High Speed SERDES Design with ADS

Nash TU

Application Engineer / Keysight EEsof EDA

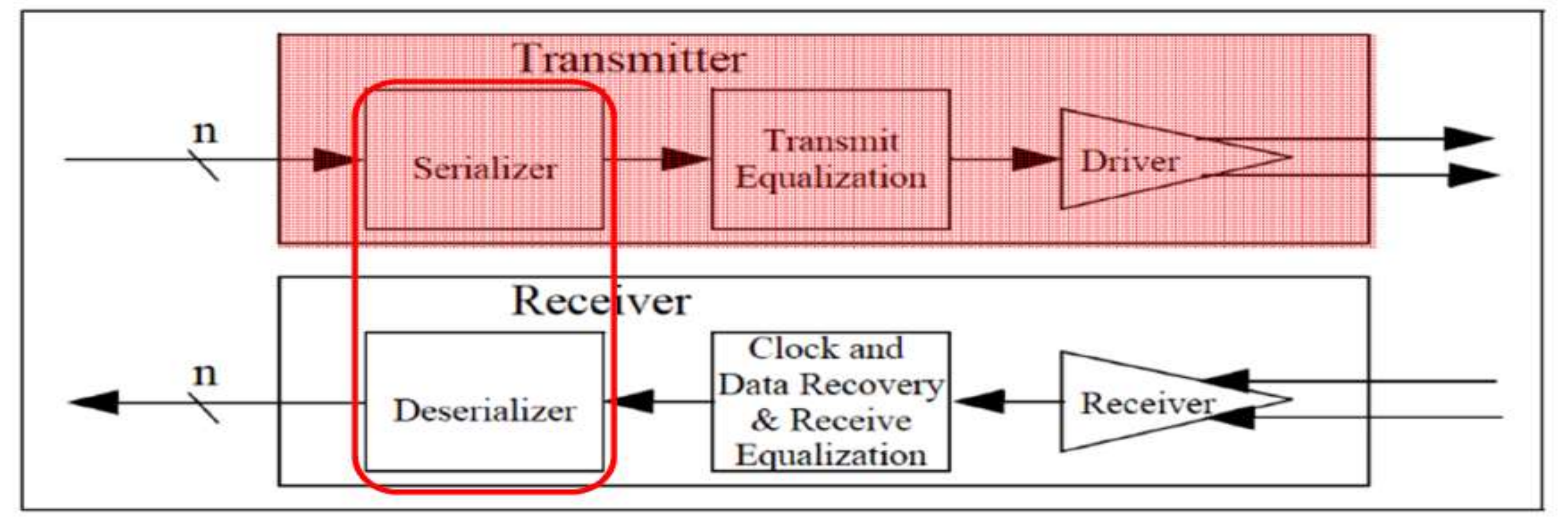
2019 OCT

KEYSIGHT TECHNOLOGIES

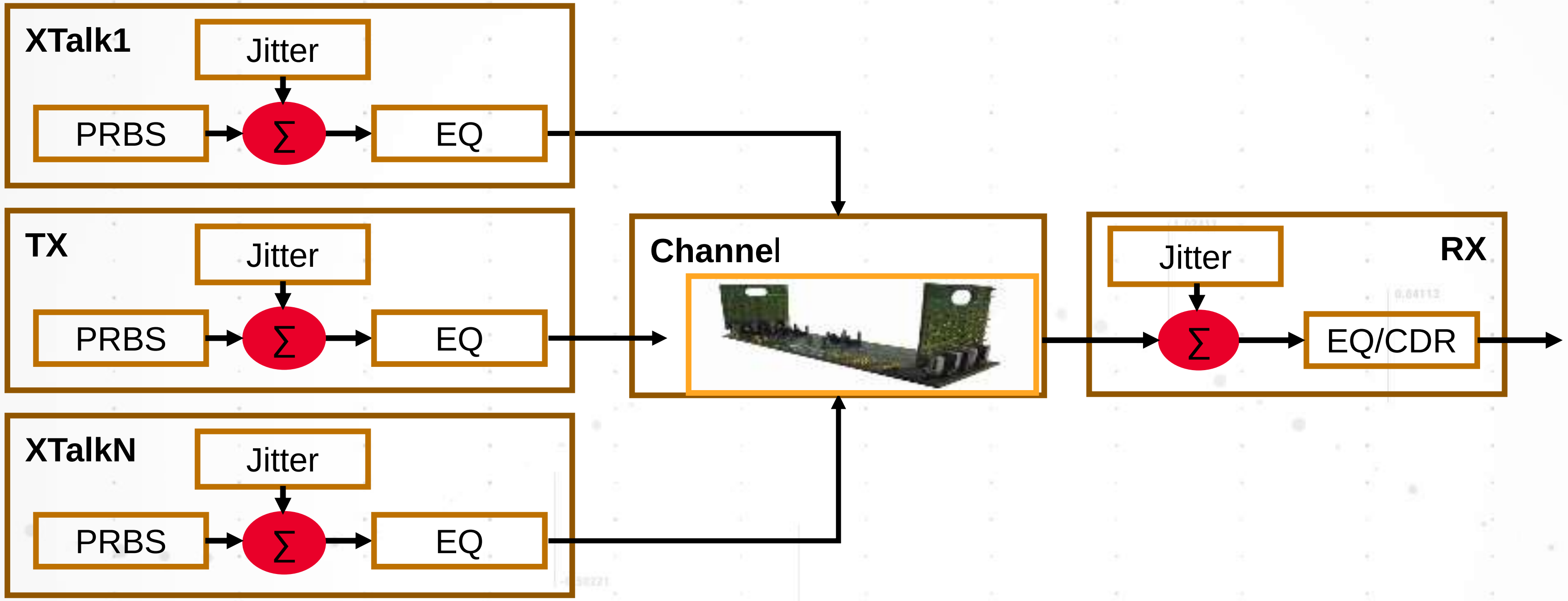
What is SERDES ?

SERDES = SERializer - DESerializer

- Used to transmit high speed I/O data over a serial link in I/O interfaces
- SerDes TX: convert parallel data to series data and transmit to high speed link
- SerDes RX: receive data from serial link and deliver parallel data to next stage



SERDES Link Introduction and Design Challenges



- Low BER performance (10e-12 or less) used to imply long simulations
- Issues with interconnect models: limited frequency domains model leads to causal issue
- Multiple crosstalk channels
- Jitter modeling for TX &RX
- Equalization in TX &RX

Tx & Rx Equalizer

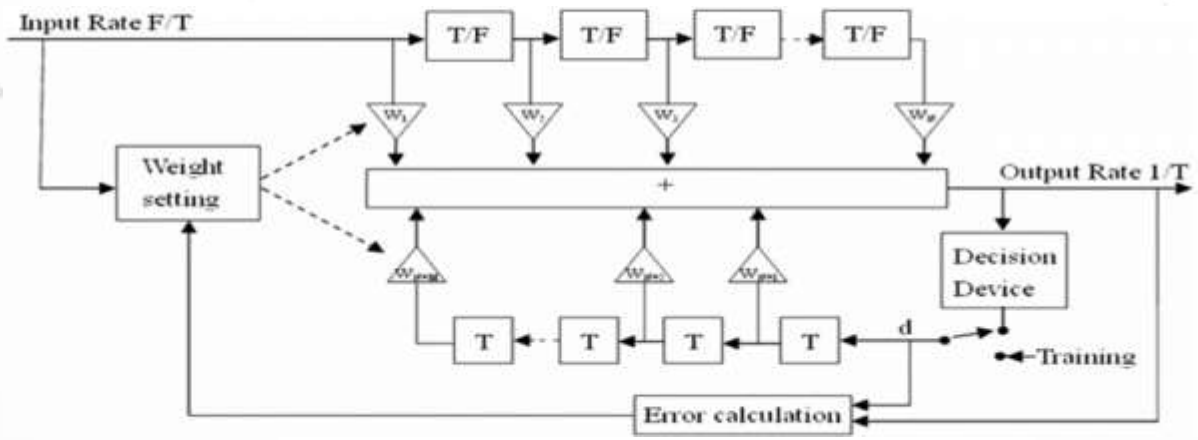
- **Feed-forward-equalizer (FFE)**

$$V_{out}(t) = a_0 V_{in}(t) + a_1 V_{in}(t-T) + a_2 V_{in}(t-2T) + \cdots$$

- **Continue-time-equalizer (CTE): pole-zero**

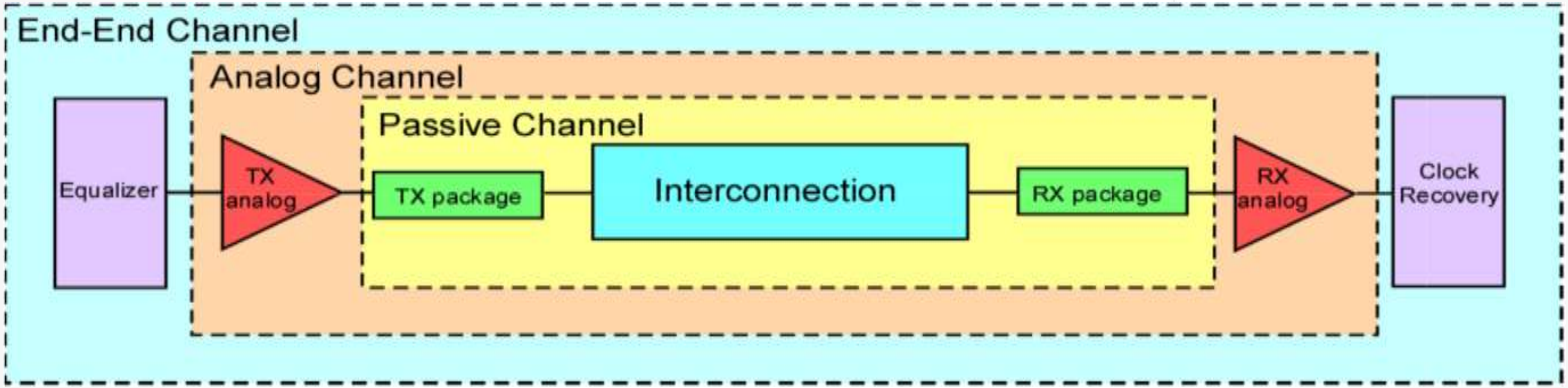
$$H(s) = A\frac{(s-z_1)(s-z_2)\cdots}{(s-p_1)(s-p_1)\cdots}$$

- **Decision-Feedback-equalizer**



What is IBIS and AMI?

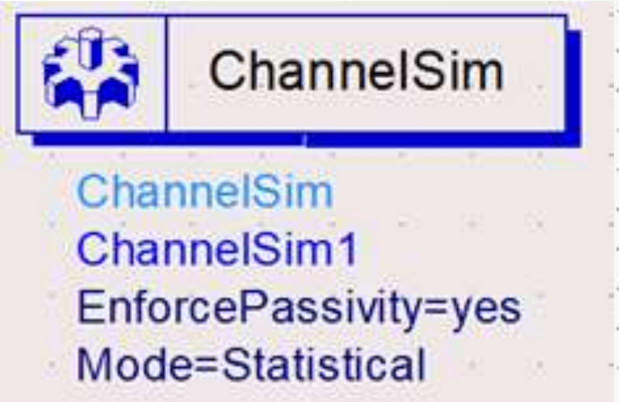
- IBIS is “Input/output Buffer Information Specification”
- AMI is “Algorithmic Modeling Interface”
- IBIS Open Forum added the AMI flow an alternate to the traditional (SPICE-based) flow in IBIS version 5.0
  - http://www.eda-stds.org/ibis/



- IBIS-AMI Modeling:
  - AMI model builders (typically IC vendors)
  - AMI model users (both IC vendors and OEMs)

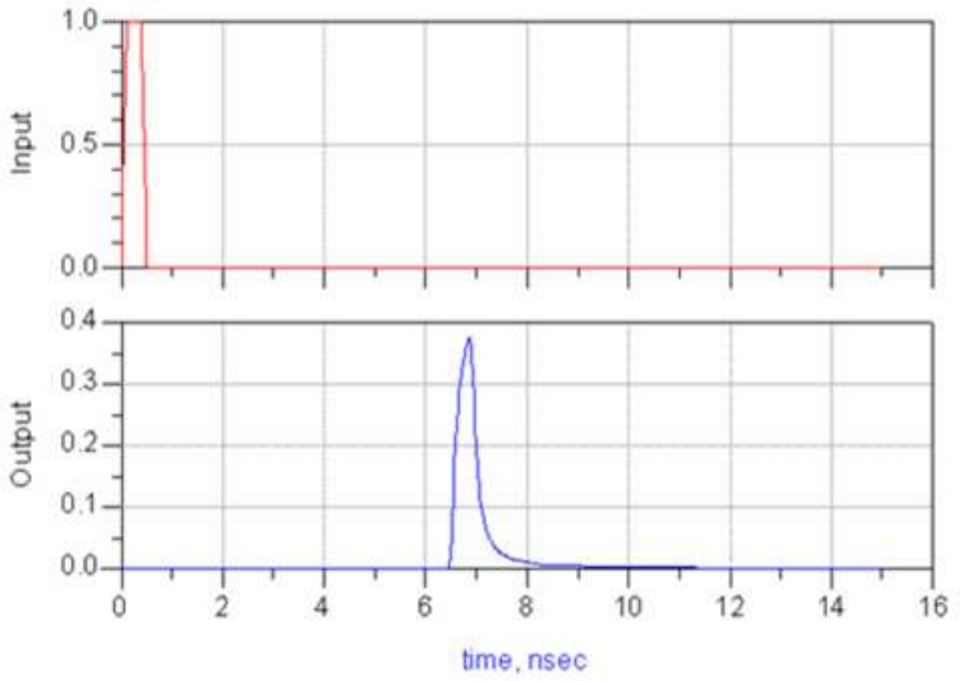
Channel Simulator

- New Class of simulator to run FAST system analysis and display results about how signals will travel through the system.
- Channel must be Linear Time Invariant (LTI) in all cases
- Allows fast techniques:
  - convolution
  - Superposition
  - statistical methods
- Tx and Rx can be NLTV in bit-by-bit mode
- Tx, Rx, and channel must also be LTI in statistical mode

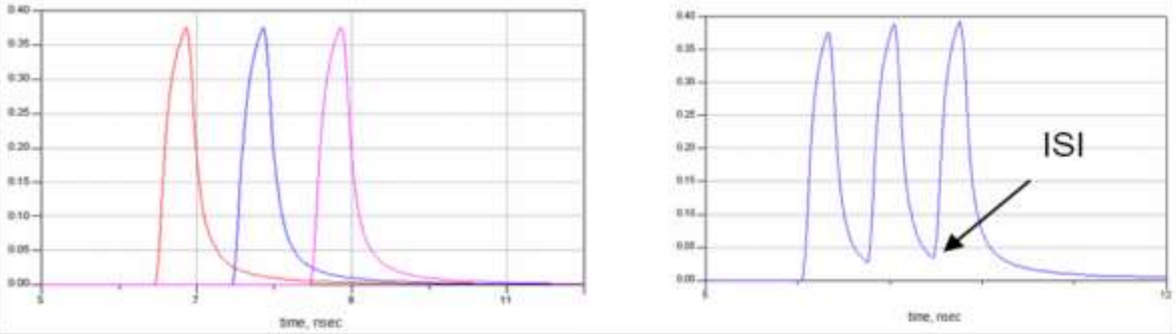


Channel Simulator Methodology

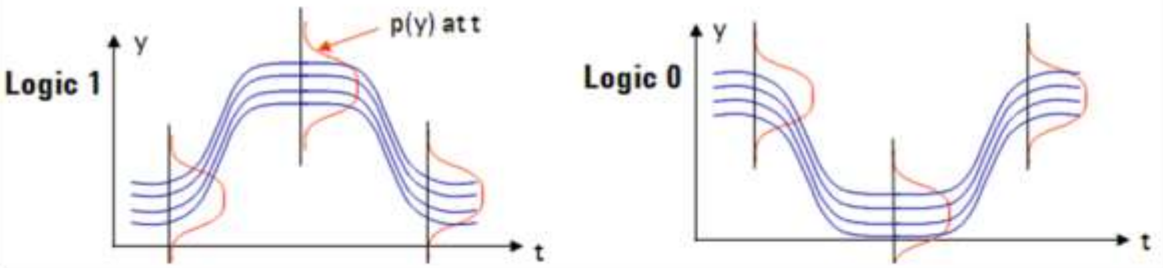
Impulse response is calculated using a short, traditional transient simulation



Bit by bit mode : Superposition of bits



Statistical mode : Statistical techniques



Industry Golden Tool for AMI Simulation and Channel Sim

INDUSTRY LEADING AMI SIMULATION BY ADS CHANNEL SIM

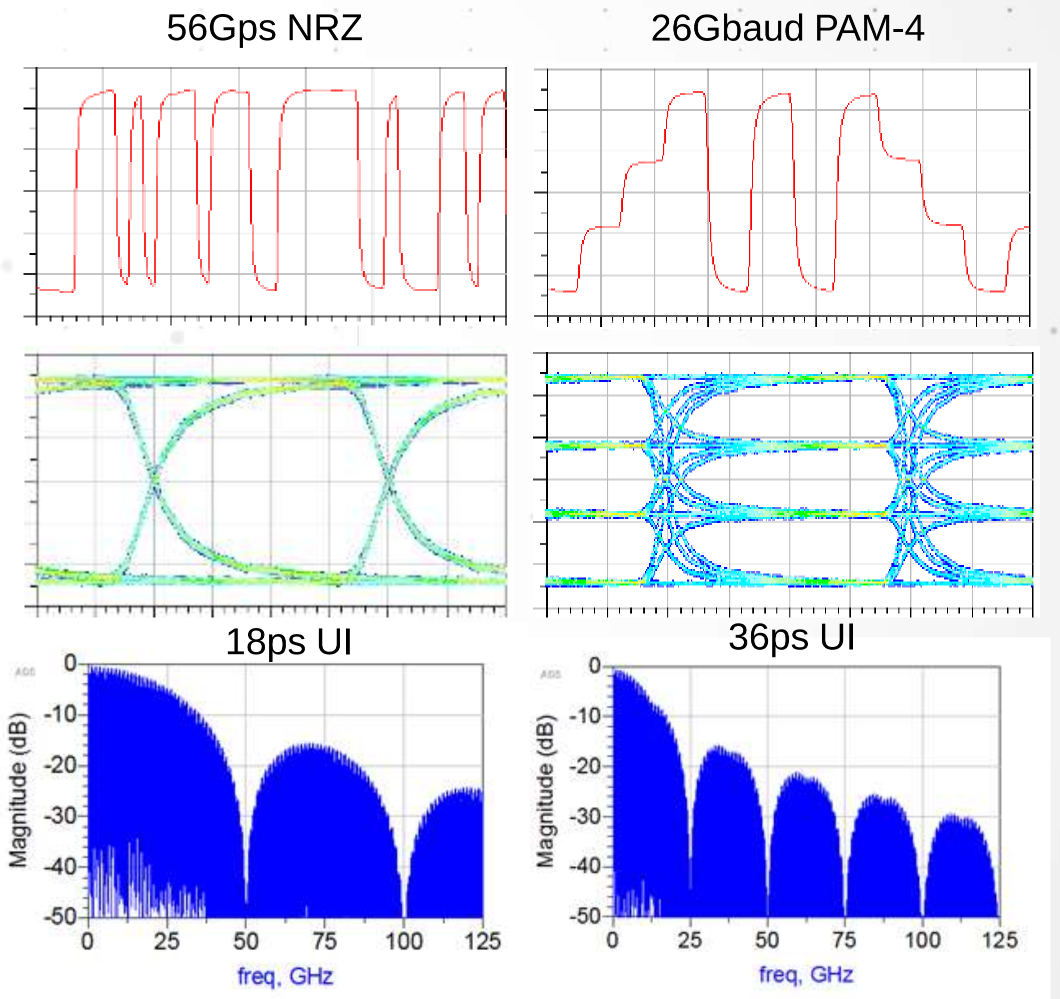
- Unique Treatment of Jitter Amplification in ADS
- The Rao Method Pattern
- PAM-4 Channel Simulation

United States Patent — **7,962,541**
Rao — **June 14, 2011**

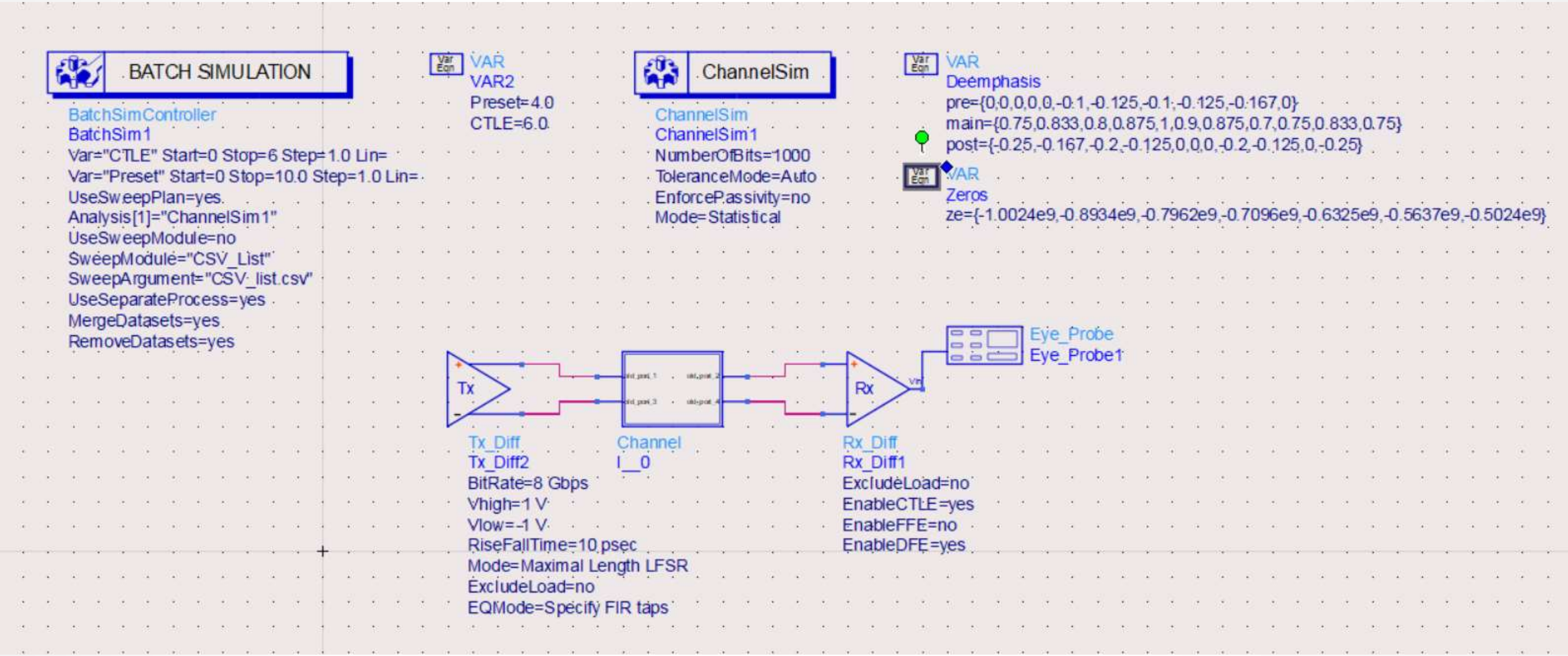
Optimization of spectrum extrapolation for causal impulse response calculation using the hilbert transform

Abstract

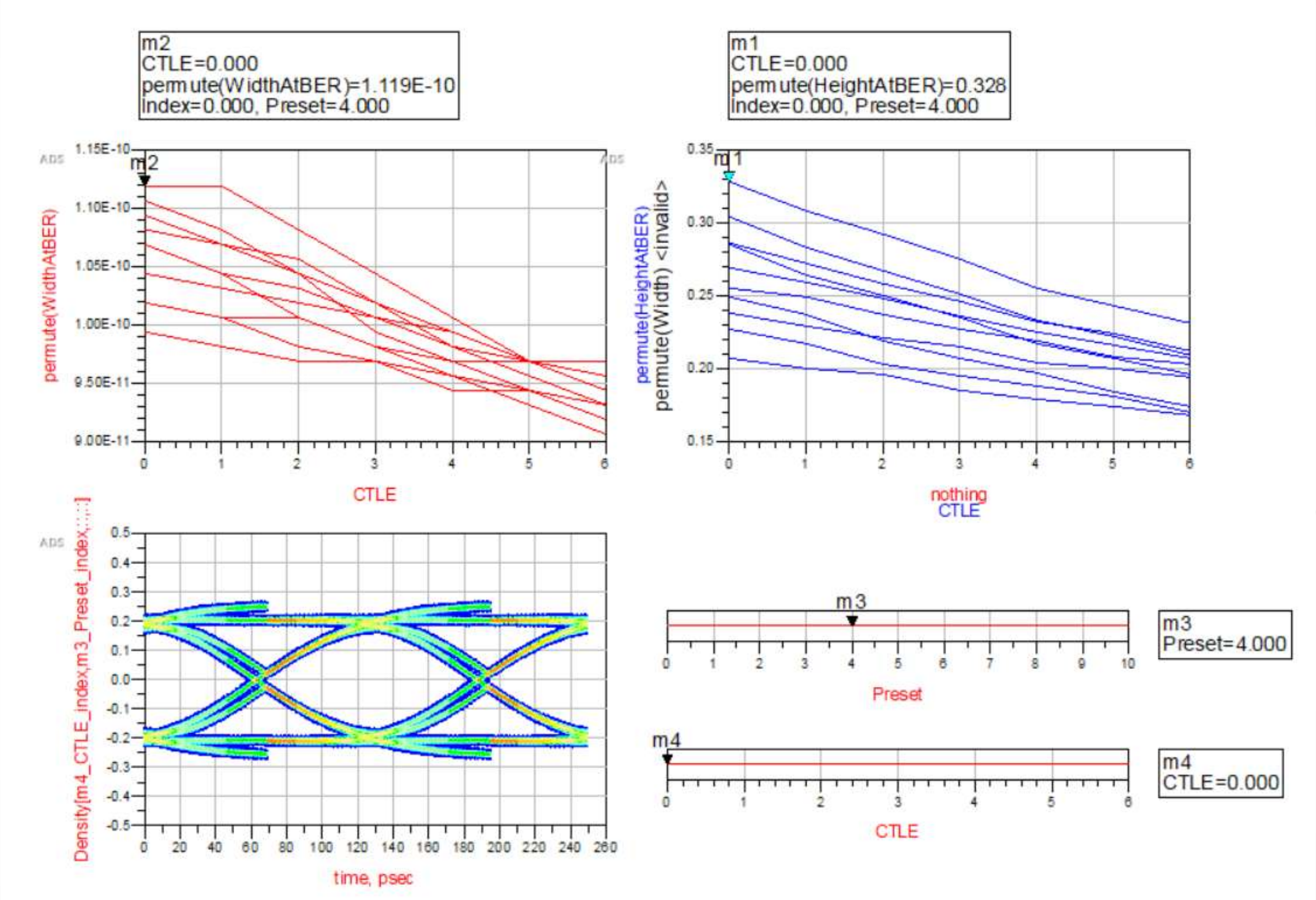
A causal impulse response function is calculated from a truncated spectrum by extending the real part of the spectrum beyond the truncation frequency and computing the imaginary part with the Hilbert transform to enforce causality. The out of band extrapolation is optimized to reduce the discrepancy between the computed and the original imaginary part in the in band frequency range so that the causal impulse response accurately represents the original spectrum. The technique can be applied to spectral with the delay phase subtracted to enforce delay causality. The Hilbert transform may be employed to maintain causality in S-parameter passivity violation correction. At frequencies where violation happens, the S-parameter matrix is scaled down by the inverse of the magnitude of the largest eigenvalue. Magnitudes at other frequencies are unchanged. An additional phase calculated by the magnitude phase Hilbert transform is added to the scaled spectrum to maintain the causality.



PCIe Gen3 Example



Find Best TX&RX Equalizer Setup to Open EYE



KEYSIGHT
TECHNOLOGIES