AMI Model in SI Simulation

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Outline

AMI Model in Serial Link Simulation

- Background
- Serial Link Introduction
- Experiencing AMI Simulation
- Highlights and Questions

PLL Model and AMI

- Background
- JTF and PNS

Background

Generally, the development of serial link SI simulation is left behind the Serdes development.

- It is difficult to acquire the chip model for SI simulation. For data rate of 6Gbps＋，Serdes encrypted Hspice Model is not available;
- Even with some private simulation tools and models from chip vendors, a high confident result is difficult to get through simulation;
- Now, evaluating the serial link system through measurement is normally used;
- However only measurement is not enough, and simulation is still an important way;

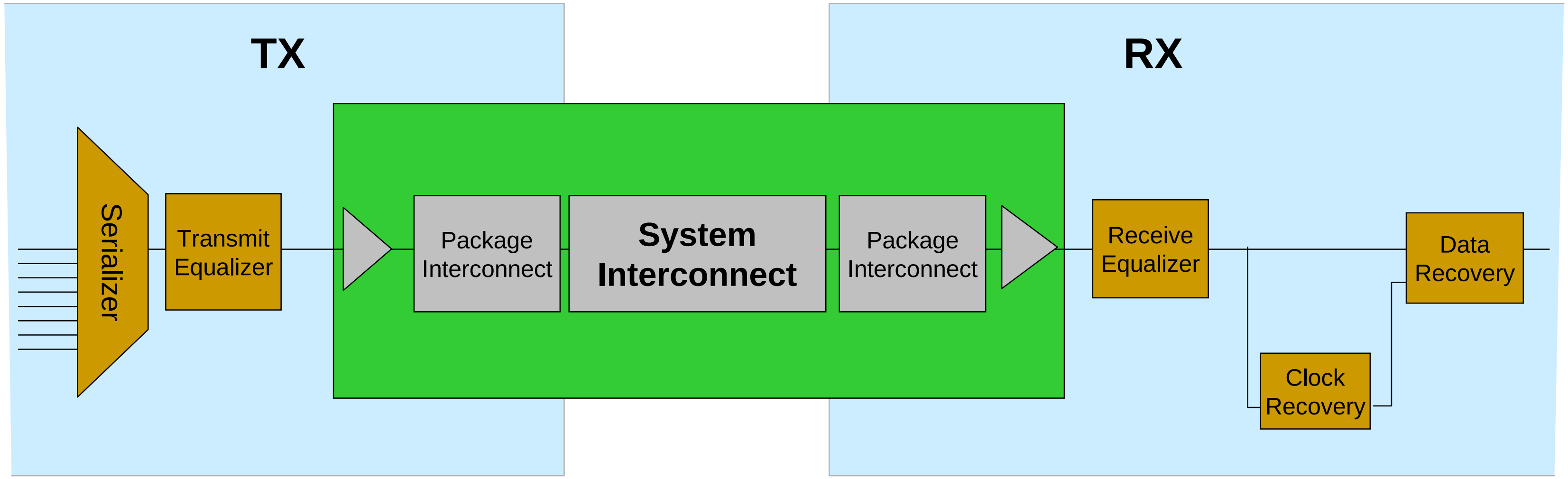
IBIS 5.0 was ratified at 29th August, 2008, which provides users a good solution for serial link simulation.

IBIS committee makes a great progress on Serdes model and serial link simulation.

Background

IBIS-AMI Modeling:

- Constructing sub-components in transmitter with AMI model;
- The channel is characterized with impulse response;
- Constructing sub-components in the receivers with AMI model, including CDR;
- Providing a process on how to use AMI models.

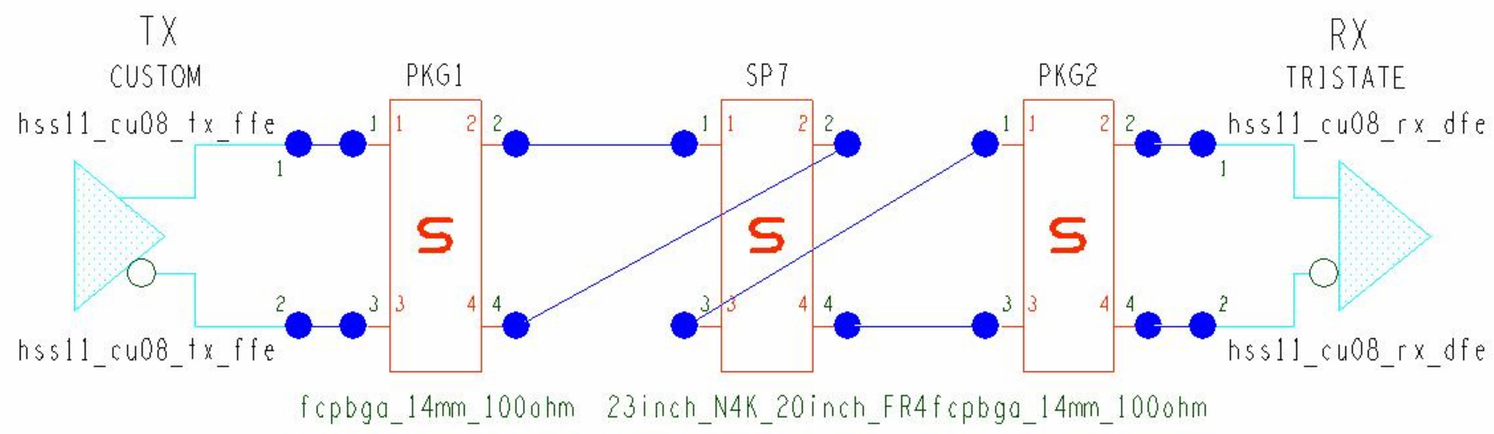


Picture reference from "SerDes Modeling and IBIS" at DAC_2007_IBIS_Summit

Experiencing AMI Simulation

Simulation setup:

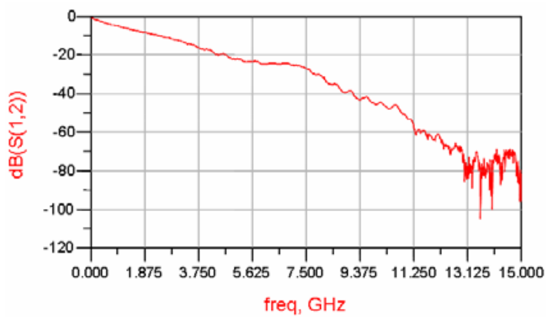
- IBM AMI model includes 3-tap Tx FFE, 5-tap Rx DFE;
- CDR behavior model embedded in RX model;
- 11.0Gbps data rate and one million bits simulated;
- Tx and Rx package models included;
- Three different backplane channels used;
- Three data patterns: CJPAT, PRBS 7, PRBS 31.



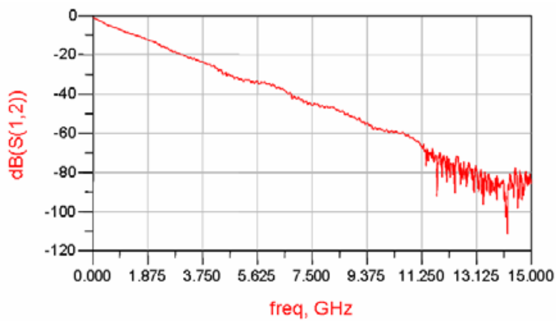
Experiencing AMI Simulation

Channel descriptions:

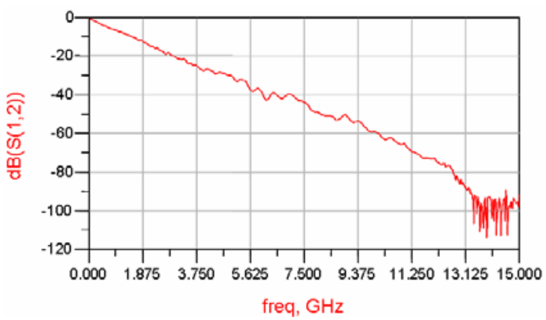
- Channel 1 : 10.72inch FR4 + 25inch Rogers Backplane + 2 connectors
- Channel 2 : 23inch N4000+20inch FR4 + 2 connectors
- Channel 3 : 30inch FR4 + 2 connectors



Channel 1



Channel 2



Channel 3

Experiencing AMI Simulation

AMI Model Introduction:

("hss11_cu08.dml"
(IbisIOCell
(ideal_50term_pulldown
(MacroModel
(MacroType TDiffIO)
(NumberOfTerminals 8)
(SubCircuits “)
……
(hss11_cu08_rx_dfe
(ami
(ibmhssrx_103_win "E:\IBMSerdes\dll_lib"
(ibis 1)
(ndfe 5)
(dfelimit
(0.5 0.25 0.125 0.125 0.125))
(dfe
(0 0 0 0 0))
(rotlin "E:\IBMSerdes\include_files\pr_fast.dat")))

AMI Rx model

(hss11_cu08_tx_ffe
(ami
(ibmhsstx_104_win "E:\IBMSerdes\dll_lib"
(ibis 1)
(nffe 3)
(rffe 1)
(cffe 1)
(qffe 6)
(lffe
(0.25 1.0 0.5))))

AMI Tx model

This is the IBM Serdes AMI model supporting 11Gbps.

Experiencing AMI Simulation

Report Sample:

****Channel Analysis Report******

Tue Sep 02 09:45:44 2008

Channel Inputs:

- Bit period = 9.09090909091e-011
- No of drivers = 1
- No of taps = 1
- Tap optimization = No
- Stimulus configuration = poly31
- Channel coding = No
- Char Directory =

E:IBMSerdes/result_channel/char/

Simulation Controls:

- No of bits simulated = 1000000
- Measurement Delay = 4.4e-005

Eye Measurements:

- Eye height = 91 mV
- UI at max height = 0.48 UI
- Eye jitter = 0.36 UI

Eye Height

BER Report:

logBER	UI
-9	0.57
-10	0.56
-11	0.55
-12	0.54
-13	0.53
-14	0.52
-15	0.51

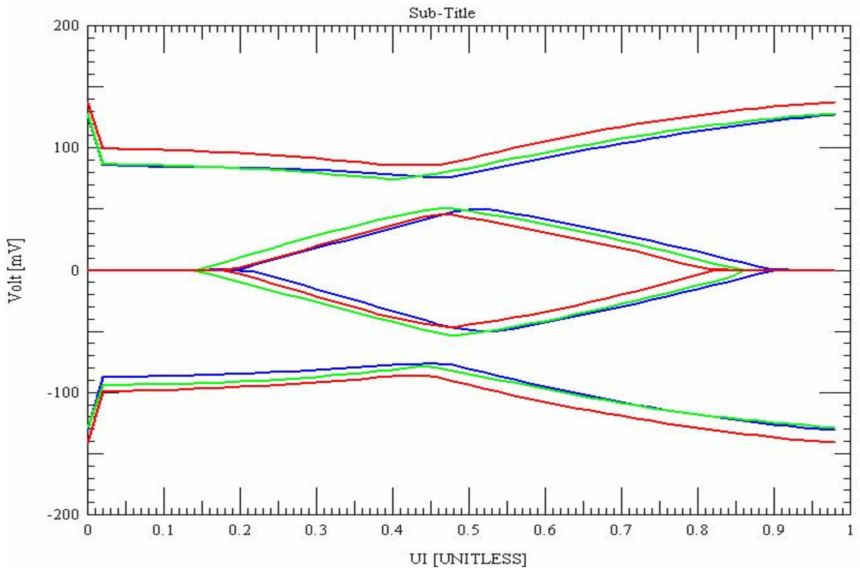
Eye width under different bit error ratios

Simulation Input Parameters:

- Simulation Type = Time Domain Channel Simulation
- Random Jitter = 0.44 %
- Periodic Jitter:
  - Magnitude = 0.05 UI
  - Freq (cycles per ui) = 0.01
- Frequency Offset = 0 ppm
- Duty Cycle Distortion = 0 %

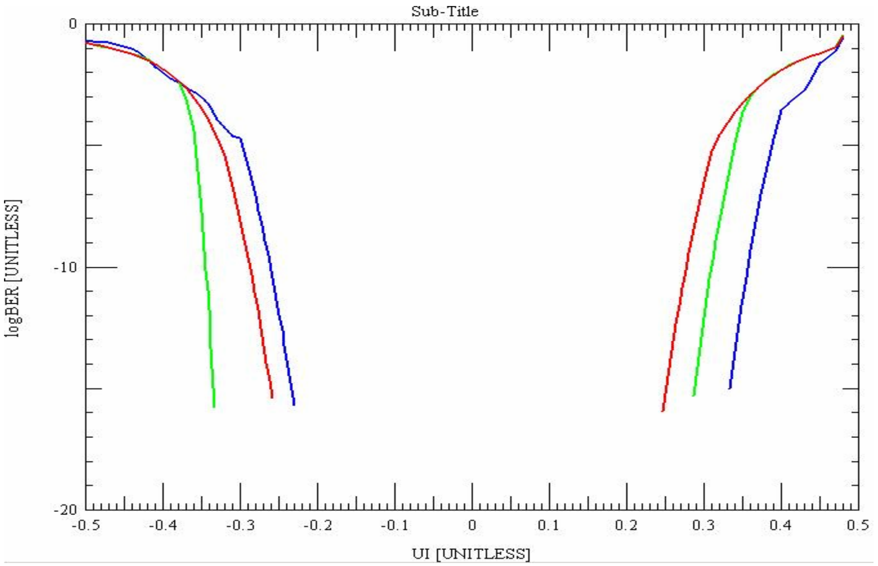
Experiencing AMI Simulation

Channel 1



Eye Diagram

Channel 1



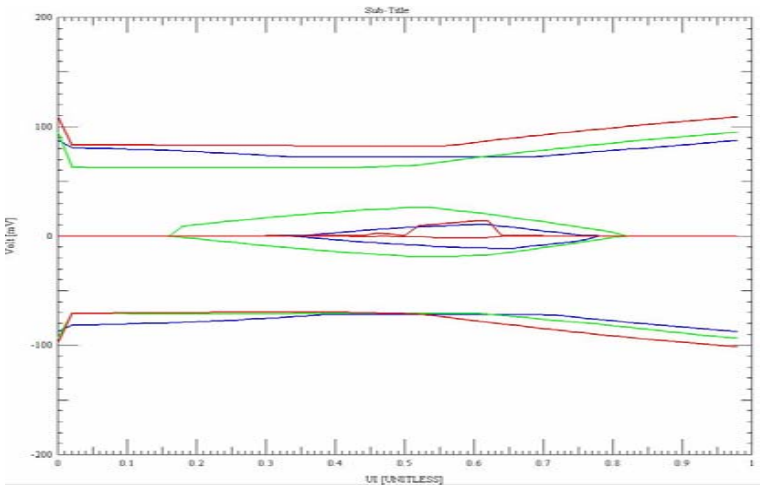
Bathtub

- CJPAT-- blue
- PRBS 7-- cyan
- PRBS 31– red

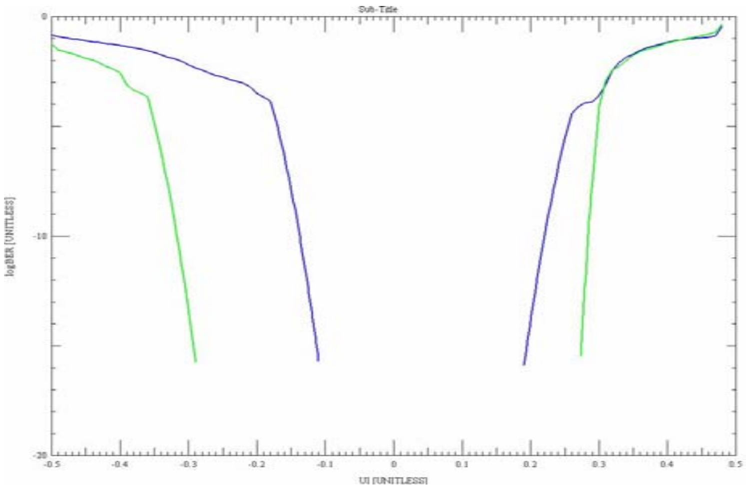
Cases of channel 2 and channel 3 are listed in the following page>>>

Experiencing AMI Simulation

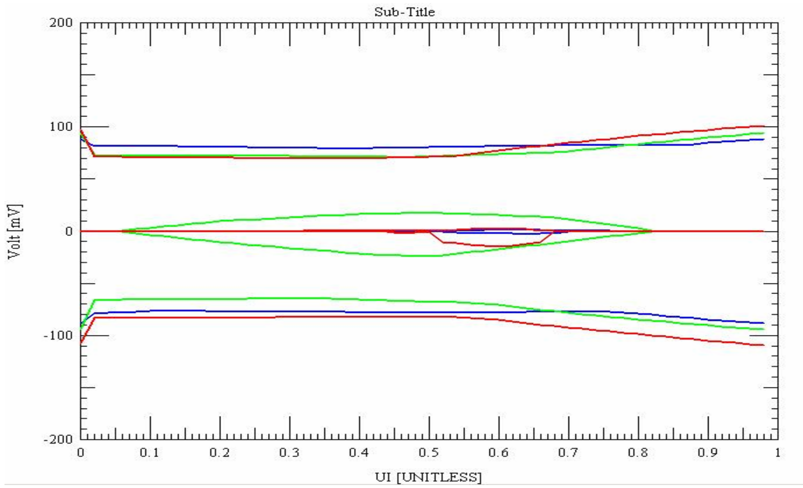
Channel 2



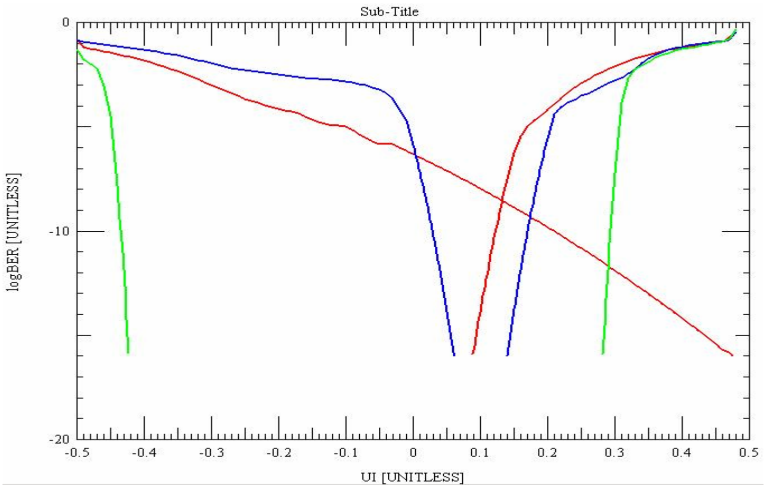
Channel 2



Channel 3



Channel 3



Experiencing AMI Simulation

Data pattern \ Channel 1	Eye Height (mV)	Eye Width (UI)
CJPAT(8B/10B)	100	0.59
PRBS 7	104	0.64
PRBS 31	91	0.54
Data pattern \ Channel 2	Eye Height (mV)	Eye Width (UI)
CJPAT(8B/10B)	21	0.33
PRBS 7	45	0.58
PRBS 31	15	0
Data pattern \ Channel 3	Eye Height (mV)	Eye Width (UI)
CJPAT(8B/10B)	3	0.11
PRBS 7	41	0.71
PRBS 31	16	0

Highlights

- AMI model includes FFE, DFE and CDR. The model integrity is better. The encrypted Hspice Model always excludes the DFE and CDR.
- It is feasible for users to do a large amount of bits simulation, and ISI effect is fully taken into consideration.
- Users could set jitter parameters of Tx and Rx, so the jitter of Serdes could be considered..
- AMI model support calculating the coefficients of DFE and FFE automatically, and it could shorten the simulation cycle.

Drawbacks

- Modeling method is complicated and no auxiliary tools helping generate the AMI model. Most IC vendors do not supply AMI models.
- Users cannot evaluate the simulation results, owing to lack of the mask specification. So it is difficult for users to judge whether the serial link meets the requirement.
- It is impossible for users to judge the accuracy of AMI models and to improve it.
- Some IC vendors suggest that the simulation is a reference for design and cannot be used for a final decision.
- The AMI model, used in the previous example, is a vendor-specific format model, not based on IBIS. The interoperability is not good.
- With current AMI model, users couldn't analyze the contribution of clock jitter and power noise, owing to lack of JTF (jitter transfer function) and PNS (power noise sensitivity).

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PLL Model and AMI

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- JTF and PNS

Background

- In the current product, clock jitter and power noise are important contributions of BER;
- According to our survey, it is feasible to construct PLL model through measurement;
- It is a good solution to add the JTF and PNS into the AMI model, This could improve the integrity of Serdes model.
- Users could use the solution to estimate the link jitter contributed by the jitter of reference clock and power noise of the PLL.

Chun xing Huang gives an initial idea on analyzing PLL model in the *Serial Link Analysis and PLL Model* at Asian IBIS Summit 2007, Beijing. The engineers of Huawei continue a research on constructing the PLL model.

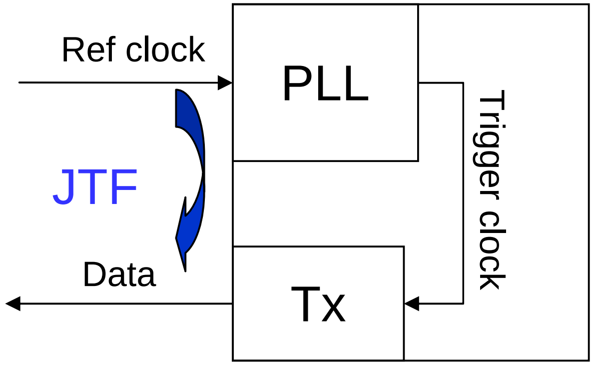
JTF and PNS

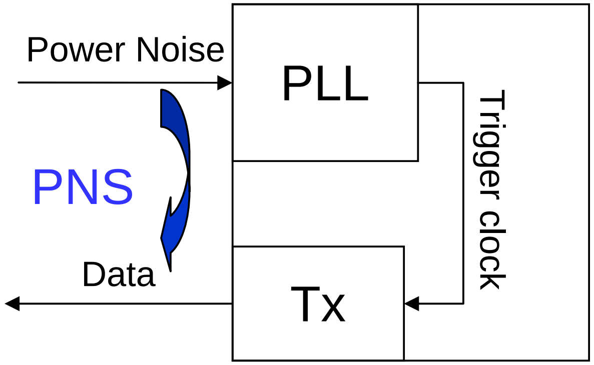
- Jitter Transfer Function (JTF) is defined as the ratio of output data jitter and reference clock jitter;

$$Transfunction = \frac{Jitter_{data}}{Jitter_{refclock}}$$

- Power Noise Sensitivity (PNS) is defined as the ratio of output data jitter and power noise.

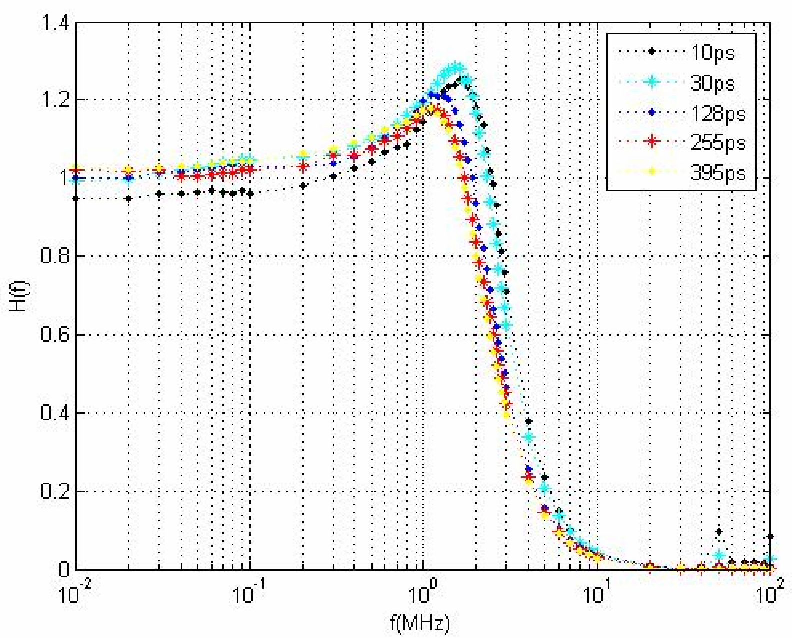
$$Powersensitivity = \frac{Jitter_{data}}{U_m}$$



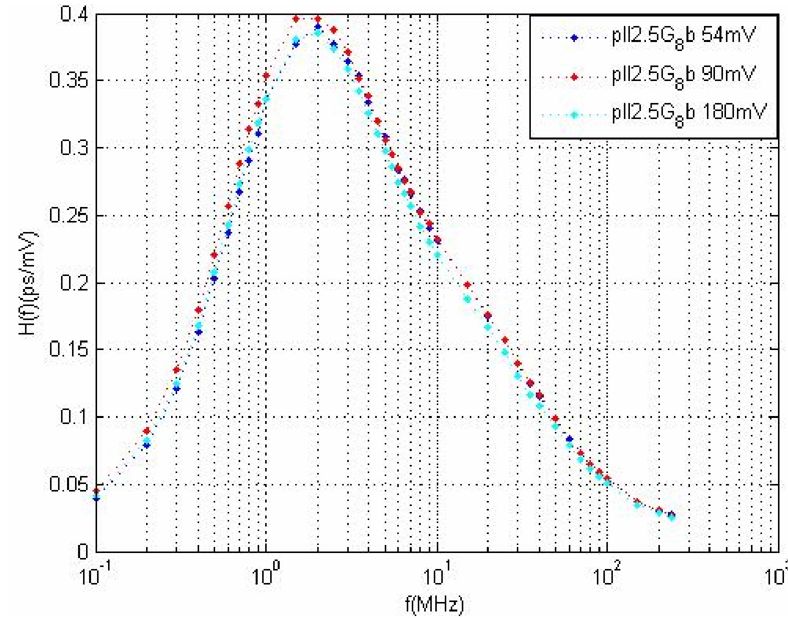


JTF and PNS

PLL characteristics are derived by measurement



Jitter Transfer Function



Power Noise Sensitivity

The measurement environment is the IBM Serdes, supporting 2.0Gbps~3.2Gbps.

JTF and PNS Application

- When jitter transfer function is known, jitter introduced from input clock could be calculated;

  Jitter_out(f) = transfunction(f)*jitter_clock_in(f)

- When power noise sensitivity is known, jitter introduced from power noise could be calculated:

  Jitter_out(f) = powersensitivity(f)*power_noise(f)

According to the description above, users could analyze the output jitter introduced by reference clock jitter and power noise, and optimize the power of PLL.

It is time for us to consider the PLL model in the SI analysis.

Suggestions

Users will feel more convenient, if AMI model could provide the following features:

- Some keywords of eye mask specification, such as eye height and width, which is used to estimate simulation results, should be provided in the AMI model;
- Checklist for AMI model is necessary to guarantee AMI model quality.
- Adding the jitter transfer function and power noise sensitivity in AMI model