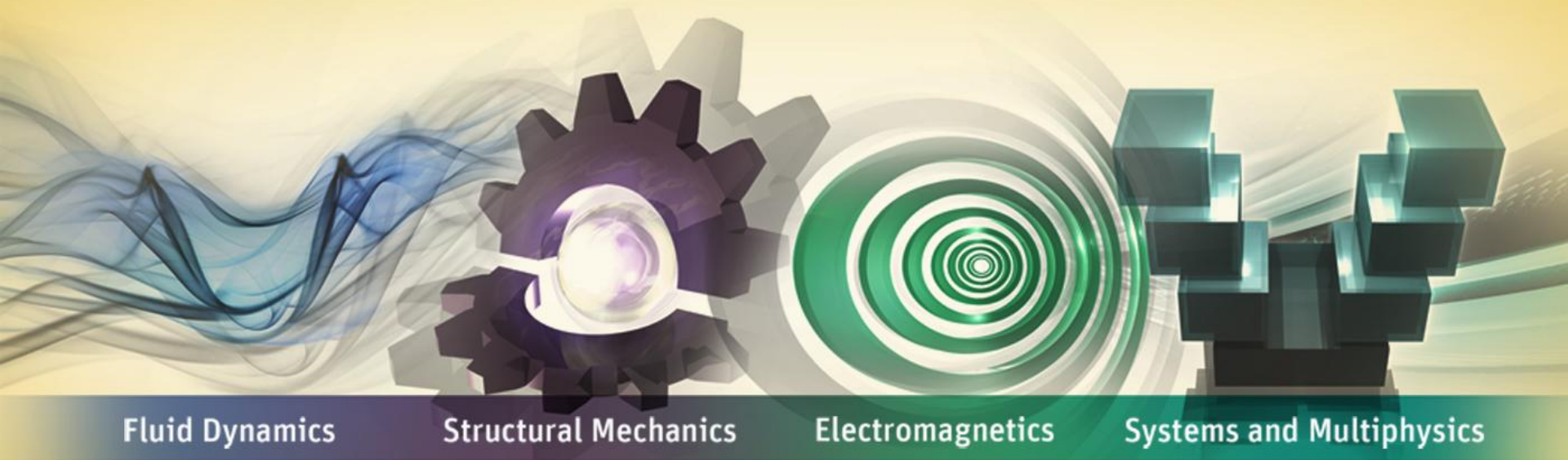


Pseudo transient eye analysis by convolution method



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- 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

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

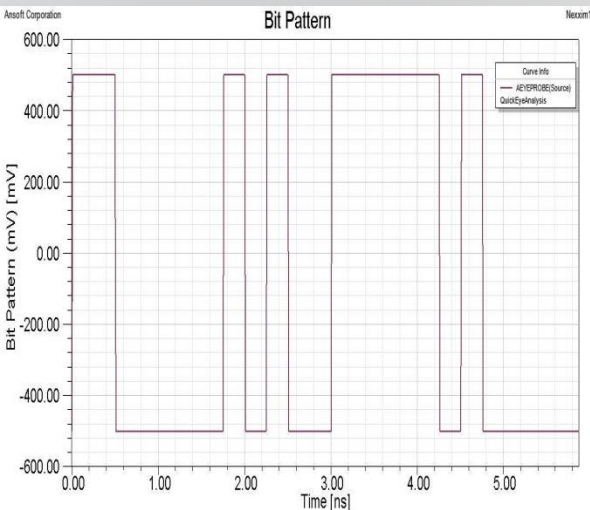
Input yields output

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

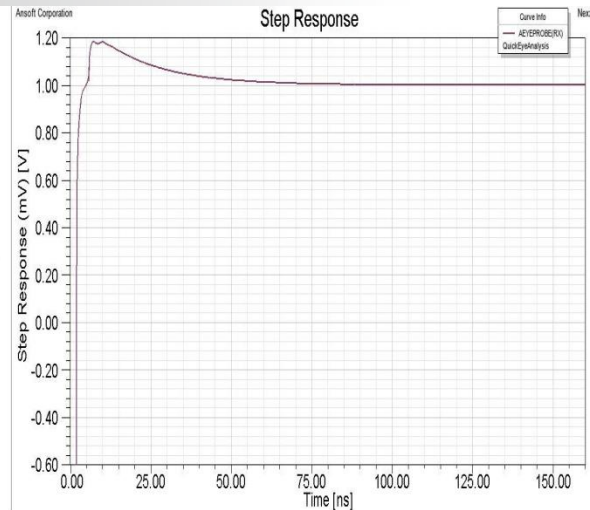
$$X_1(t) + X_2(t) \Rightarrow Y_1(t) + Y_2(t) \quad \text{Additive property}$$

$$aX_1(t) \Rightarrow aY_1(t) \quad \text{Homogeneity property}$$

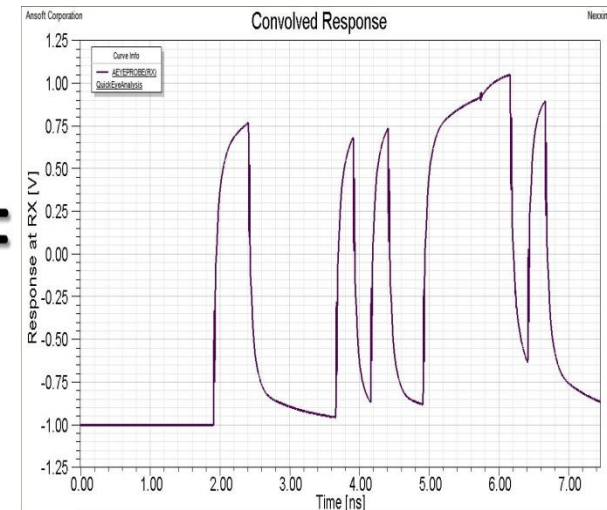
$$X_1(t - \tau) \Rightarrow Y_1(t - \tau) \quad \text{Time invariant property}$$



*



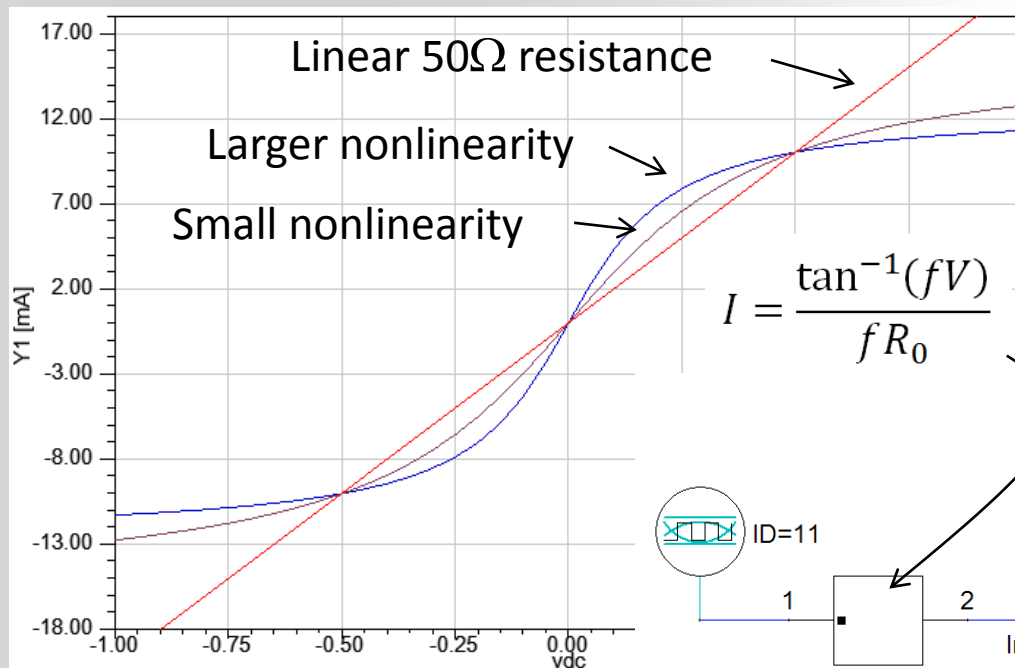
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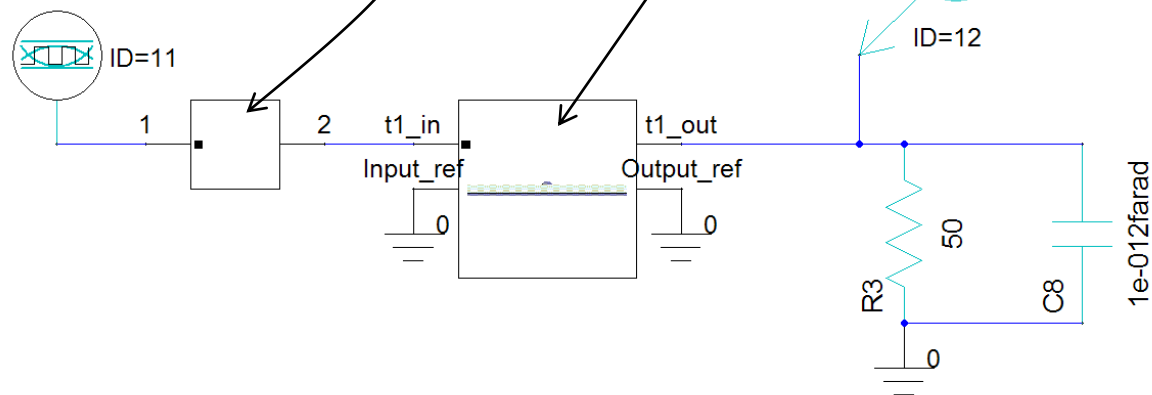
How About Non-linear System?

Simple channel with driver that has a nonlinear self impedance:

- 3 curves tested for driver impedance



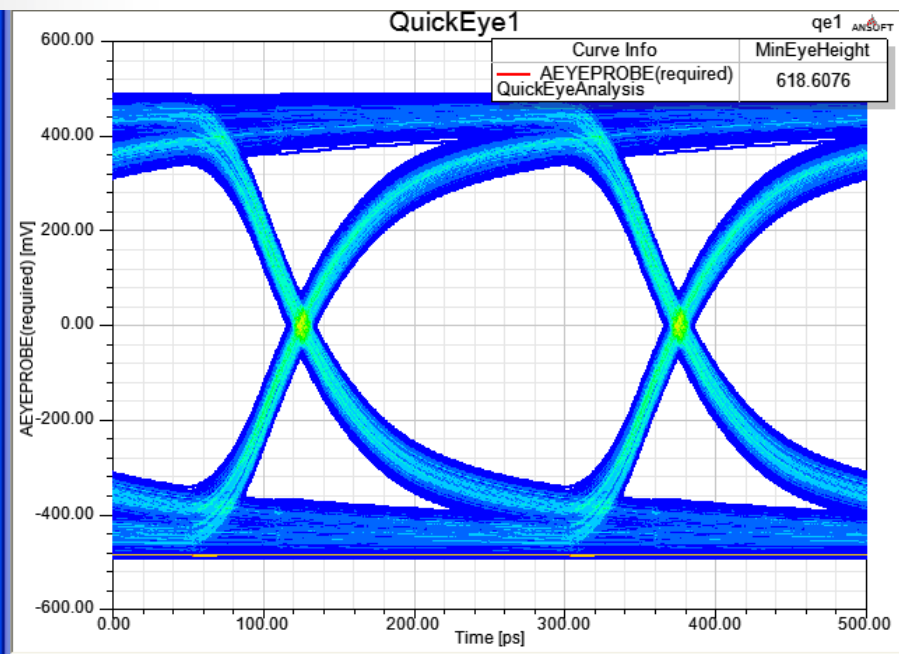
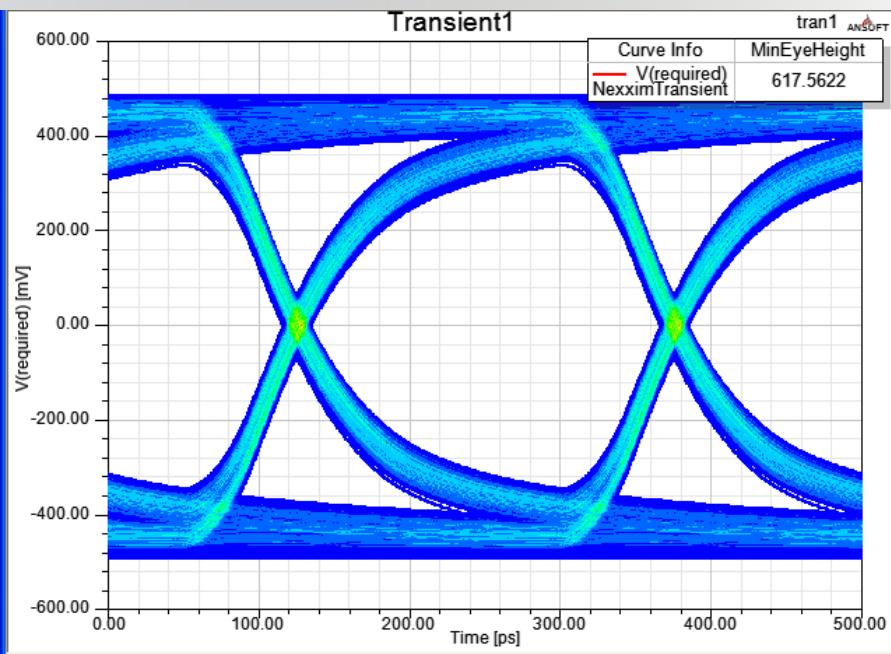
10 inch microstrip trace



Transient vs. Convolution for Linear network

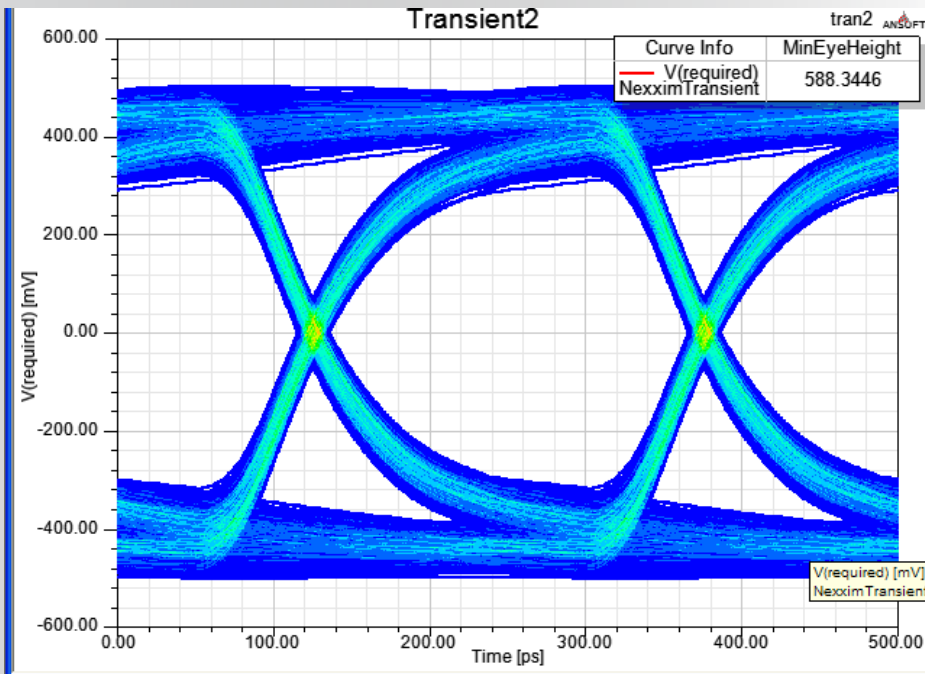
Transient Eye Height = 618 mV

Convolution Eye Height = 619 mV

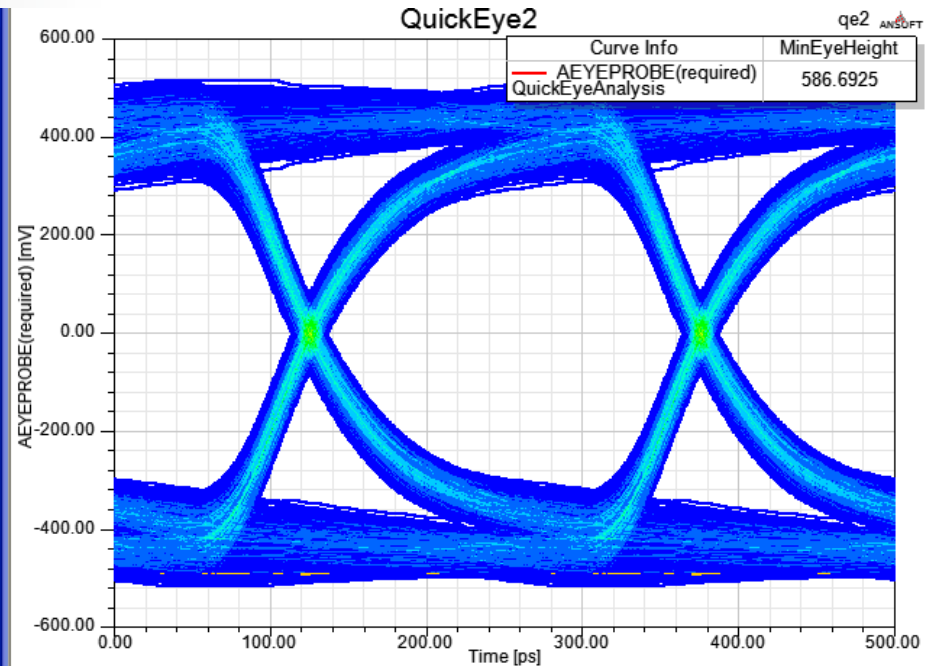


Transient vs. Convolution for Small Nonlinearity

Transient Eye Height = 588 mV

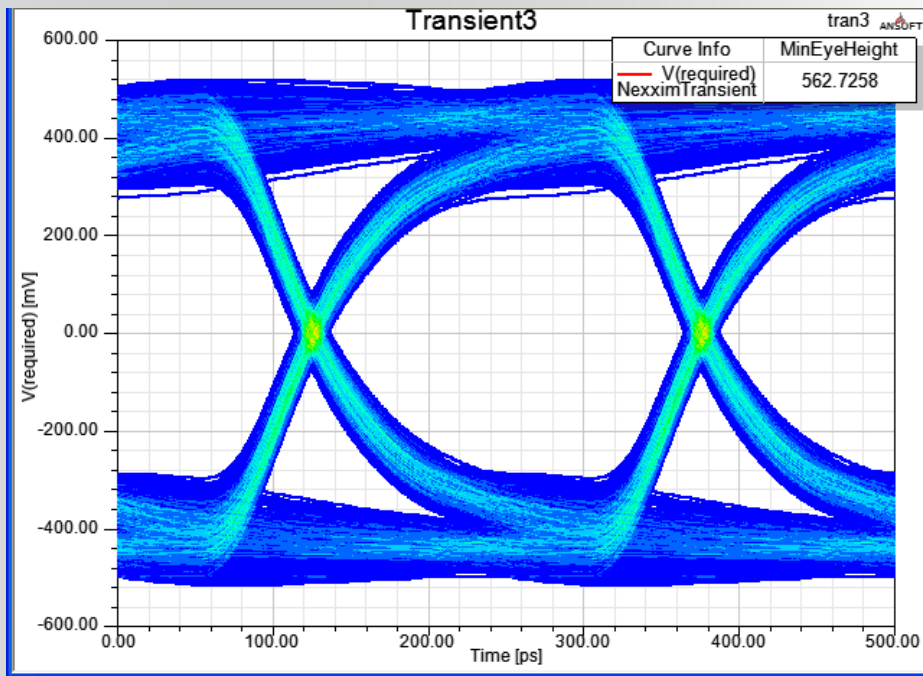


Convolution eye Height = 587 mV

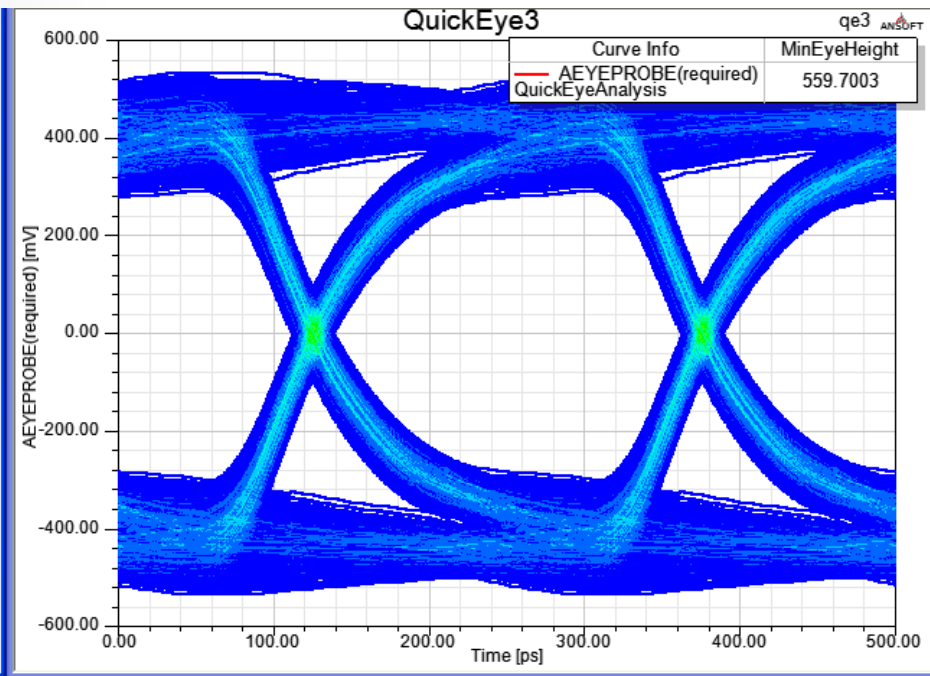


Transient vs. Convolution for Larger Nonlinearity

Transient Eye Height = 563 mV

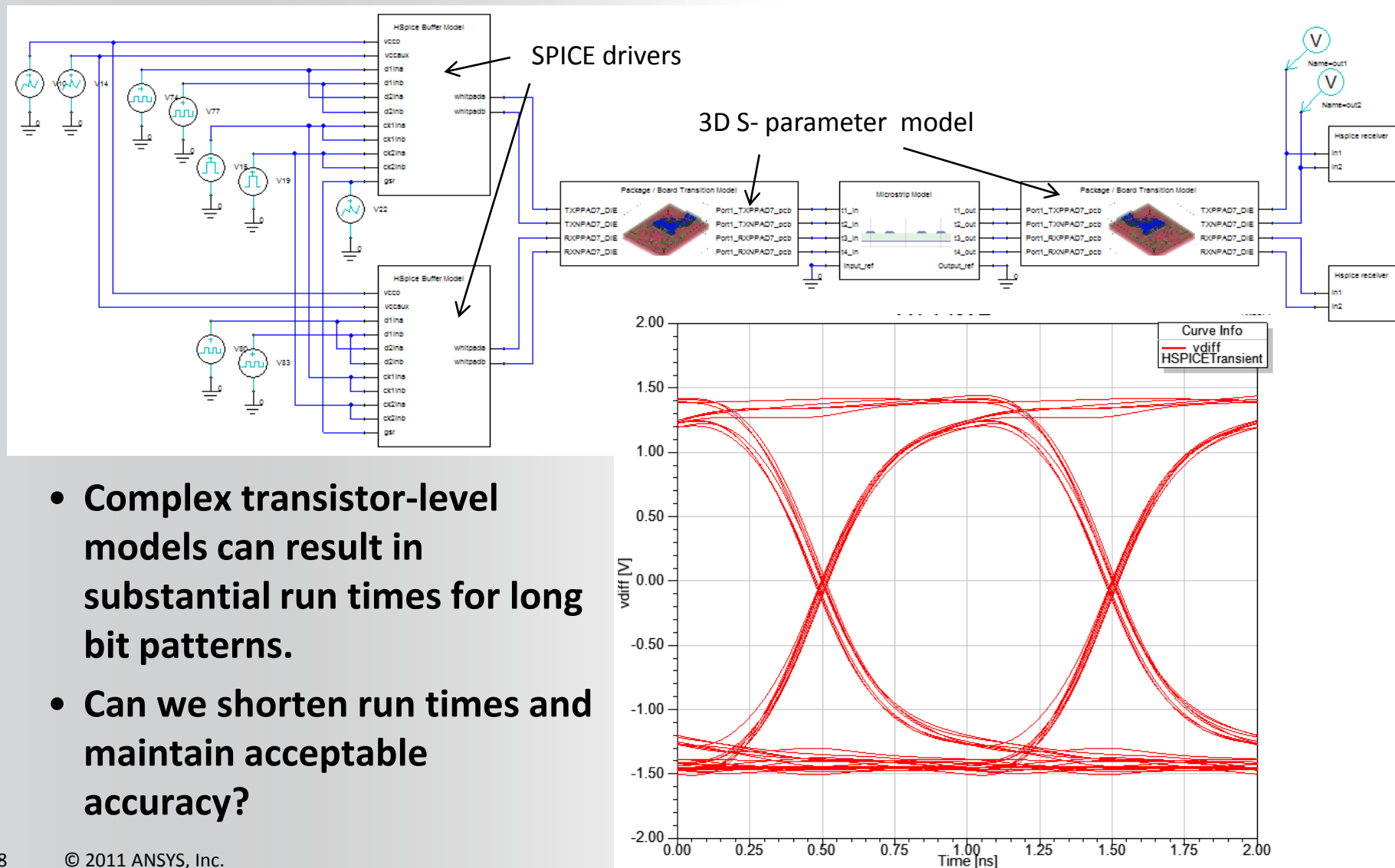


Convolution Height = 560 mV



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

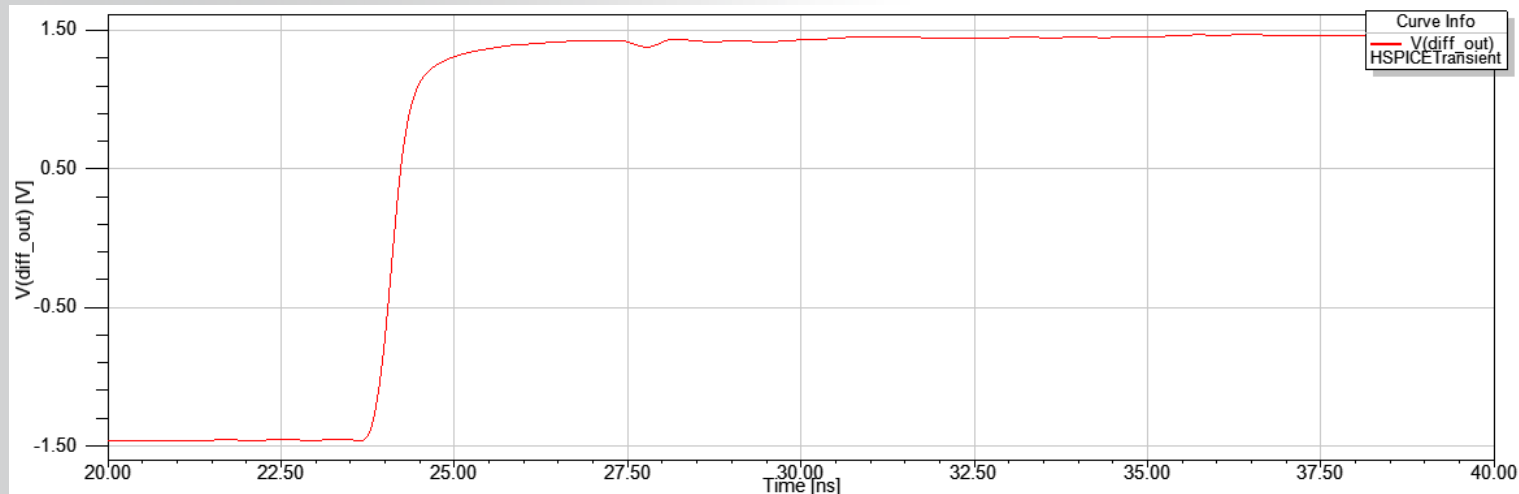
Typical GHz Transient simulation



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

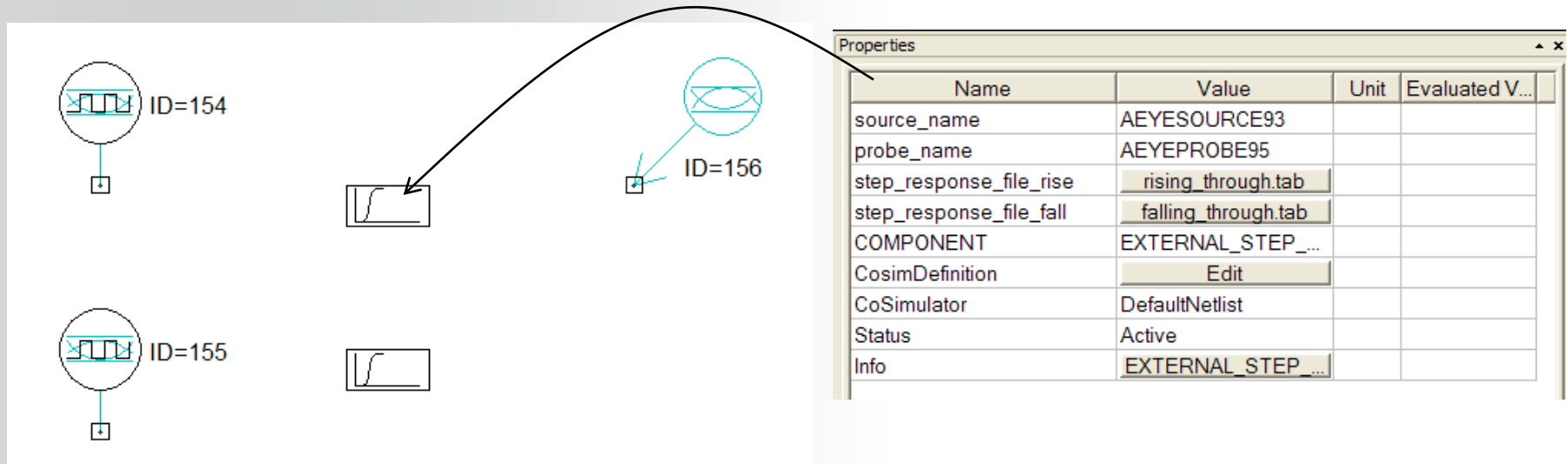
Pseudo transient like IBIS' V-T curve:

- 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.)

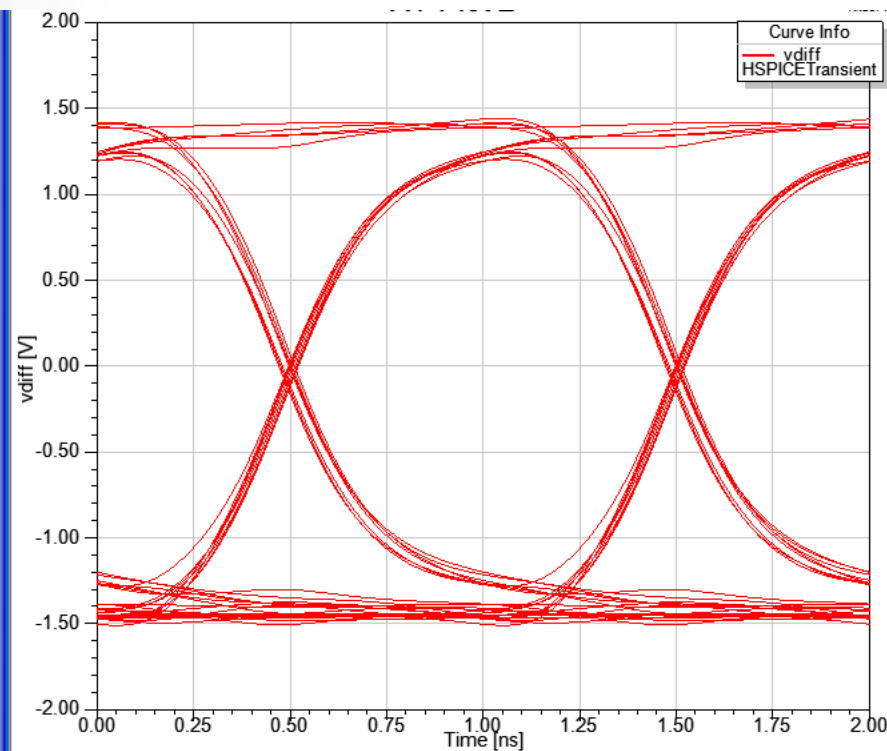
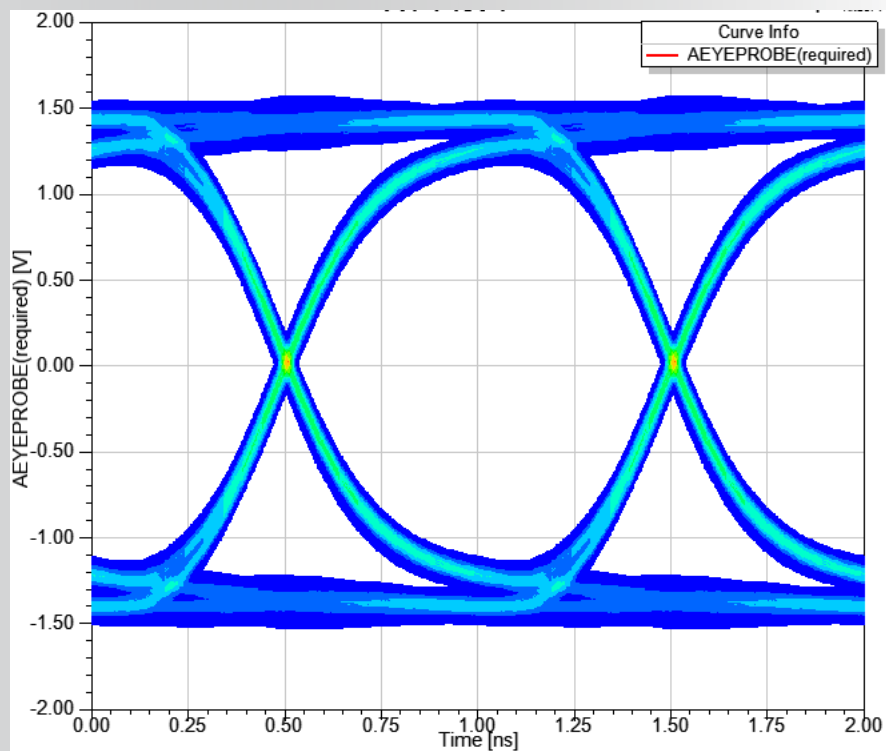
Pseudo transient eye results will closely match transient if buffers are approximately linear



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



- **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.**