-AMI model created has these deliverable files:
  - <name>.ibs (IBIS buffer specification file)
  - <name>.ami (Model definition based on the IBIS standard)
  - <name>_x64.dll (64 bit Windows dynamic linked library file)
  - <name>.so (64 bit Linux shared object file)
  - <name>.pdf (Model documentation; one or more files)
  - Optional:
    - SV_<name>.dll (64 bit Windows dynamic linked library file for a SystemVue model for use in the Keysight Technologies SystemVue tool)
    - SV_<name>.wsv (One or more Workspace files for use with SystemVue)
- <name> is the customer specified name for the model.
- If you order training for the model, you get source code plus:
  - AMI_Solution (Microsoft Visual Studio Windows build directory for changing and recompiling/linking your IBIS-AMI model; includes Linux support).
  - Optional: SV_Solution (Microsoft Visual Studio Windows build directory for changing and recompiling/linking your SystemVue model).

Models

- Many models have been created for customers at over 40 High Speed Digital IC companies. These models can be transmit (Tx) or receive (Rx) models that are linear-and-time-invariant (LTI) or nonlinear-or-time-variant (NLTV).

- Some of the IBIS-AMI models created and delivered to customers include:
  - Models with over 1000 LTI characteristics; selection of the LTI characteristic based on model parameter settings (digital register settings, etc.).
  - Feed-forward equalizers (FFE) with automated optimization of the FFE taps.
  - Continuous time linear equalizers (CTLE) with automated selection of of the CTLE state and with automated gain control (AGC) at the CTLE output.
  - Clock and data recovery (CDR) models with user specifiable observed jitter transfer function (OJTF) corner frequency (Fc).
  - Decision feedback equalizers (DFE) with automated updates of the DFE taps.
  - Models with random and deterministic jitter.
  - Models with states defined for different process variables (typ, min, max, slow, fast) and temperatures (PVTs).

Training

- IBIS-AMI Modeling Training is available to enable you to create your own IBIS-AMI models.

- Training does not require prior knowledge on the IBIS-AMI standard, C++ programming, compiling or linking. Training is focused to make you successful to understand the software created for you and the modification of your software to create new models.

- Customers engage SerDesDesign.com prior to the training class to create custom IBIS-AMI models per their specific needs. Then the class training is focused on the steps taken to create those specific IBIS-AMI models and on how you can further modify those models for your new requirements.

- Training is available with four options.

Training

Web Based IBIS-AMI Modeling Training

- Web based training is available from SerDesDesign.com with a 4 hour WebEx session plus up to 4 hours post training support. The source code for your models will be delivered to you. Training shows you how you can further edit and modify the models. This includes your ability to change (if applicable) the data files for all corner cases associated with this model. This training and your own model building does not require you to purchase anything else: no channel simulator, no C++ code development environment, no other tools. The training is on Windows 64 bit PCs which you use at your end when you connect to the WebEx session. The training supports Linux 64 bit machines as well.

- This training is available from SerDesDesign.com for $8000 USD with up to 12 attendees. If a portable Linux 64 bit build machine is needed, a Linux build machine (works with your PC) can be ordered as part of the IBIS-AMI Modeling Training for an additional $2000 USD.

Training

1-Day On Site IBIS-AMI Modeling Training using SerDesDesign.com tools

- 1-day on-site training with up to 8 hours post training support is available from SerDesDesign.com for creating custom IBIS-AMI models. The source code for your models will be delivered to you. Training shows you how you can further edit and modify the models. This includes your ability to change (if applicable) the data files for all corner cases associated with this model. This training and your own model building does not require you to purchase anything else: no channel simulator, no C++ code development environment, no other tools. The training is on Windows 64 bit PCs which you use at your end when you connect to the WebEx session. The training supports Linux 64 bit machines as well.

- This training is available from SerDesDesign.com for $12,000 to $16,000 based on a North America location for the training for up to 12 attendees. If a portable Linux 64 bit build machine is needed, a Linux build machine (works with your PC) can be ordered as part of the IBIS-AMI Modeling Training for an additional $2000 USD.

Training

1-Day On Site IBIS-AMI Modeling Training using Keysight Technologies tools.

- 1-day on-site training with up to 8 hours post training support for creating custom IBIS-AMI models using the Keysight Technologies tool SystemVue. Industry compliant IBIS-AMI Channel Simulation is achieved using our web based channel simulator (or using another channel simulator such as the Keysight Technologies Advanced Design System (ADS) Channel Simulator). SystemVue provides a superior IBIS-AMI modeling environment to generate industry compliant IBIS-AMI models.

- This training is provided directly by SerDesDesign.com with a fee of $12,000 to $16,000 based on the North America location for the training for up to 12 attendees. Training is at your site and using your copy of SystemVue and your Channel Simulator (ADS preferred, our Web based channel simulator, or other). You are guided through the mechanics of using the SystemVue environment.

Training

2-Day On Site IBIS-AMI Modeling Training through Keysight Technologies.

- On-site training can be for 2-days and provided through Keysight Technologies. The contract and charge is from Keysight. Keysight provides laptop PCs fully loaded with the required software for up to 12 class attendees and for use during the 2 day class. You are provided with a training manual complete with examples (created for Keysight by SerDesDesign.com).

Additional SerDesDesign.com Features

- Superior conversion from frequency domain S-Parameters to time domain impulse responses
  - No high frequency aliasing
  - Lowest requirement for (Upper S-Parameter frequency)/(Nyquist freuqency)
  - Display of S-Parameters and impulse response in the frequency domain to show accuracy tracking to the highest S-parameter frequency
- Superior BER extrapolation
  - Display of BER extrapolation and raw data BER show accuracy tracking of the extrapolated BER
- In general, use of the SerDesDesign.com Channel Simulation tools is free.
  - Channel Analysis Tool
  - SerDes System Single Channel Tool
  - SerDes System Single Repeater Tool
  - SerDes System E-O-E Repeater Tool
- Creation of custom IBIS-AMI models with training on the use and modification of these models.

Additional SerDesDesign.com Features

- Supports simulations with upto 1,000M Uis.

- An NRZ Channel Simulation typically requires 1M or more UIs for good BER extrapolations.

- A PAM4 Channel Simulation typically requires 10M or more UIs for good BER extrapolations.

- A Premium Account has a subscription-fee and enables these features:
  - A Windows based copy of our Web based channel simulator dedicated to your Windows Physical Address.
  - For direct uploading/downloading of your data files.

Examples

- [Example NRZ SerDes system using IBIS-AMI models...](#)

- [Example PAM4 SerDes system using behavioral models...](#)

- Typical IBIS-AMI model generation example: [SerDes_25p78Gbps_NRZ_Example.pdf](#)