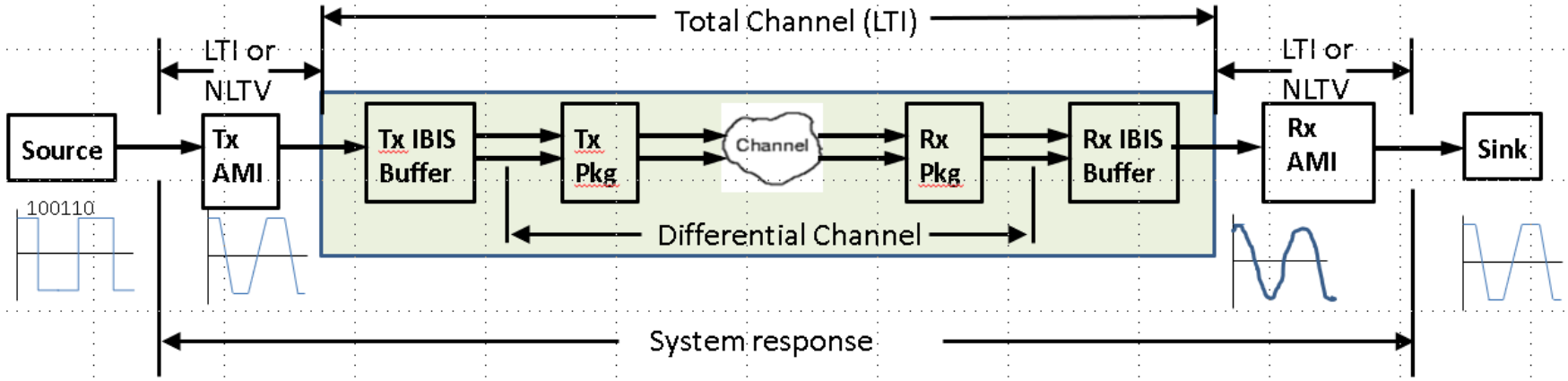
Subject: About the SerDes Channel Simulation Tool

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

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



This tool supports the I/O Buffer Information Specification (IBIS) 7.2 ratified January 27, 2023 with exceptions noted **here**.

The differential channel often includes a transmit (Tx) package and a receive (Rx) package.

- 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.

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- 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.

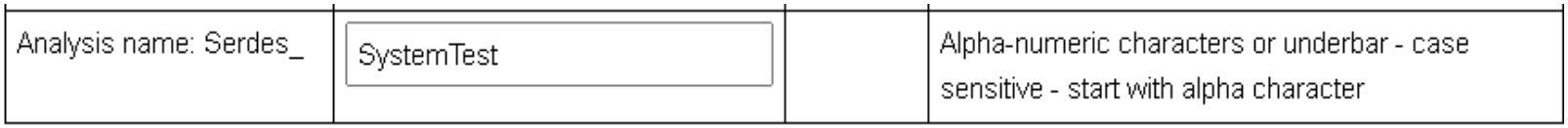
The total channel is inclusive of the Tx IBIS Buffer and Rx IBIS Buffer.

- See IBIS Buffer detail in: **IBIS Buffers used in SerDes Simulations**
- The total channel, 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 = BitRate * SamplesPerBit) 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**

For more detail on the data and graphs available from this tool, see the article: and **Typical Channel Simulation Characteristics and Displays...**

To use the Channel Simulation 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.

2. Define the Transmitter jitter

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TransmitterJitterType	Transmitter jitter type	0		Integer	[0, 1]	0 = Use Ch0 IBIS-AMI jitter 1 = Apply this jitter

- For transmitter jitter, either use the jitter defined in the Ch0 Tx AMI model (TransmitterJitterType = 0), or the jitter can be defined locally (TransmitterJitterType = 1). For local tx jitter, open its dialog box and set EnableTxJitter to 1 (for time units) or 2 (for UI units).

Name	Description	Entry Value(s)	Status	Type	Limits	Comment
EnableTxJitter	Enable Tx jitter parameters	2		Integer	[0,2]	0 = No 1 = Yes in sec 2 = Yes in UI units
Tx_Rj	Standard deviation of a random white Gaussian phase noise process in sec/UI units	0		Real	>=0	
Tx_Dj	Worst case half the peak to peak deterministic variation in sec/UI units	0		Real	>=0	
Tx_DCD	Half the peak to peak clock duty cycle distortion in sec/UI units	0		Real	>=0	
Tx_Sj	Half the peak to peak amplitude of a sinusoidal jitter in sec/UI units	0		Real	>=0	
Tx_Sj_Frequency	Frequency, in Hz, of the sinusoidal jitter	10e6		Real	>0	

- The Tx jitter values for Tx_Rj, Tx_Dj, Tx_DCD, Tx_Sj and Tx_Sj_Frequency can be set (select Apply and OK).
- See the model documentation for details: **IBIS_AMI_Jitter_Summary.pdf**

3. Define the channel including IBIS-AMI.

ChSpec	Channel specification	3		Integer	[3]	3 = Enable main channel (Ch0)

- Its dialog box represents the above block diagram.
- See detail documentation at: **Channel_wTxRx_IBIS_Pkg**
- The blocks Tx_Pkg, Channel, and Rx_Pkg are all S-parameter files. The Tx/Rx IBIS buffers may optionally be represented with S-parameter files..
- The transmitter can be defined without or with an AMI portion. The AMI portion is defined by referencing the IBS file.
- The Tx IBIS Buffer can be setup with the EnableTxBuffer parameter:

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EnableTxBuffer	Enable transmit IBIS buffer	0		Integer	[0, 3]	0 = No 1 = Yes 2 = Use IBIS 3 = Use Alt IBIS

- When EnableTxBuffer = 0, no Tx IBIS-AMI model is used. When EnableTxBuffer = 1, no Tx AMI model is used, but the Tx IBIS buffer is defined with an R/L/C network per output differential pin. When EnableTxBuffer = 2, the Tx IBIS-AMI model is defined by uploading the Tx *.ibs file and the Tx model name used in the *.ibs file. The AMI model referenced in the .ibs file is used when TransmitterType = 0. When EnableTxBuffer = 3, the Tx IBIS buffer is modeled with an S4P file or S2P file.
- See model documentation for details: **IBIS Buffers used in SerDes Simulations**
- The Rx IBIS Buffer can be setup with the EnableRxBuffer parameter in a similar way as was done with the Tx IBIS buffer.:
- The receiver can be defined without or with an AMI portion. The AMI portion is defined by referencing the IBS file.
- 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.

4. Define the Receiver jitter

ReceiverJitterType	Receiver jitter type	0		Integer	[0, 1]	0 = Use Ch0 IBIS-AMI jitter 1 = Apply ths jitter

- Set to '1' to override the Rx jitter defined with the AMI model.

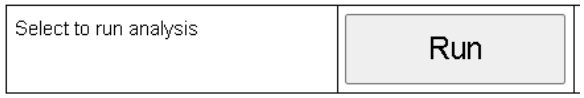
5. Setup the analysis.

SymbolRate	Symbol rate (same as bit rate for NRZ)	2.50E+10		Real	> 0	Symbols per second (same as bits per second for NRZ)
SamplesPerSymbol	Samples per symbol (same as samples per bit for NRZ)	32		Integer	[4, 128]	
SetupOptions	Setup analysis options	1		Integer	[1]	0 = No 1 = Yes

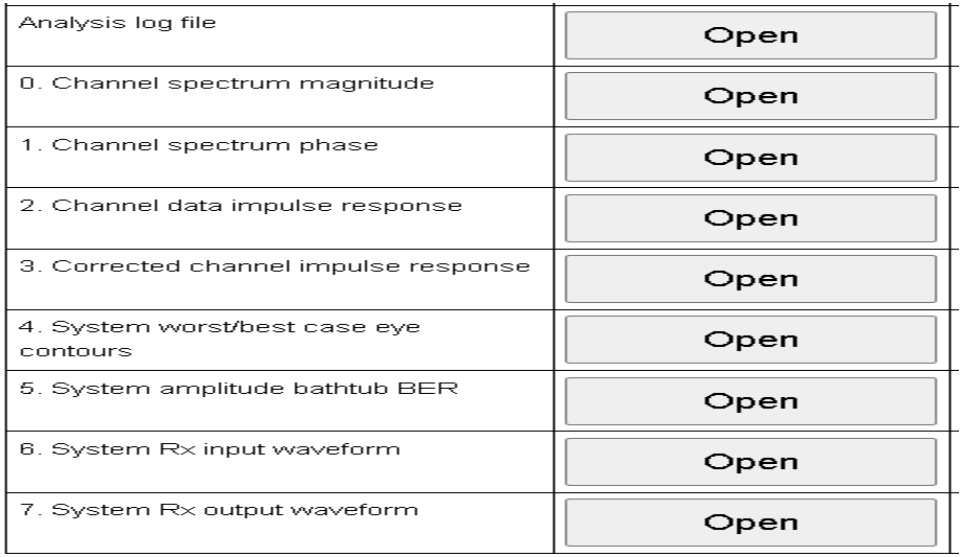
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- Define the bit (symbol) rate in bits (symbols) per second.
- Define the number of samples per bit (symbol).
- Set SetupOptions = 1 to 'Open' its dialog box.
- See detail documentation at: **Setup Options**
- Note: Set ForceBitByBitMode =1 to force Bit-by-Bit simulation model when the SerDes system is LTI.

6. Run the analysis.

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7. Display results.

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

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- 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.

```
Go to the Eye Analysis Tool for detail eye analysis for this SerDes system (set ChAnalysisName = Serdes_SystemTest).
Exiting SerDes System Analysis with success; run time = 17 sec.
```

8. Open the Eye Analysis Tool to observe the detail eye analysis results.

- Fill in the ChAnalysisName to be the same name used in the Channel Simulation Tool.

ChAnalysisName	Channel analysis name	Serdes_SystemTest

- See detail discussion at: **About_the_Eye_Analysis_Tool**
- These displays are available:

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1. System eye worst/best case contours; no additional applied jitter	Open
2. Applied jitter PDF	Open
3. System eye amplitude PDF	Open
4. System eye timing PDF	Open
5. System eye density plot	Open
6. System eye amplitude bathtub BER	Open
7. System eye timing bathtub BER	Open
8. System BER vs eye height	Open
9. System BER vs eye width	Open
10. System constant BER eye contours	Open

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