AMI Modeling Methodology and Measurement Correlation of a 6.25Gb/s Link

Putting Intelligence in the Network™

Ryan Coutts
Antonis Orphanou
Manuel Luschas

Amolak Badesha
Nilesh Kamdar

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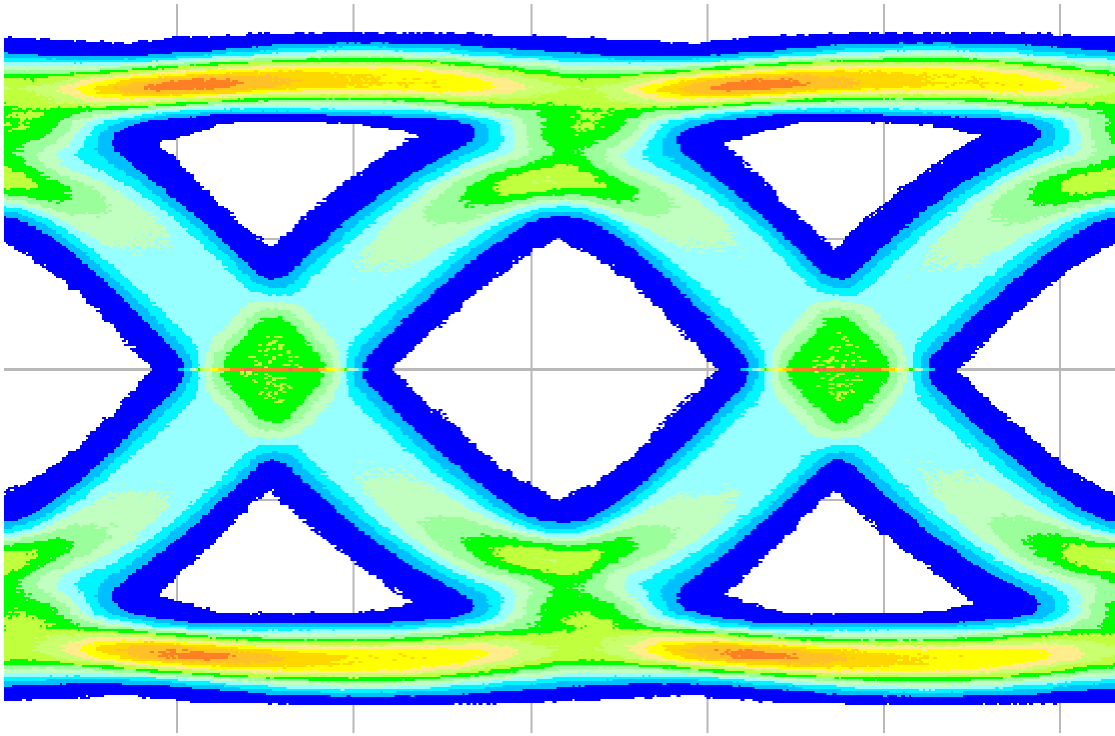
Agenda

- Correlation Flow Overview
- Tx AMI Modeling & Correlation
- Rx AMI Modeling
- Rx Measurement
- Correlation Results



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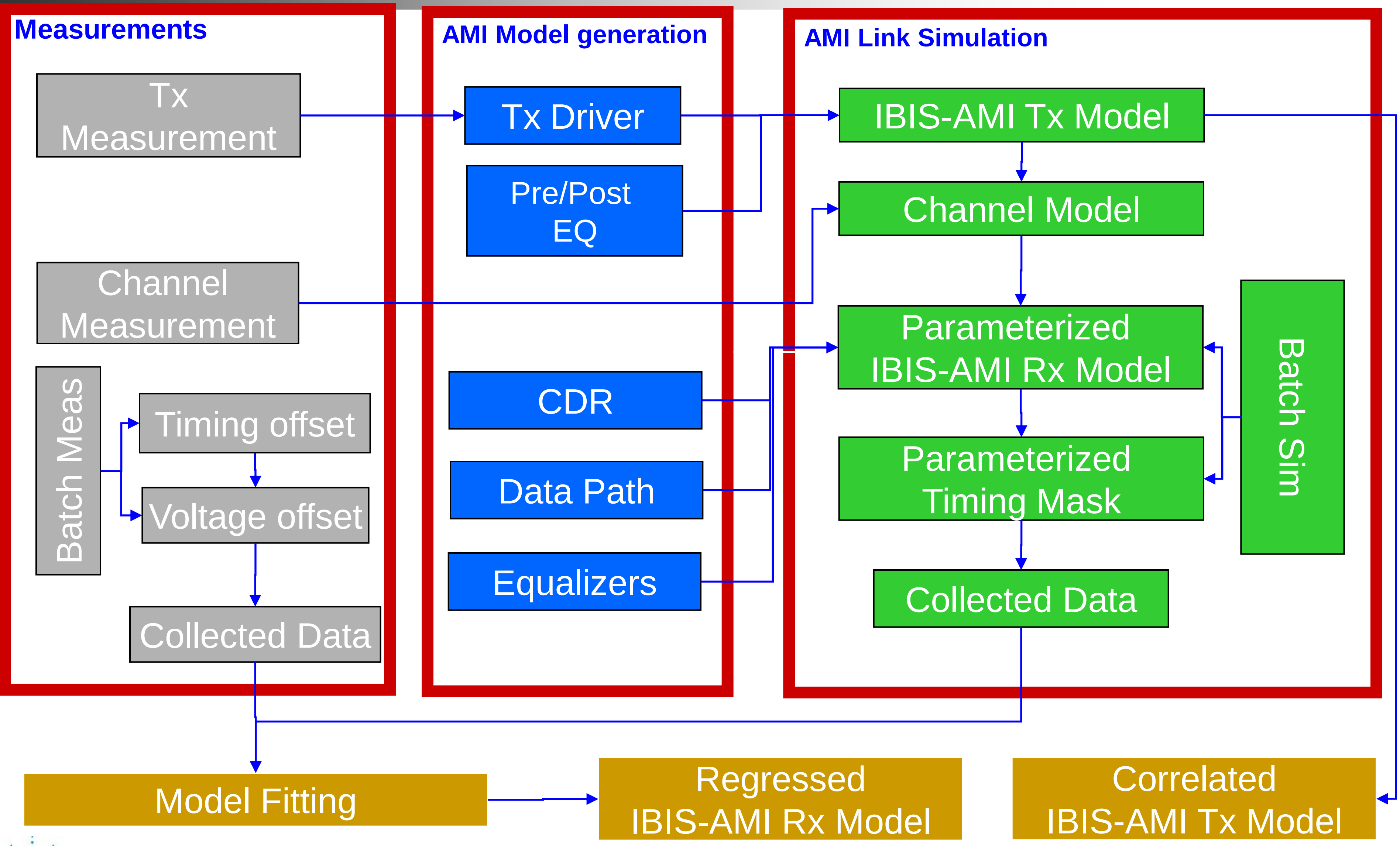
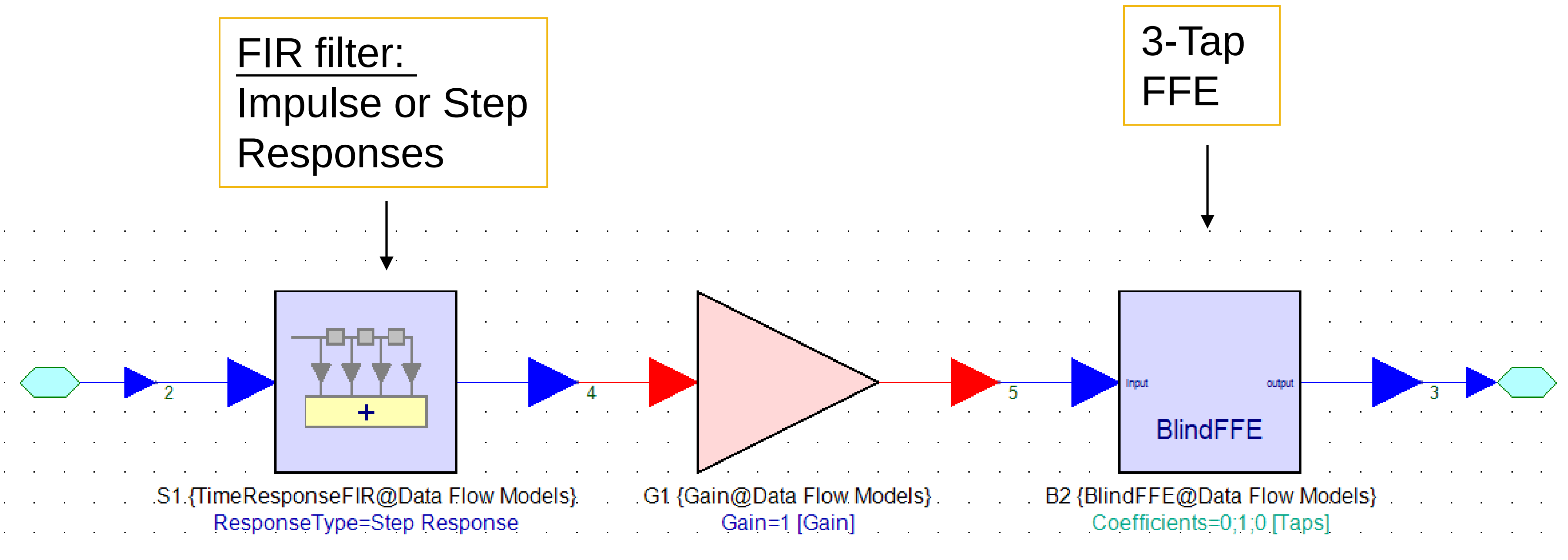
Correlation Flow Overview



AMI Tx "Architecture"

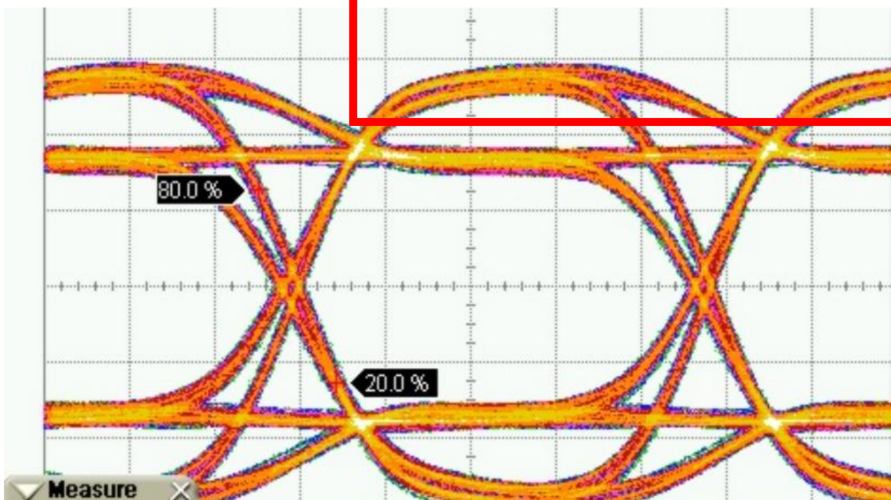
Mathematically De-embedded Impulse response is passed on to FIR filter model:



This enables us to extract AMI model (.ami and .dll files…)
for Link simulation with IBIS 5.0 compliant Channel Simulators…

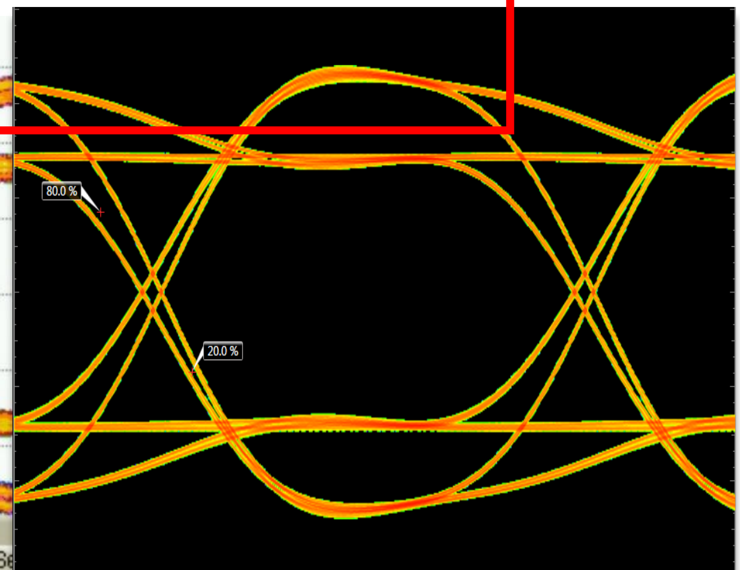
Initial TX correlation results

non-linearity



Measure

	current	minimum	maximum	total meas
Jitter RMS(f1)	2.017 ps	640 fs	2.020 ps	168
Jitter p-p(f1)	8.444 ps	2.667 ps	8.444 ps	168
Rise time(f1)	17.78 ps	17.33 ps	114.22 ps	158
Fall time(f1)	18.22 ps	18.22 ps	114.67 ps	168



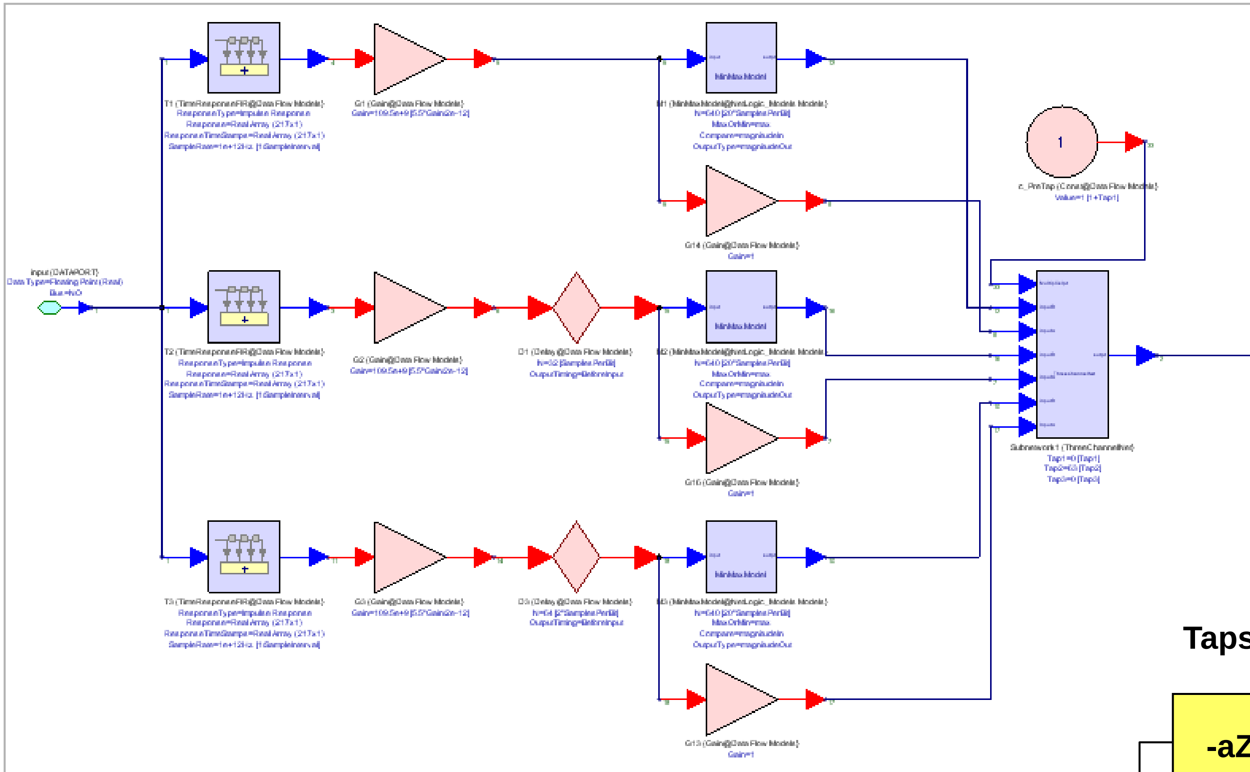
Measurement		Current	Minimum	Maximum
Jitter[rms]	1B	2.160 ps	2.154 ps	2.162 ps
Jitter[p-p]	1B	6.464 ps	6.248 ps	6.464 ps
Rise Time	1B	20.4 ps	20.4 ps	20.4 ps
Fall Time	1B	20.4 ps	20.4 ps	20.4 ps

- Good Correlation in linear region
- OK correlation in non-linear region

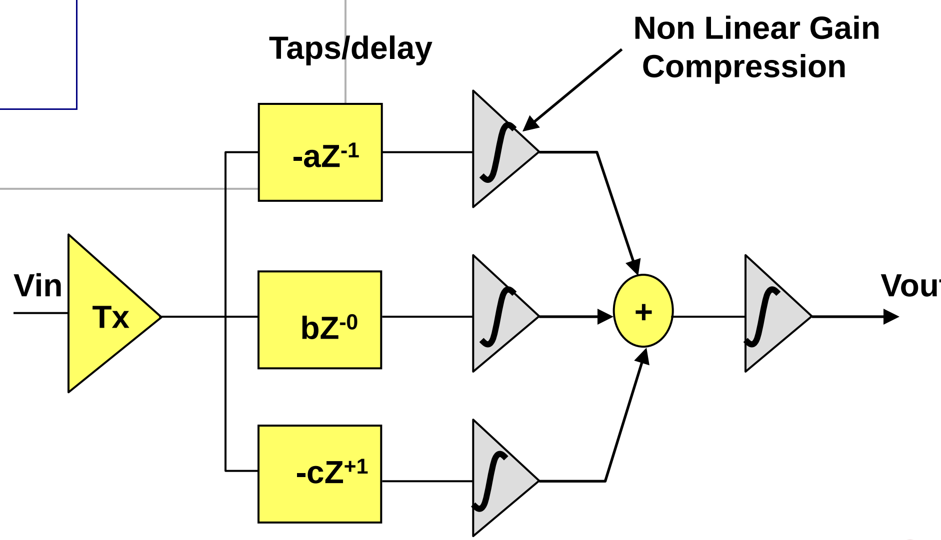
http://www.eda.org/ibis/summits/jun10/pino.pdf

Results presented last year (DAC-2010)

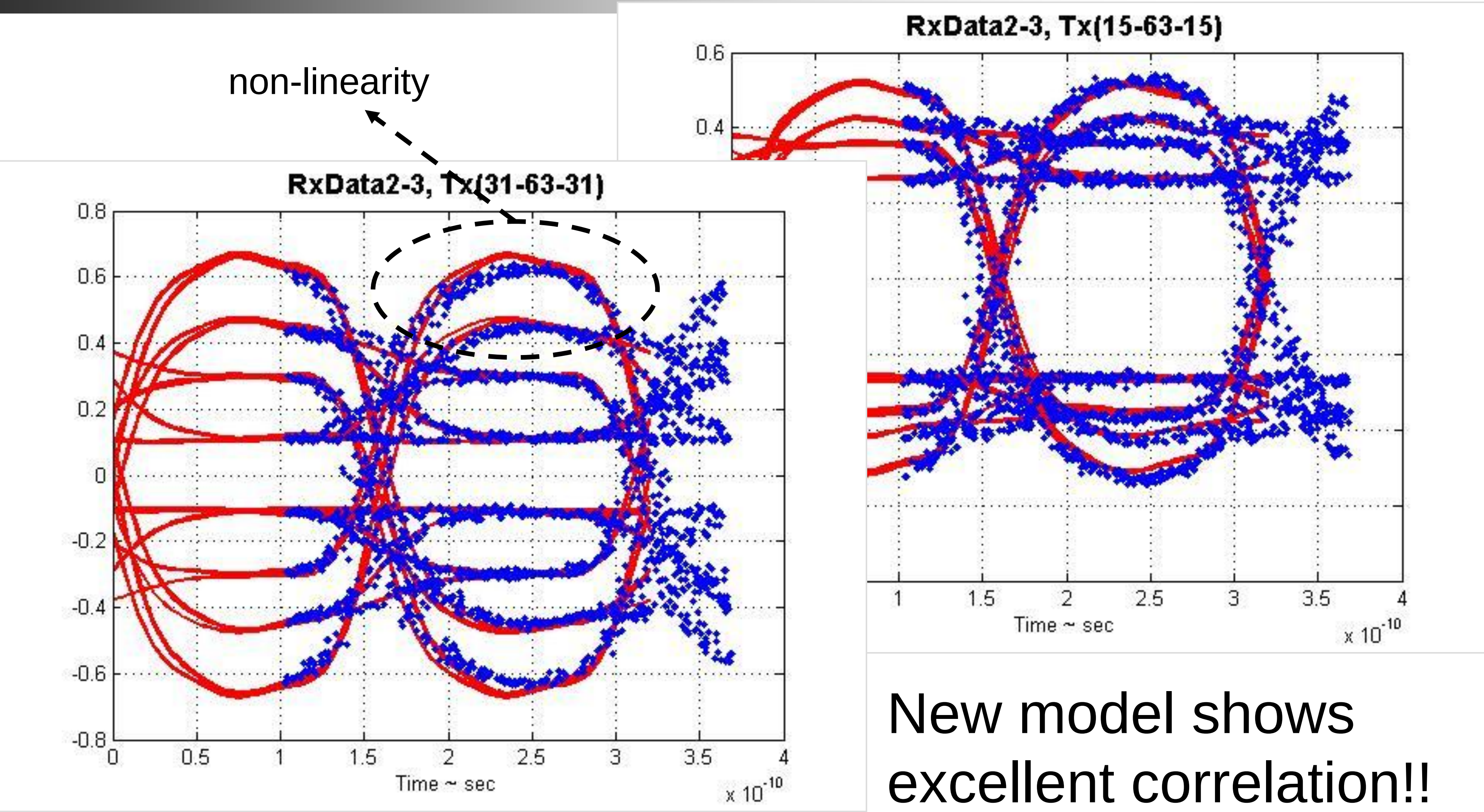
Addressing Tx Non Linearity using “Table Compression”



New model architecture allows accurate modeling of non-linear TX effects…



Non-Linearity Over Emphasis Settings



New model shows <u>excellent</u> correlation!!

------- Measured

------- Simulated

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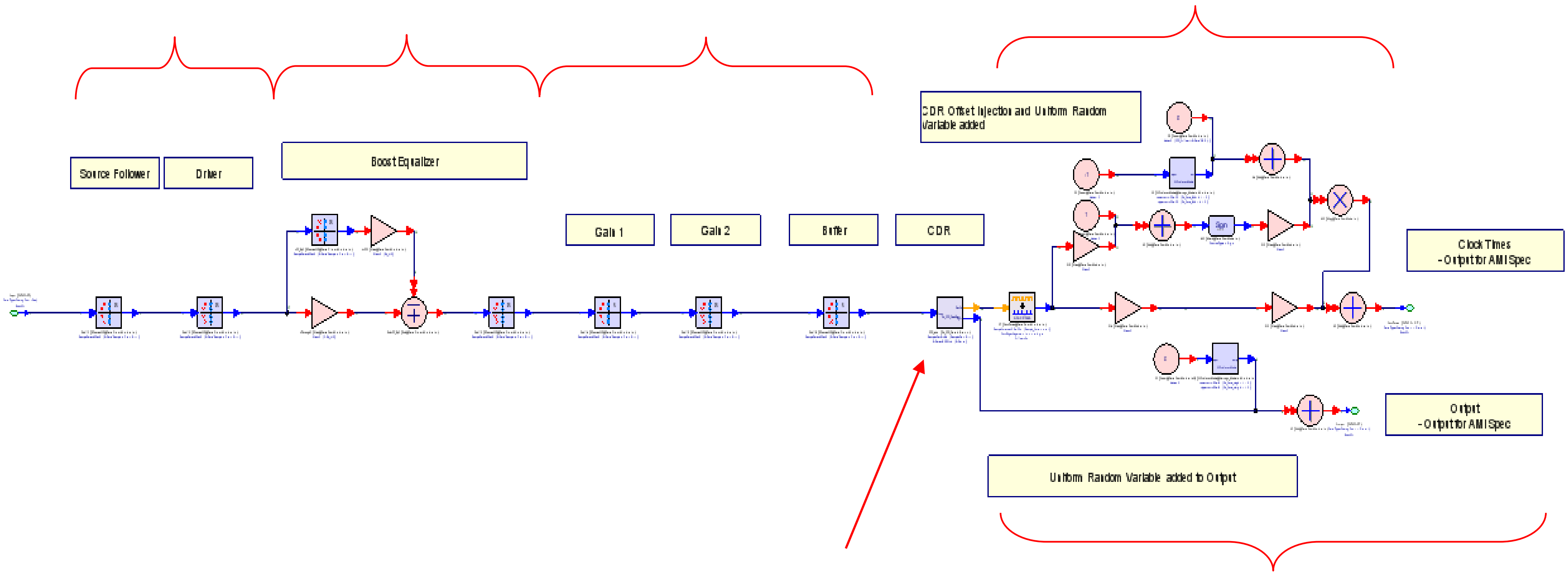
Anatomy of Our IBIS-AMI Receiver

Voltage Domain Conversion

Linear Channel Equalizer

Gain and Buffer Signals

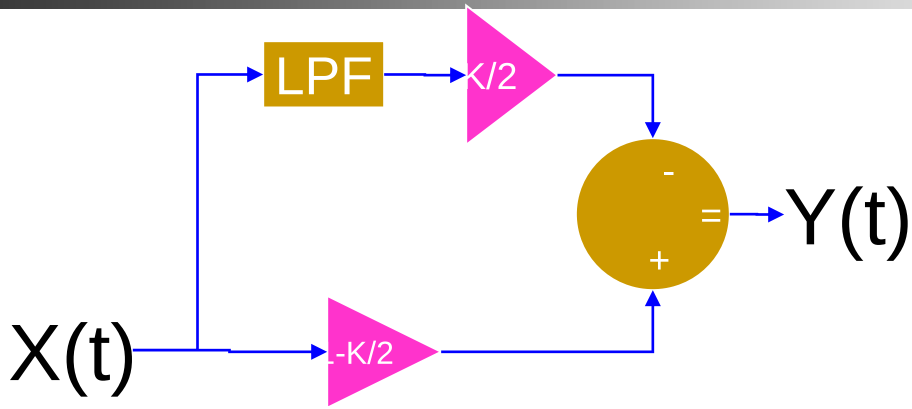
Clock_Times Noise (when valid)

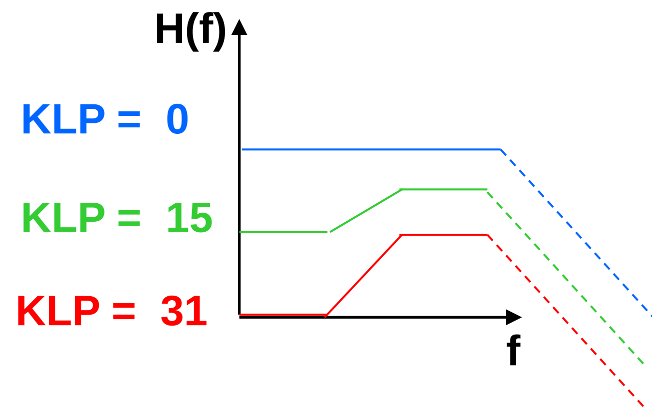


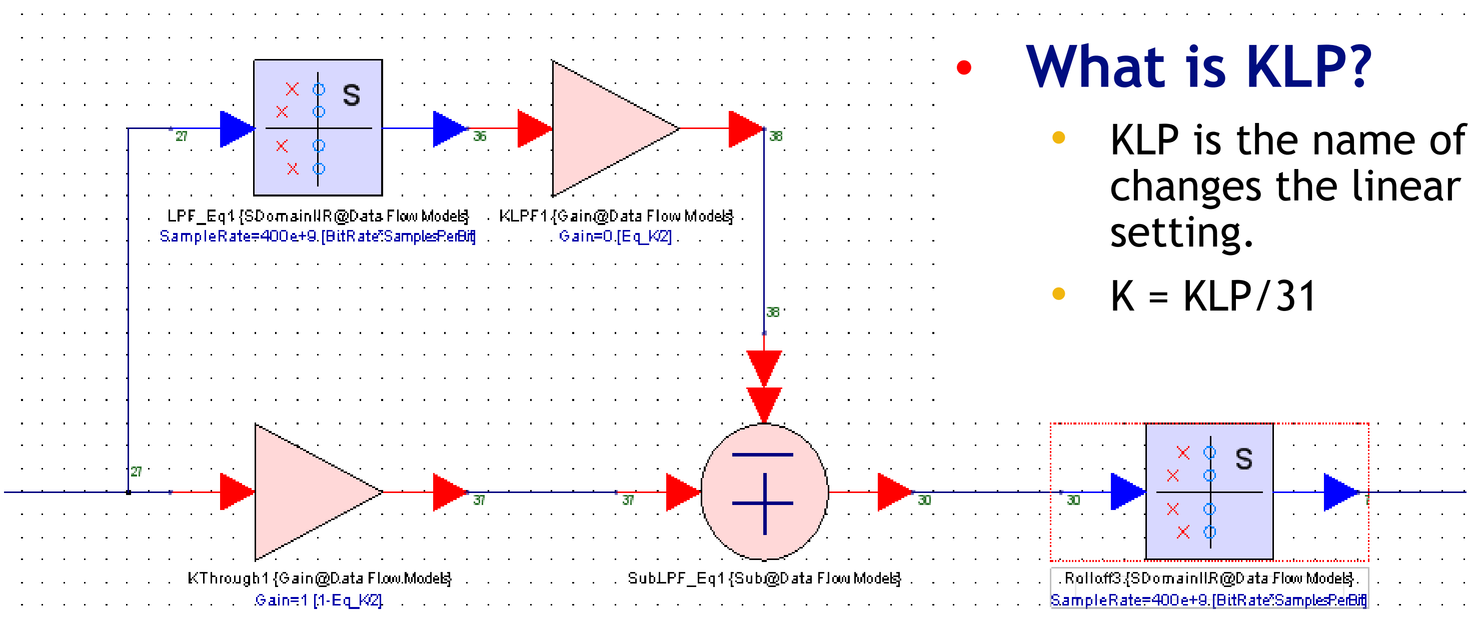
CDR

Voltage Noise

KLP Trimmer in the RX EQ

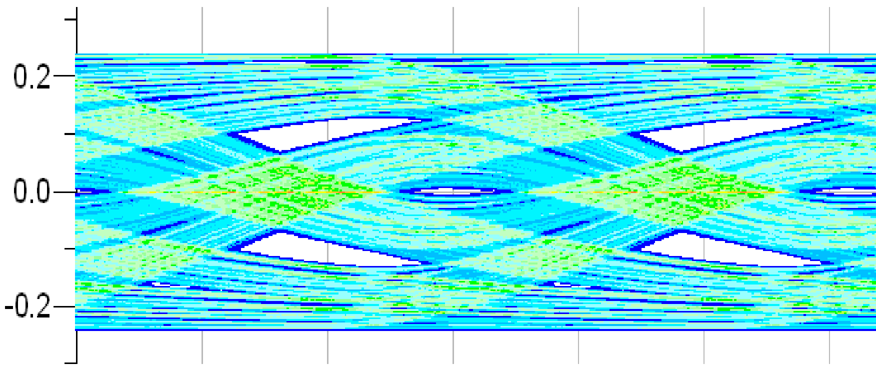




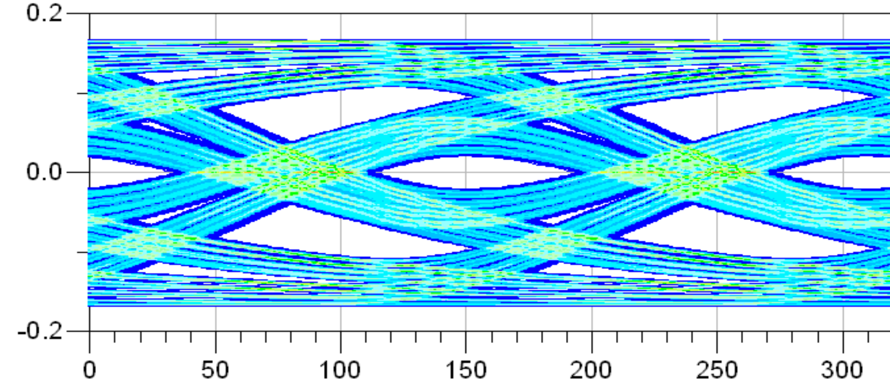


- **What is KLP?**
  - KLP is the name of our register that changes the linear equalization setting.
  - K = KLP/31

RX Linear Channel Equalization In Action



KLP = 0 Eye Opening= 0%

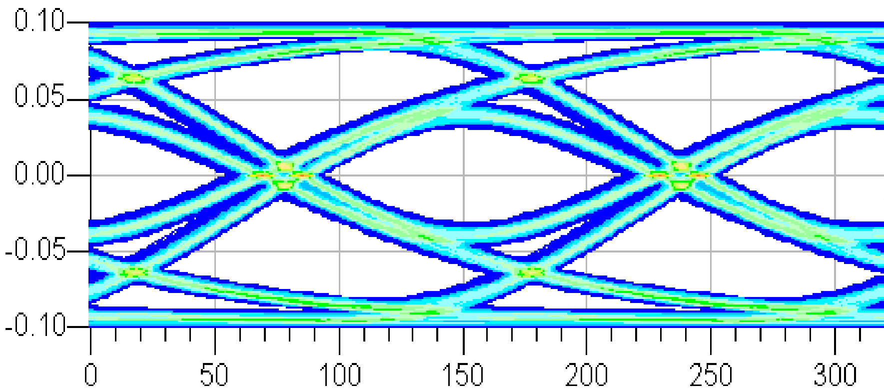


KLP = 12 Eye Opening = 18%

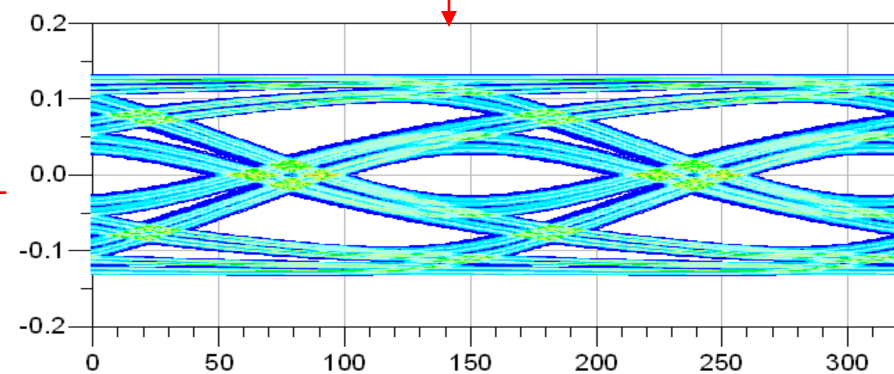
Note: Jitter decreases as the channel is equalized.

Increasing KLP

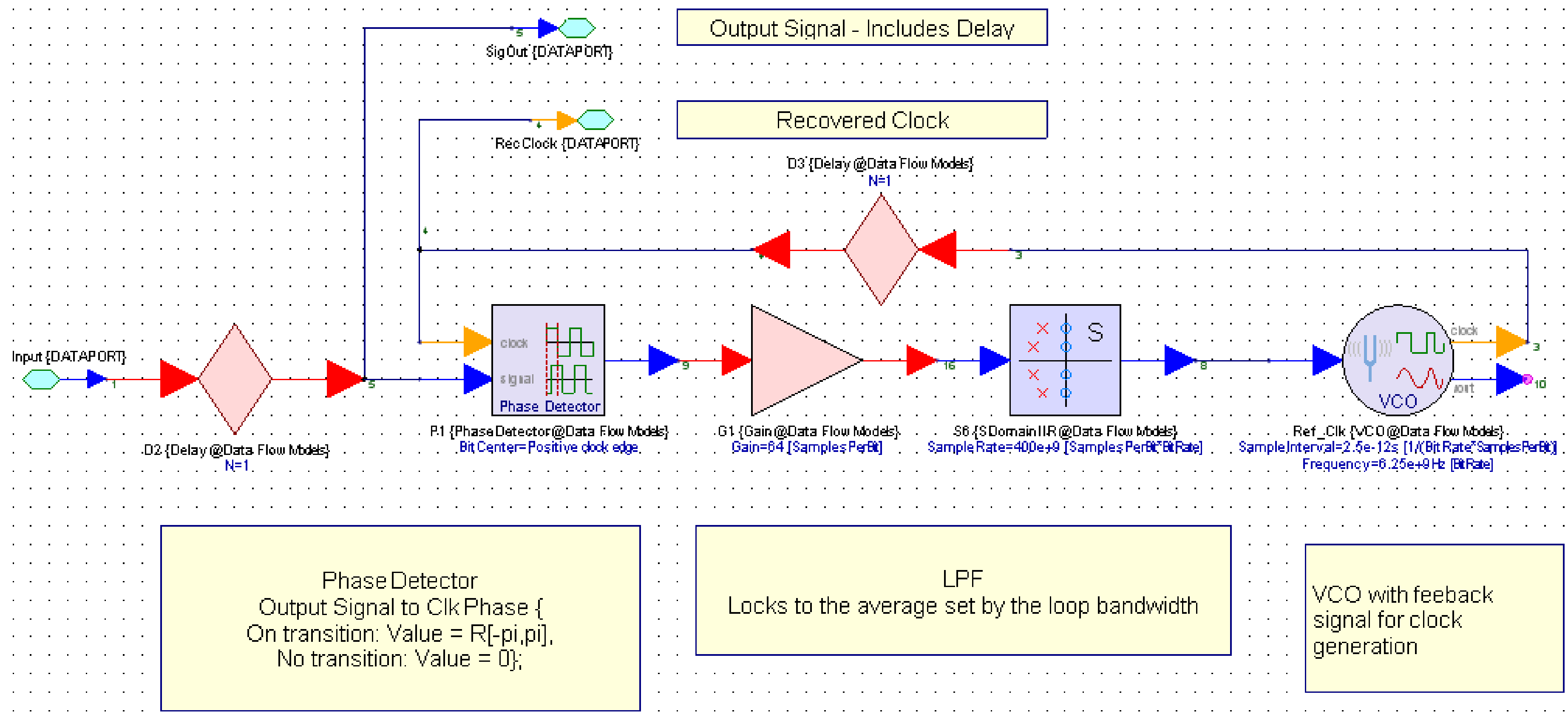
KLP = 24 Eye Opening = 54%



KLP = 18 Eye Opening = 34%

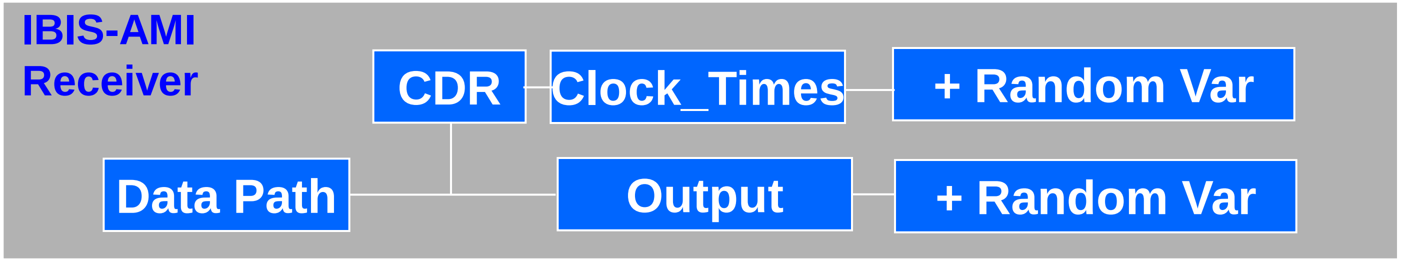


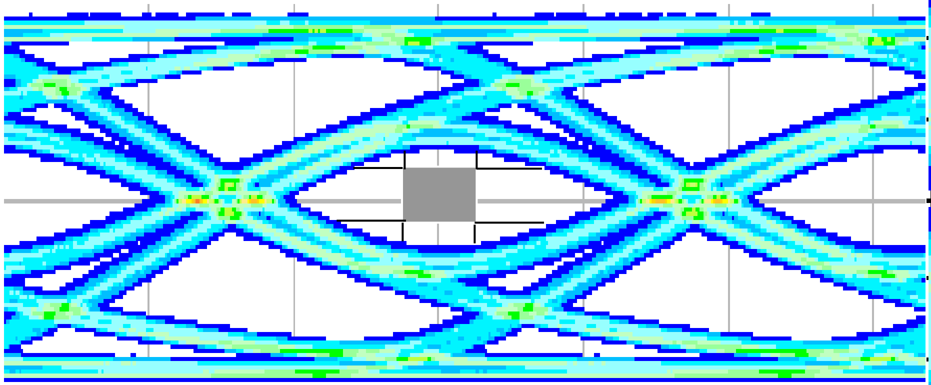
Generic CDR Model



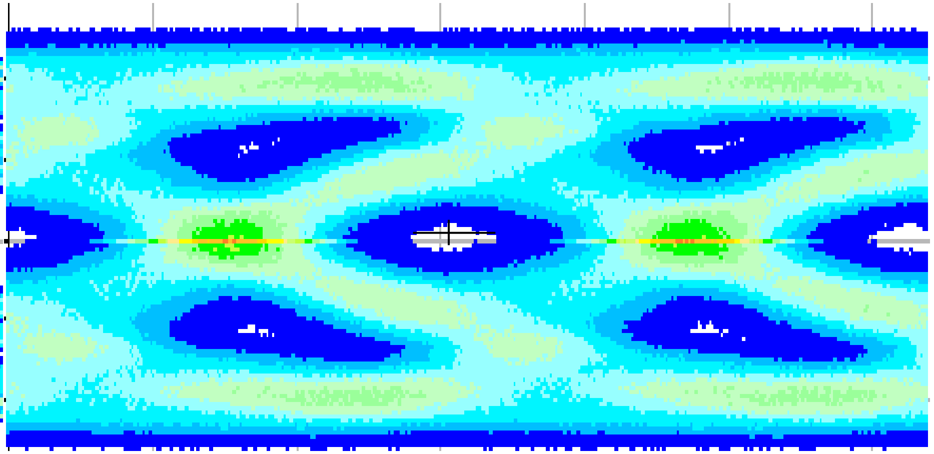
- **Architecture**
  - Our CDR architecture can be modeled by the generic CDR architecture.
  - Design specific loop bandwidth is included to model the deterministic jitter introduced by the CDR.

Inclusion of a Model Contained Receiver Eye Mask





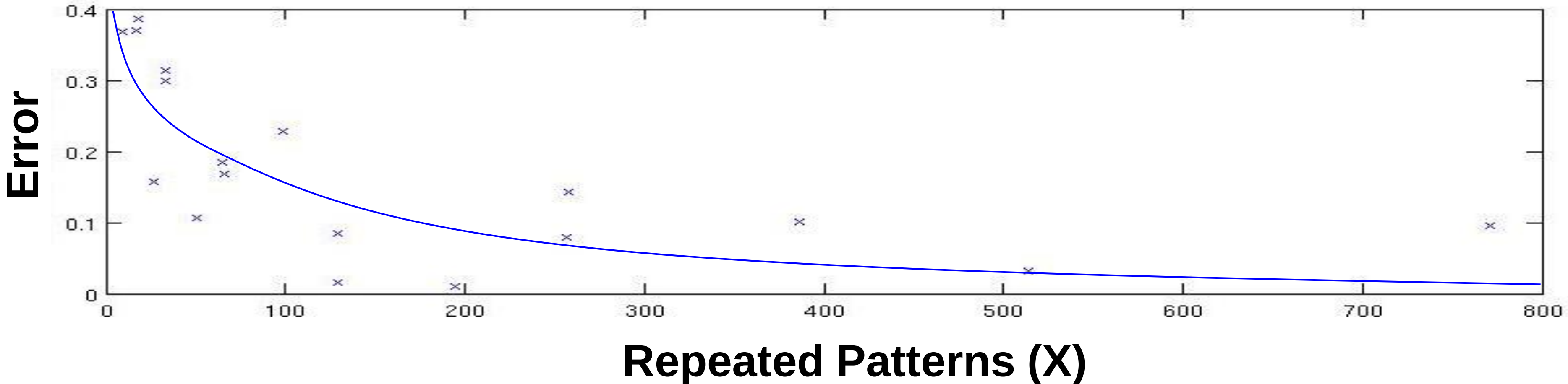
Noiseless



Noise added

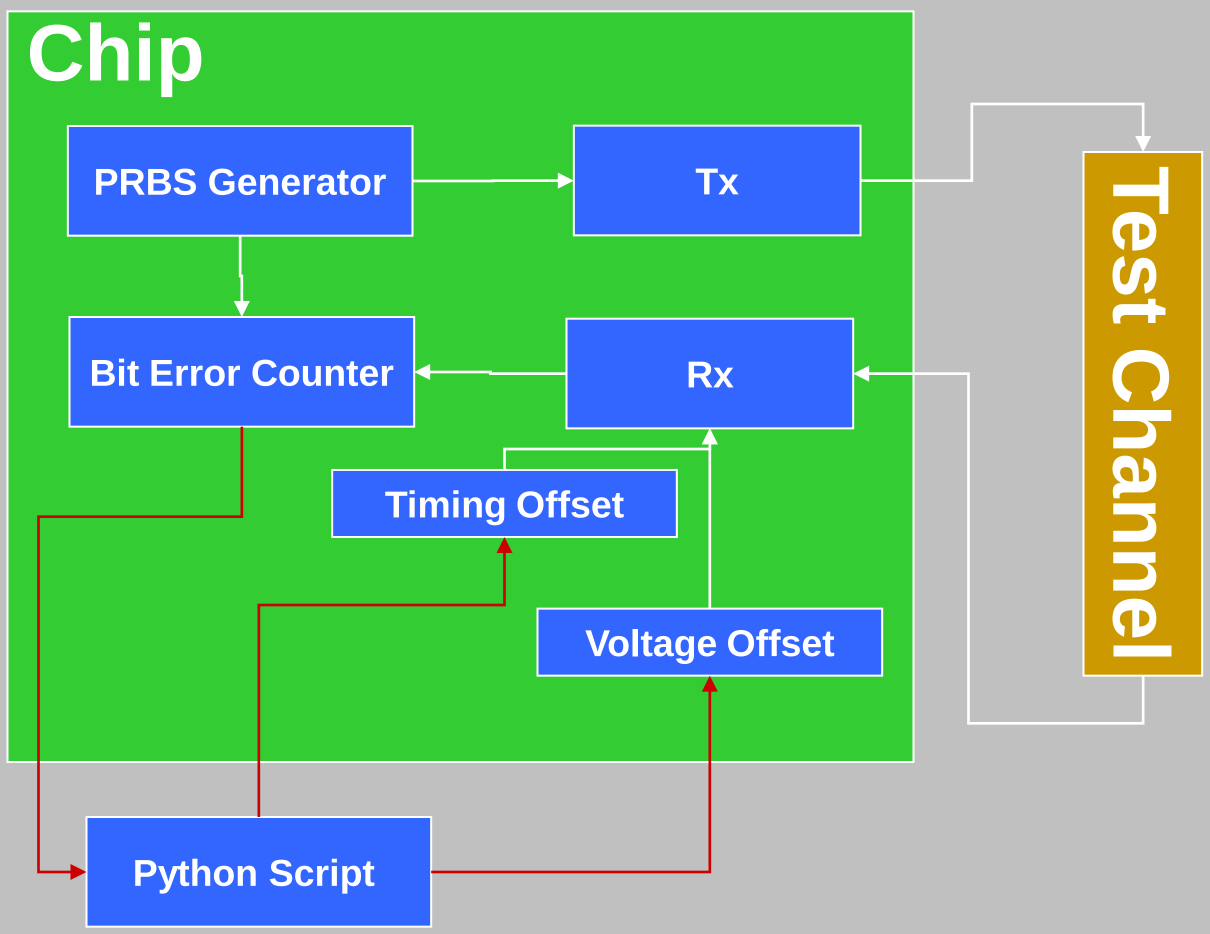
- The model now contains the eye mask requirement for correct operation.
- Instead of producing eye height the model reports eye margin.
- Eye mask must assume voltage and time is separable.

Modeling - Accuracy vs Time



- **Purpose**
  - When a random element is included in the model, we must evaluate the accuracy of the simulation as a function of repeated data patterns.
- **Description**
  - A PRBS15 signal running through the channel was simulated through the entire 2^15-1 bits for X samples of iterations.
- **Result**
  - Simulation with 32767 bits (1x) gives you ~30% accuracy.
  - As the number of bits in the simulation approaches infinity, the accuracy will converge on 0% error.
  - A simulation running 500x 2^15-1 bits (32M bits) was considered converged for design purposes.

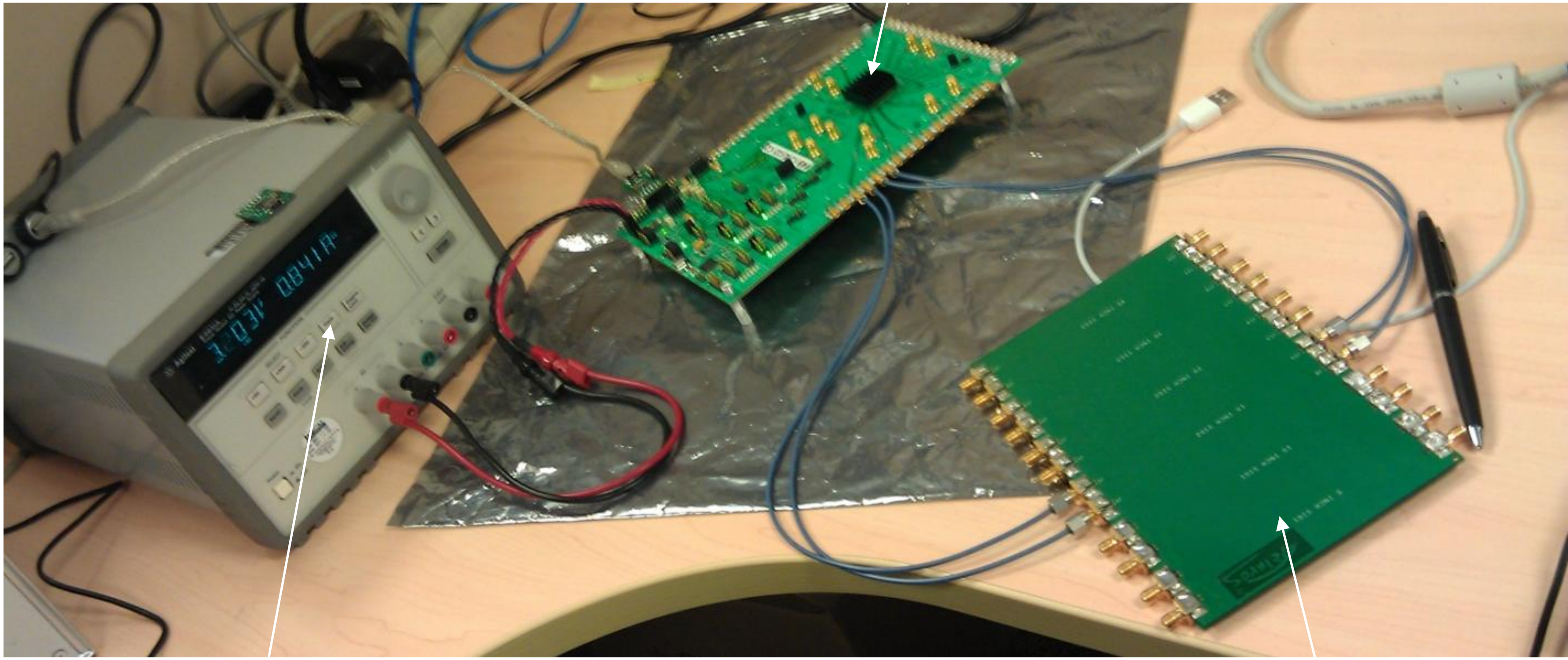
Eye Margin Measurement Setup



- **Initialize System**
  - Set CDR Offset
  - Set Voltage Offset
  - Set Equalizer
  - Reset Bit Error Counter
- **Wait**
  - Wait time depends on BER accuracy requirement
- **Poll**
  - Poll Bit Error Counter

Receiver Measurement

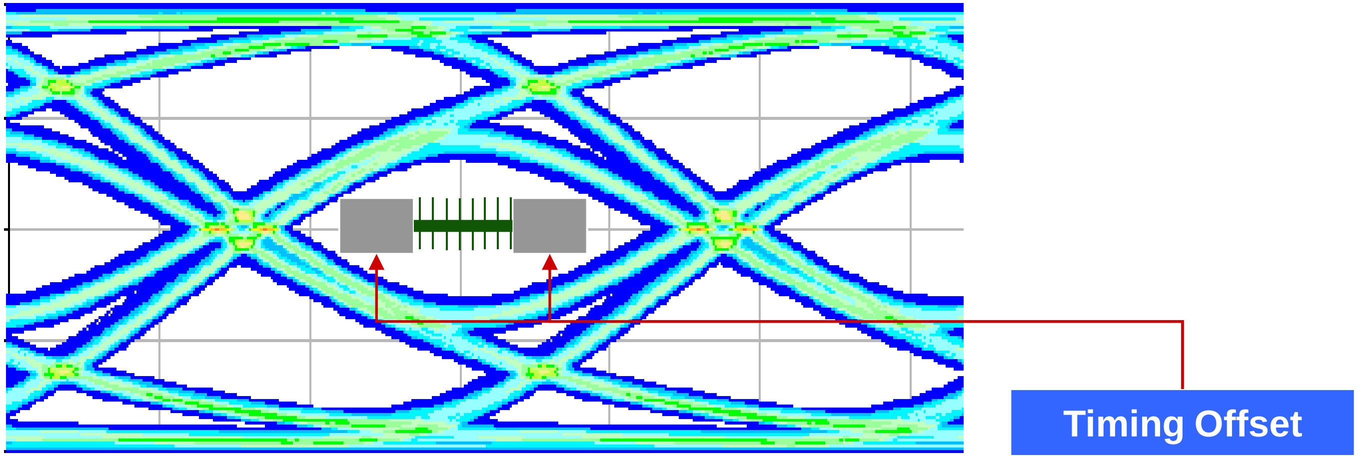
Test Setup



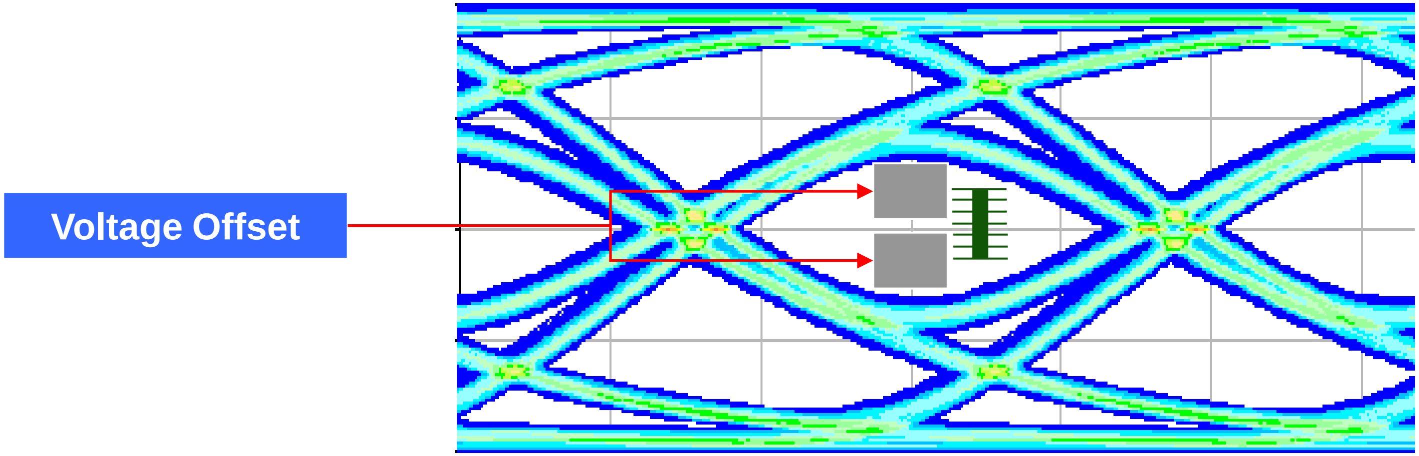
Power Supply

Loopback to DUT channel

Measured Eye Height Margin and Width Margin

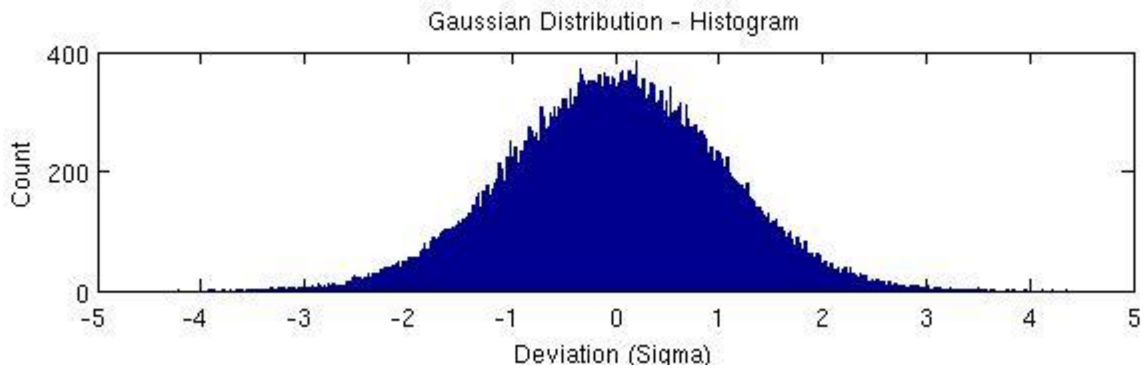


Eye Width Margin = The number of error free trimmer settings left and right from the eye center.



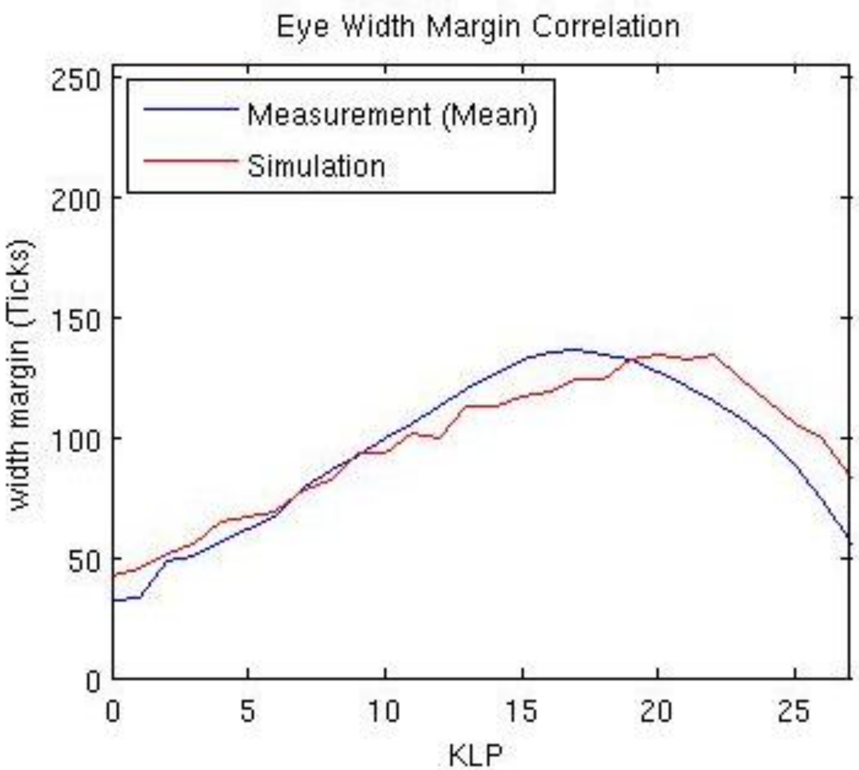
Eye Height Margin = The number of error free trimmer settings up and down starting at eye center.

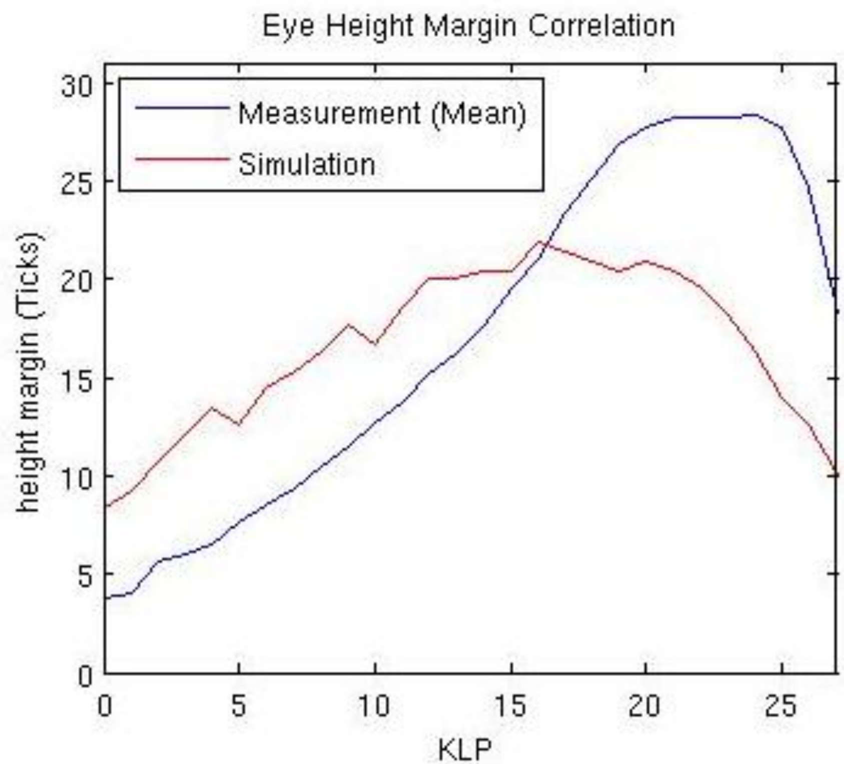
Accounting for Process Variation



- **Measurement Variation**
  - Tap size as a function of process
  - Bandwidth of gain stages will change as a function of process.
  - Package impedance will also change as a function of the package manufacturing process.
- **How to Account for this?**
  - Take measurements of many different packages and collect statistical distributions.
  - Align your model on the **mean** of the samples.
  - Provide a standard deviation to your customers so they can design their system to a yield spec.

RX Linear EQ Correlation Results





- **Setup**
  - Transmitter
    - Freq = 6.25GHz (RXAUI)
    - EQ Settings (Pre, Main, Post) = [0, 25, 4]
    - Data Pattern = PRBS 15
  - Channel
    - DUT =15 Inch FR4

Height Margin Error Causes

- **Non-Linear Gain Stages**
- **Rectangular Eye Mask Assumption**

Next Steps

- Improve RX Linear EQ model (include non-linearity)
- Complete RX Correlation including Linear EQ + DFE

Questions

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