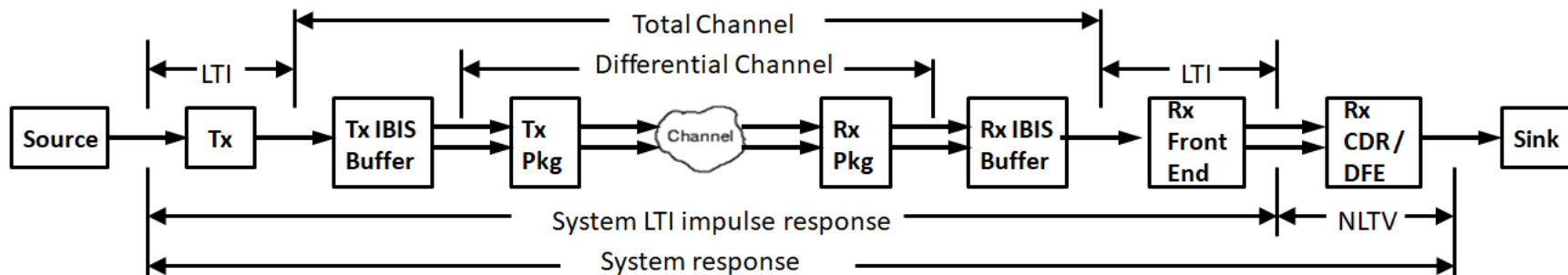**Subject: About the SerDes System Single Channel Tool**

Author: John Baprawski; John Baprawski Inc. (JB)

Date: Jan 3, 2019

This paper discusses features on the web site: **https://www.serdesdesign.com**

The SerDes System Single Channel Tool analyzes a SerDes system that has the typical structure shown in this figure.

The differential channel often includes a transmit (Tx) package and a receive (Rx) package and is linear and time invariant (LTI).

- The differential channel represents a hardware SerDes channel and is typically characterized by measuring its N-port S-parameters and is typically a 4-port. The 4-port differential input ports are typically port 1 (+) and port 3 (-). The associated differential output ports are typically port 2 (+) and port 4 (-). The differential characteristic (Port 1 – Port 3 vs. Port 2 – Port 4) is the channel transmission characteristic and is observed versus frequency.
- See S-parameter detail in References > **S-Parameter Channel Examples**
- The S-parameters may also be obtained from various simulators. A high speed digital SerDes channel typically has substantial high frequency attenuation at and beyond the bit/symbol rate Nyquist frequency and requires compensation using equalizers at the transmit and/or receive side of the channel.

The total channel is inclusive of the Tx IBIS Buffer and Rx IBIS Buffer. Per the IBIS-AMI standard, the IBIS Buffers are to be considered LTI for use in a Channel Simulator. Thus, the total channel is LTI.

- See IBIS Buffer detail in: **IBIS Buffers used in SerDes Simulations**
- The total channel, as used in a Channel Simulator and inclusive of the S-parameters, is converted to an equivalent single ended impulse response.
- See channel impulse response detail in References > **Channel Time-Domain Response**
- The typical approach involves zero-padding the S-parameters for the time domain SampleRate (SampleRate = Bit/Symbol Rate * SamplesPer Bit/Symbol) for a maximum frequency of SampleRate/2.0 and applying the constraints for physical realizability which include meeting the mathematical aspects of the Kramers-Kronig relations applied to linear time invariant (LTI) systems. This zero-padding approach often results in high frequency aliasing.
- SerDesDesign.com uses a proprietary algorithm to obtain the causal channel impulse response which inherently does not result in any high frequency aliasing.
- See Causal S-Parameters detail in: **About the Generate Causal S-Parameters Tool**

In addition to the total channel, the single channel SerDes system includes:

- SOURCE: a signal source that supports either an NRZ or PAM4 signal.
- TX: a transmit equalizer (Tx) that is LTI as used in this Channel Simulator.
- Rx Front End: a receive front end equalizer that is LTI as used in this Channel Simulator.
- Rx CDR/DFE: receiver clock and data recovery (CDR) unit and decision feedback equalizer (DFE) and is a nonlinear and/or time variant (NLTV) model.

To use the SerDes System Single Channel Tool, follow the steps on the web page.

1. Define the analysis name

   - An alpha-numeric character string; including underbar - case sensitive - start with alpha character.
   - The full analysis name = Serdes_<your entered name>
   - This full name is used in the Eye Analysis Tool for further processing of the SerDes system analysis output data.

2. Define the Transmitter.

- The transmitter (Tx) is considered to be LTI and can be defined in a number of different ways.
  - As a feed forward equalizer (FFE) with optional filtering.
  - As an FFE with quantized values defining the pre and post cursors with optional filtering.
  - As an FFE with integer codes defining the pre and post cursors with optional filtering.
  - As a family of step responses
  - As the AMI model associated with an LTI Tx IBIS-AMI model.
- See detail: **Define Transmitter**

3. Define the Channel.

- The channel is considered to be LTI and can be defined in a number of different ways.
  - ChannelType = 0; no channel is included
  - ChannelType = 1; channel is defined with impulse response data file with *.csv (comma separated variables) format with two columns. First column is for time (with constant time step) and second column is for impulse value. The time data must start with zero and have constant time step equal to the sampling interval (= 1/SampleRate = 1/BitRate/SamplesPerBit).
  - ChannelType = 2; channel is defined with an S-parameter file with at least 4 ports that represent a differential channel.
  - ChannelType = 3; channel is defined with an S-parameter file with at least 4 ports that represent a differential channel pulse options for:
    - Transmitter IBIS output buffer. See detail: **IBIS Buffers used in SerDes Simulations**
    - Transmitter differential channel packaging S-parameter file with at least 4 ports.
    - Receiver differential channel packaging S-parameter file with at least 4 ports.
    - Receiver IBIS input buffer. See detail: **IBIS Buffers used in SerDes Simulations**
- Any S-parameter file used is automatically adjusted as needed to conform to the physical realizability constraints of passivity, reciprocity, and causality, as well as reduction of noise in the S-parameters.
- See detail: **Define Channel**

4. Define the Receiver Front End.

- The receiver (Rx) front end is considered to be LTI and can be defined in a number of different ways.

- o As a 1 section continuous time linear equalizer (CTLE) defined with a family of step responses and with optional automatic gain control (AGC).
  - o As a 2 section CTLE each defined with a family of step responses and with optional AGC.
  - o As a 3 section CTLE each defined with a family of step responses and with optional AGC.
  - o As a 4 section CTLE each defined with a family of step responses and with optional AGC.
  - o As the AMI model associated with an LTI Rx IBIS-AMI model.
- See detail: **Define ReceiverFrontEnd**

5. Define the Receiver CDR/DFE.

- The receiver (Rx) CDR/DFE is considered to be nonlinear and/or time variant (NLTV) and can be defined in a number of different ways.
  - o As a pass through model for use with Bit-by-bit analysis.
  - o As a model with only a clock and data recovery (CDR) model.
  - o As a model with a CDR and decision feedback equalizer (DFE).
  - o As a model with a CDR and DFE with DFE taps that are quantized.
  - o As a model with a CDR and DFE with DFE taps that are integer codes.
  - o As the AMI model associated with an NLTV Rx IBIS-AMI model.
- See detail: **Define ReceiverCDRDFE**

6. Setup the analysis.

- Define the bit (symbol) rate in bits (symbols) per second.
- Define the number of samples per bit (symbol).
- Set up analysis options: **Setup Options**
- Set up bit-by-bit mode options: **Setup Bit-by-Bit Mode**
- Specify whether to generate IBIS-AMI models from the Tx and/or Rx designs: **Portable IBIS-AMI Models**

7. Run the analysis.

8. Display results.

- Observe the channel frequency domain characteristic, its equivalent impulse response, its eye diagram, and its BER bathtub curve.
- See detail: **Typical SerDes System Characteristics and Displays**

10. Download the channel data files.

- Download the total channel causal impulse response. Use this file in other tools to speed up their analysis without duplicating the work (time) to convert the channel into its causal impulse response.
  - For example, for detail SerDes system analysis, including jitter and BER analysis, use the causal impulse response in the 'Define Channel' section with ChannelType = 1.

After the Analysis is Run, the Analysis Log file is displayed.

Look at the bottom of the file to see that the analysis was successful:

```
Writing Impulse files.
Writing Spectrum files.
Writing Waveform response files.
Writing System worst/best case eye contour files
Writing BER metric files

Exiting Channel Analysis with success; run time = 14 sec.
```

Open the **Eye Analysis Tool** for detail eye and BER analysis of the SerDes system results.

Terms & Conditions | Privacy Policy