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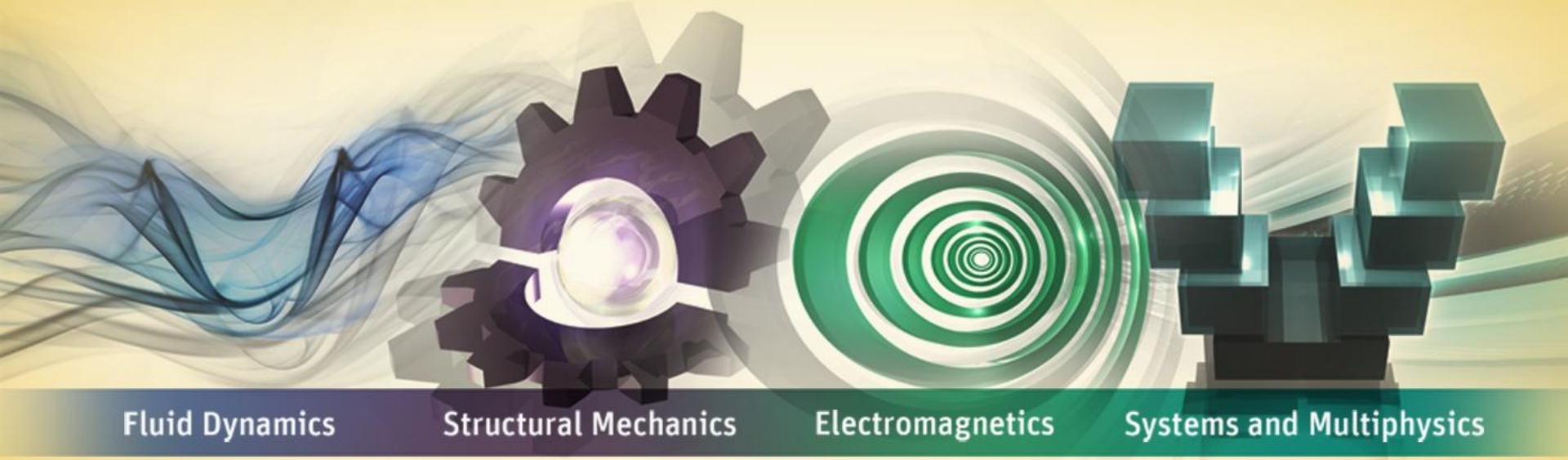
Pseudo transient eye analysis by convolution method



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Background

- In IBIS Asia summit 2008, we have first introduced statistical analysis method for GHz analysis

http://www.eda.org/ibis/summits/nov08a/li.pdf

- Statistical analysis used convolution method for fast SSE (Solution Space Explorer), but it has limits
  - Suitable for LTI system
  - Not as accurate as SPICE transient eye
- Today, we'll discuss the convolution method for Non-LTI system and introduce pseudo transient eye analysis by convolution method

Convolution and LTI system

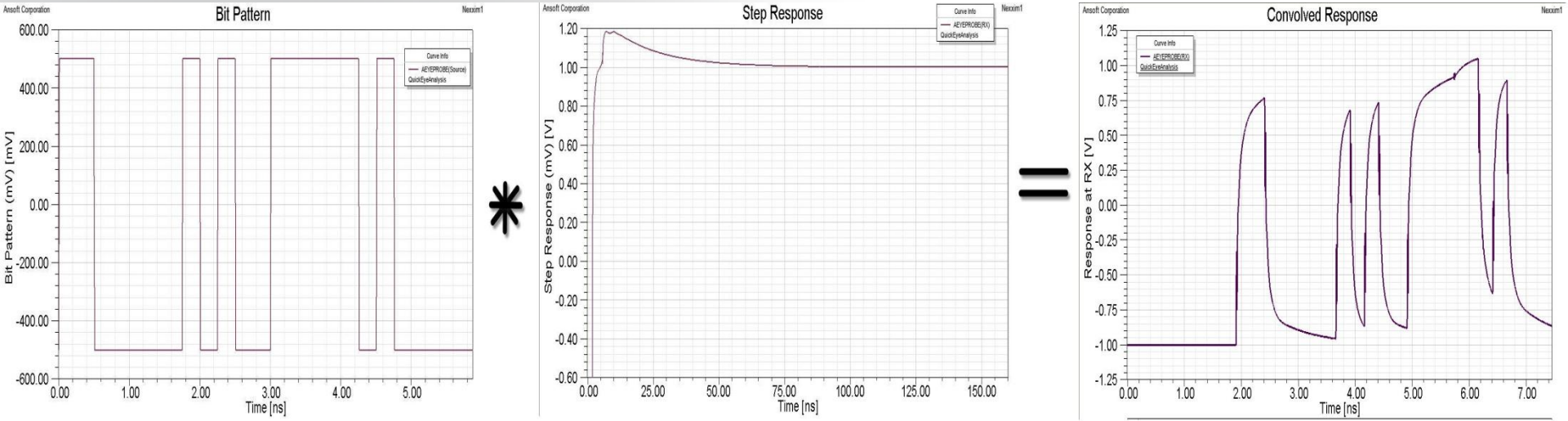
$X_1(t) \Rightarrow Y_1(t)$
$X_2(t) \Rightarrow Y_2(t)$

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

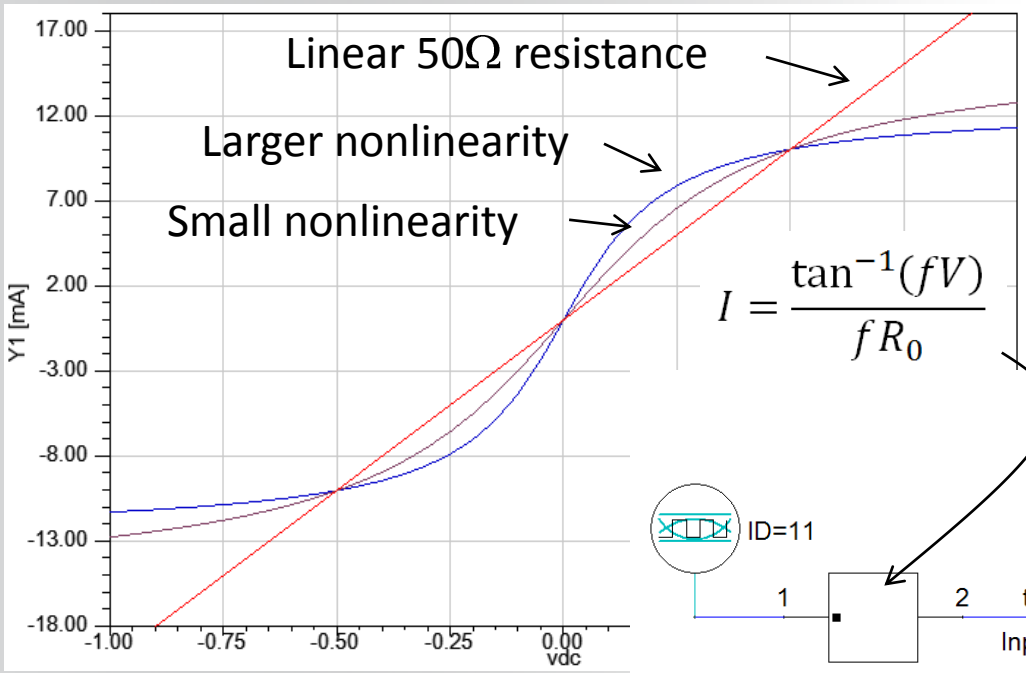
$X_1(t-\tau) \Rightarrow Y_1(t-\tau)$ Time invariant property



How About Non-linear System?

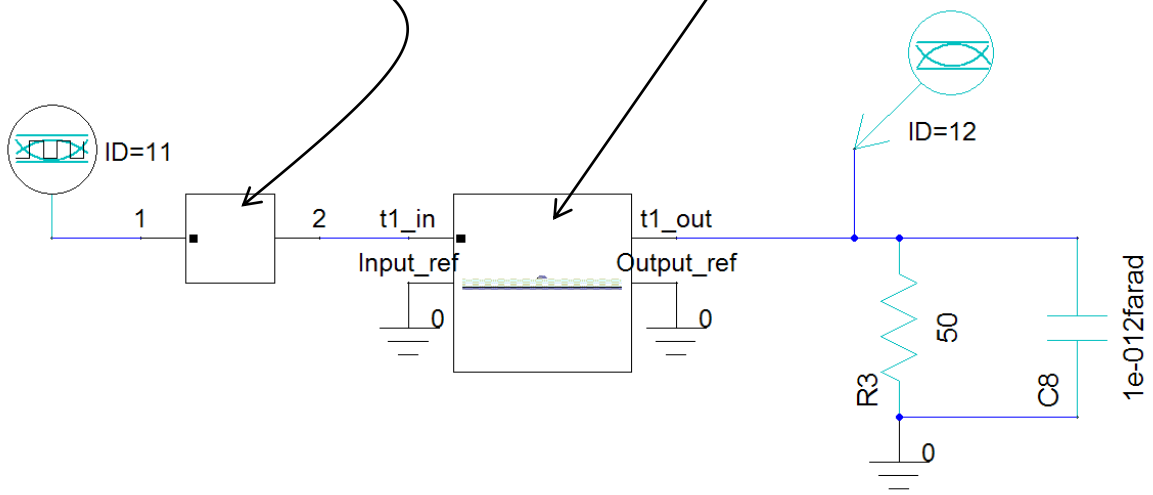
Simple channel with driver that has a nonlinear self impedance:

- **3 curves tested for driver impedance**



$$I = \frac{\tan^{-1}(fV)}{fR_0}$$

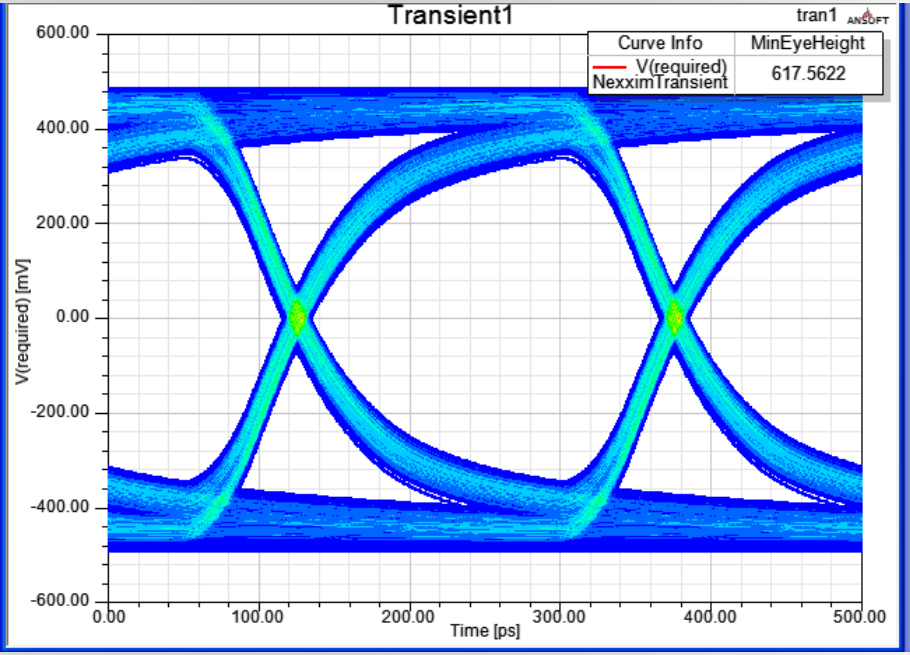
10 inch microstrip trace

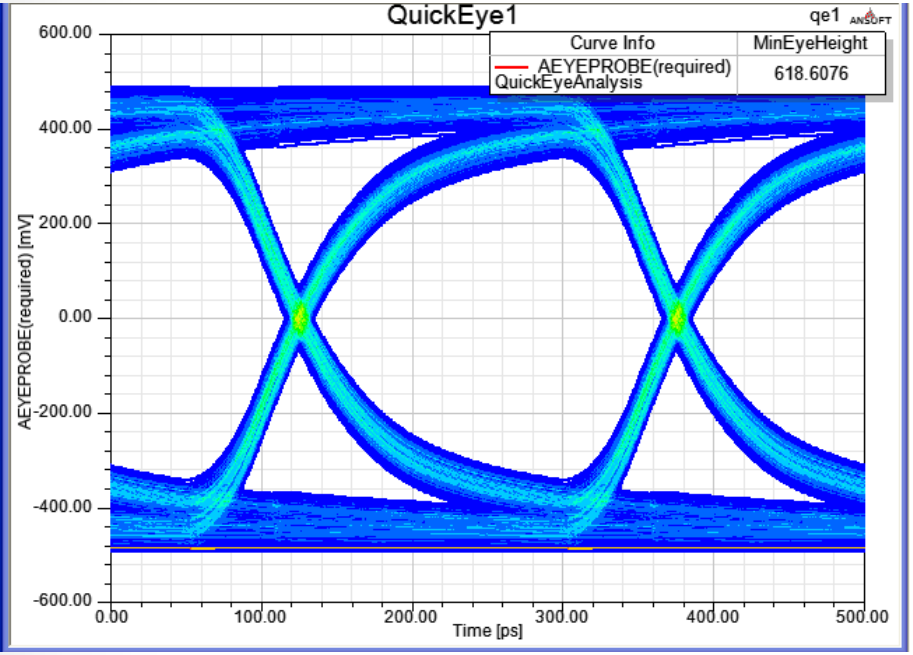


Transient vs. Convolution for Linear network

Transient Eye Height = 618 mV

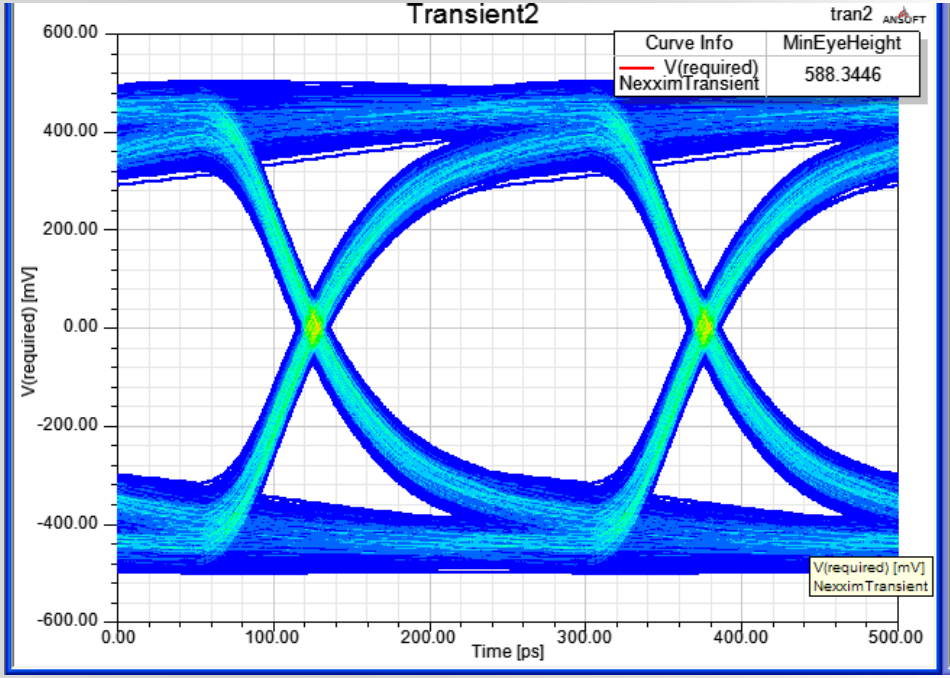
Convolution Eye Height = 619 mV



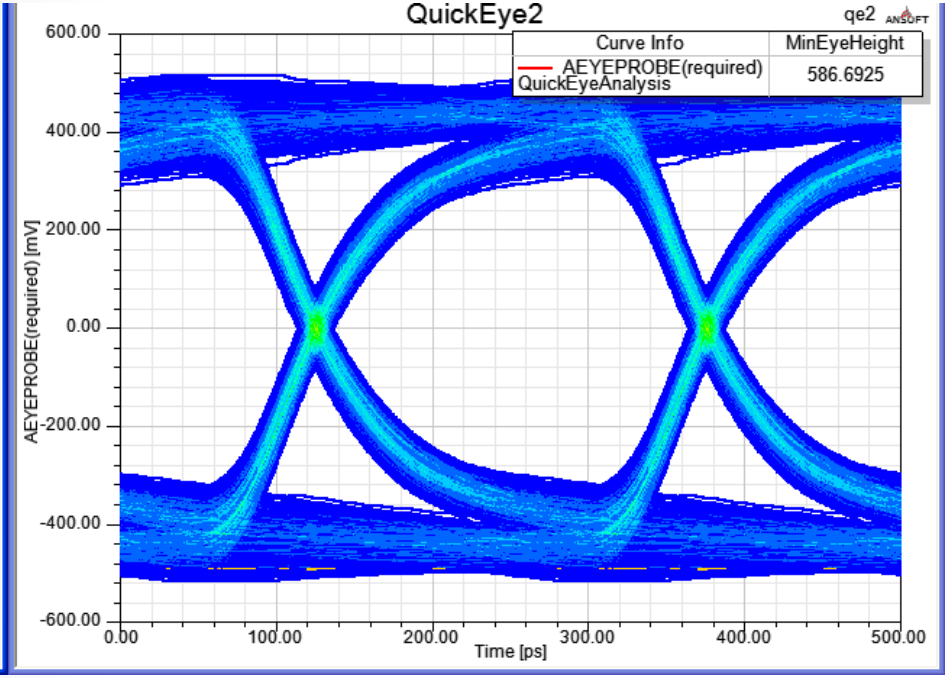


Transient vs. Convolution for Small Nonlinearity

Transient Eye Height = 588 mV

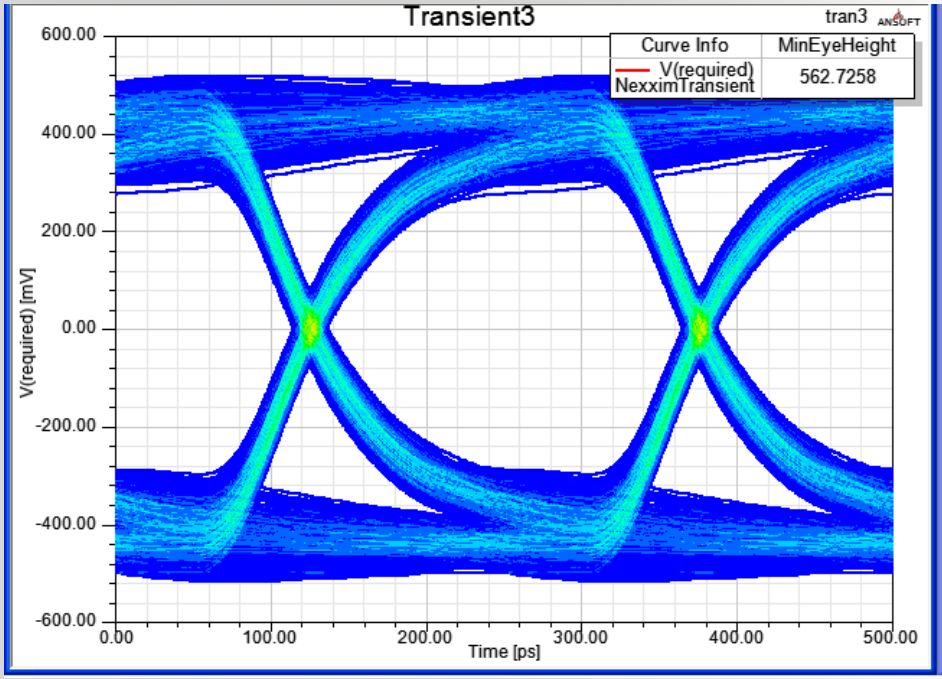


Convolution eye Height = 587 mV

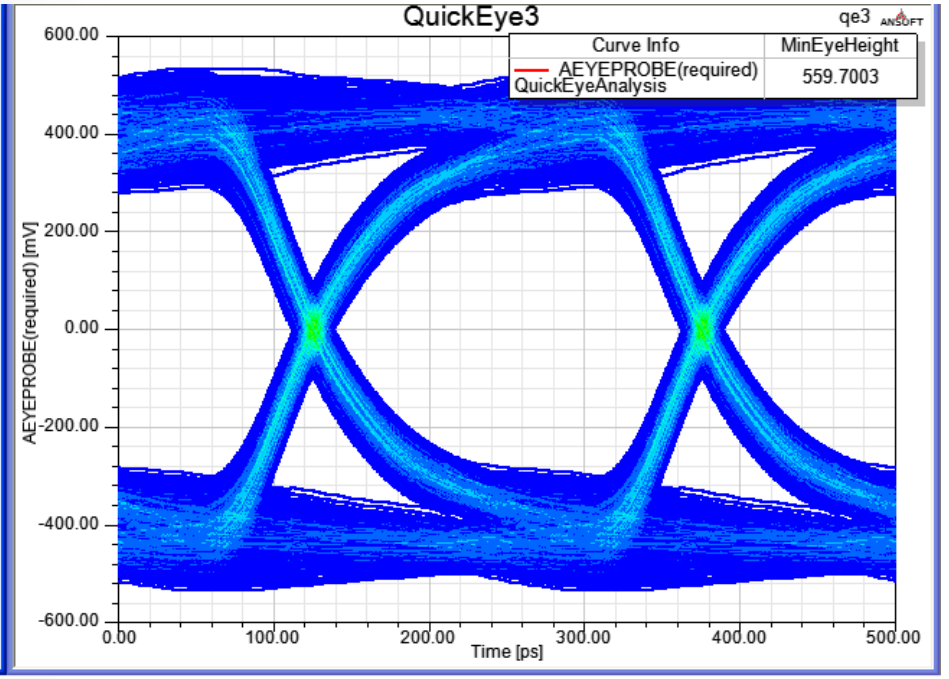


Transient vs. Convolution for Larger Nonlinearity

Transient Eye Height = 563 mV

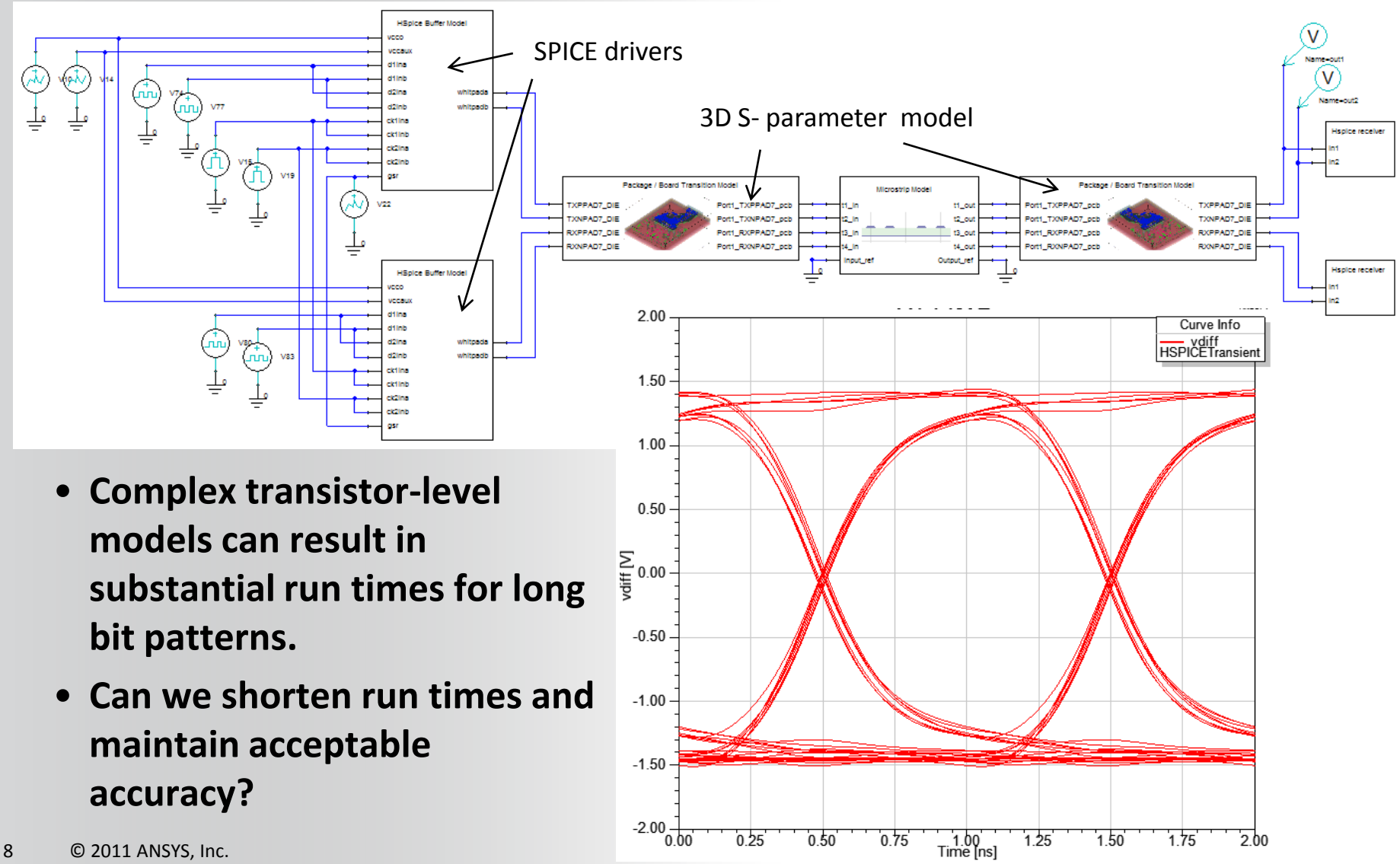


Convolution Height = 560 mV



- **Test cases show that even Convolution make an assumption of linearity, accuracy is often excellent for moderately nonlinear drivers**

Typical GHz Transient simulation

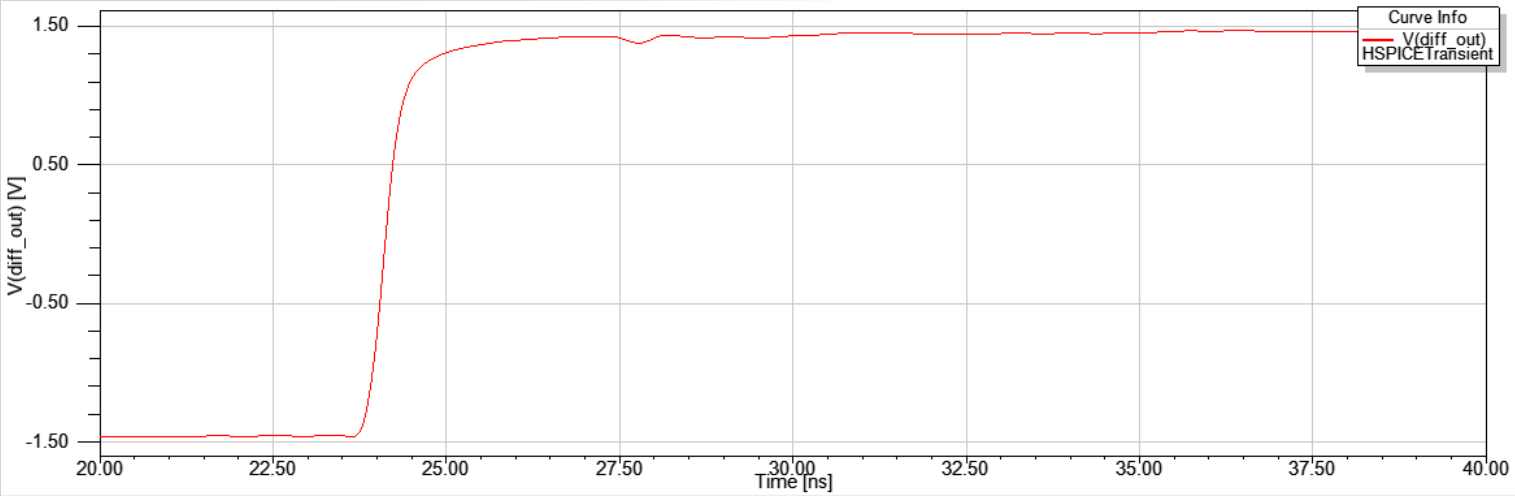


- **Complex transistor-level models can result in substantial run times for long bit patterns.**
- **Can we shorten run times and maintain acceptable accuracy?**

Pseudo transient eye analysis

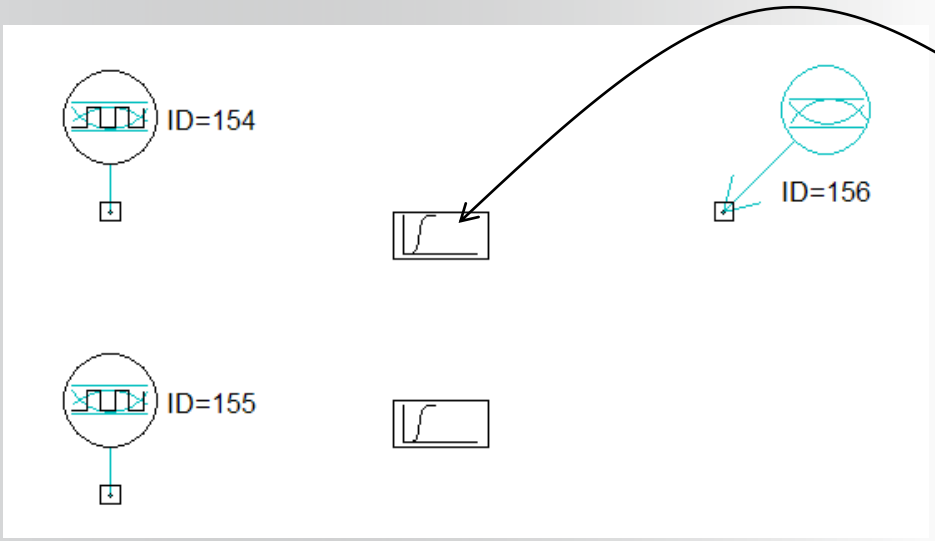
Pseudo transient like IBIS' V-T curve:

- Run transient simulations using SPICE to capture the step response of the channel, Store step responses in text files
- Separate rising and falling responses can be specified
- Run convolution using these external step responses
- Theory is based on LTI assumption



Pseudo transient eye analysis(cont.)

Pseudo transient eye results will closely match transient if buffers are approximately linear



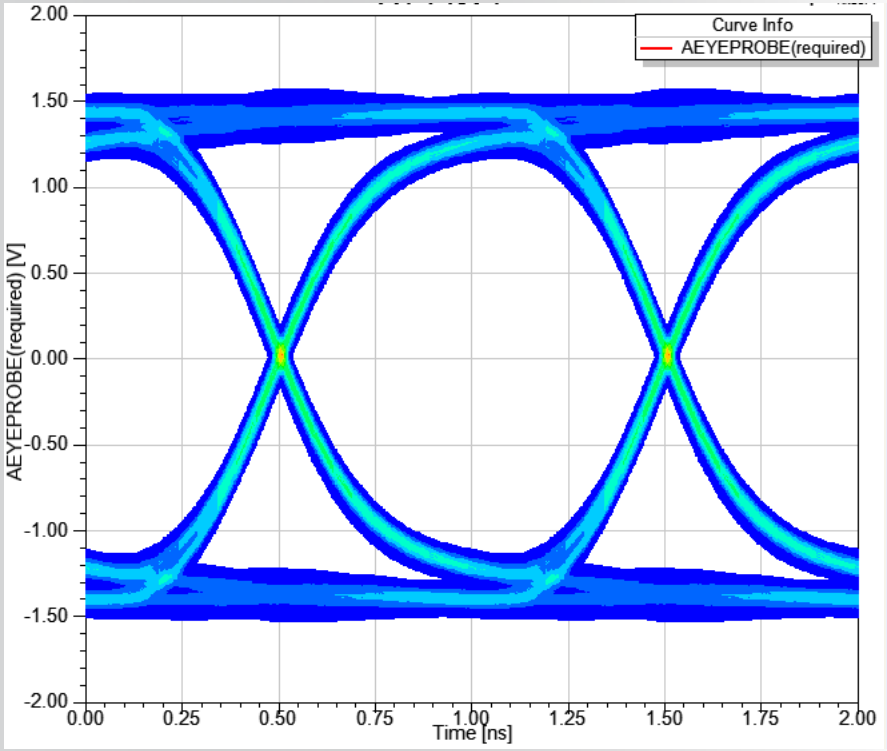
Properties

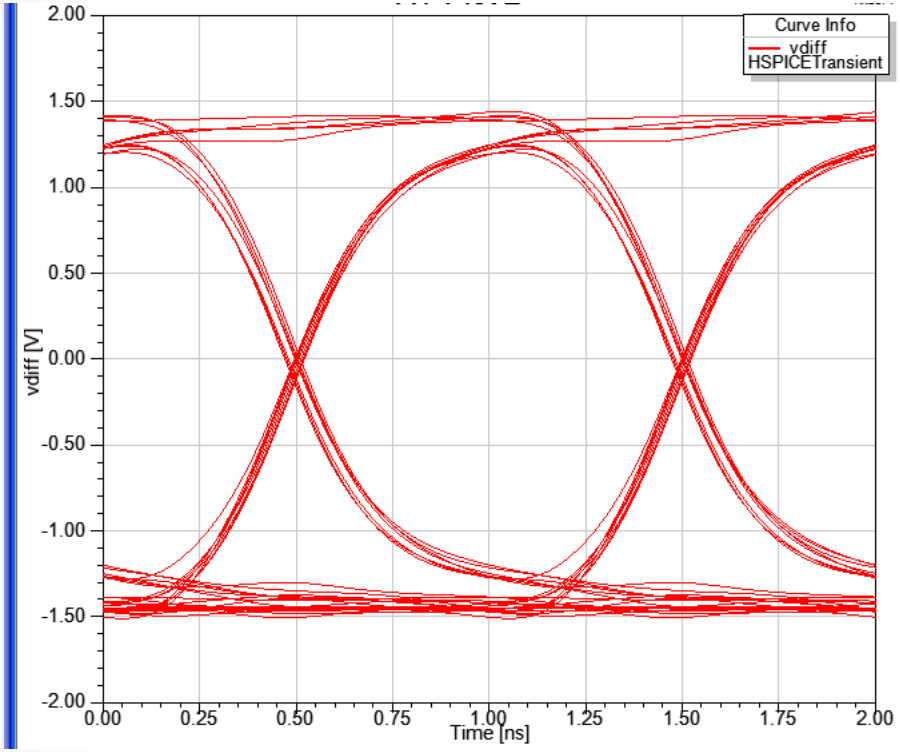
Name	Value	Unit	Evaluated V...
source_name	AEYESOURCE93		
probe_name	AEYEPROBE95		
step_response_file_rise	rising_through.tab		
step_response_file_fall	falling_through.tab		
COMPONENT	EXTERNAL_STEP_...		
CosimDefinition	Edit		
CoSimulator	DefaultNetlist		
Status	Active		
Info	EXTERNAL_STEP_...		

Pseudo transient eye vs. SPICE transient eye

Pseudo transient and SPICE transient

- After capturing 100ns transient step response for rising, falling, and crosstalk edges, 100,000 bits run in seconds by convolution
- Results consistent with SPICE transient





Conclusion

- Even Statistical eye analysis by using convolution method is assumption LTI system, sometimes it also can be used for Non-Linear system, but the simulator must be tested
- SPICE transient step response can also be used in Statistical analysis for Pseudo transient
- Chip vendor maybe supply typical channel's step response for end user evaluation. EDA vendor also can give the comparison of pseudo transient and SPICE transient for user reference.