# A Time/Frequency Domain Statistical Channel Compliance/Specification Method

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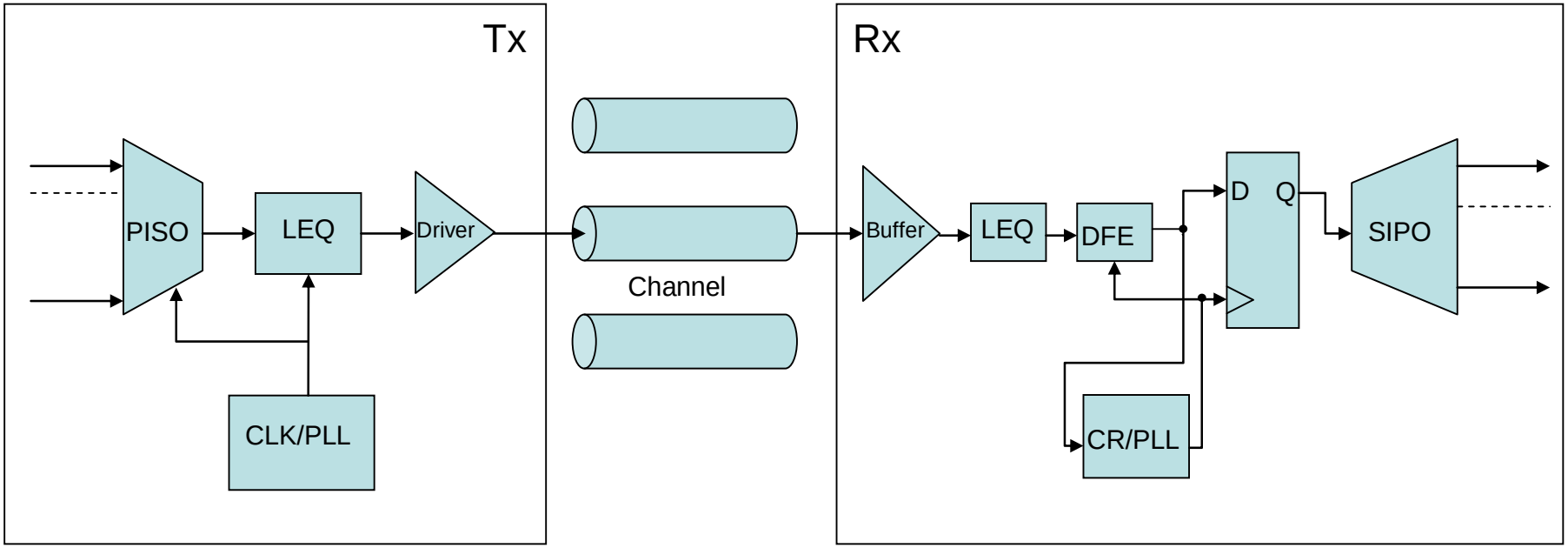
# Introduction, A BP Link Block Diagram



# Motivation

- For 25 G BPs, all kinds of equalizations (Tx FIR, and Rx CTLE/FFE, and DFE) have to be utilized in order to achieve channel loss and targeting BER objectives (see e.g., Patel_01b_0911)
- It is not possible to accurately develop the time and voltage bounds for the channel relevant to the BER goal w/o knowing or assuming the Tx and Rx equalization capabilities for a BP
- Channel loss characteristics (e.g., IL, RL, and Xtalk (NEXT and FEXT)) alone can only give conservative time and voltage bounds
- Tx, channel, and Rx interact statistically and a compliance method following this rule will receive RSS (root-sum-square) jitter and noise relief benefits, enabling optimal (*NOT* conservative) jitter and noise budgeting for Tx, Rx, and Channel w/o increasing the cost/power

# Motivation (cont)

- A reference Tx and Rx based channel specification/compliance method is proposed to treat the interaction between Tx, channel, and Rx similar to that in an actual link system, warrants a better accuracy for channel compliance determination and flexibility of trade-offs between channel impairments (IL vs RL vs Xtalk)

# A Reference Tx

- A N-tap FIR EQ
  - N is TBD and will be consistent with the Tx electrical specification
- A LPF for Tx driver
  - LPF is TBD
- A reference package represented by a S.np file
  - Driver LPF and package loss need to be consistent with the rise/fall times of the Tx electrical specification

# A Reference Rx

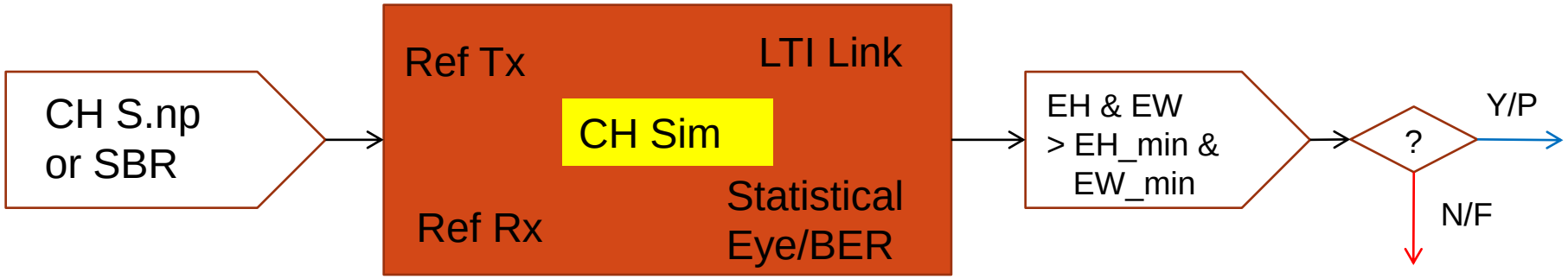
- A buffer LPF
- A Q zero, and P pole CTLE
  - P> Q,  P and Q are TBD, and will be consistent with Rx electrical specification
- A M-tap DFE
  - M is TBD, and will be consistent with Rx electrical specification
- A golden PLL CDR
  - will be consistent with the Rx electrical specification
- A reference package represented by a S.np file

# Channel

- Channel is the device under test (DUT) or device under simulate (DUS)
- Channel input is represented with a S.np file, or a single bit response (SBR), capturing IL, RL, and Xtalk impairments
- Simulation output is the eye-height (EH) or eye-width (EW) at a target BER of the link
- The channel pass/fail criteria are EH_min (TBD), and EW_min (TBD)

# Interaction Between Tx, Channel, and Rx

- The interaction between Tx, channel, and Rx is assumed to follow the LTI (linear time-invariant) system theory
- Optimal settings for Tx, and Rx EQs via optimization procedure
- The eye/BER contour at the output of the DFE can be constructed statistically (see, e.g., [1], [2], [3]) using the optimal EQ settings



# Implement ability

- Several device vendors already have home-grown simulators using similar method as proposed in this presentation (see, e.g., Patel_01b_0911)
- The proposed method can be implemented with various programming languages (e.g., C/C++, Matlab), or circuit simulation/modeling platforms (e.g., IBIS-AMI, Verilog-A)

# Conclusions

- A time/frequency domain reference Tx and Rx based statistical channel compliance method is proposed
- The proposed method bears intrinsic better accuracy, RSS link jitter/noise relief, and flexible trade-offs between channel IL, RL, and Xtalk

# References

[1] V. Stojanovic and M. Horowitz, "Modeling and analysis of high-speed links", IEEE CICC, 2003.

[2] A. Sanders, M. Resso, and J. D' Ambrosia, "Channel compliance testing utilizing novel statistical eye methodology", Designcon, 2004.

[3] G. Balamurugan et al, "Modeling of high-speed I/O links", IEEE Transaction on Adv Package, vol 32, May, 2009.