

1.00mm Pitch  
Flip-Top™ BGA Socket

# SIGNAL INTEGRITY ANALYSIS AND MODELING

Rev. 2

[www.advanced.com](http://www.advanced.com)

ISO  
9001

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# Signal Integrity Data Reporting

At Advanced Interconnections Corporation, our Signal Integrity reporting method differs dramatically from the common industry practice of isolating the *aggressor* and *victim* terminals from each other by introducing dedicated ground terminals between them. We believe this method represents a theoretical, best-case, scenario that does not serve the needs of most systems engineers and circuit designers. An unrealistic number of connector terminals must be assigned to ground in order to achieve this scenario.

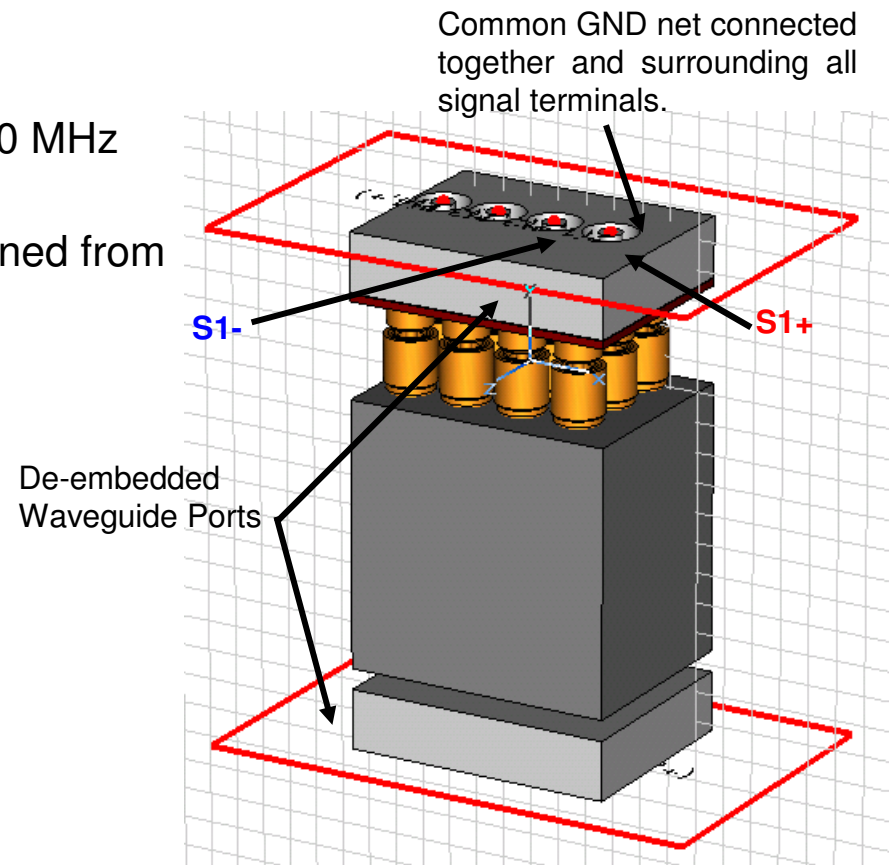
Our standard reporting practice is closely aligned with the decision-making processes of most systems engineers and circuit designers. The reported data addresses our customers I/O assignments (net-list) and helps them determine where to best run high-versus-low frequency signals through our connectors. As such, our reporting method represents a more practical net-list scenario. Utilizing our unbiased SPICE™ and IBIS™ files, system designers are able to create and/or debug their net-list quickly and accurately.

# SI Test and Measurement Study

## SI Test Setup

- The 1.00 mm Flip-Top was measured from 50 MHz to 10.05 GHz.
- A pin-out of 3 rows and 4 columns was assigned from a 4x4 array:

GND	GND	GND	GND
S1+	S1-	S2+	S2-
GND	GND	GND	GND



# SI Test and Measurement Study

## Performance Results

- The test and measurement tasks were completed and the recommended Operational Bandwidth for the Flip-Top System is as follows:
  - Differential: DC to 0.76 GHz @ -15dB and ~0.5 to 0.8 Gbit/sec.
  - Differential: DC to 1.25 GHz @ -10dB and ~0.8 to 1.3 Gbit/sec.
  - Single-ended: DC to 0.9 GHz @ -15dB and ~0.6 to 1.0 Gbit/sec.
  - Single-ended: DC to 1.7 GHz @ -10dB and ~1.1 to 1.8 Gbit/sec.
- At the above Bandwidths, the Impedance of this connector system is low. This has been attributed to the geometry of the female shell and the proximity of adjacent terminals.

# SI Test and Measurement Study

## Performance Results – continued

- Differential Eye Diagrams were successfully formed at 5 Gbits/sec., with Jitter at 8psec and 25% eye closure.
  - *The eye opening sustains a Data Mask with a voltage swing of  $\pm 175\text{mV}$  @ 100psec period.*
  
- Single-ended Eye Diagrams were successfully formed at 5 Gbits/sec., with Jitter at 12psec and 20% eye closure.
  - *The eye opening sustains a Data Mask with a voltage swing of  $\pm 125\text{mV}$  @ 140psec period.*

# SI Test and Measurement Study

## Performance Results – continued

	<b>Return Loss</b> ( $S_{\omega, \theta}$ )	<b>Insertion Loss</b> ( $S_{\phi, \beta}$ )	<b>Zo @ 200 psec</b> (10-90%)
<b>Differential</b> (Terminals <b>S1+</b> , <b>S1-</b> )	<b>(S1,1)</b> -15.0dB @ 0.76 GHz -10.0dB @ 1.25 GHz	<b>(S2,1)</b> -0.30dB @ 0.76 GHz -0.60dB @ 1.25 GHz	<b>70.0Ω</b>
<b>Single-ended</b> (Terminals <b>S1+</b> )	<b>(S1,1)</b> <u>-15.0dB @ 1.3 GHz</u> <u>-10.0dB @ 2.3 GHz</u>	<b>(S2,1)</b> <u>-0.4dB @ 1.3 GHz</u> <u>-0.7dB @ 2.3 GHz</u>	<b>40.9Ω</b>
<b>Single-ended</b> (Terminals <b>S1-</b> )	<b>(S3,3)</b> <u>-15.0dB @ 0.9 GHz</u> <u>-10.0dB @ 1.7 GHz</u>	<b>(S4,3)</b> <u>-0.35dB @ 0.9 GHz</u> <u>-0.75dB @ 1.7 GHz</u>	<b>38.0Ω</b>

- A Return Loss at -15dB (~18% Reflection) is the normally accepted industry standard. Most applications will tolerate data at -10 dB (~32% Reflection), however in this instance, performance safety margins may be increased by *de-rating* the connectors Operational Bandwidth and Data Rate.
- A Insertion Loss at -3dB (~50% of applied Power & ~71% of applied Voltage arrives at the Output Port) is the normally accepted industry standard.
- An Effective Impedance of 100Ω ±10Ω for Differential and 50Ω ±5Ω for Single-ended is the normally accepted industry guideline. De-rating the signal input risetime will improve the above Zo values.

# SI Test and Measurement Study

## Performance Results– continued

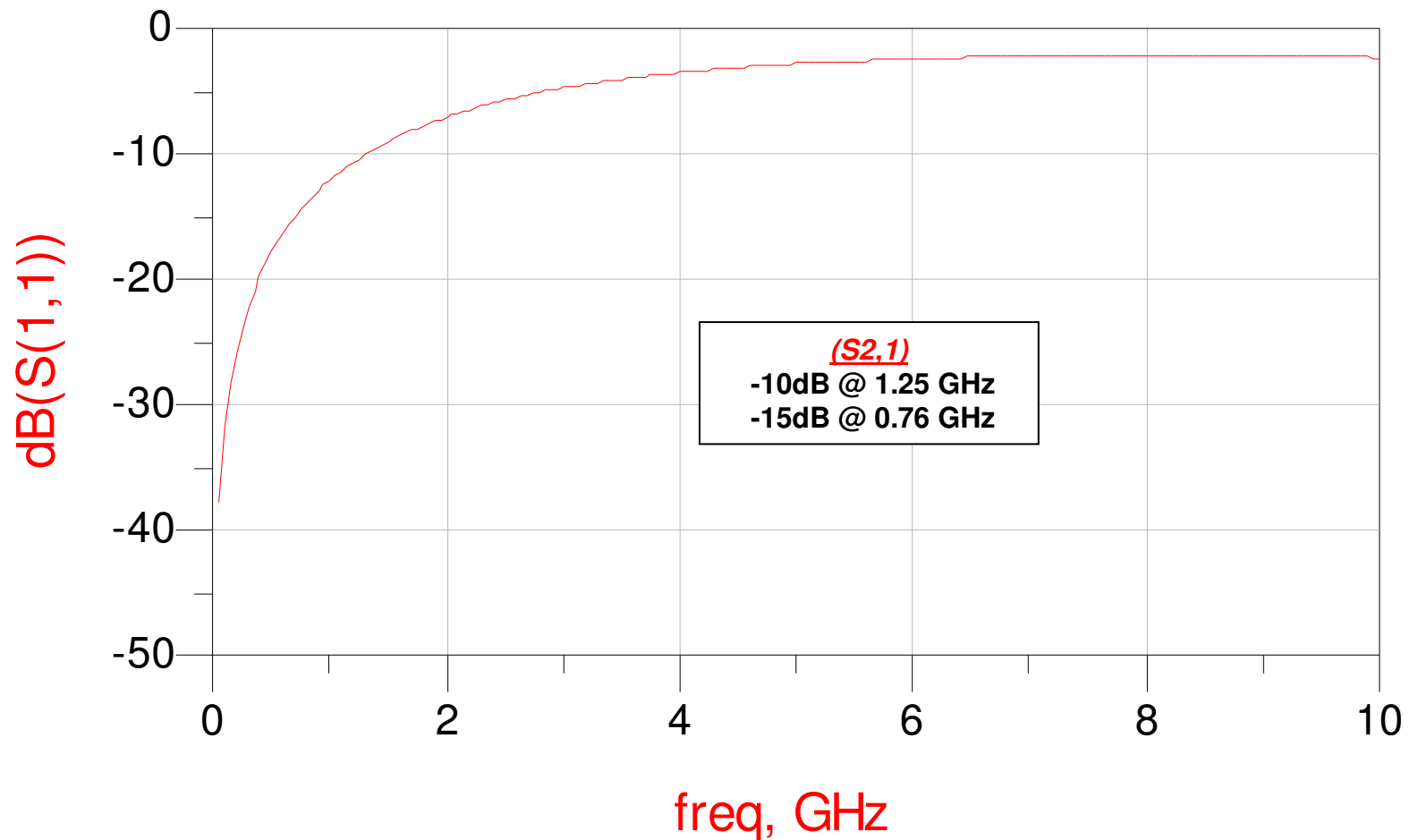
	<i>NeXT @ 200 psec (10-90%)</i>	<i>FeXT @ 200 psec (10-90%)</i>	<i>Eye-Diagram @ 5 Gbit/sec</i>	<i>Eye-Diagram @ 5 Gbit/sec with 6 Gbit/sec Aggressor</i>
<i>Differential (Terminals S1+, S1-)</i>	2.1%	1.8%	Peak-to-Peak Jitter = 3 psec Eye-Closure = 19%	Peak-to-Peak Jitter = 8 psec Eye-Closure = 25%
<i>Single-ended (Terminals S1-)</i>	5.5%	3.4%	Peak-to-Peak Jitter = 2 psec Eye-Closure = 8%	Peak-to-Peak Jitter = 12 psec Eye-Closure = 20%

- A *NeXT* at 5% maximum is the normally accepted industry standard. Some customers may specify a value as low as 2% maximum for this attribute.
- A *FeXT* at 2% maximum is the normally accepted industry standard. Some customers may specify a value as low as 1% maximum for this attribute.
- A successful Eye-opening was created at 5 Gbit/sec and at this data rate is well within the Operational Bandwidths recommended for this connector system. See note below.

NOTE: It's not practical to define *pass-or-fail* criteria for Jitter and Eye-Closure. However, guidelines for the connector's transmit Data Mask can be defined to quantify the effective performance of the eye formation. For a Differential data mask, the total voltage equals 35% of the eye's applied *peak-to-peak* voltage, (1V in this report), and its period equals 50% of the risetime, (200psec in this report). For a Single-ended data mask, the total voltage equals 50% of the eye's applied *peak-to-peak* voltage, (500mV in this report), and its period equals 70% of the risetime, (200psec in this report).

# Differential Return Loss

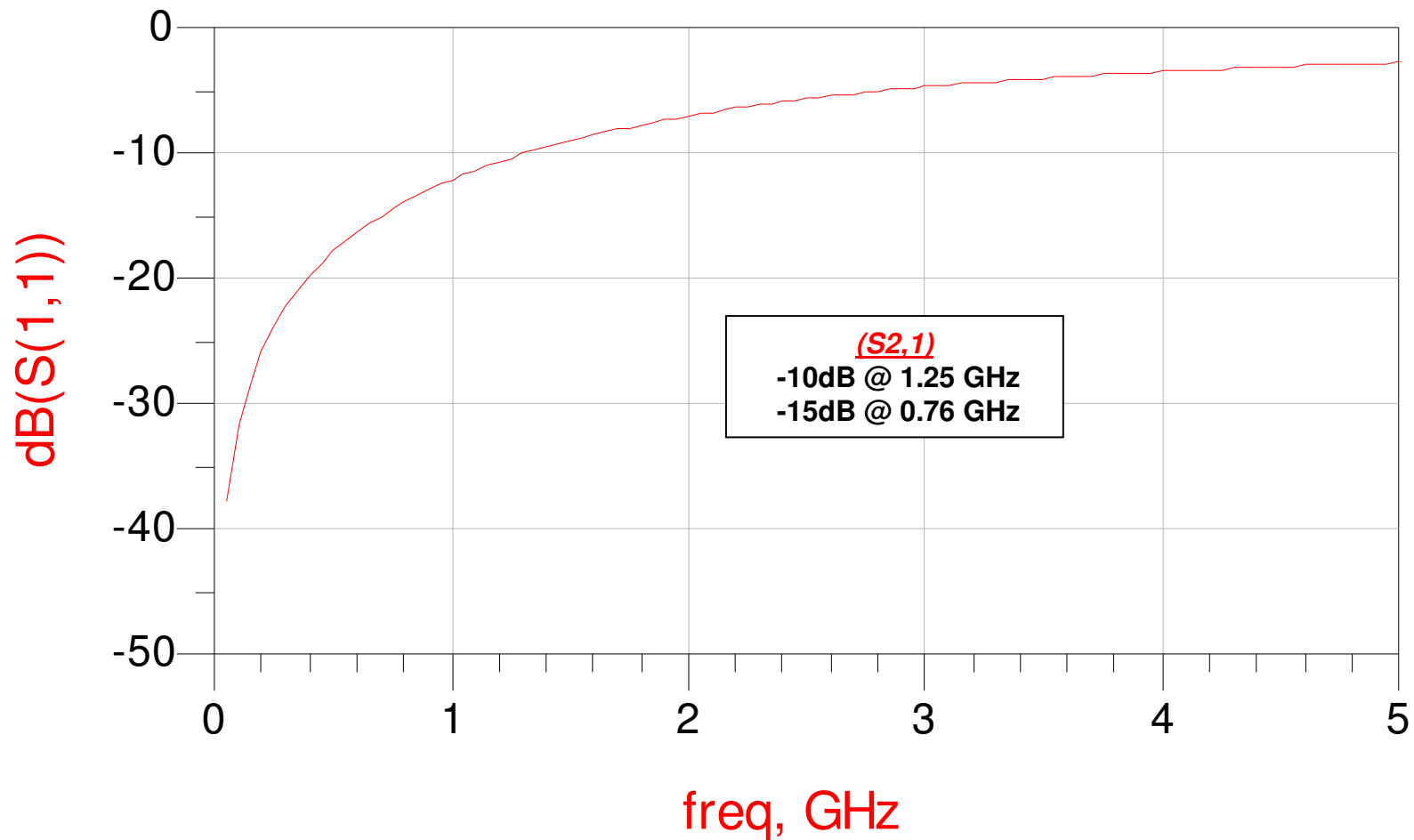
Plot Range: DC to 10 GHz





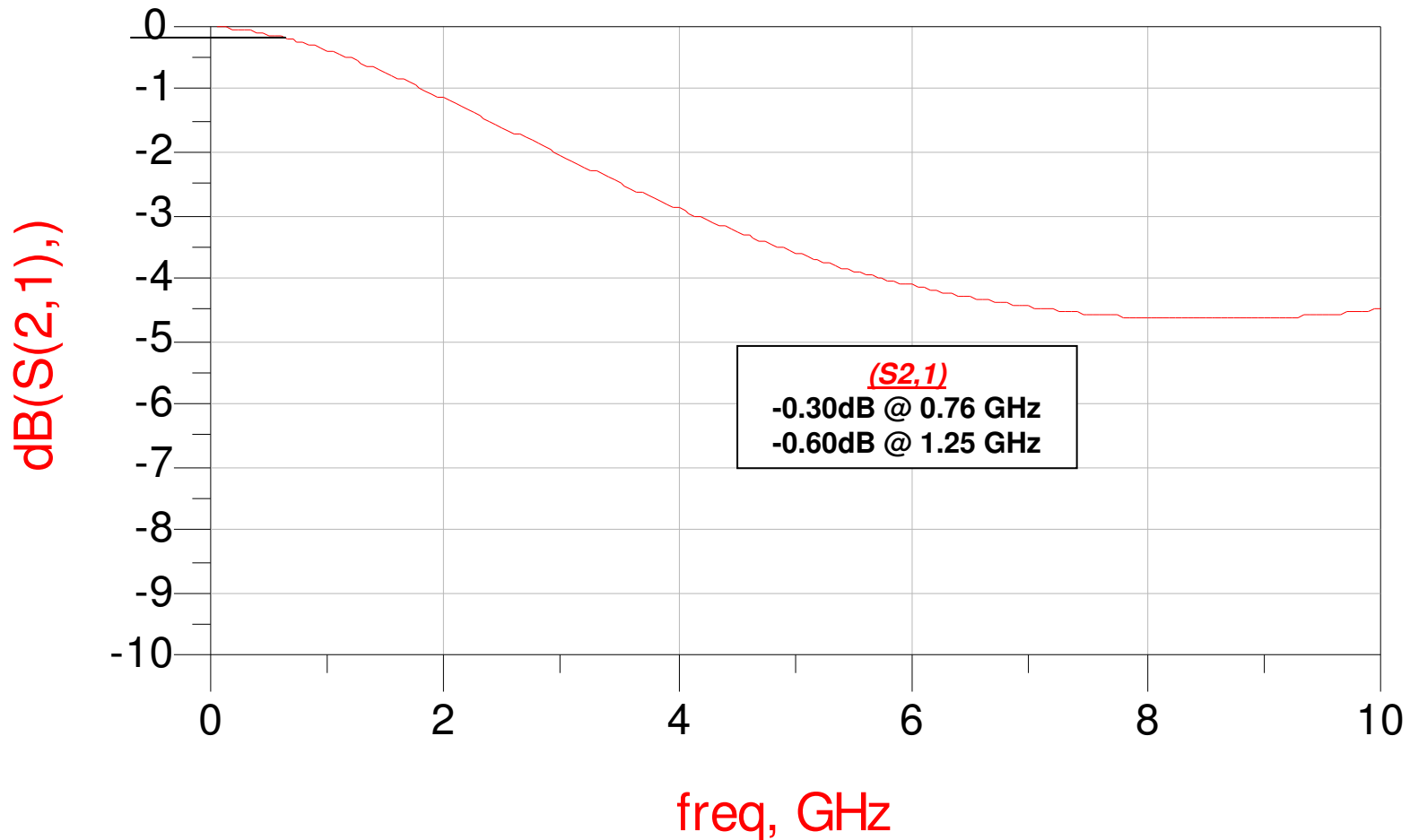
# Differential Return Loss

Plot Range: DC to 5 GHz



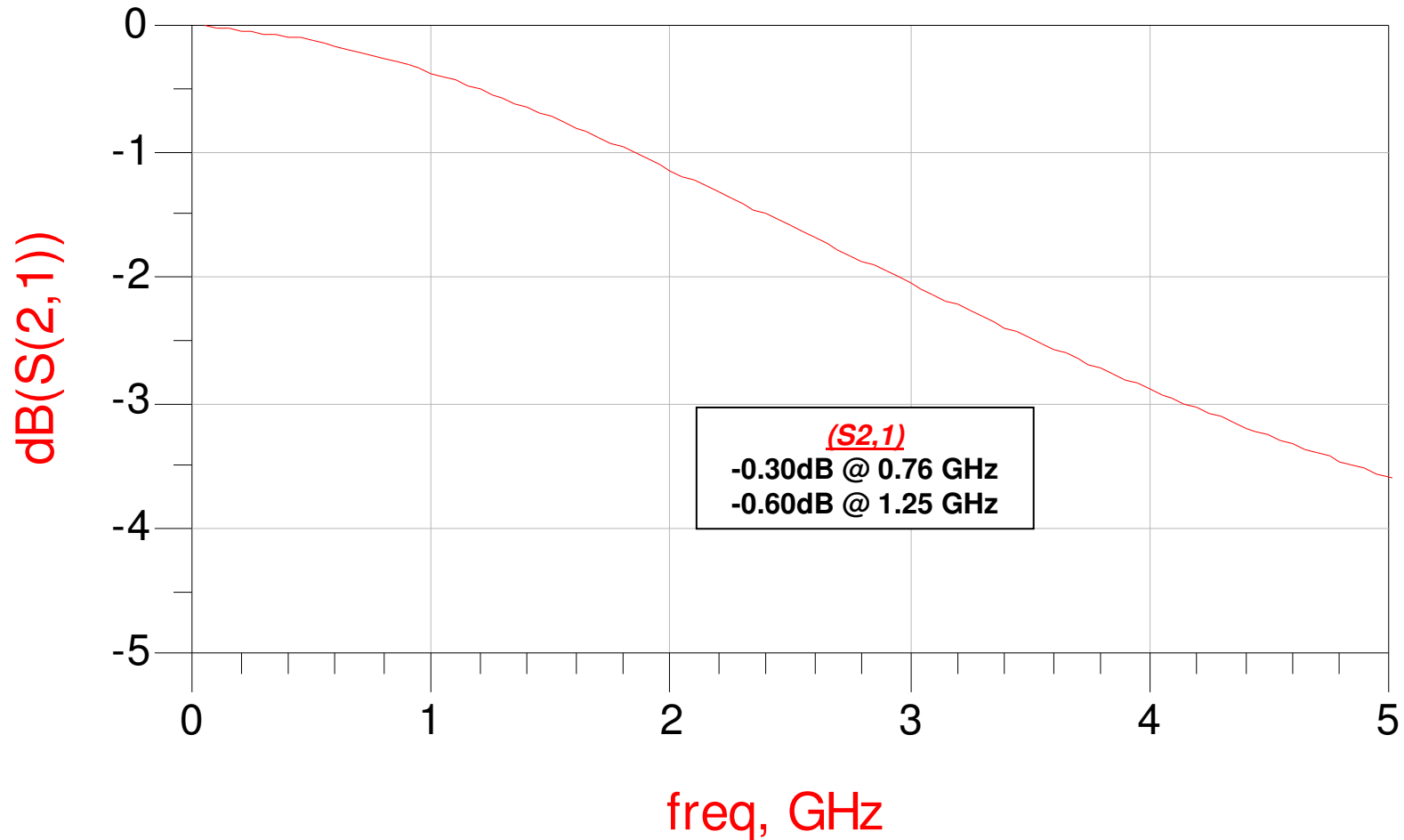
# Differential Insertion Loss

Plot Range: DC to 10 GHz



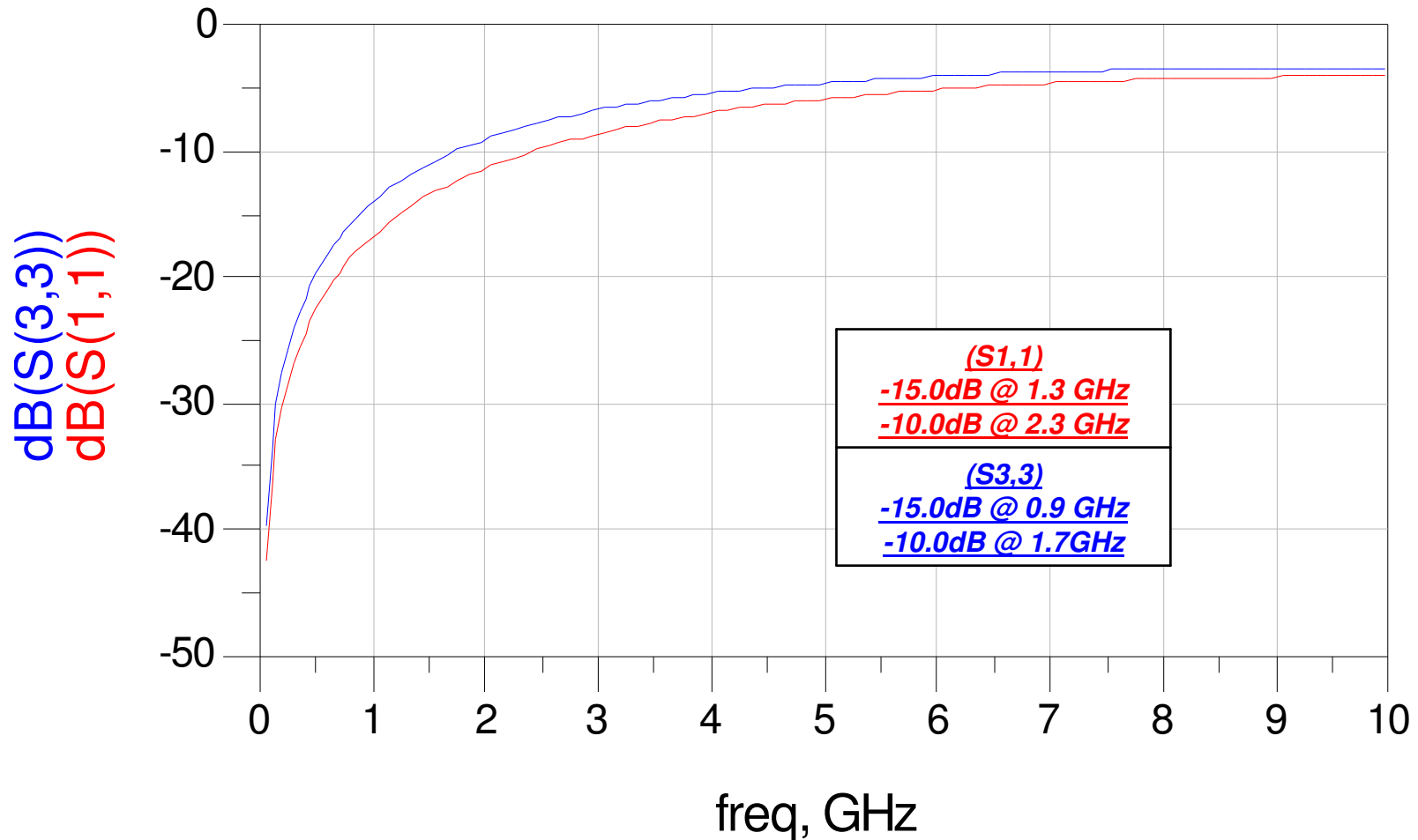
# Differential Insertion Loss

Plot Range: DC to 5 GHz



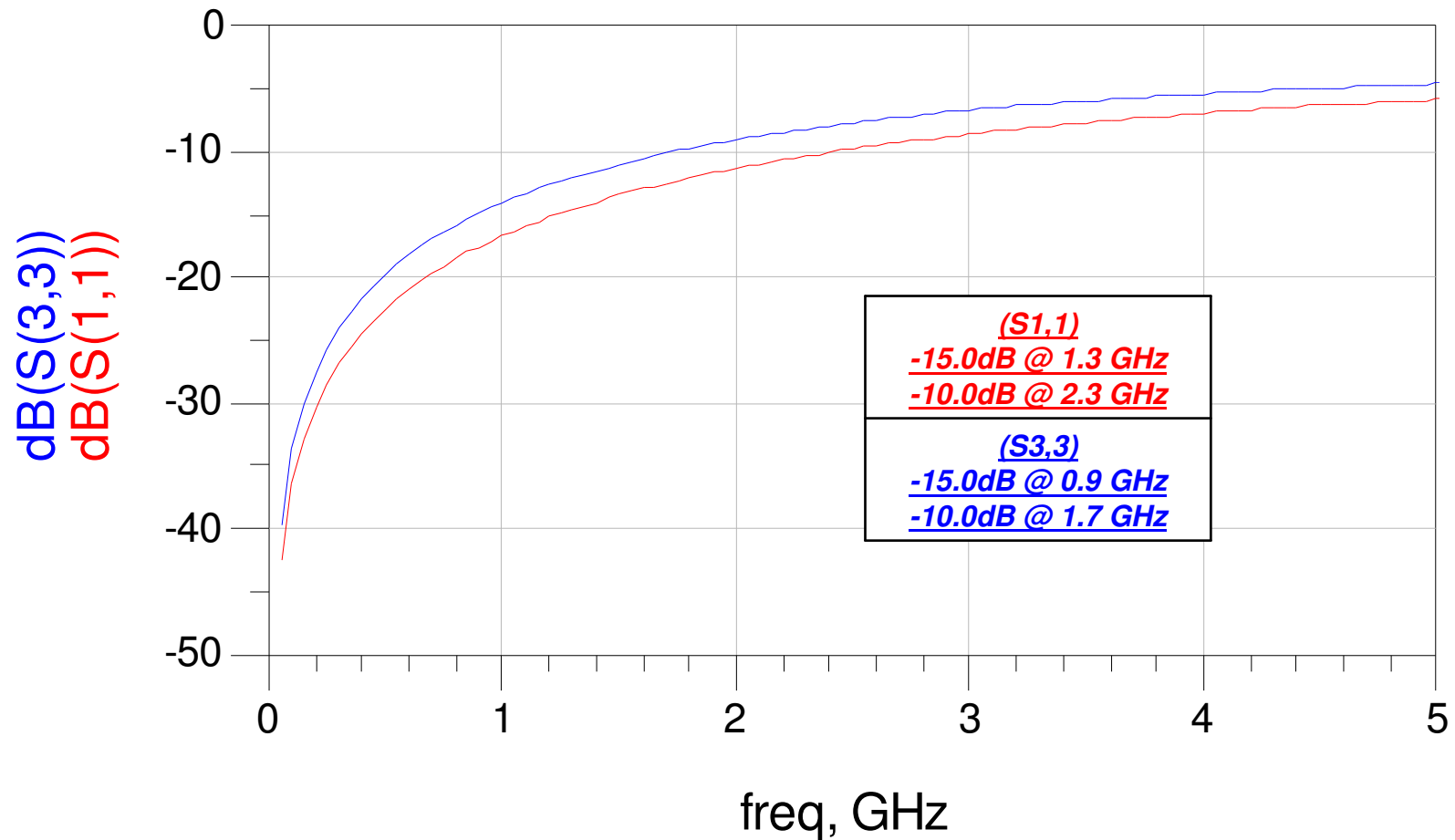
# Single-ended Return Loss for S1+ & S1-

Plot Range: DC to 10 GHz



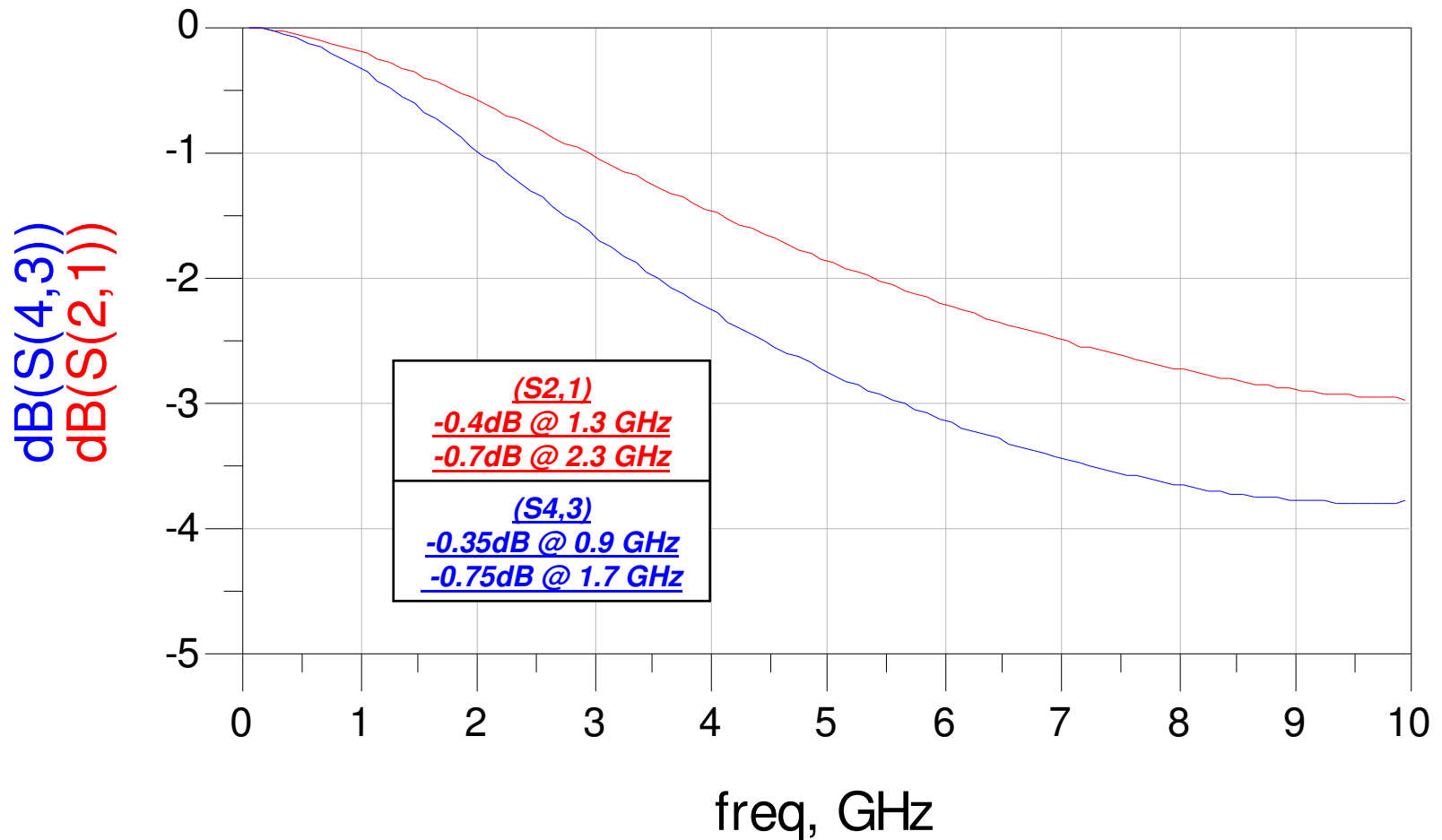
# Single-ended Return Loss for S1+ & S1-

Plot Range: DC to 5 GHz



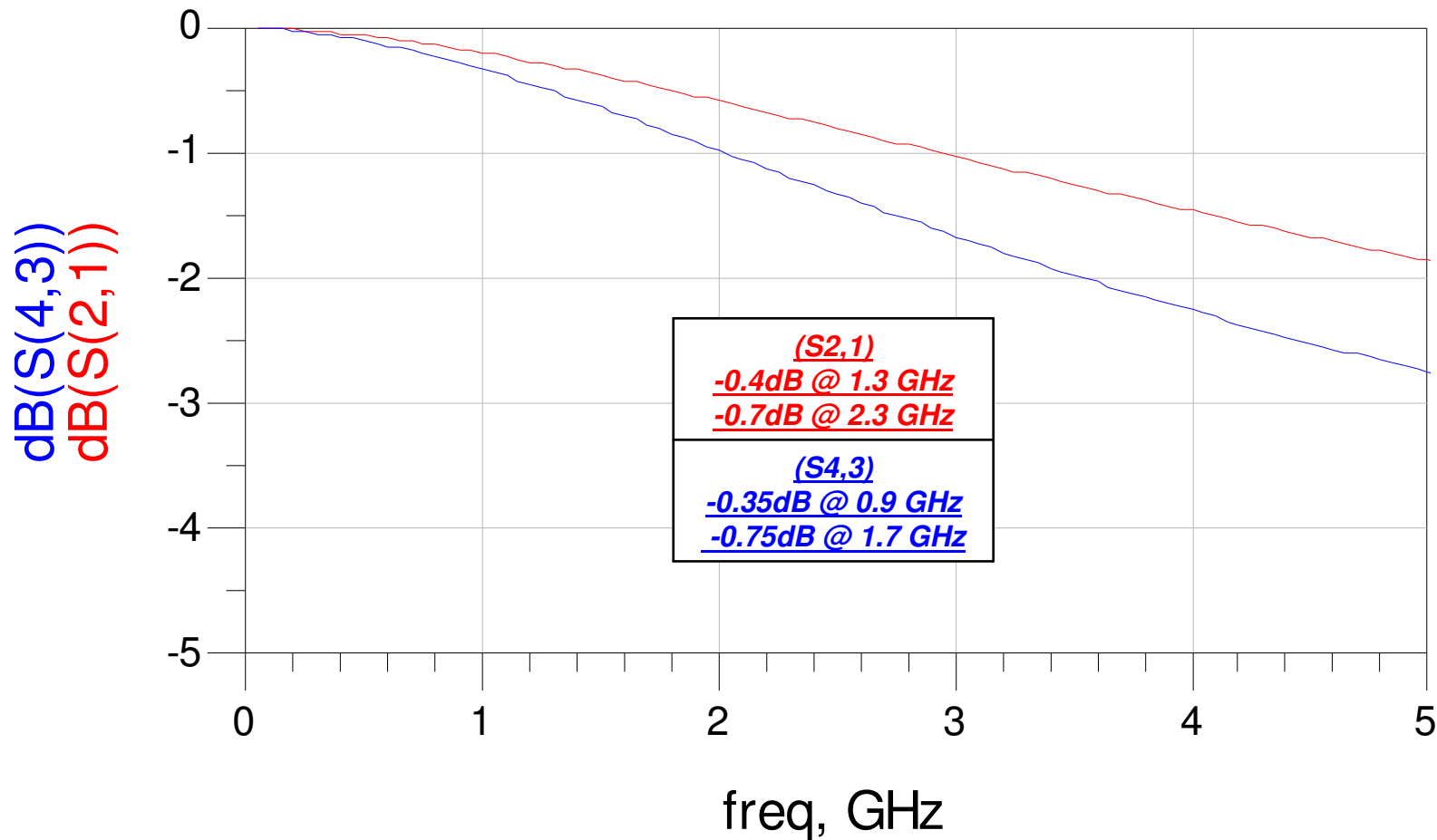
# Single-ended Insertion Loss for S1+ & S1-

Plot Range: DC to 10 GHz

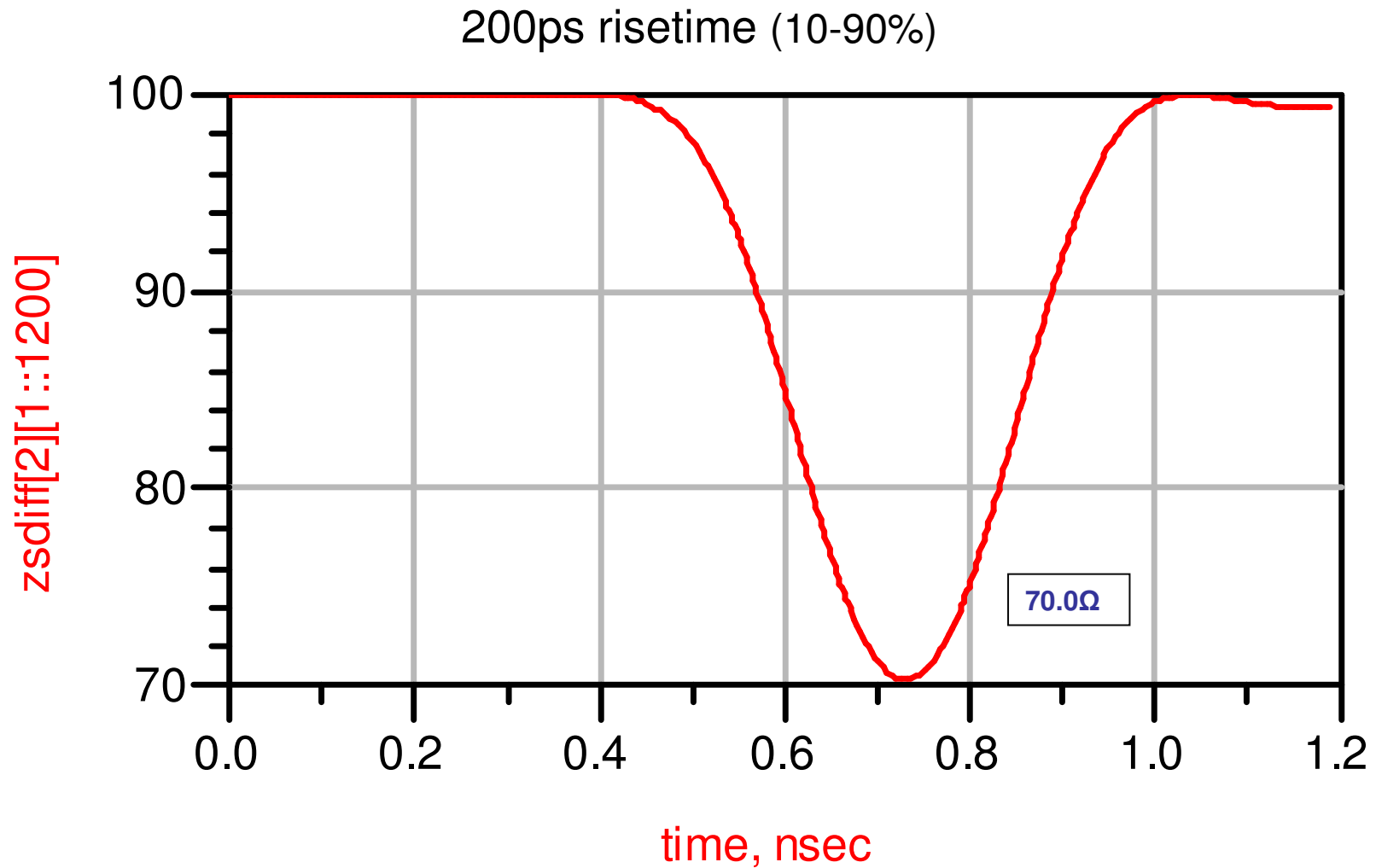


# Single-ended Insertion Loss for S1+ & S1-

Plot Range: DC to 5 GHz



# Differential Impedance Profile

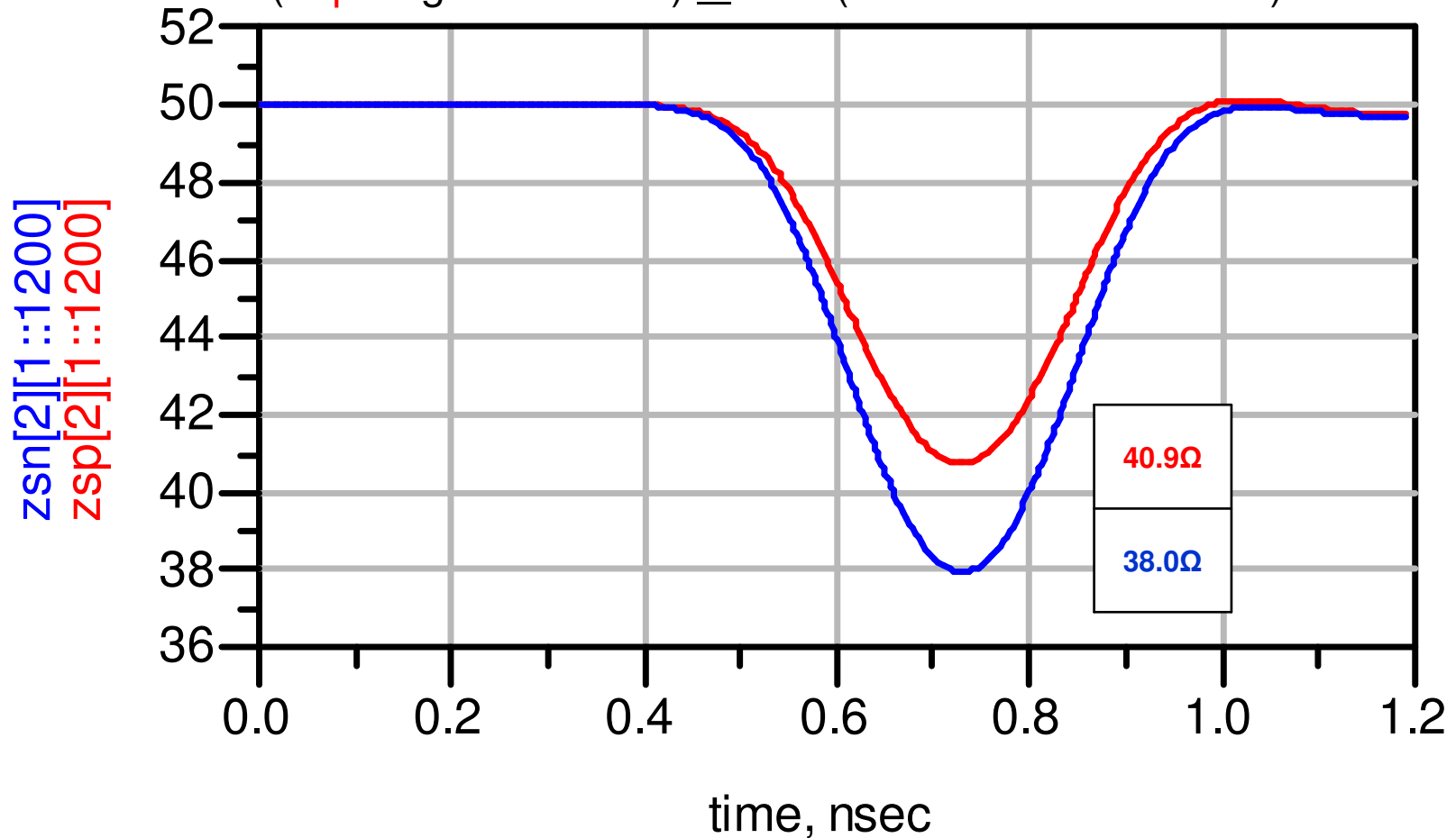




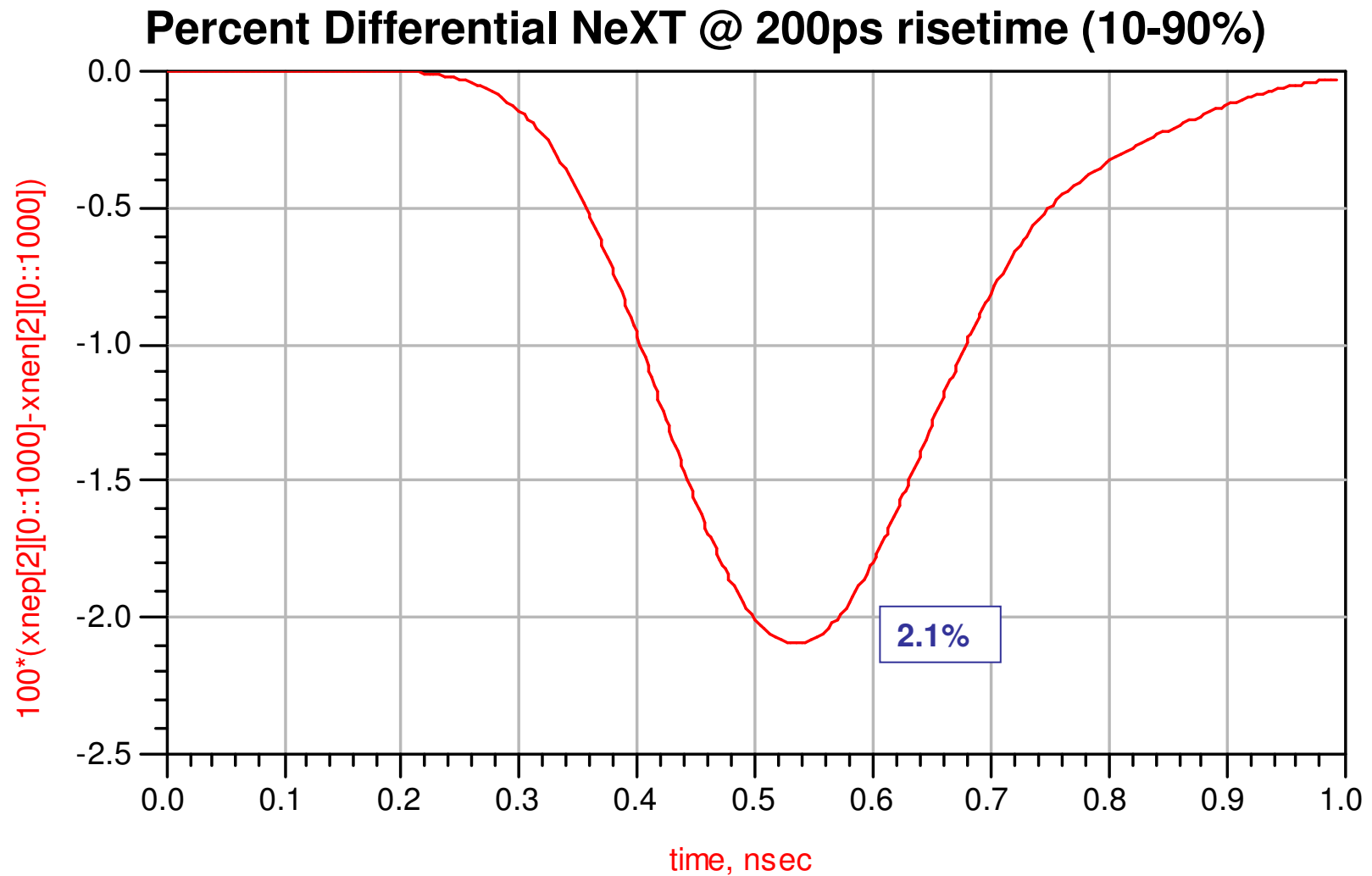
# Single-ended Impedance Profile for S1+ & S1-

Simultaneous Plots at **200 psec** risetime (10-90%)

**S1+ (Zsp Edge Terminals) vs. S1- (Zsn Interior Terminals)**

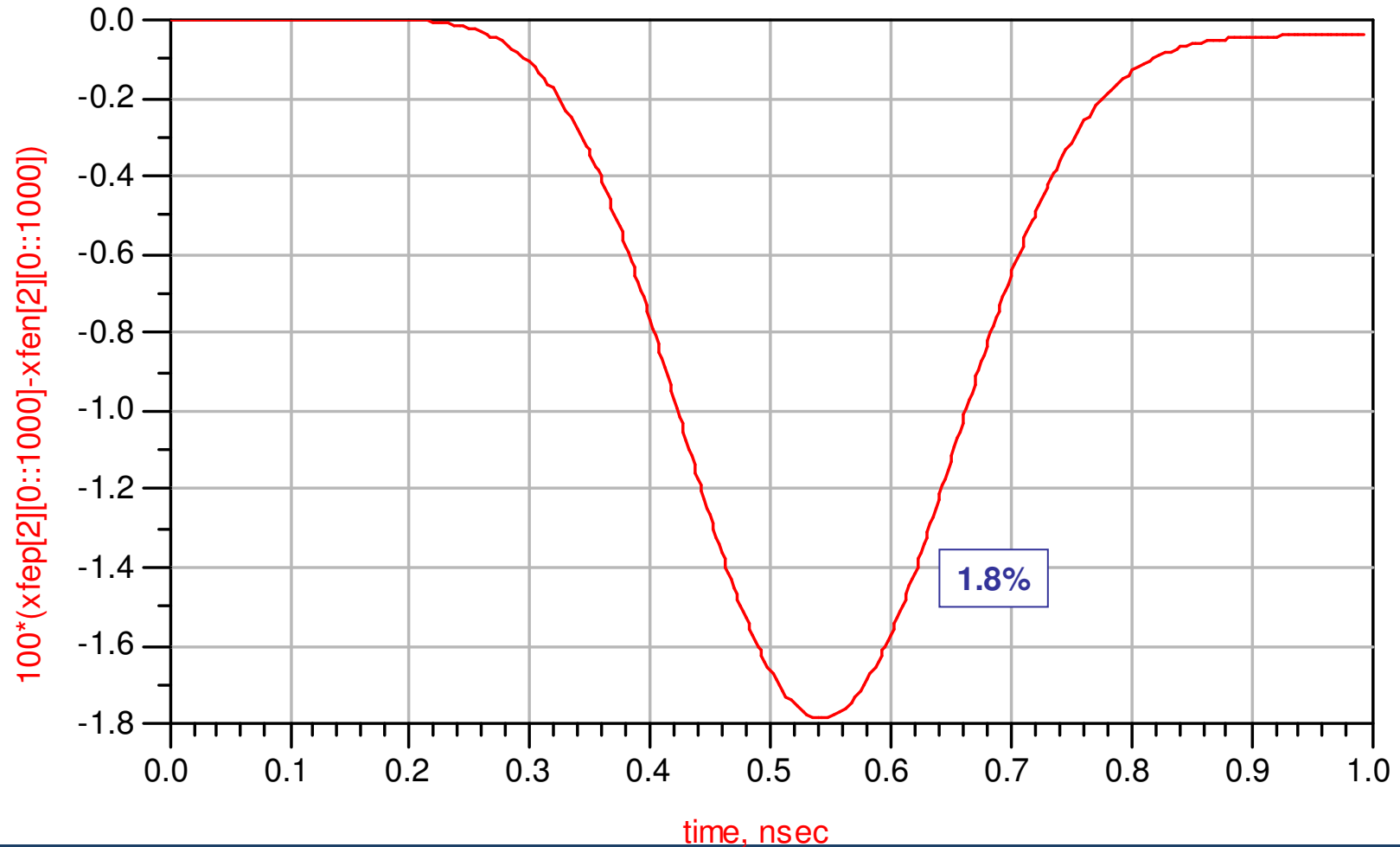


# Differential Near-end Crosstalk (NeXT)



# Differential Far-end Crosstalk (FeXT)

Percent Differential FeXT @ 200ps risetime (10-90%)



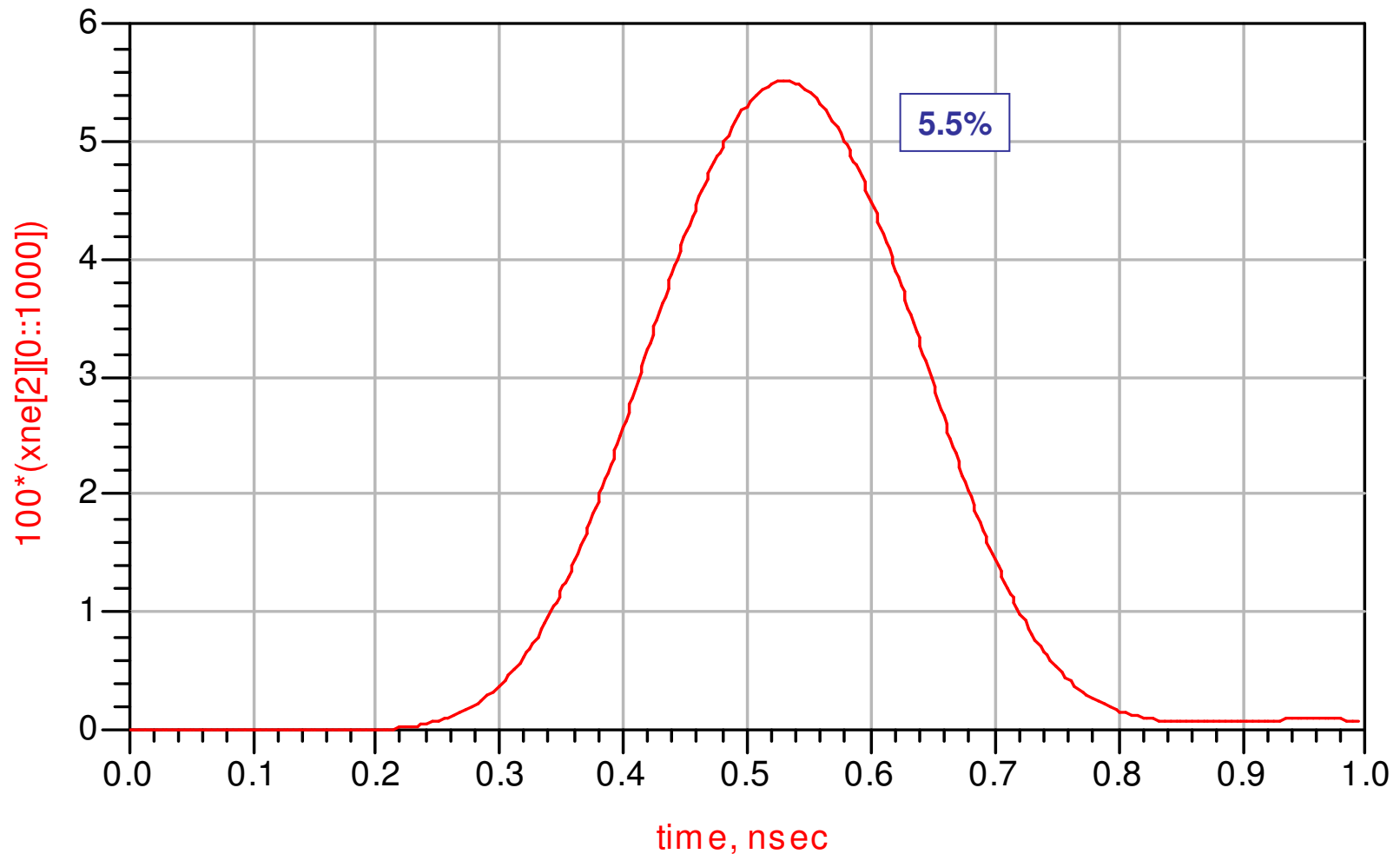
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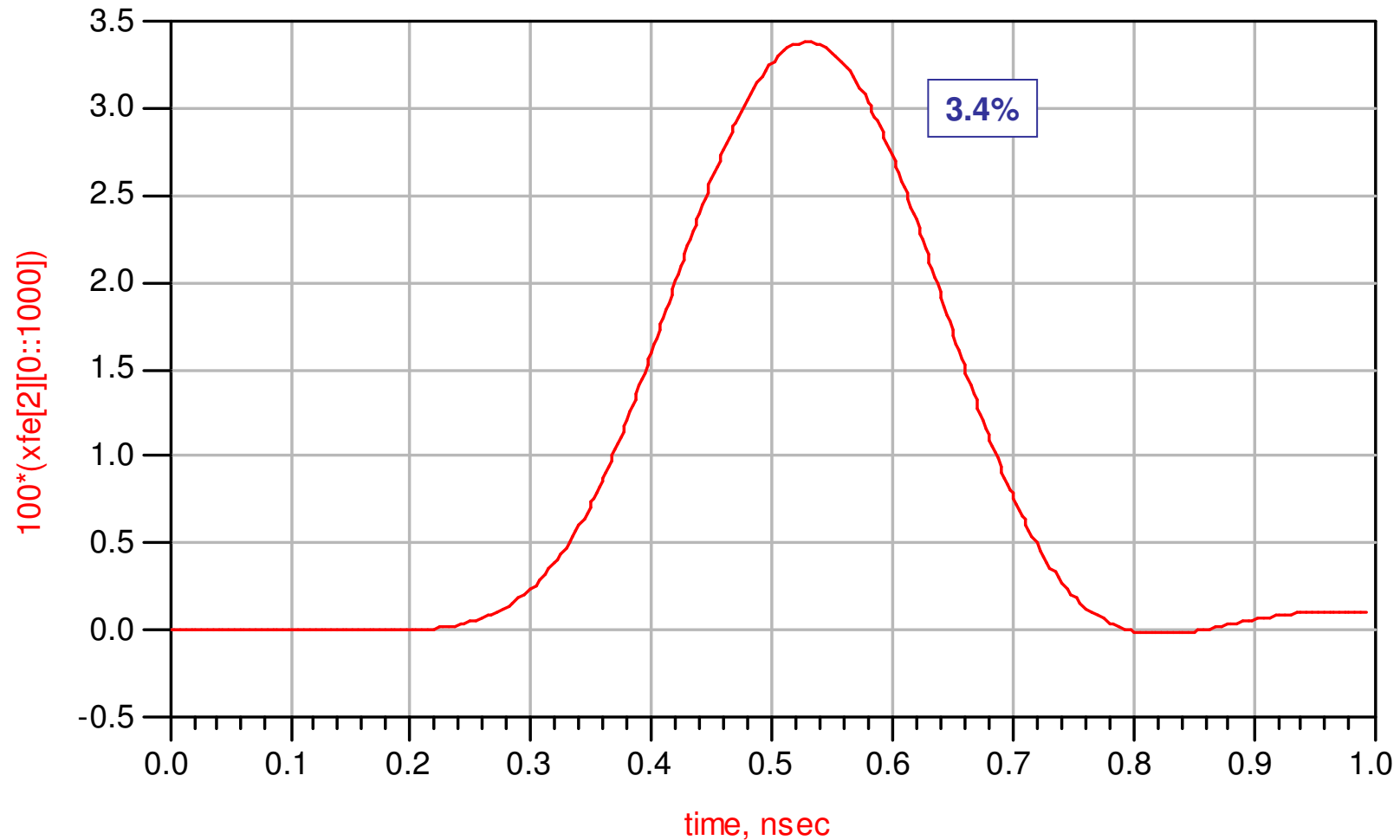
# Single-ended Near-end Crosstalk (NeXT)

Percent Single-ended NeXT @ 200ps risetime (10-90%)



# Single-ended Far-end Crosstalk (FeXT)

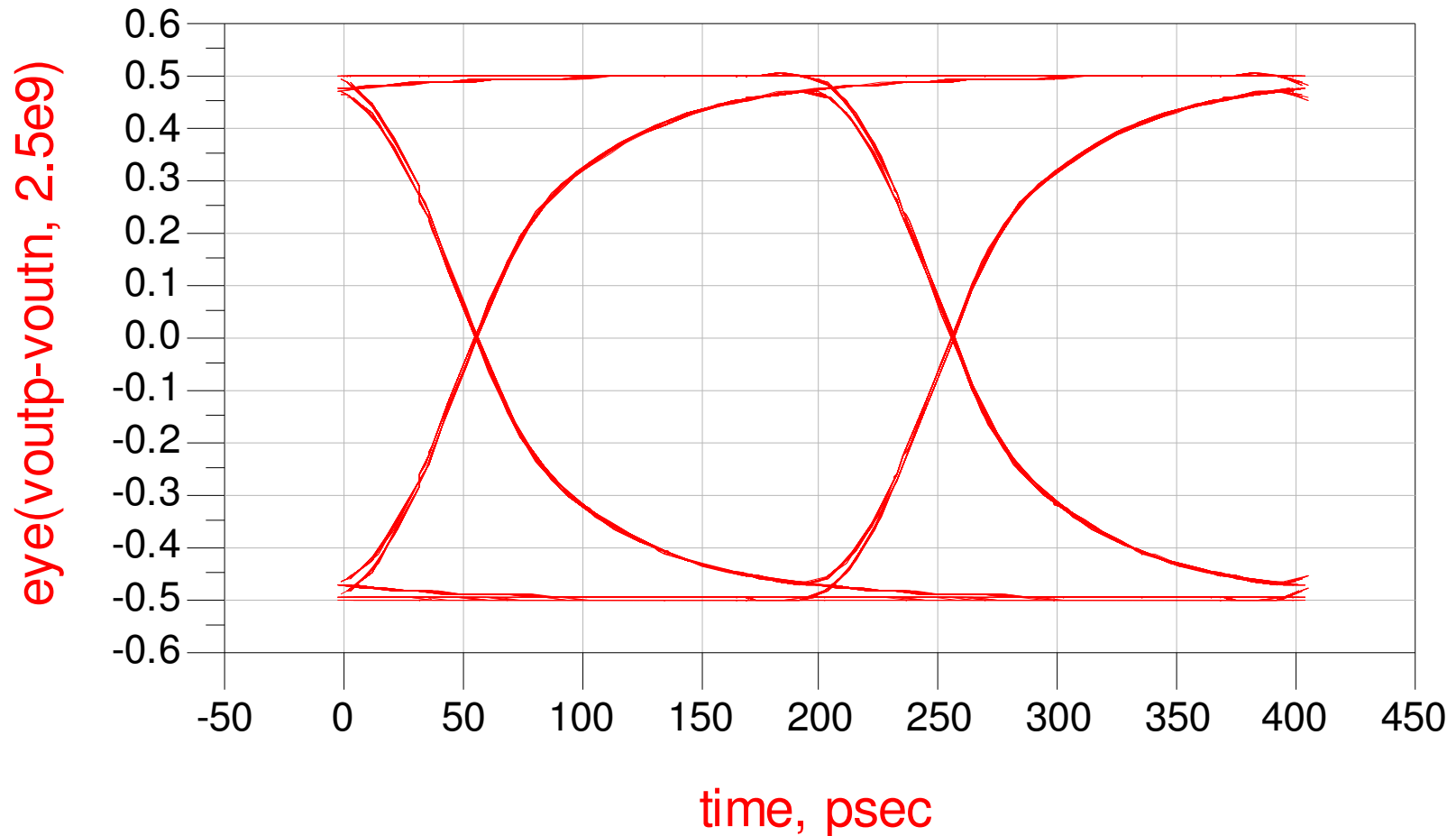
Percent Single-ended FeXT @ 200ps risetime (10-90%)



# Differential Eye-Diagram

Eye Opening @ 5 Gbit/sec.

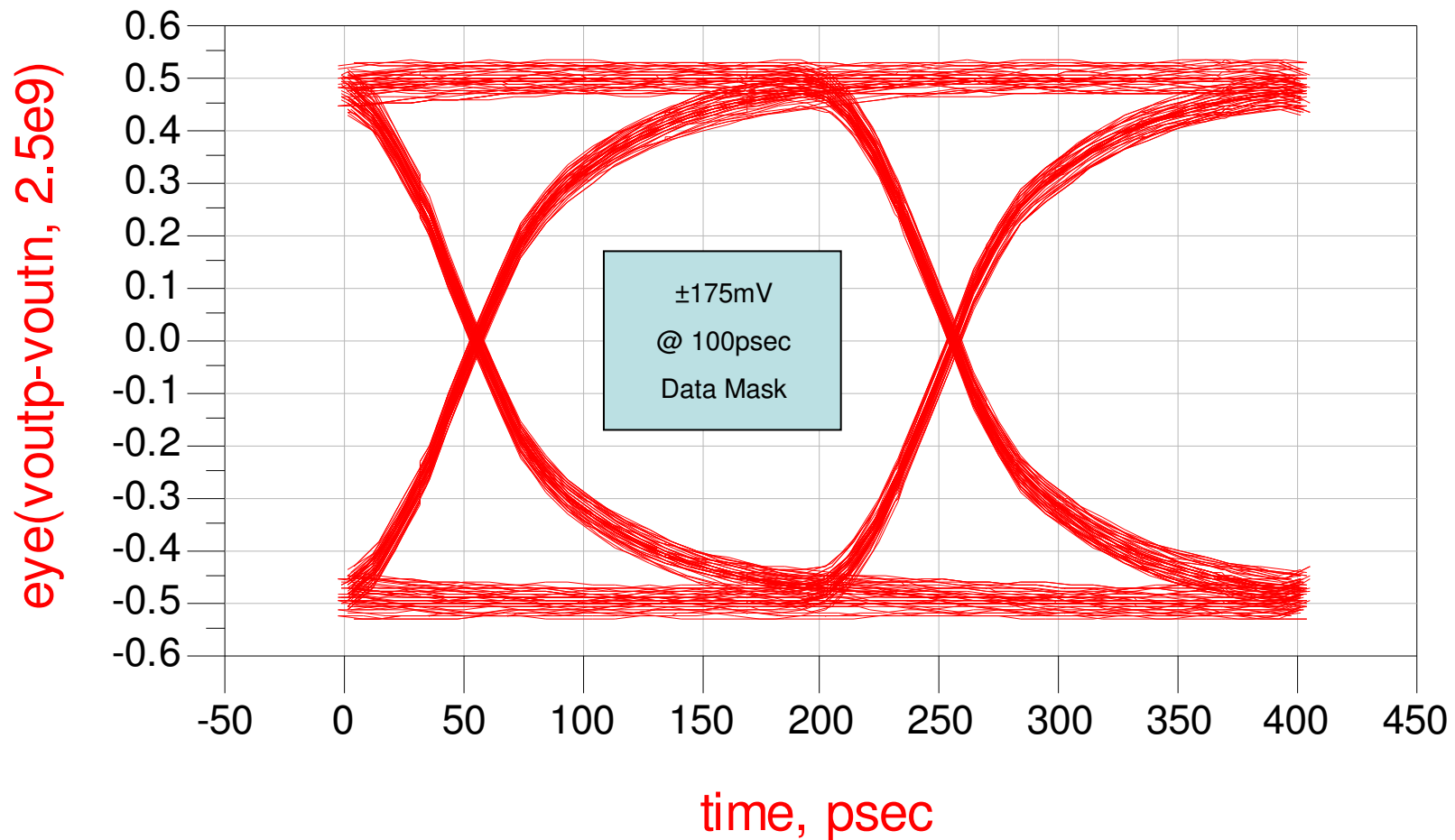
Peak-to-peak jitter is 3 psec and Eye-Closure is 19%



# Differential Eye-Diagram w/Aggressor

## Eye Opening @ 5 Gbit/sec with a 6 Gbit/sec Aggressor

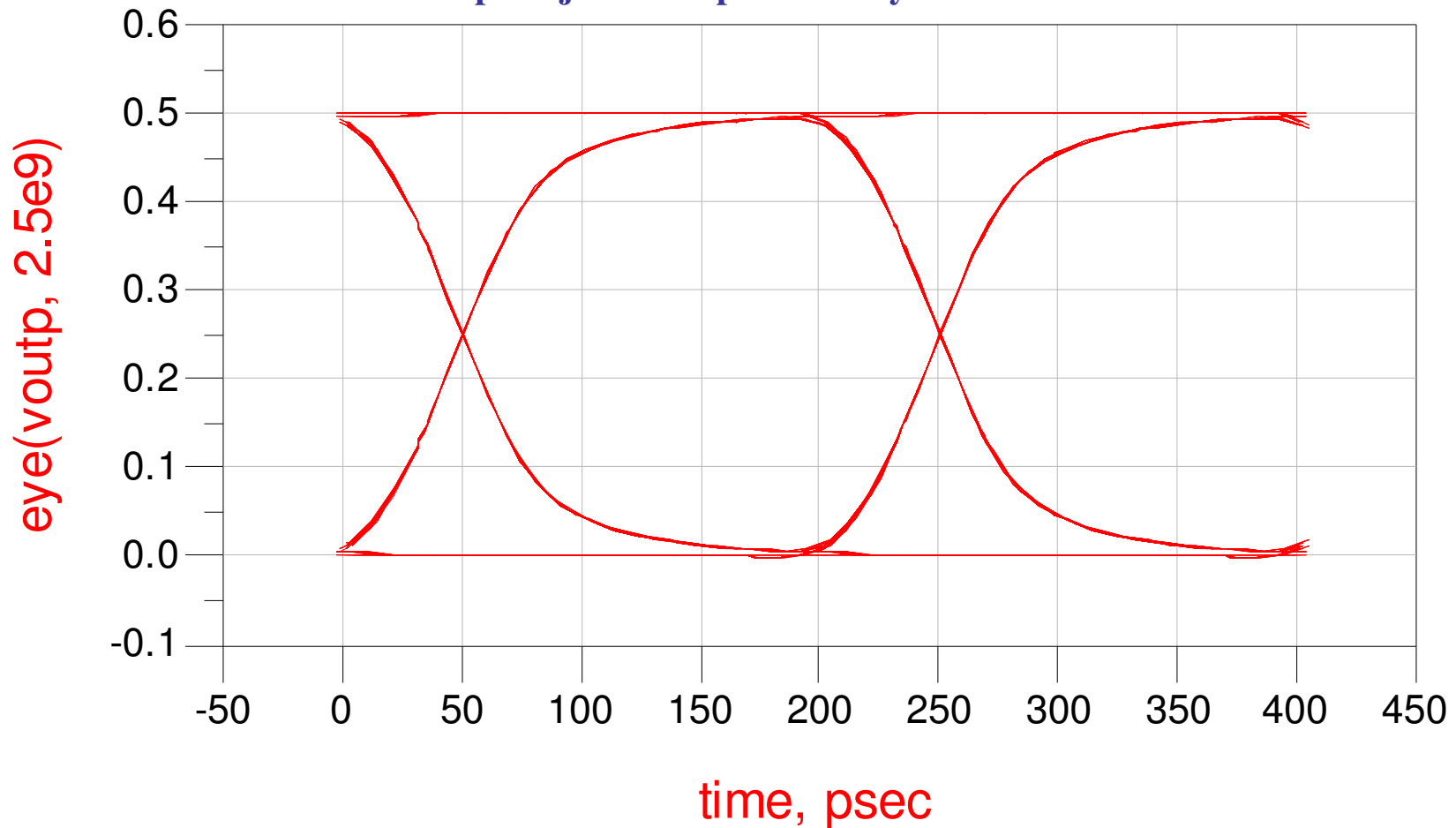
Peak-to-peak jitter is 8 psec and Eye-Closure is 25%



# Single-ended Eye-Diagram

Eye Opening @ 5 Gbit/sec.

Peak-to-peak jitter is 2 psec and Eye-Closure is 8%

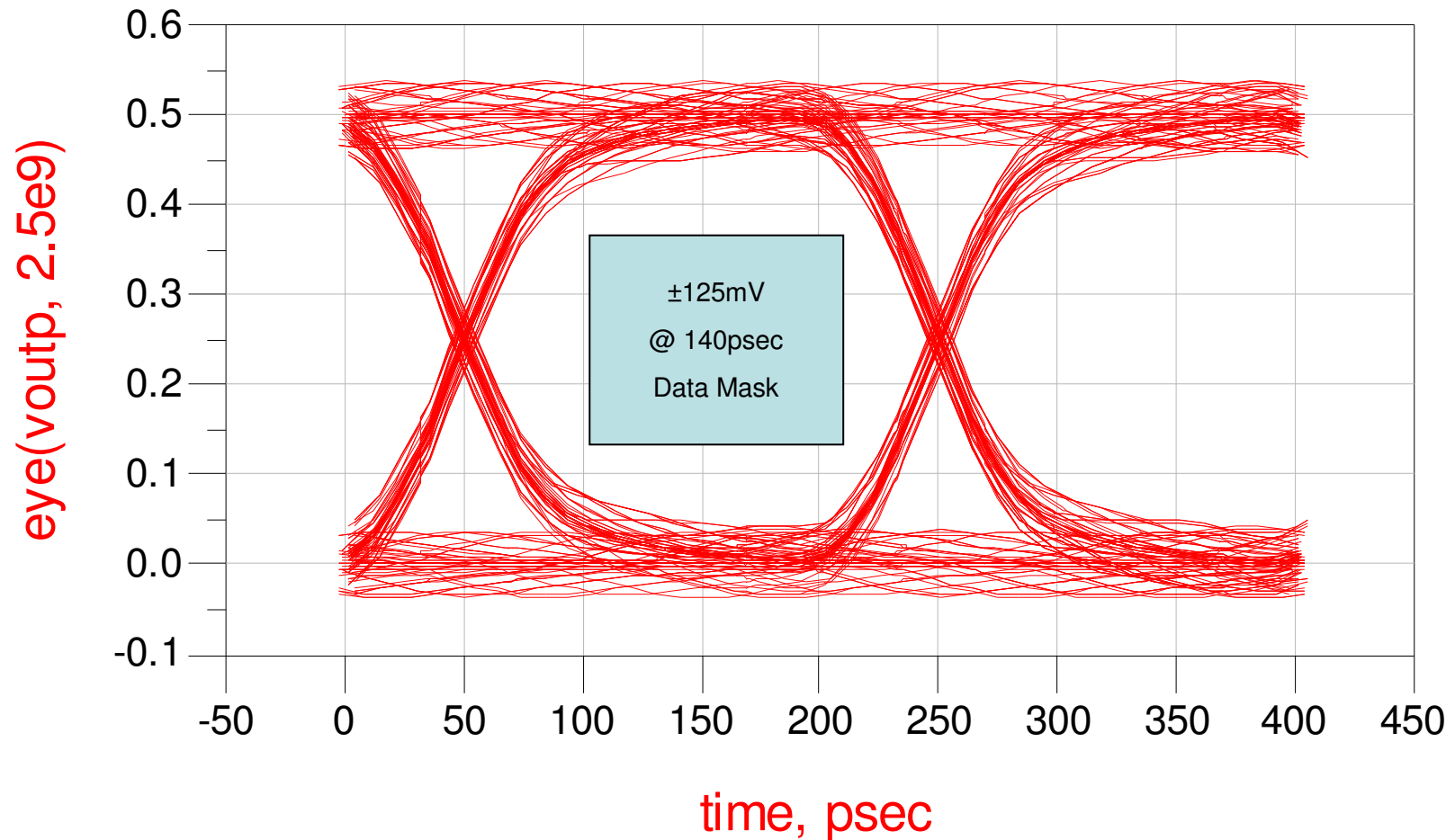




# Single-ended Eye-Diagram w/Aggressor

Eye Opening @ 5 Gbit/sec with a 6 Gbit/sec Aggressor

Peak-to-peak jitter is 12 psec and Eye-Closure is 20%



# Propagation Delay

