Accurate GHz channel simulation and statistical analysis for SSE(Solution Space Exploration)

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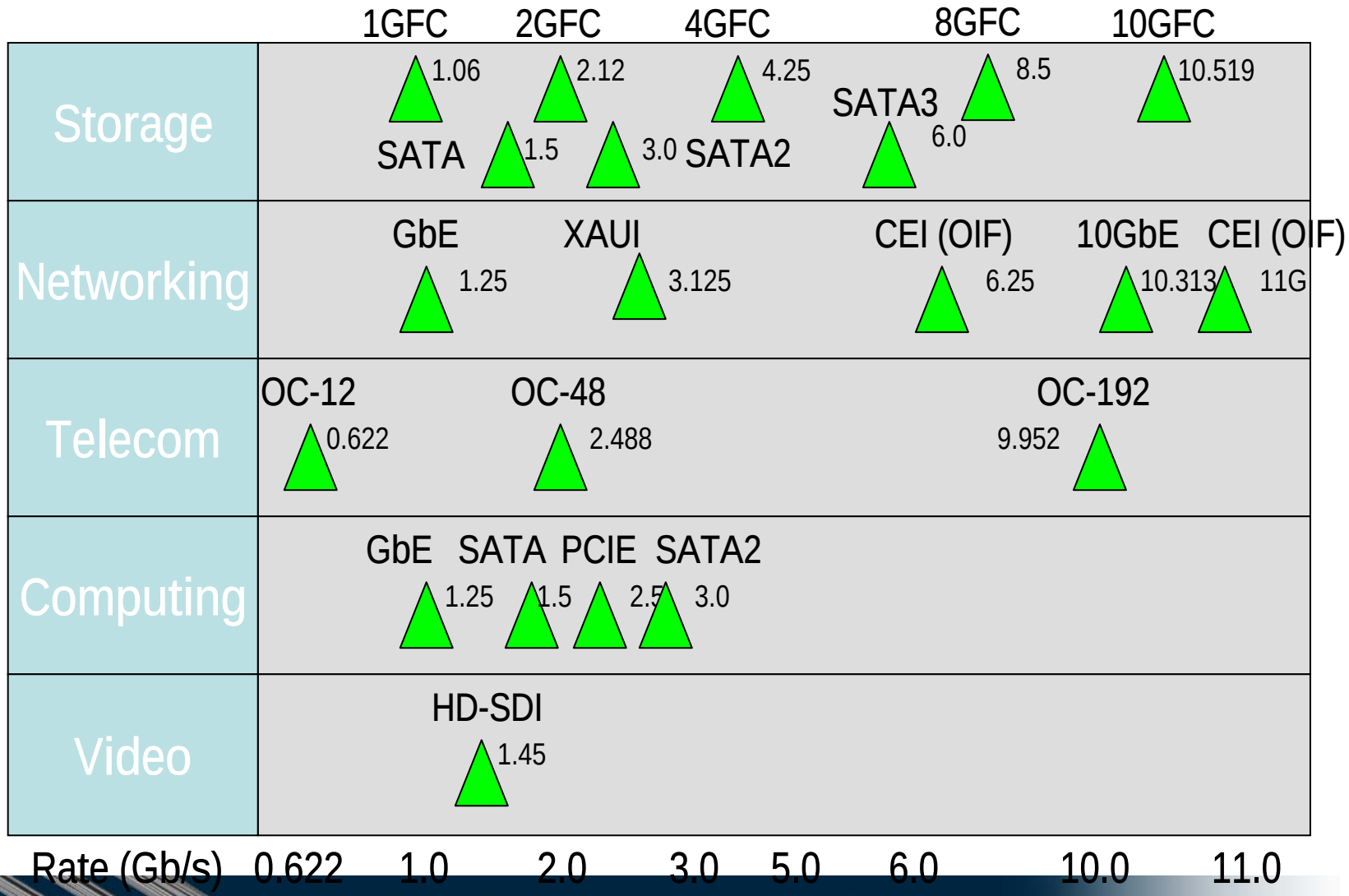
ANSOFT

Serial Link Landscape



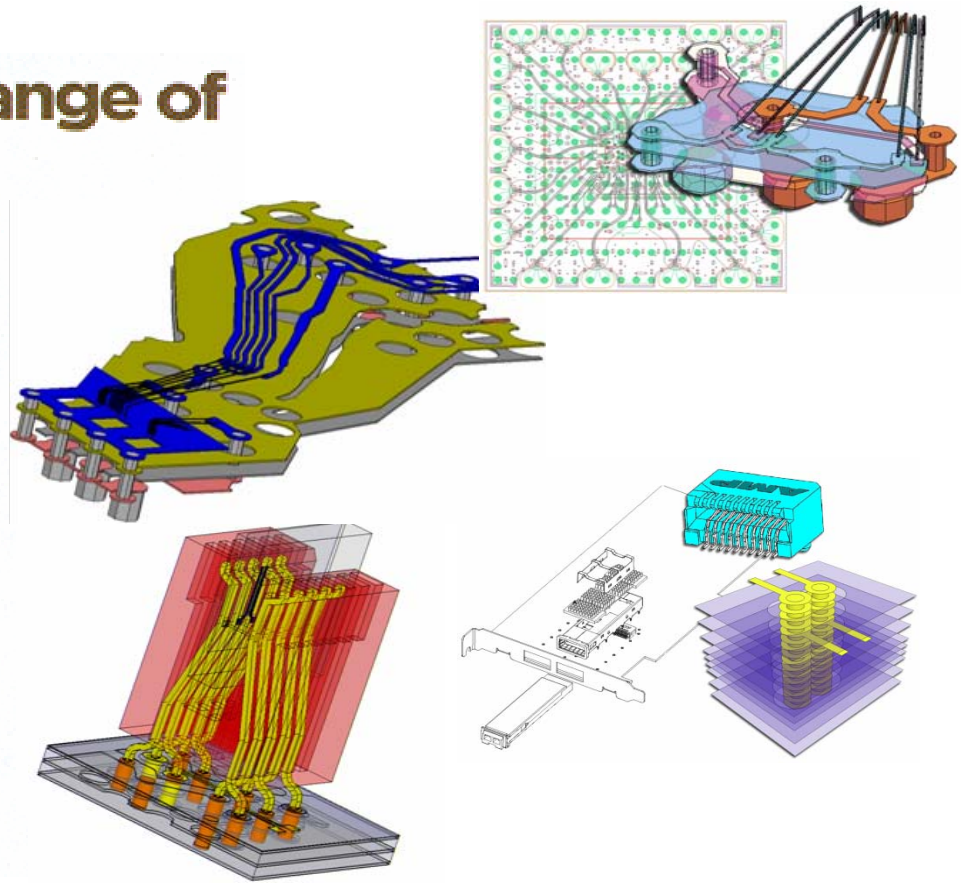
Gigabit Design Requirements
- “Accuracy models are in fashion…”

OEMs eye a broad range of simulation models

3-D models are in fashion with a large minority of users

What kind of simulation models do you prefer?
Percentage

HSpice	70.1
IBIS	51.9
3-D	45.5
MatLab programs	42.4
2-D	39.8
Verilog/VHDL/VCS	1.7
Spector	1.3
S-Parameters	1.3
Other	3



Traditional simulation method

Method1 : SPICE– transient simulation

- High accuracy
- Difficult edit
- Long time, non-convergence

Method2 : Mathematics

- Matlab based program
- Vendor depend
- Only S- parameter channel model

SPICE level transient simulation

Altera StratixII 6.25Gb/s example

Properties

Name	Value	Unit	Evaluated Val
--initial_conditions			
txp_near	0.6	V	0.6V
txn_near	0.6	V	0.6V
inpp	0.6	V	0.6V
innn	0.6	V	0.6V
rx_inp	0.9	V	0.9V
rx_inn	0.9	V	0.9V
CosimDefinition	Edit		
CoSimulator	DefaultNetlist		
Status	Active		

Initial statues

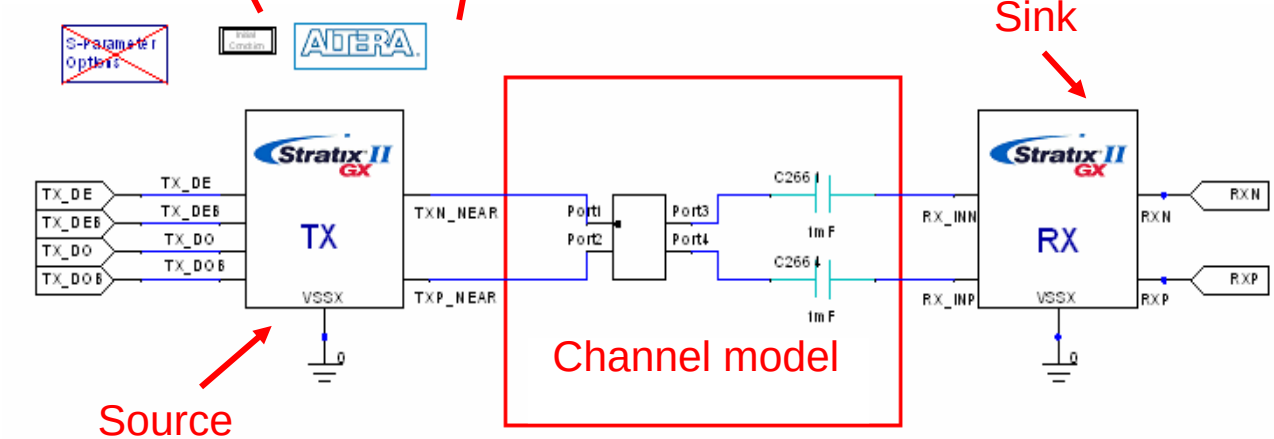
Name	Value	Unit	Evaluated Val
Global_Settings			
Corner	tt		
temperature	85	ce	85cel
--RX_Settings			
Termination_RX	r100_tt		
Equalizer_RX	eq_bp		
DCGain_RX	dc_gain0		
VCM_RX	vcm_0p9		
--TX_Settings			
Termination_TX	r100_tt		
VCM_TX	vcm_0p6		
VOD_TX	vod_8ma		
PreTap_TX	tx_prtap0		
1Tap_TX	tx_1tap0		
2Tap_TX	tx_2tap0		
CosimDefinition	Edit		
CoSimulator	netlist		
Status	Active		

Tx/Rx contol

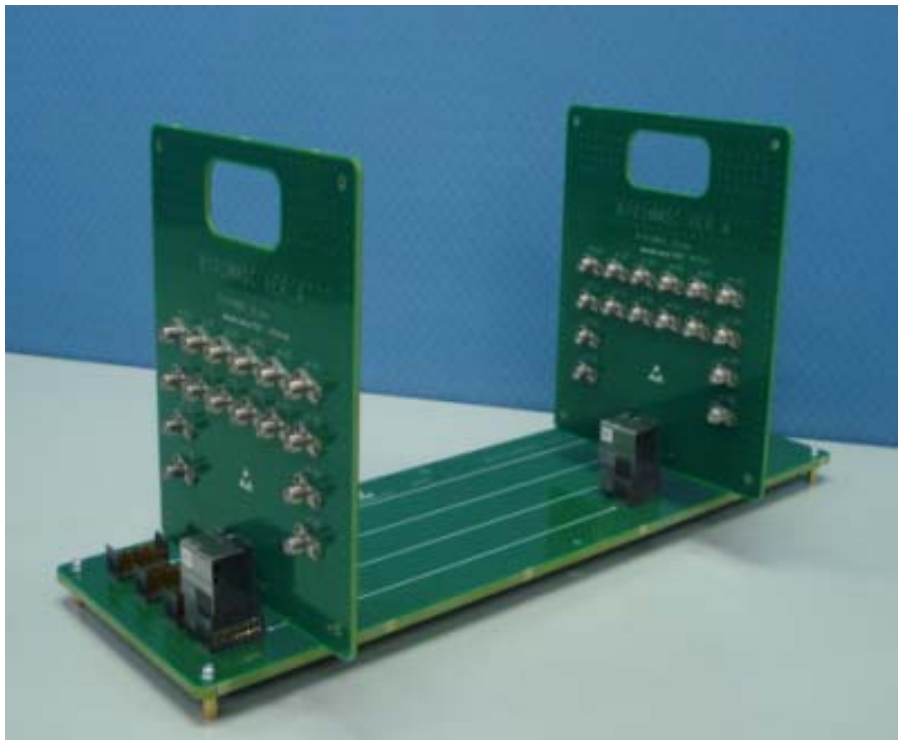
Properties

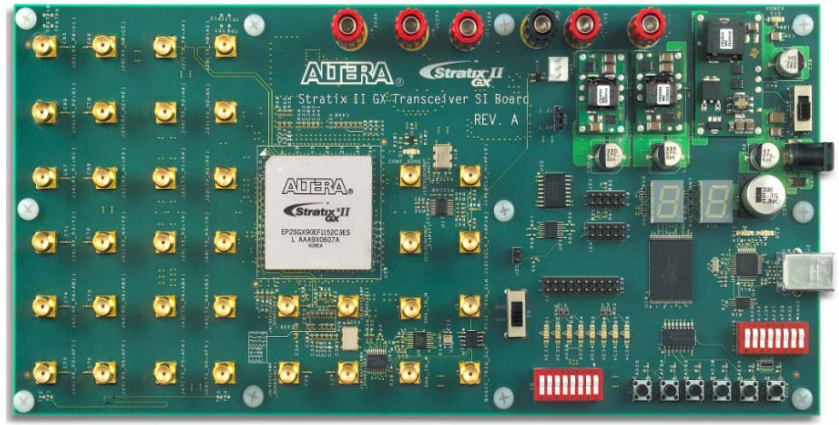
Name	Value	Unit	Evaluated Value
pwrq	1.2	V	1.2V
pwrqm	1.5	V	1.5V
vssx	0	V	0V
tdrate	6500000000		6500000000
trfx	30	ps	30ps
vlox	-0.3	V	-0.3V
vhix	0.3	V	0.3V
vcom	(vhix+vlox)/2		0V
bit_num	30		30

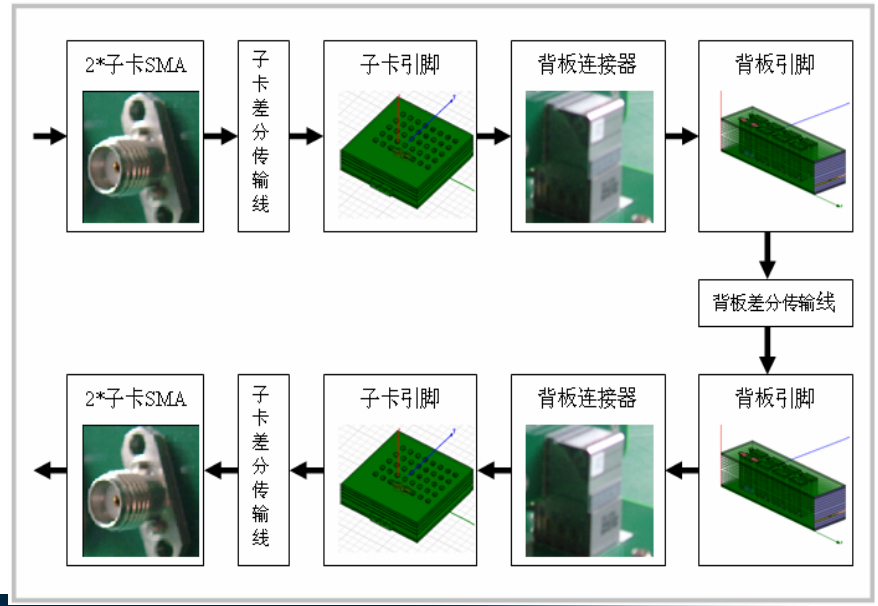
Simulation setting



Evaluation system

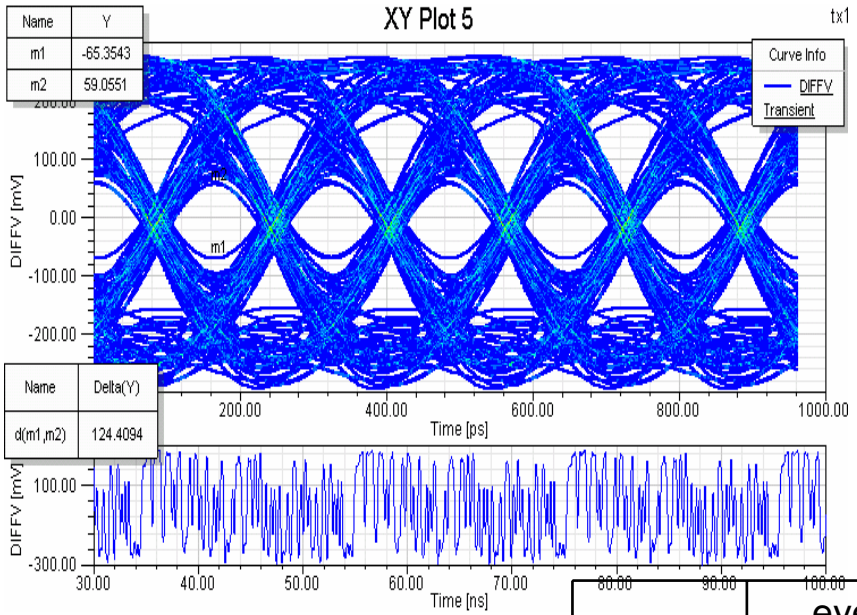


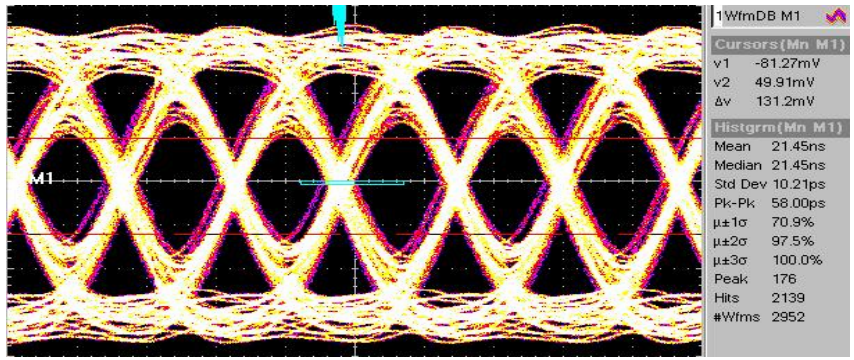




Simulation result

- UDT：tranciever＋2.5”daughter board＋26” mother board
- Tx pre-emphasis：1st post=9
- code：PRBS7





Results：

	eye (mV)
Sim	124
Meas	131

Tolerance<10%!!!

Transient simulation Vers. statistical analysis

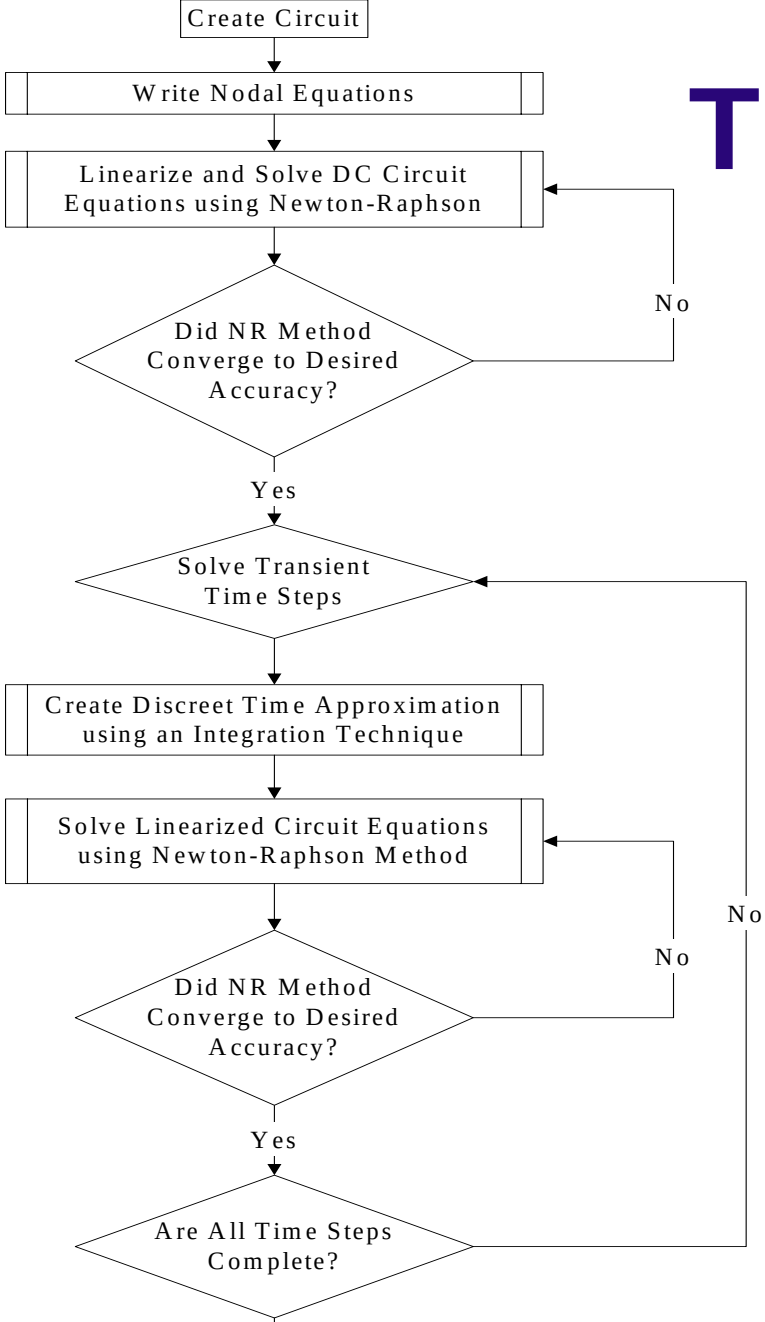
Traditional Transient Methods

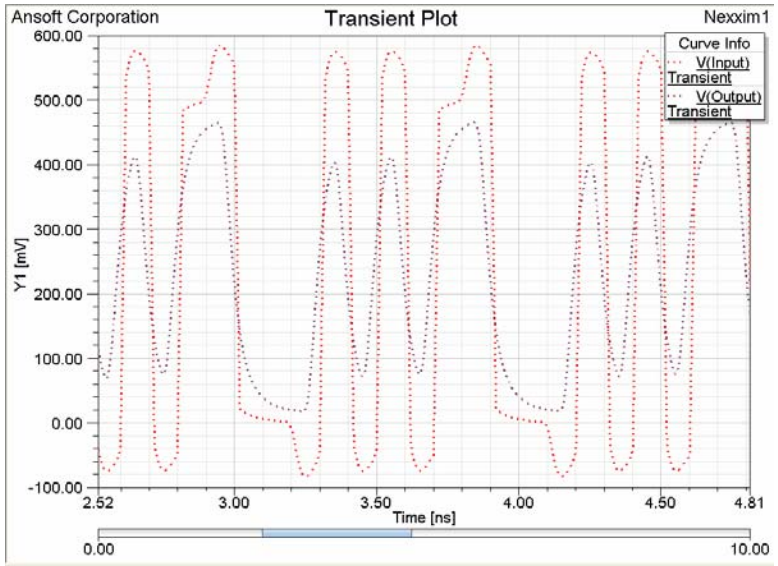
- Solve the system response for each time step
- System response predicted using unequal time steps
- Slow simulation time for a large number of bits $\Rightarrow$ 1/BER

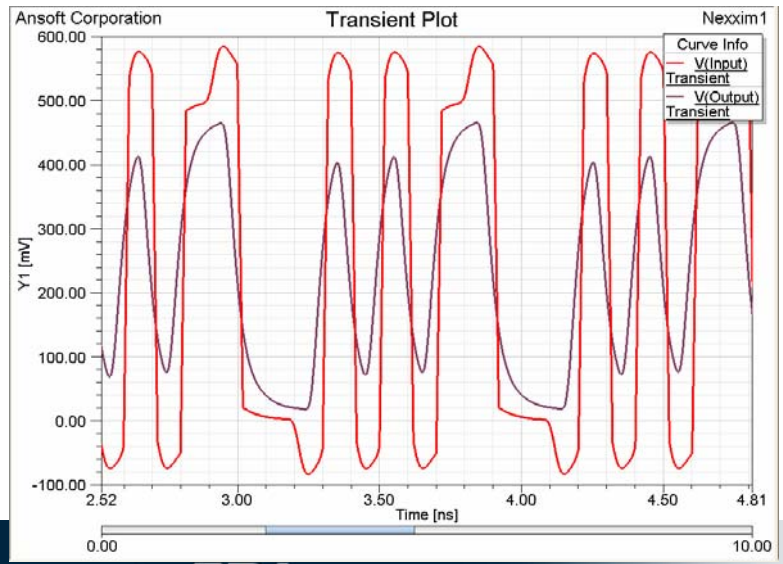
Statistical– The Fast Convolution Method

- Takes advantage of superposition assumption to create a system response. – “generally bounded by the LTI Assumption”

Transient Analysis







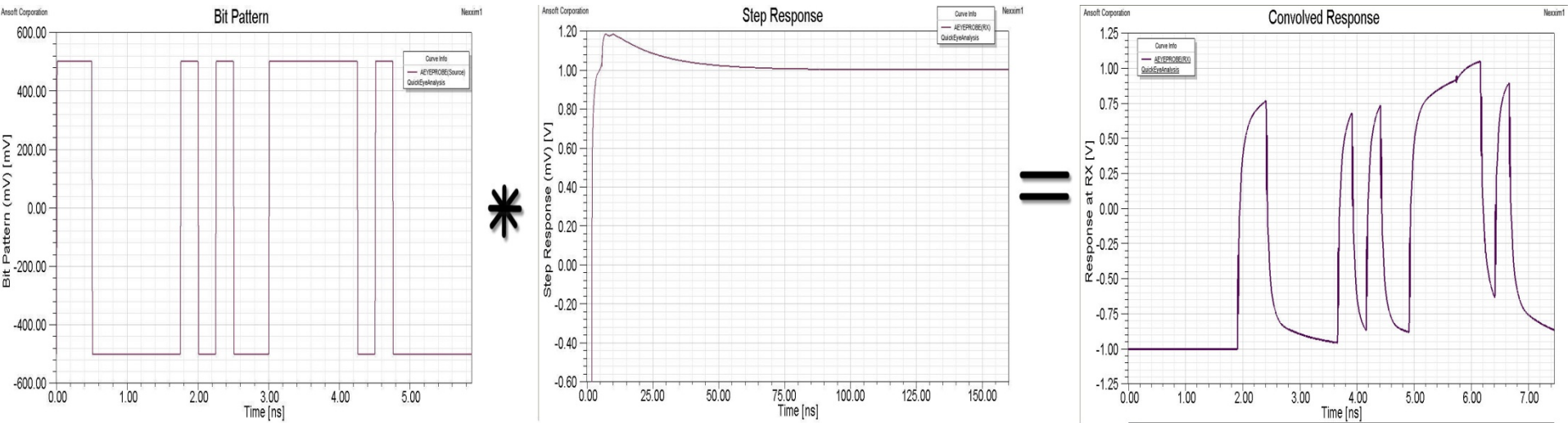
statistical analysis – The Fast Convolution Method

$X_1(t) \Rightarrow Y_1(t)$
$X_2(t) \Rightarrow Y_2(t)$ Input yields output

$X_1(t) + X_2(t) \Rightarrow Y_1(t) + Y_2(t)$ Additive property

$aX_1(t) \Rightarrow aY_1(t)$ Homogeneity property

$X_1(t-\tau) \Rightarrow Y_1(t-\tau)$ Time invariant property



SSE——Solution Space Exploration

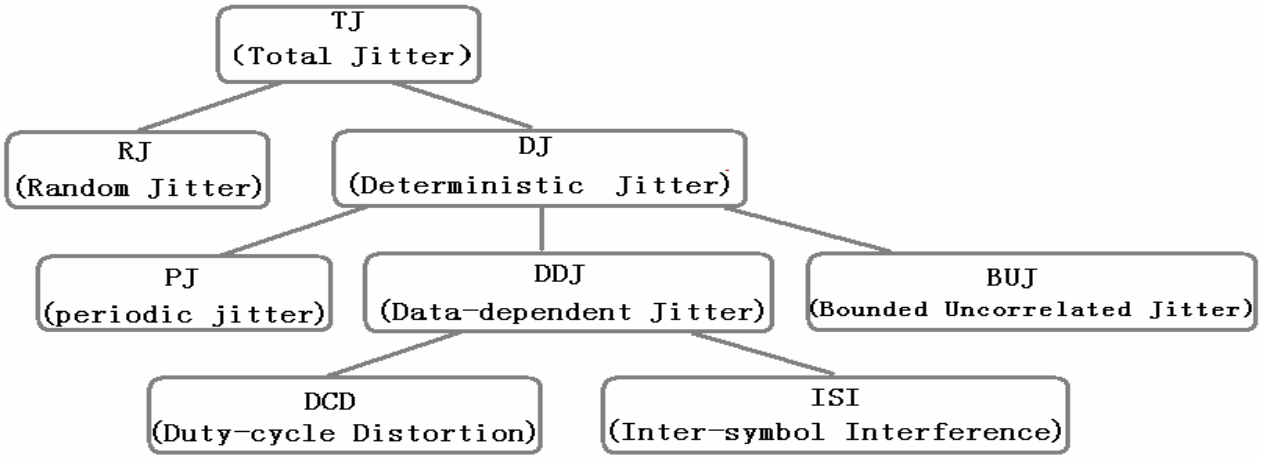
Simulation requirements at first step

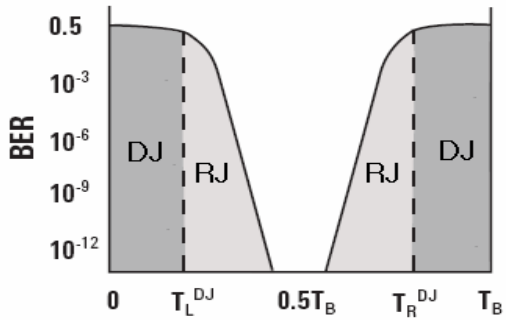
- Trade-off among multi-elements in the design
  ⇒Approximations for speed
  - Each element of the channel have different effect to the final results
  - Cost and time-to-market pressure
- Variants sweep for Solution Space Exploration is critical

Sweep variants：

- T-Line length：system framework
- connector：Performance = Price
- Footprint ：perfect layout and routing cost long time

Jitter and BER





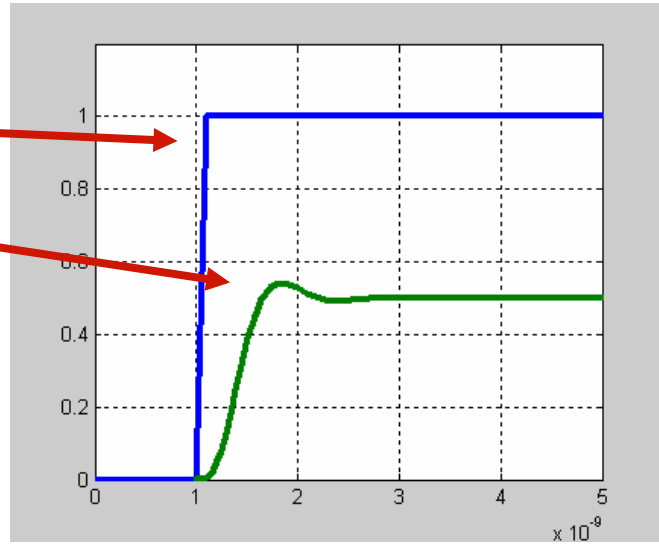
Jitter is a critical elements of BER !

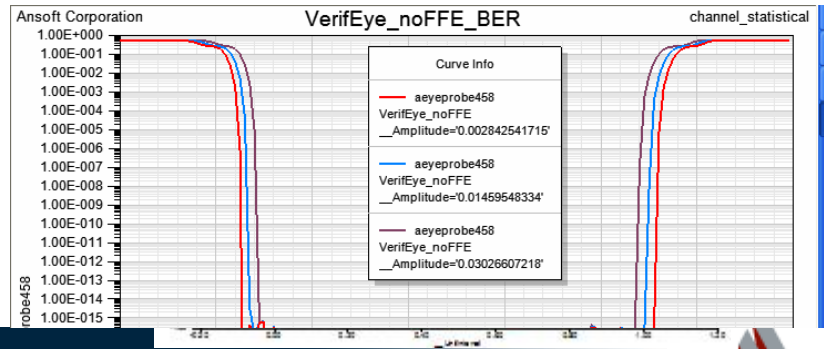
statistical analysis1-- BER

"statisticalal Eye" Analysis
(lower accuracy, highest speed)

Algorithm:

- Run transient
  - Generates step response
- Detect the delay
- Impose the step response
  - On UI grid
- Calculate probability of error (BER)
  - For a single cell in the grid
  - Based on statistical assumptions
- Generate Eye contour
- Visualizes worst eye



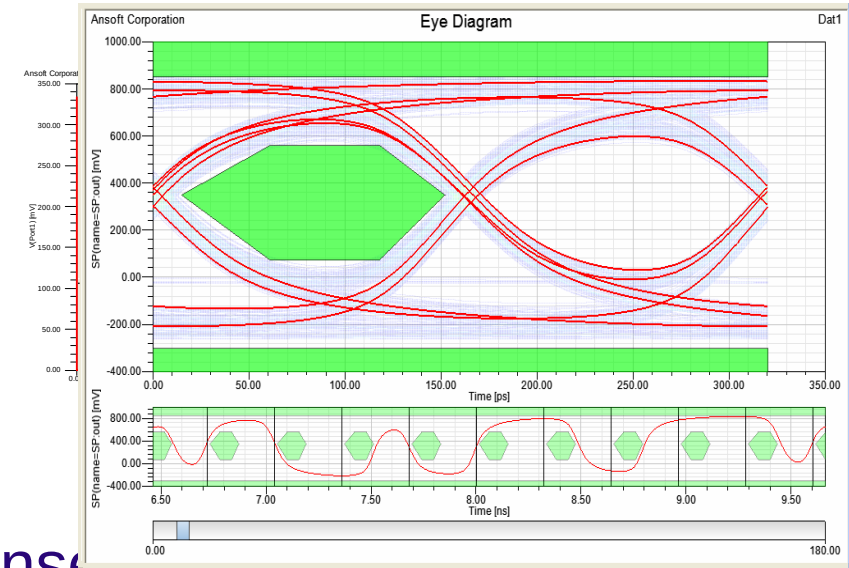


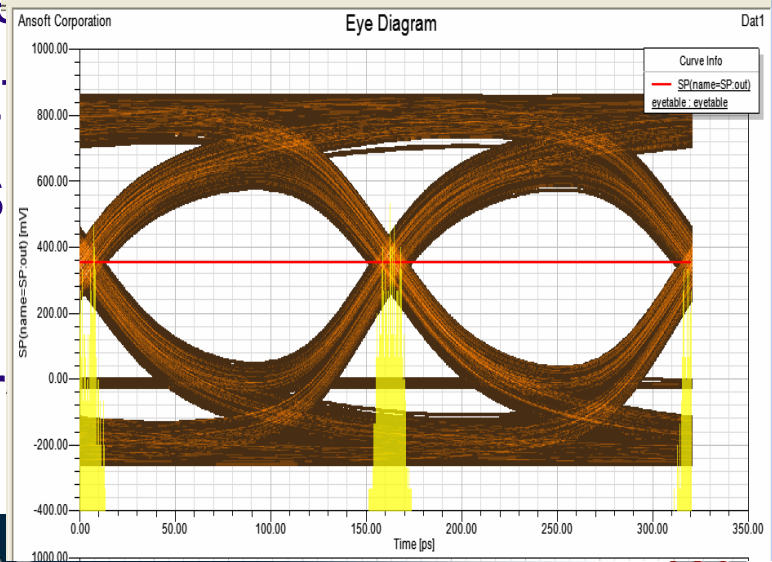
statistical analysis2– Eye mask and jitter

Bridge between statisticalal Eye & transient
(medium accuracy, medium speed)

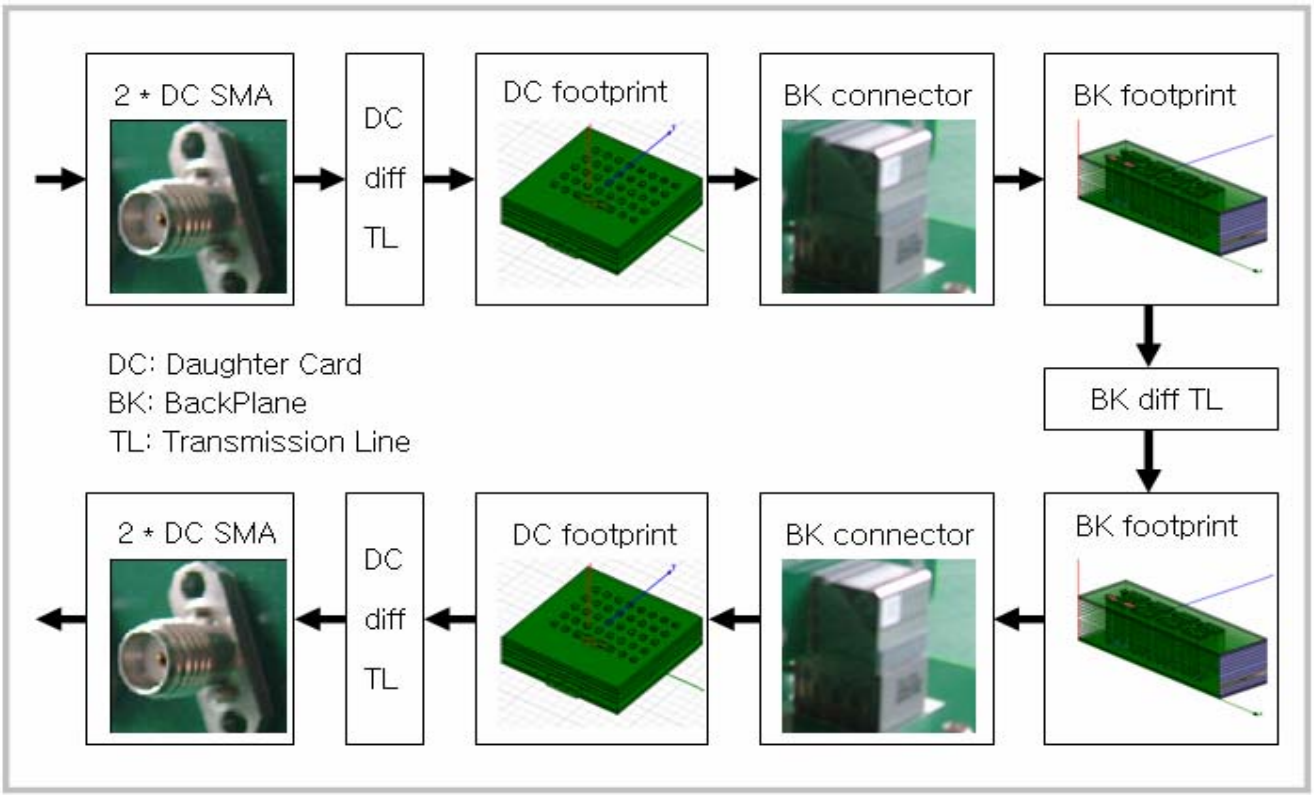
Algorithm:

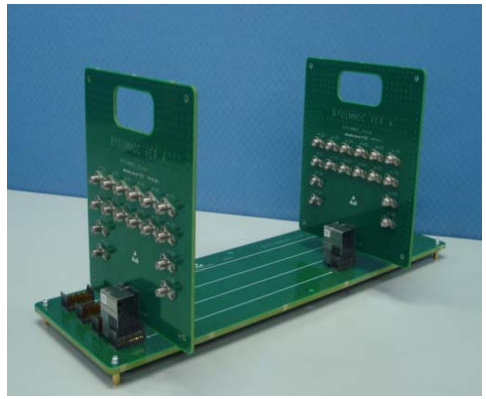
- Run transient
  - Generates step response
- Convolve
  - Input bit-stream with step response
- Allows for very long input bit pat
- Provides fast time and eye plots
- Visualize eye mask violations
- Determine Jitter through Histogr
  threshold crossings





Full channel model

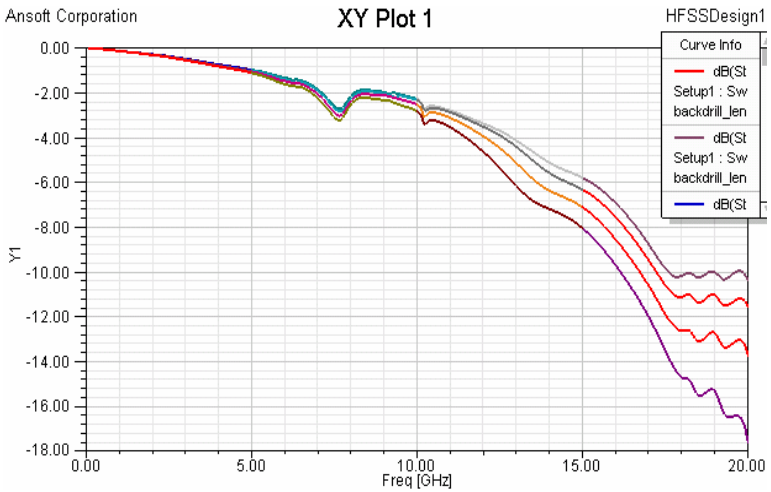


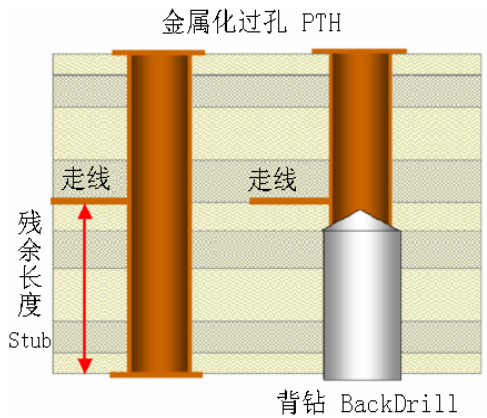


1. Sweep the variants of each element
2. Optimize full channel

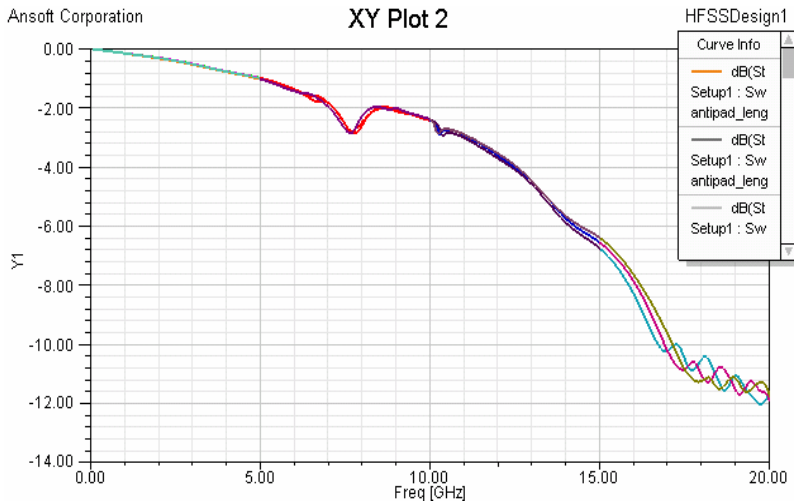
Footprint effect

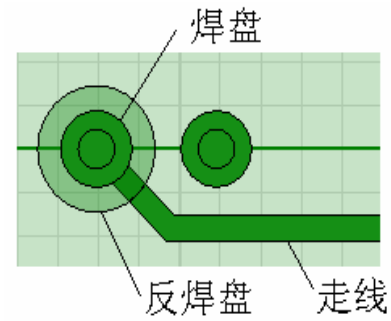
Back-drill length



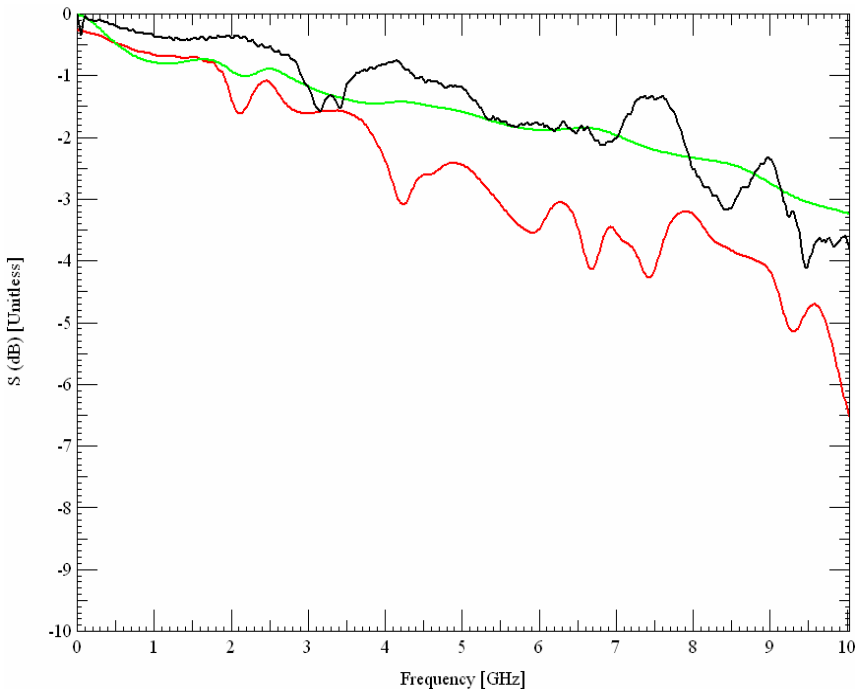


Anti-pad diameter

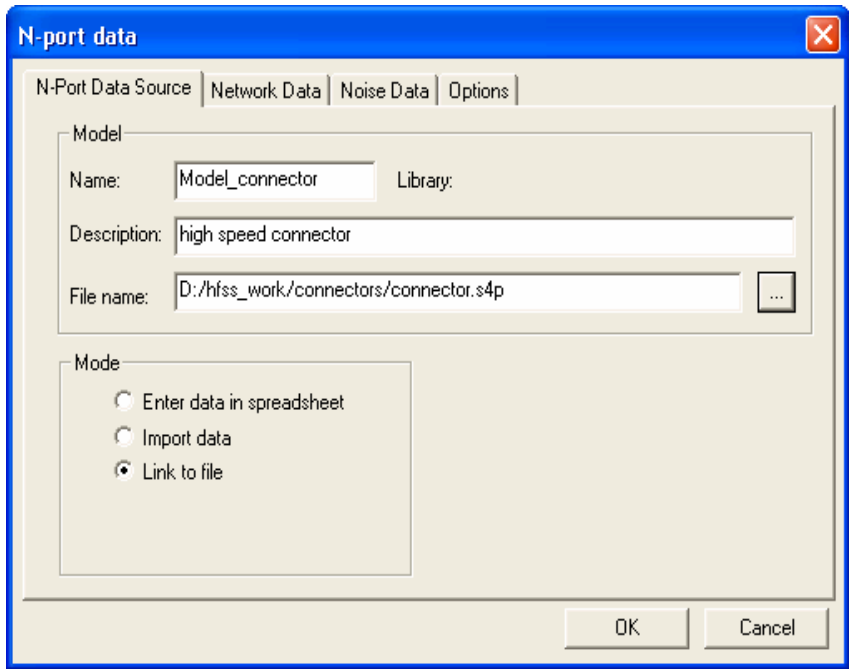




Connector effect



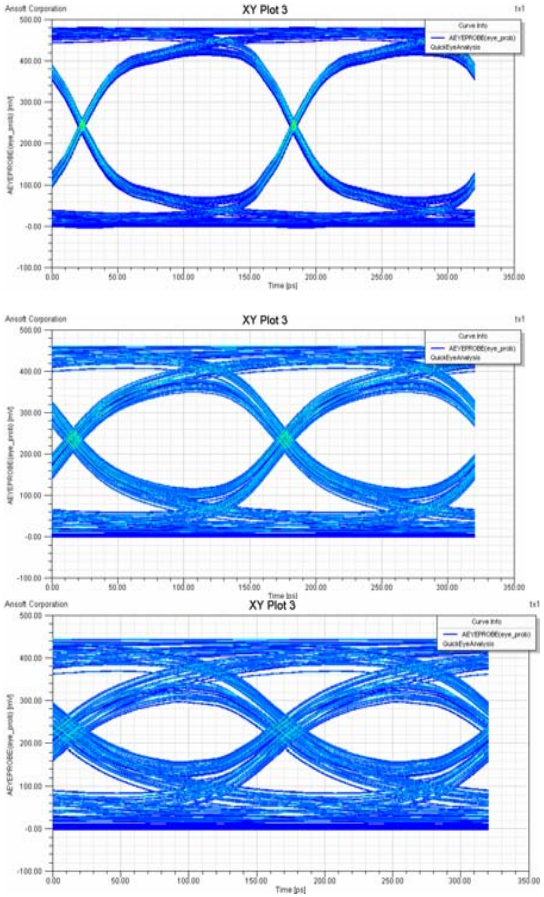
Connector performance

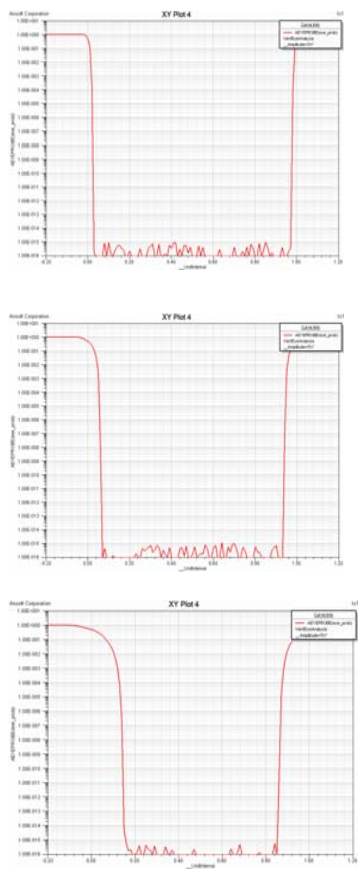


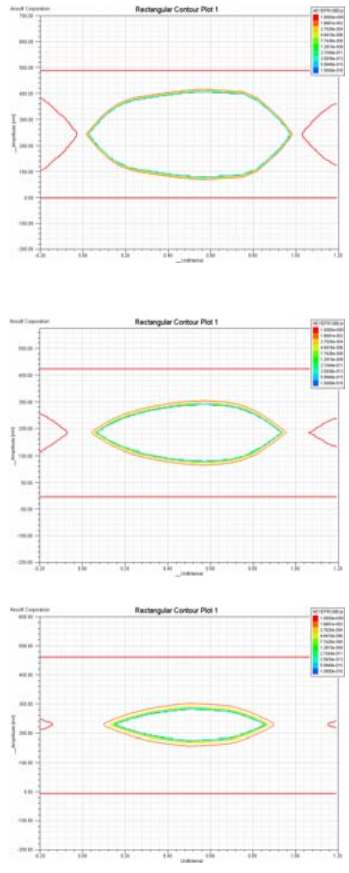
Connector model– Spice or S-

Transmission line Length effect

Length





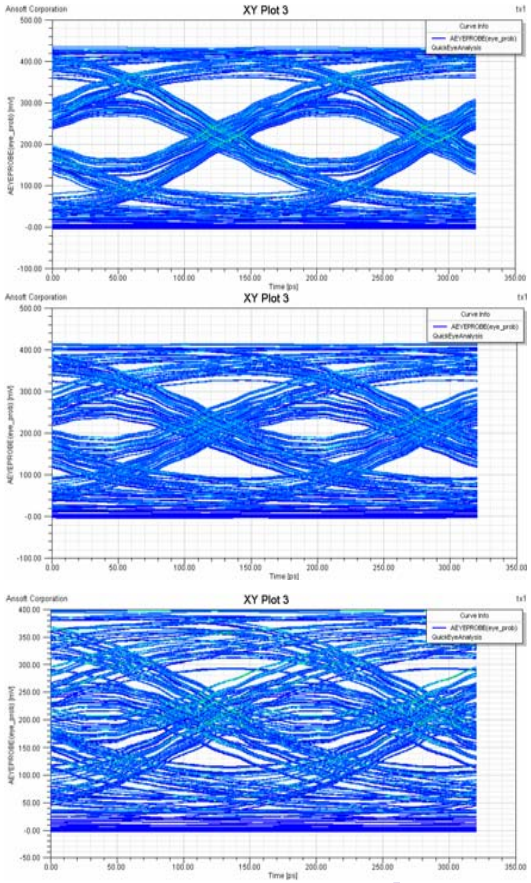


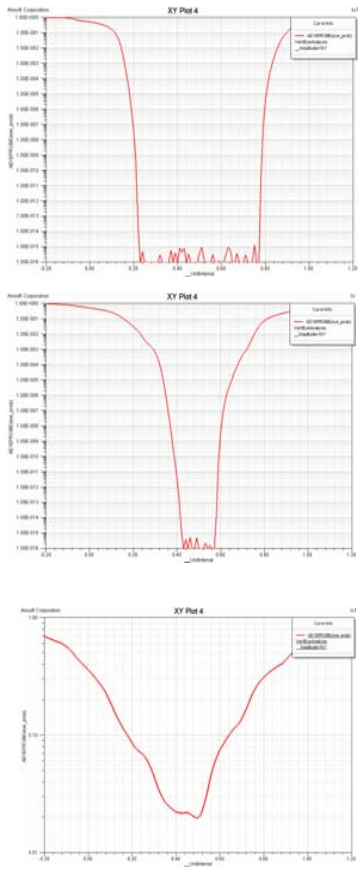
Eye mask BER PDF

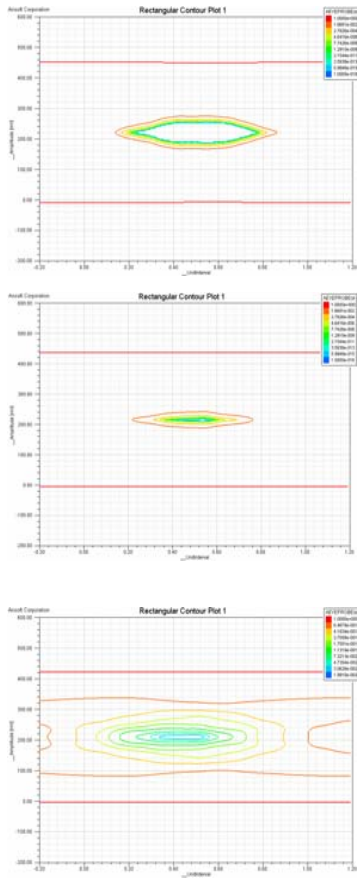
Total effect

Including T_line length, connector and footprint effect 。

length

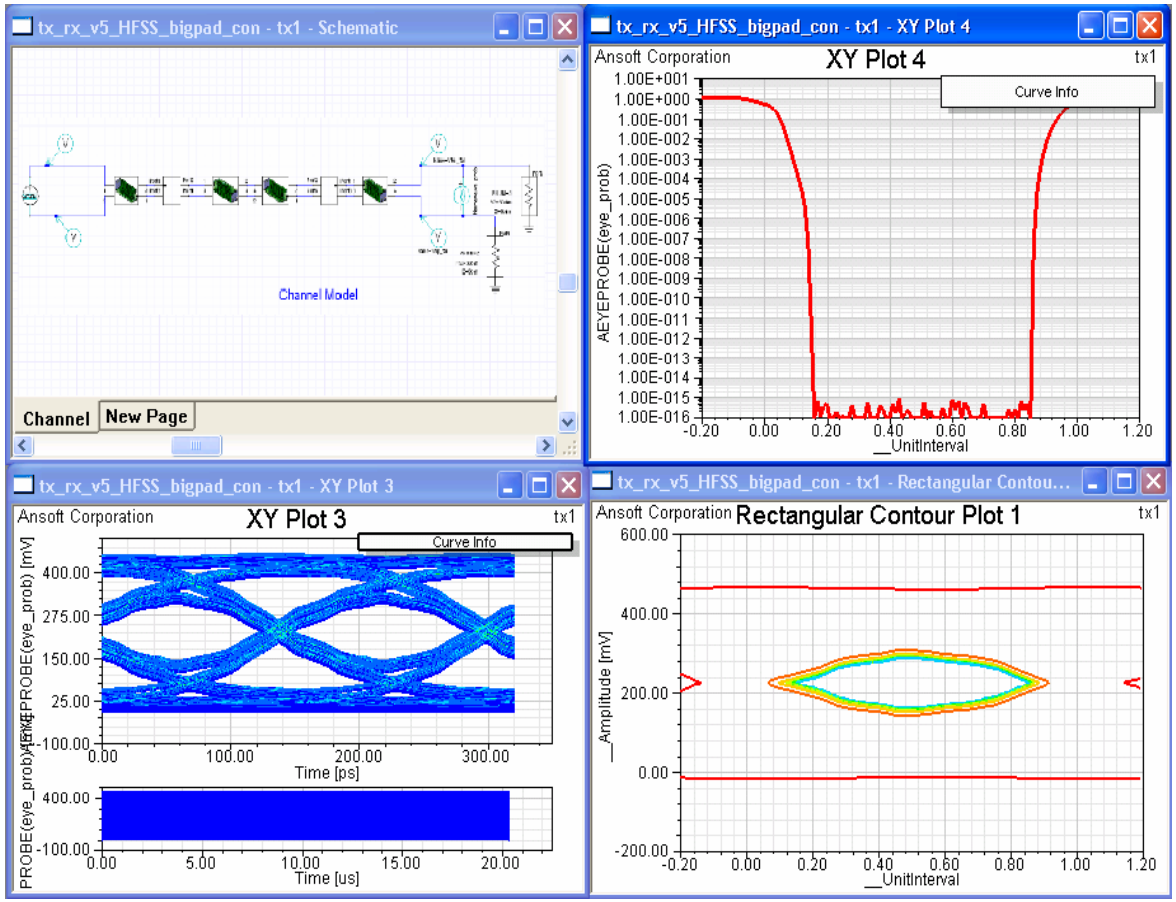






Eye mask BER PDF

SSE for full channel



Fast trade-off among T-Line length, connector and footprint at first step

Conclusion

- Spice transient simulation
  - Accuracy
  - Take long time
- statistical analysis
  - Speed!
  - Easy for SSE

Thanks Huawei Beijing Institute
Miss Hou Weiping's great help!