

A Practical Guide to Signal Integrity: From Simulation to Measurement

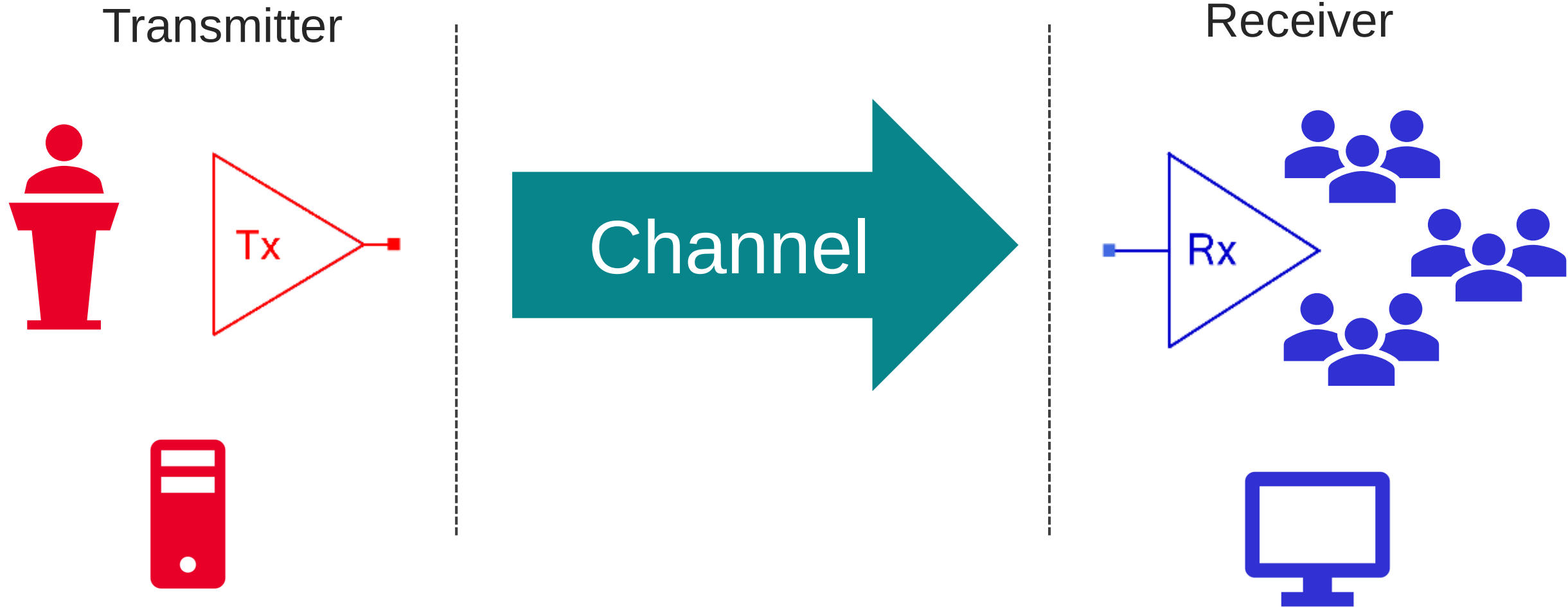
Keysight Technologies

2020.2.13

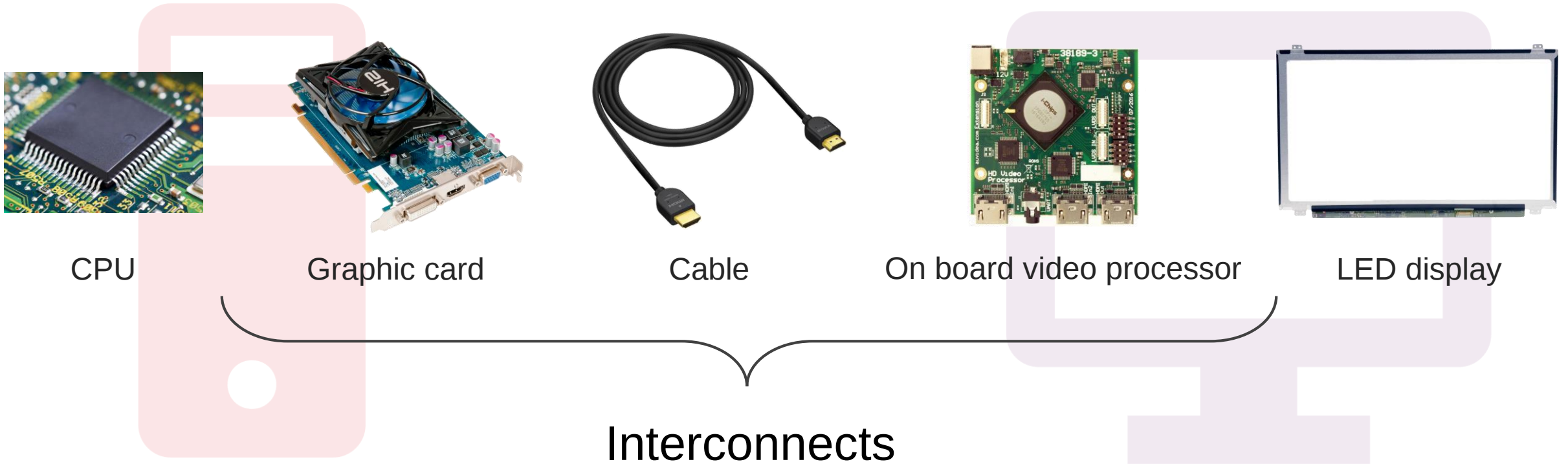
Tim Wang Lee, Signal Integrity Application Scientist



Signal Integrity Is All Around Us



Signal Integrity in Digital Communication Channel



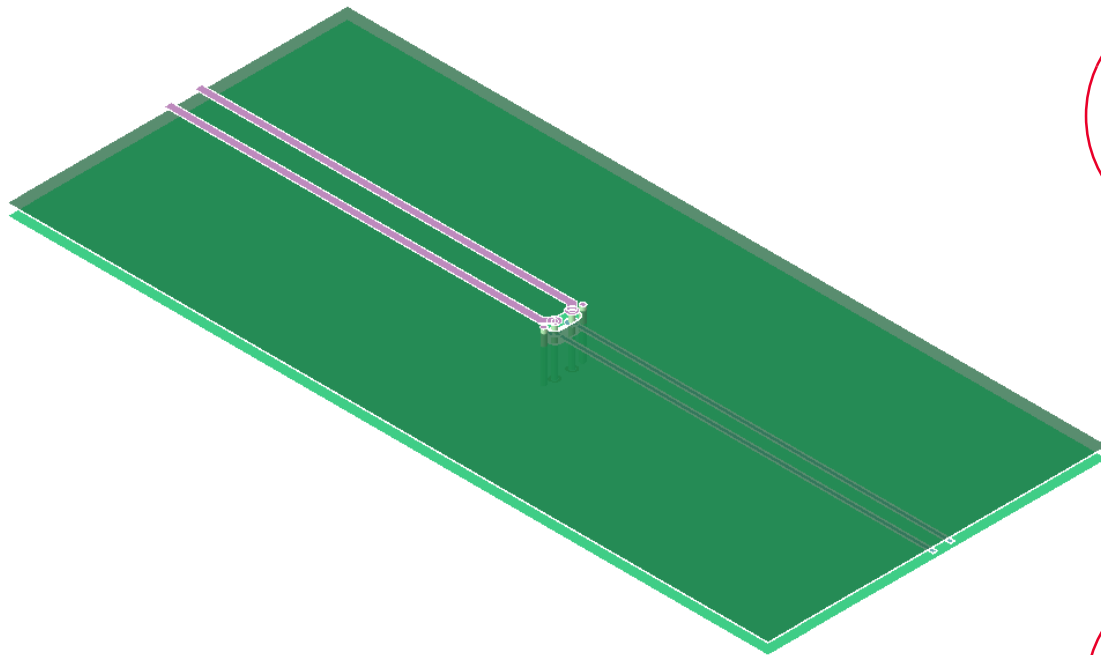
“

Signal integrity is about the problems interconnects introduce and how to avoid them.

– Dr. Eric Bogatin

Understand Signal Integrity Analyses with a Case Study

The case of the failing virtual channel



1

Analyze the channel

2

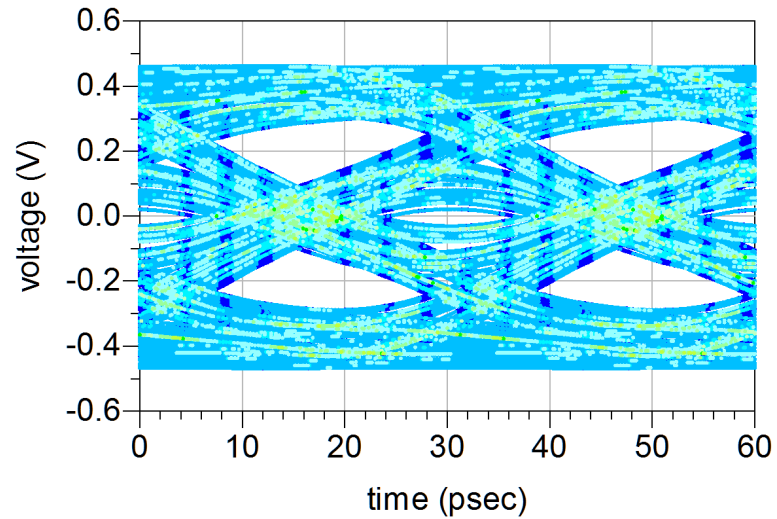
Find the root cause of degradation

3

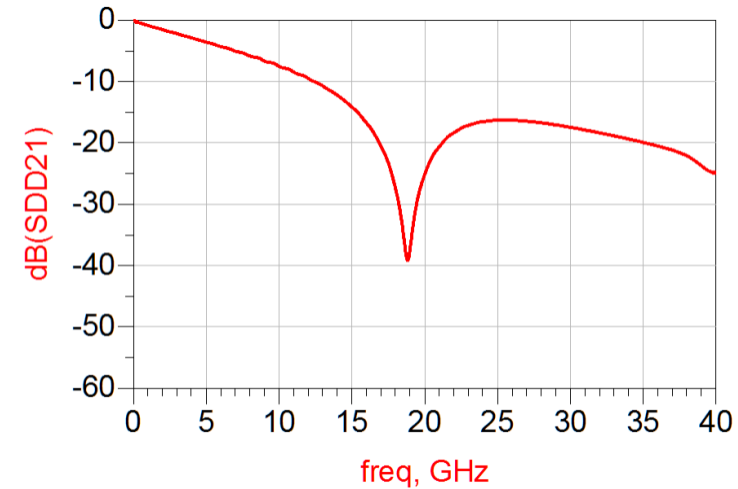
Explore design solutions

Essential Signal Integrity Analyses in Simulation

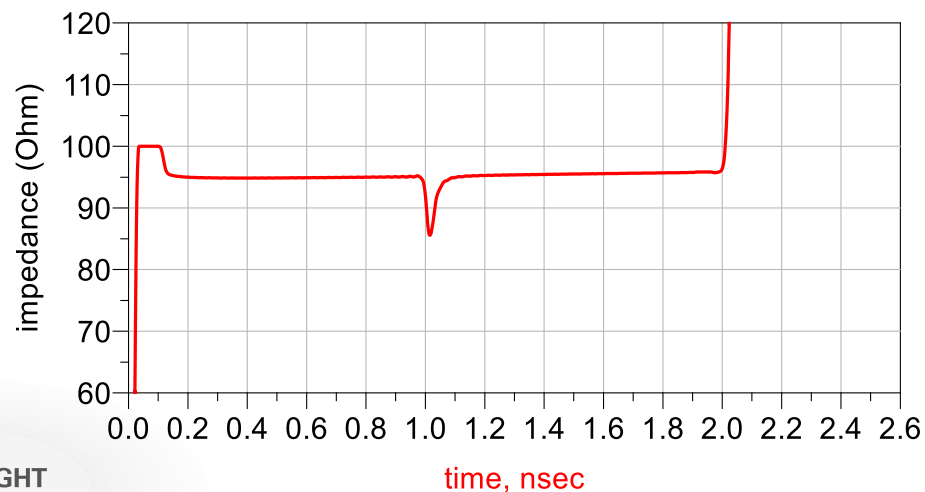
Eye diagram



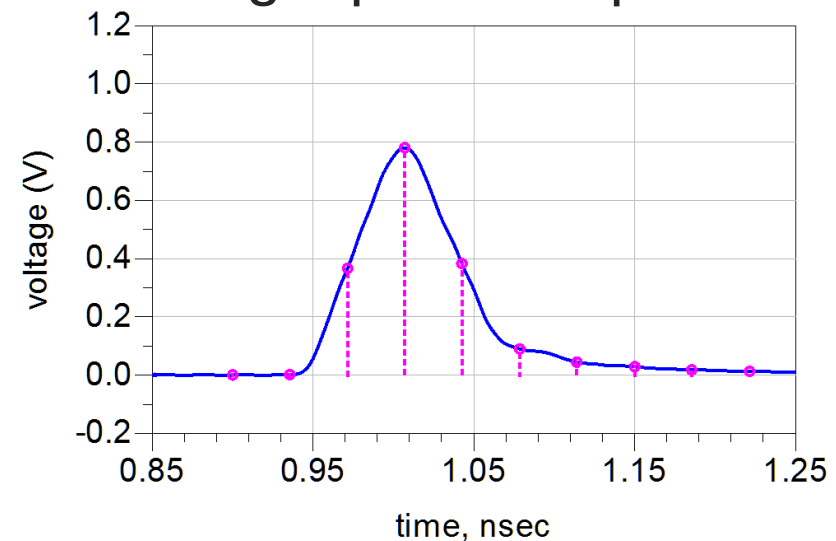
Mixed-mode S-parameters



Time domain reflectometry

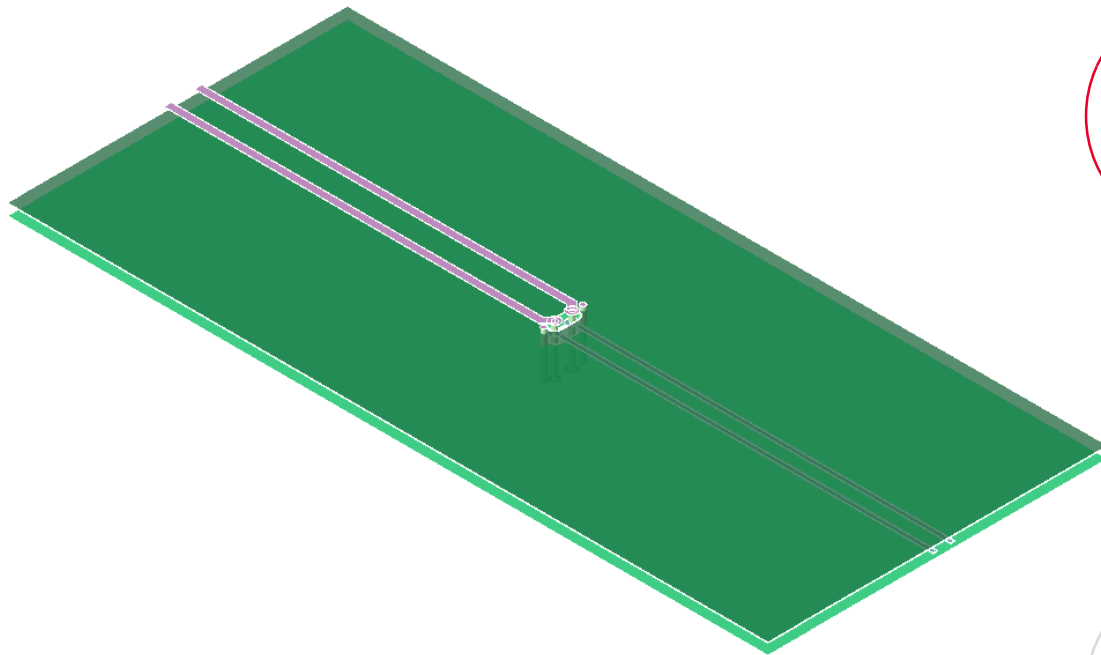


Single pulse response



Understand Signal Integrity Analyses with a Case Study

The case of the failing virtual channel



1

Analyze the channel

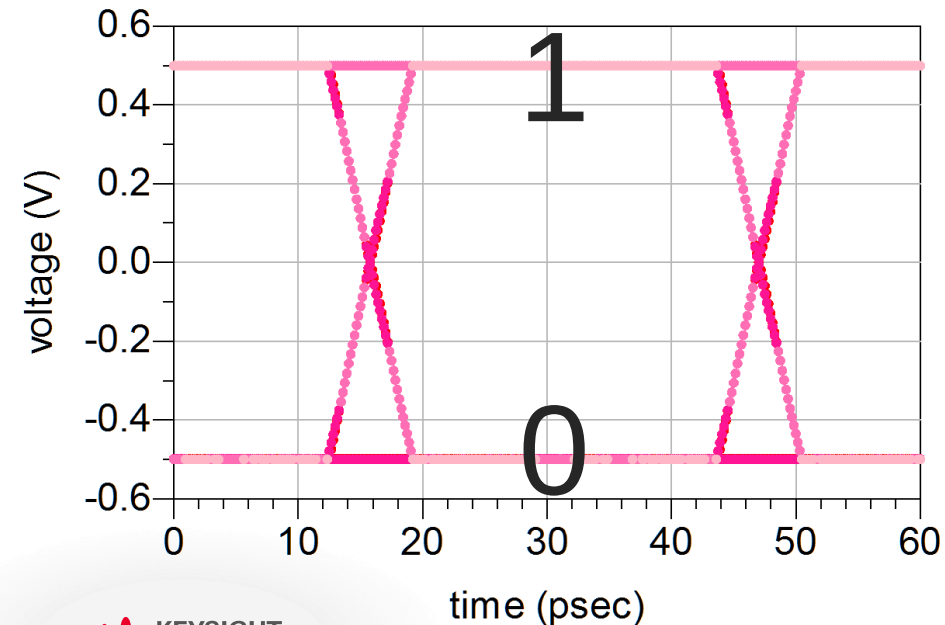
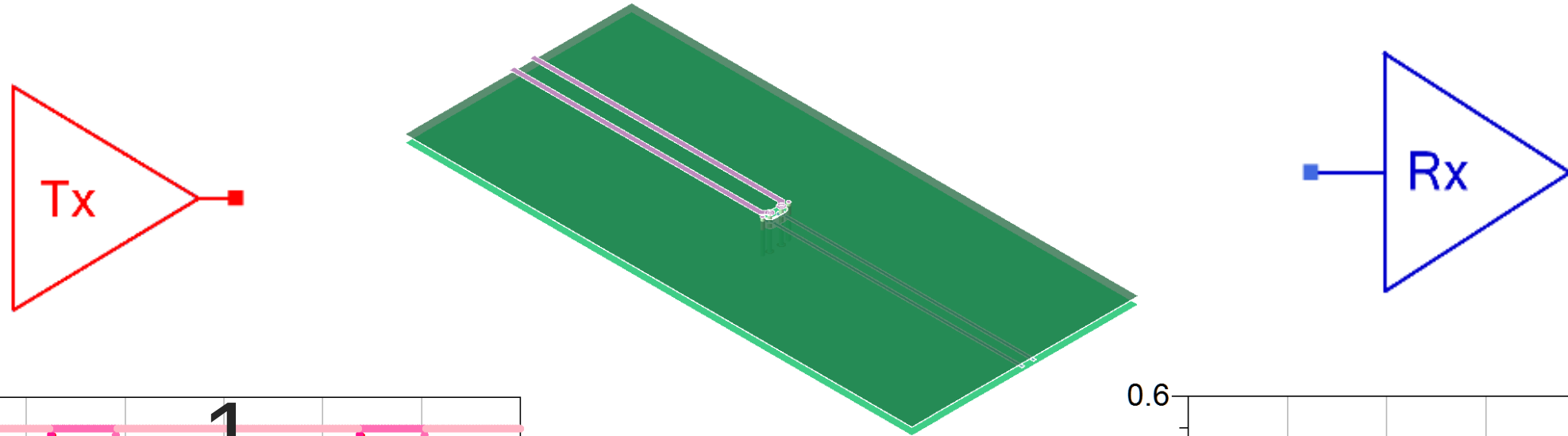
2

Find the root cause of degradation

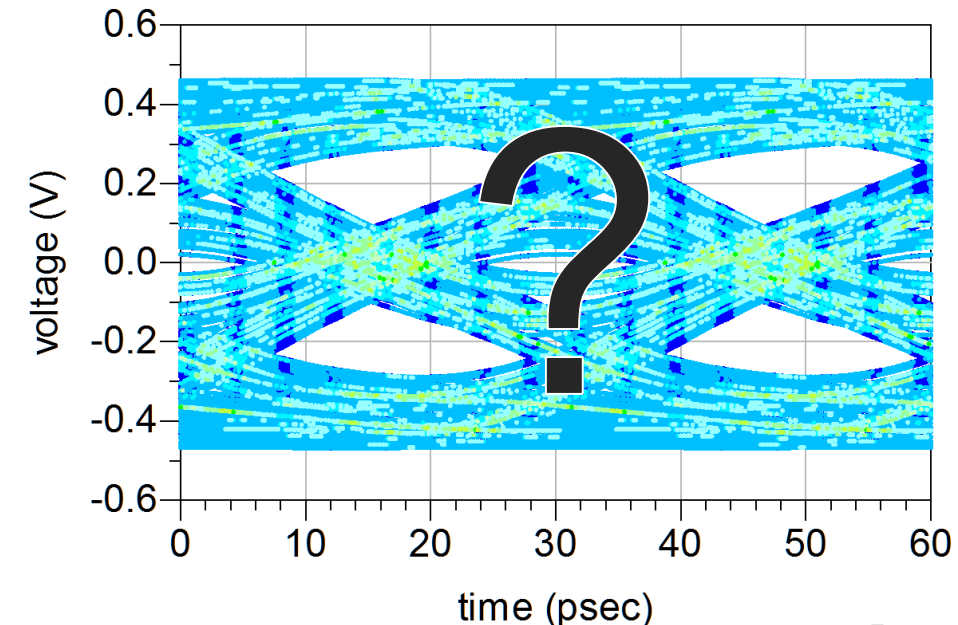
3

Explore design solutions

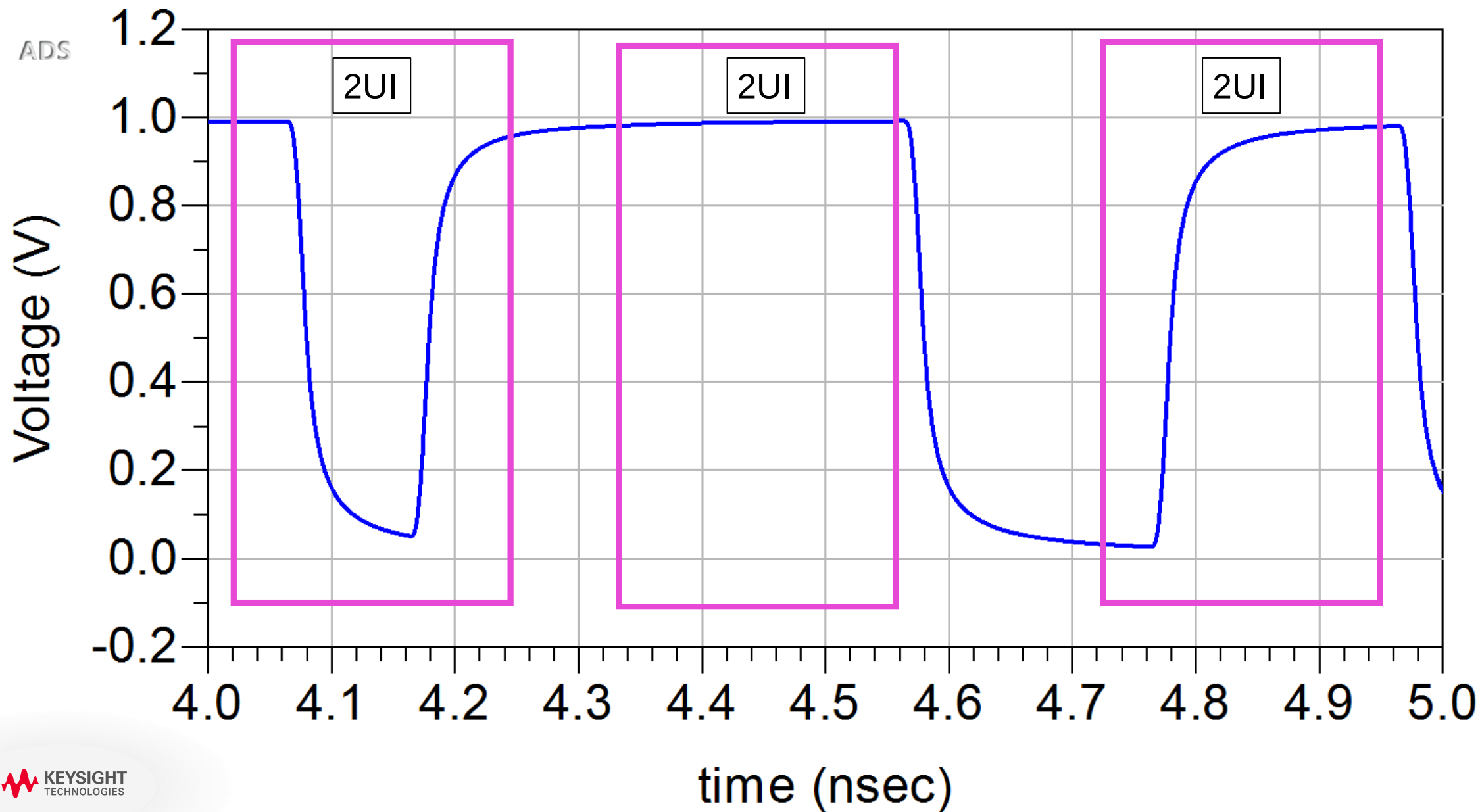
Use Eye Diagram Simulation to Evaluate a Channel



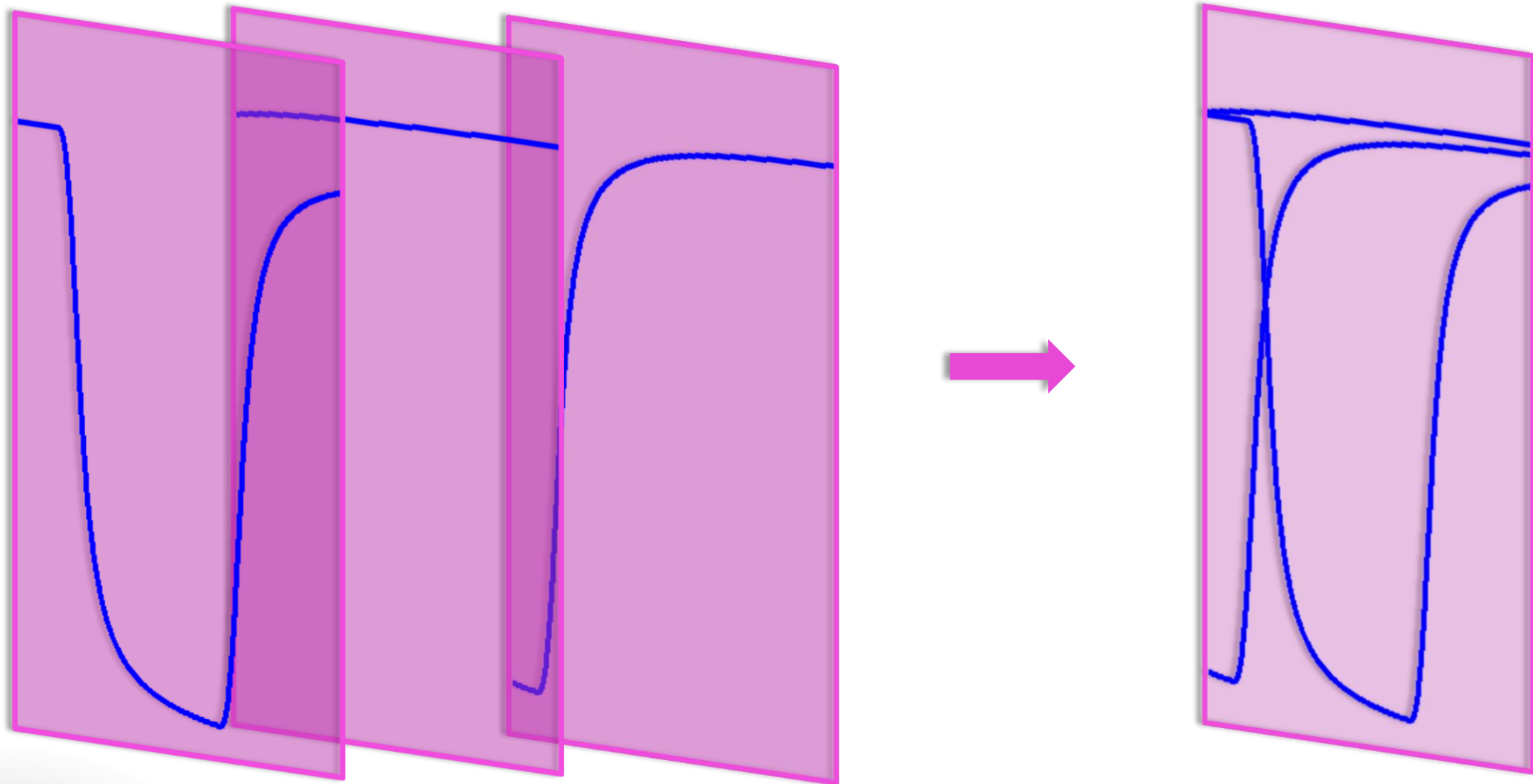
Channel



Partition PRBS Pattern by Unit Intervals

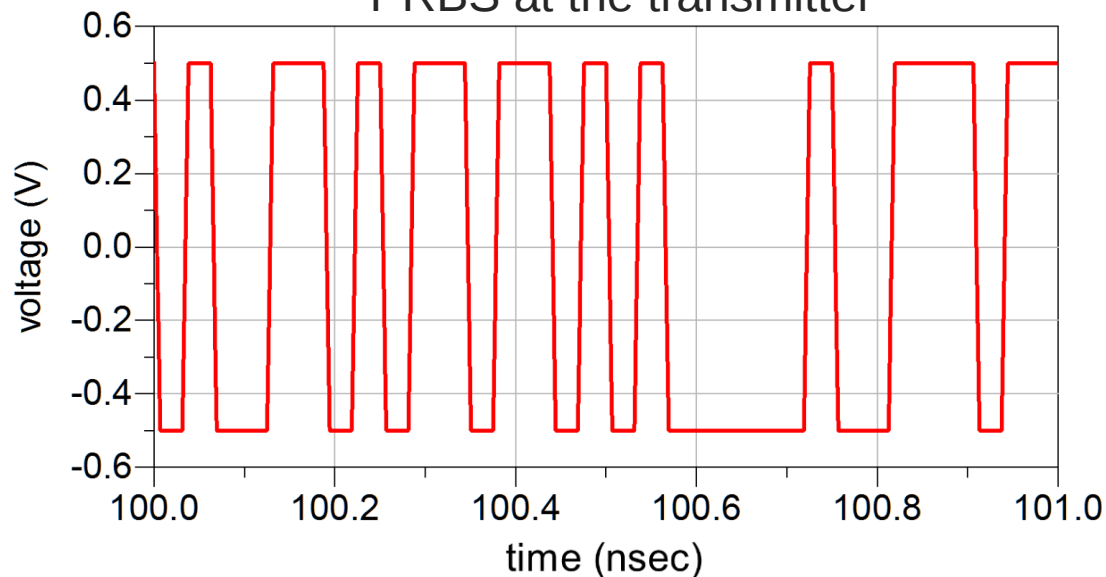


Overlay Partitioned PRBS Slices to Create the Eye

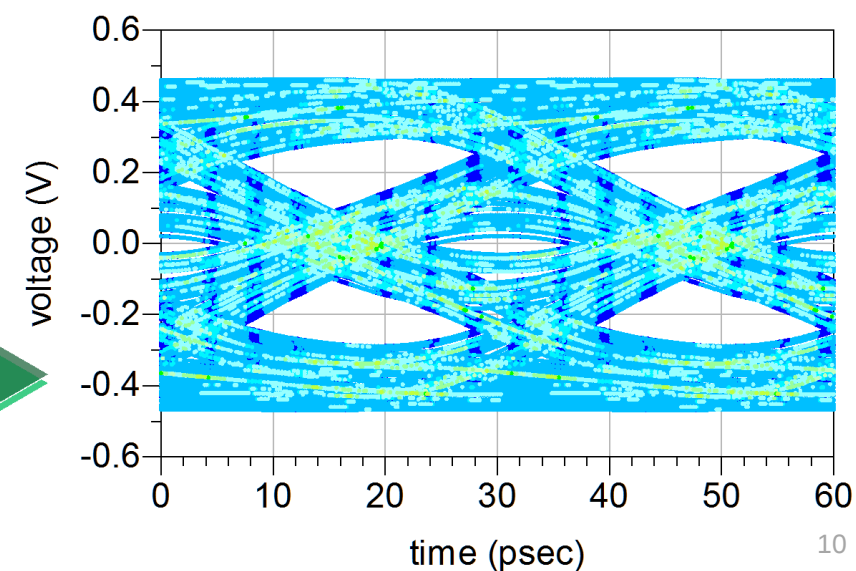
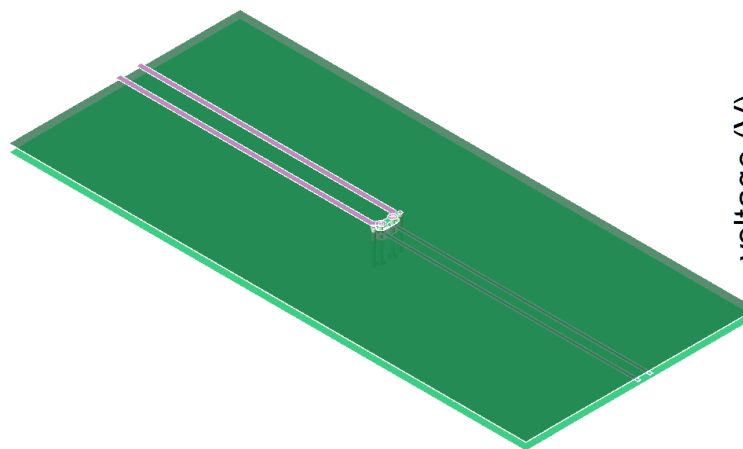
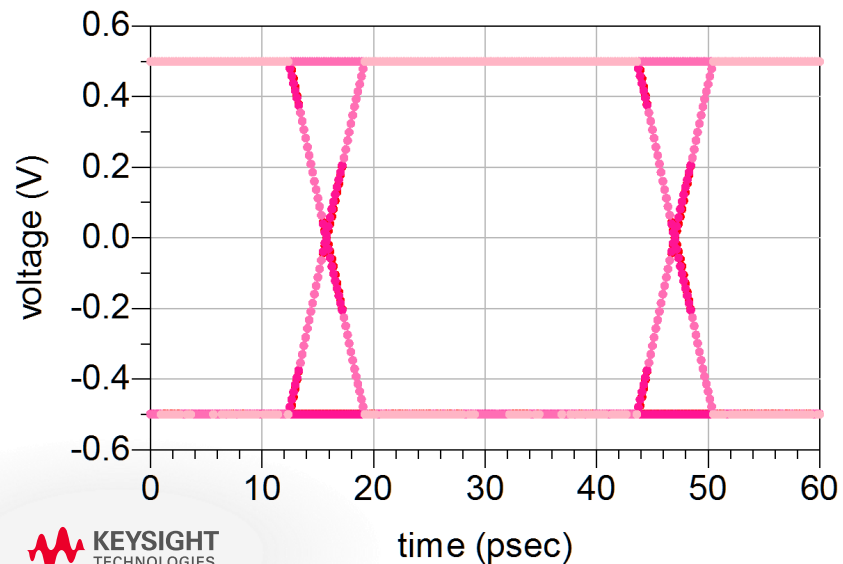
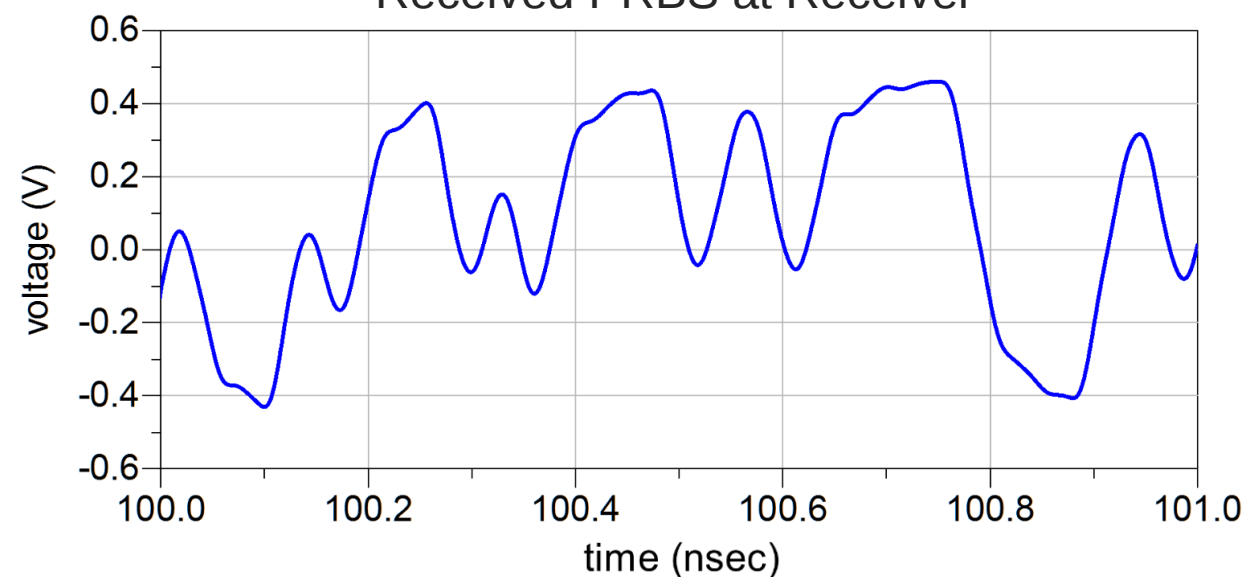


Closed Eye at the Receiver: Signal Integrity Problem

PRBS at the transmitter



Received PRBS at Receiver



Lab Structure

Demo

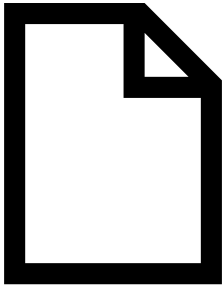


Do It Yourself

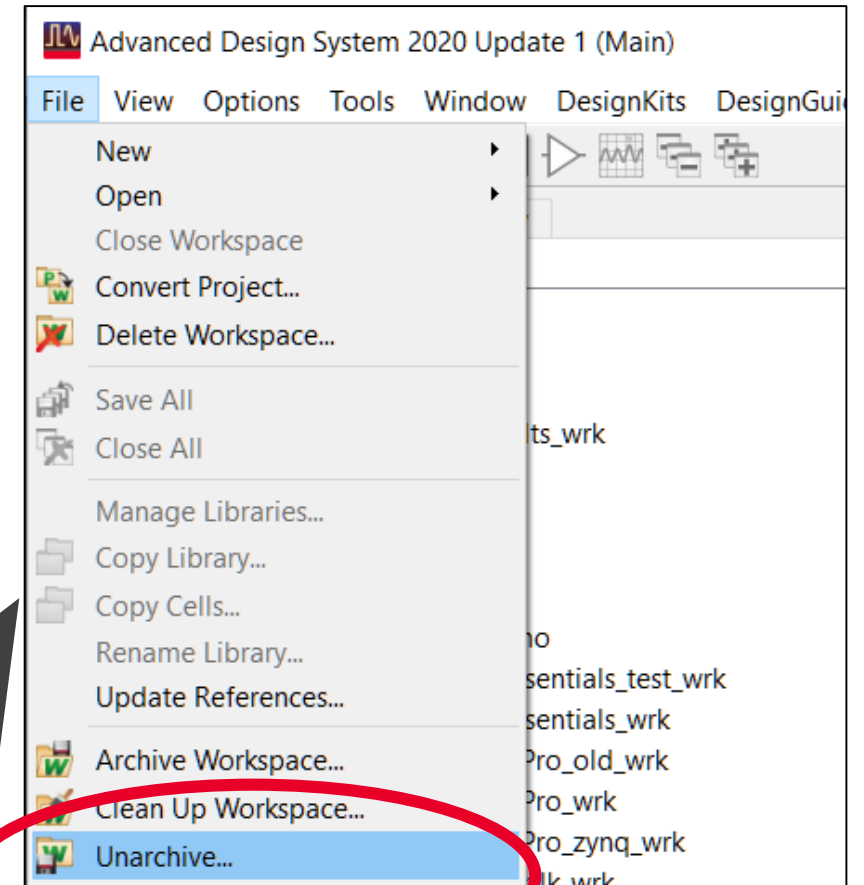
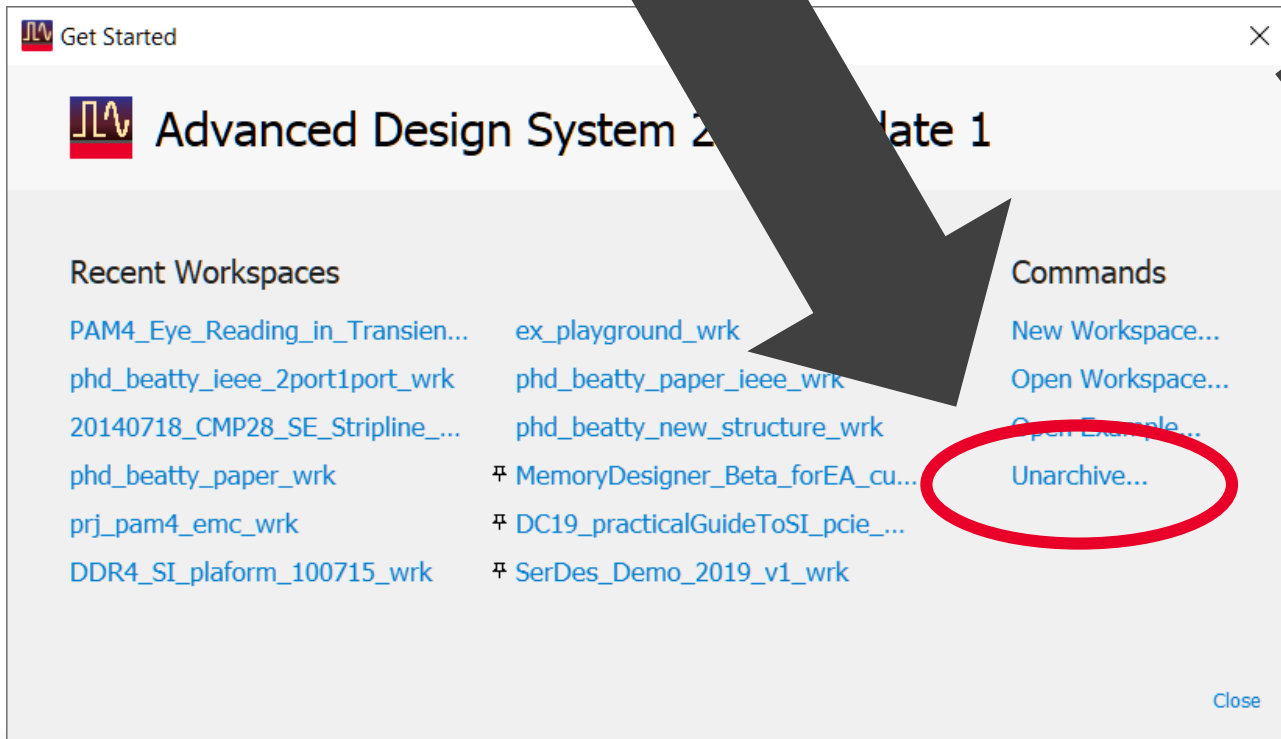


Discussion

Lab 0: Unarchive Workspace

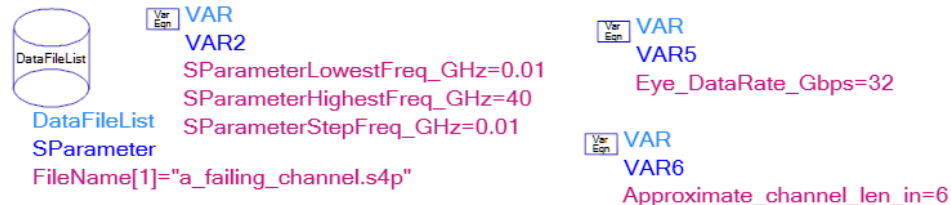


Workspace_name.7zad



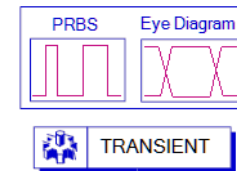
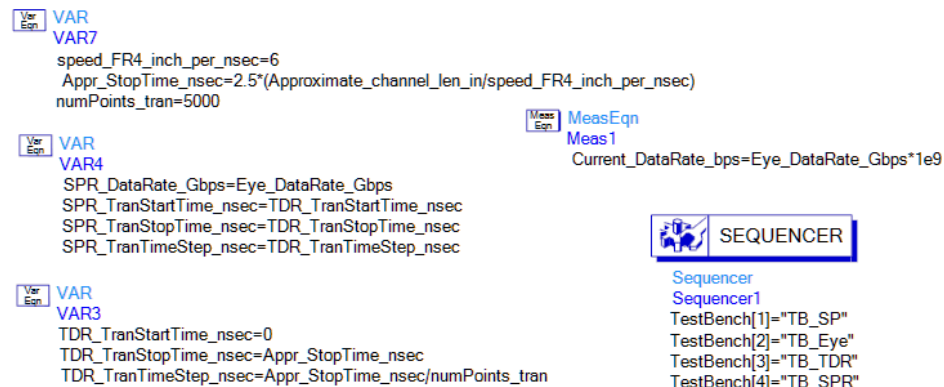
Lab 1: Essential Signal Integrity Analyses

Analysis Setup -Requires User Input-

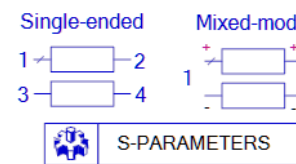


Browse to you s4p file and enter file information to perform all analyses.

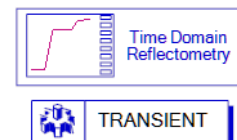
Analysis configuration -No User Input Required -



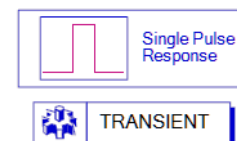
TB_Eye
fileName=SParameter.FileName
BW_GHz=SParameterHighestFreq_GHz
DataRate_Gbps=Eye_DataRate_Gbps



TB_SP
fileName=SParameter.FileName
Start_GHz=SParameterLowestFreq_GHz
Stop_GHz=SParameterHighestFreq_GHz
Step_GHz=SParameterStepFreq_GHz



TB_TDR
fileName=SParameter.FileName
BW_GHz=SParameterHighestFreq_GHz
StartTime_nsec=TDR_TransStartTime_nsec
StopTime_nsec=TDR_TransStopTime_nsec
TimeStep_nsec=TDR_TransTimeStep_nsec



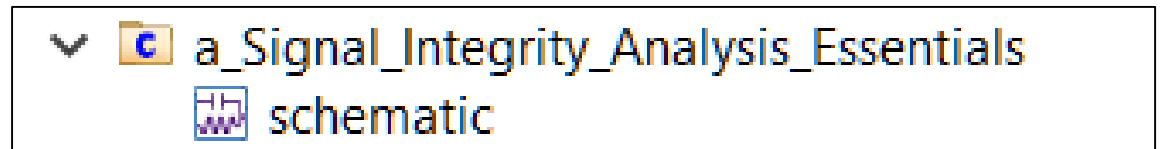
TB_SPR
fileName=SParameter.FileName
BW_GHz=SParameterHighestFreq_GHz
DataRate_Gbps=SPR_DataRate_Gbps
StartTime_nsec=SPR_TransStartTime_nsec
StopTime_nsec=SPR_TransStopTime_nsec
TimeStep_nsec=SPR_TransTimeStep_nsec

Lab 1 Exercises

1. Unarchive workspace:

Signal_Integrity_Analysis_Essentials_wrk.7zads

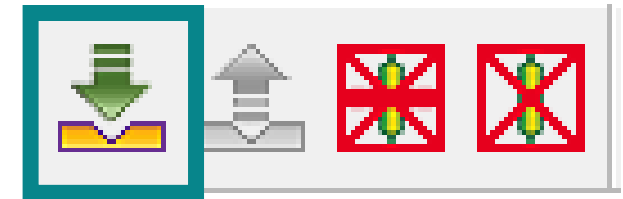
2. Investigate cell:



a_Signal_Integrity_Analysis_Essentials

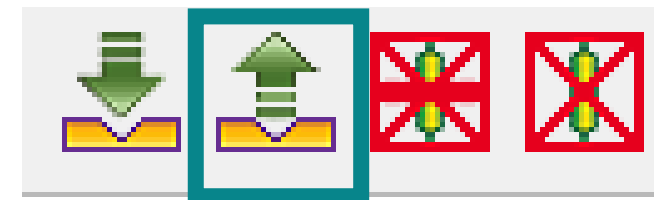
3. Push into (Shift+E) or right click:

TB1_eye_diagram_analysis



4. Pop out of:

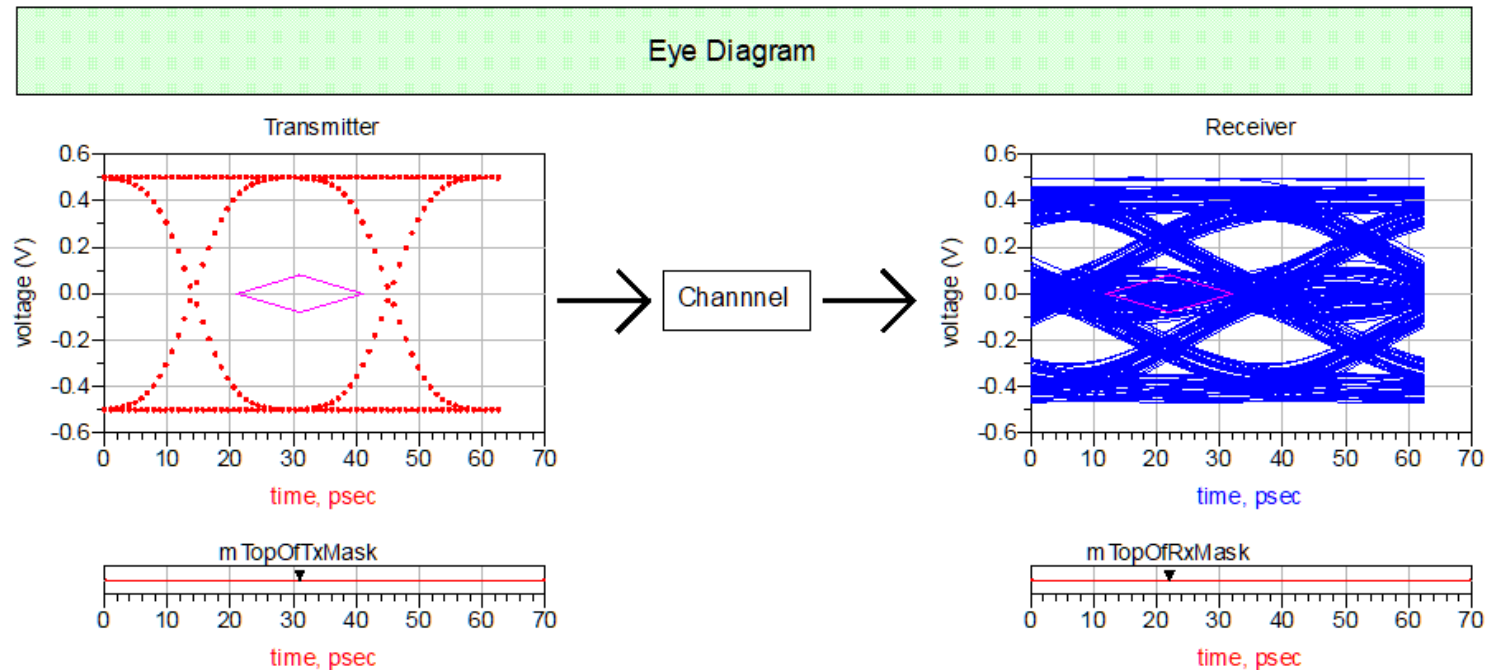
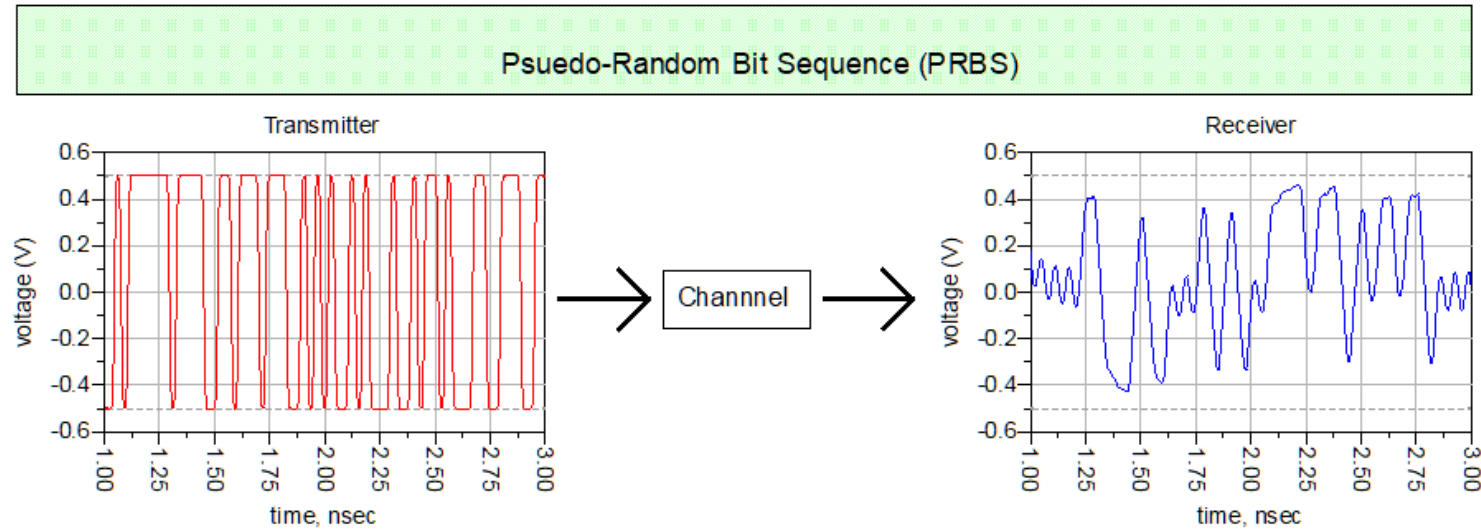
TB1_eye_diagram_analysis



5. Simulate cell

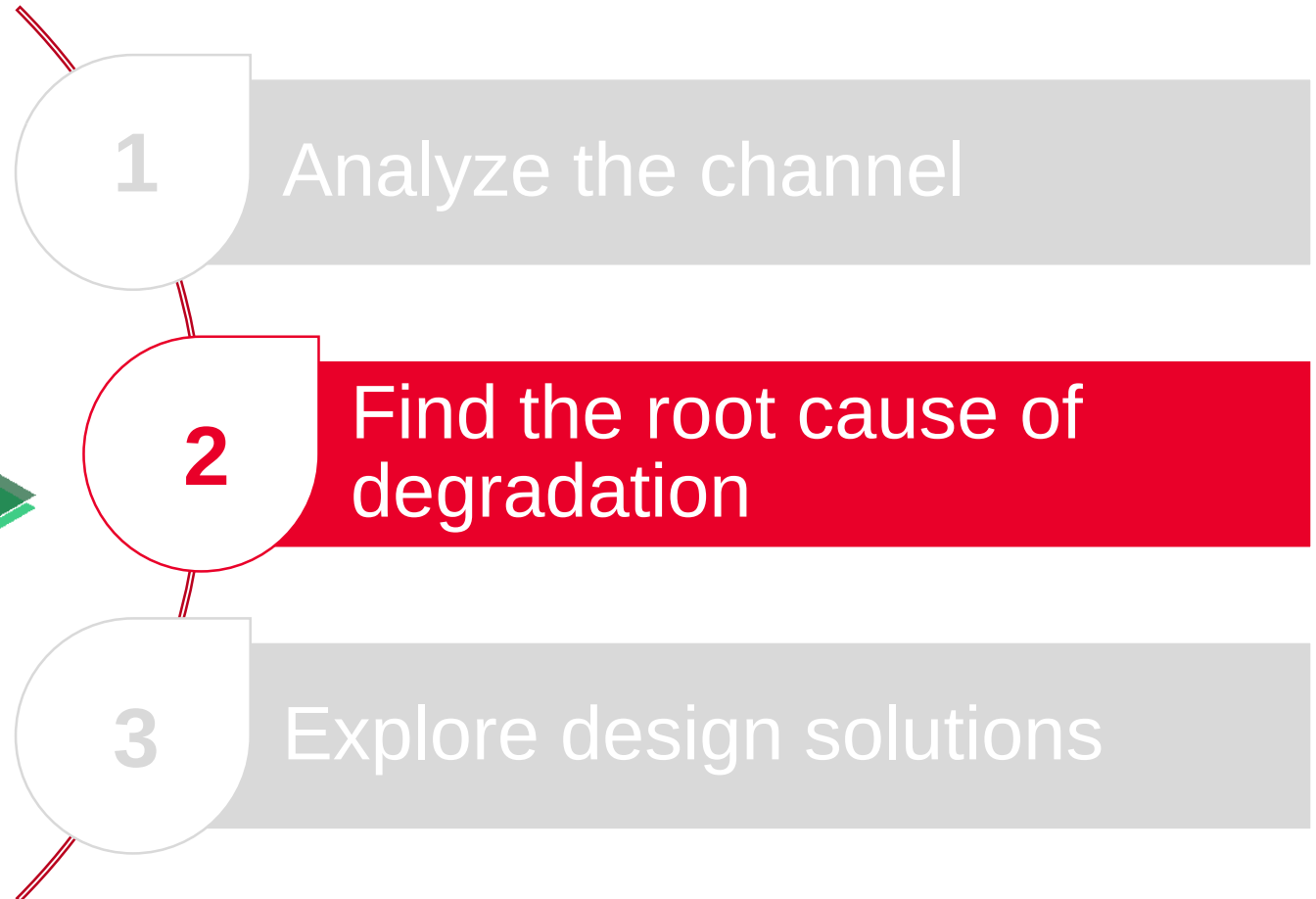
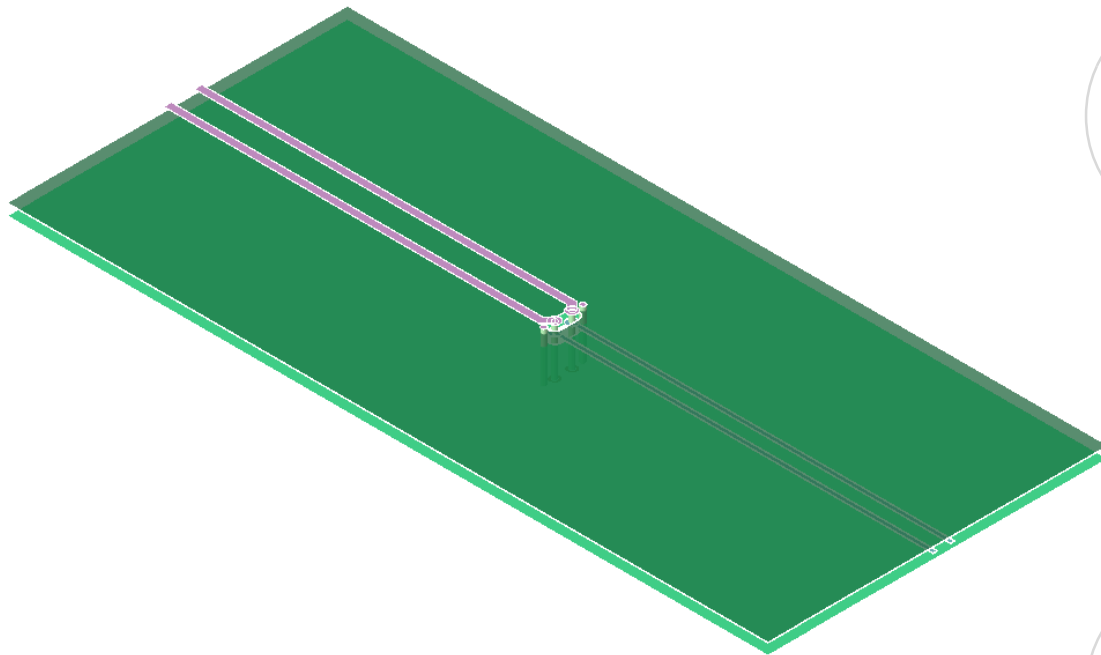


Lab 1 Takeaway: The Eye is Closed!

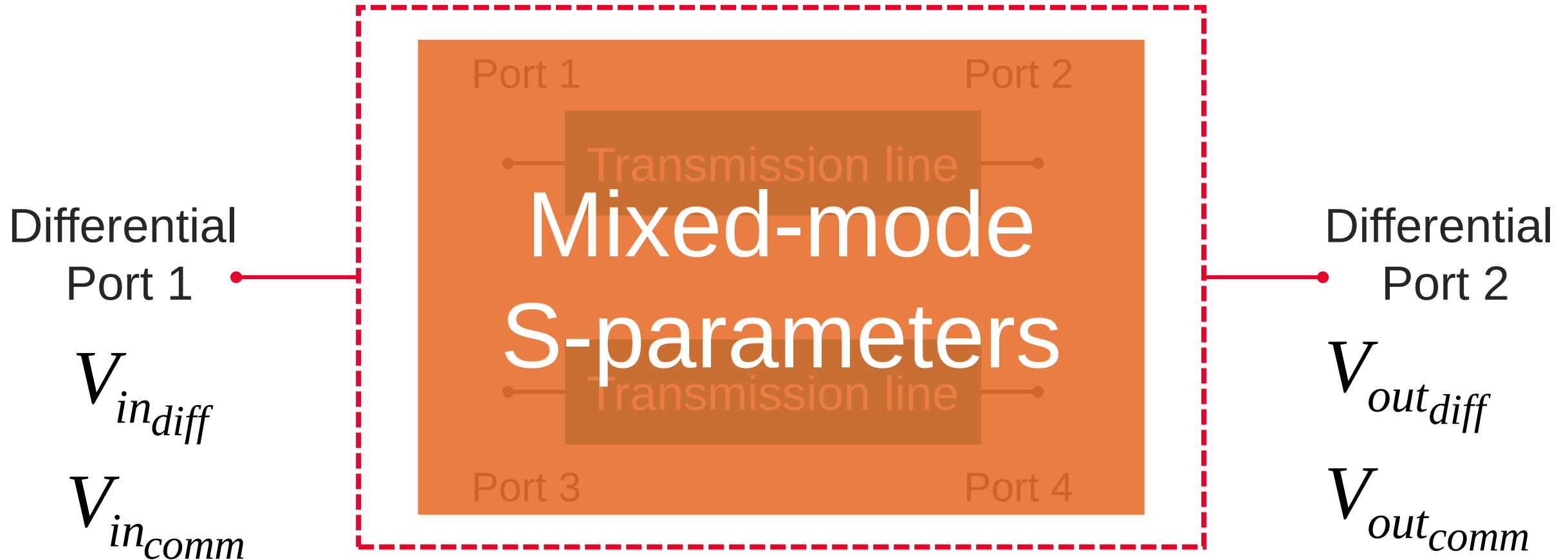


Understand Signal Integrity Analyses with a Case Study

The case of the failing virtual channel



Use Mixed-mode S-parameters for Differential Channels



Stimulus and Responses in Mixed-mode S-parameters

$[S_{\text{mixed-mode}}]$

Differential Signal
Stimulus

Common Signal
Stimulus

Differential
Response

S_{DD11} S_{DD12}

S_{DD21} S_{DD22}

S_{DC11} S_{DC12}

S_{DC21} S_{DC22}

Common
Response

S_{CD11} S_{CD12}

S_{CD21} S_{CD22}

S_{CC11} S_{CC12}

S_{CC21} S_{CC22}

Important Mixed-mode S-parameters

S_{DD11} Differential response at port 1, excited by Differential input at port 1.

S_{DD11} Related to differential return loss.

S_{DD21} Related to differential insertion loss.

S_{CD21} Mode-conversion: EM generation.

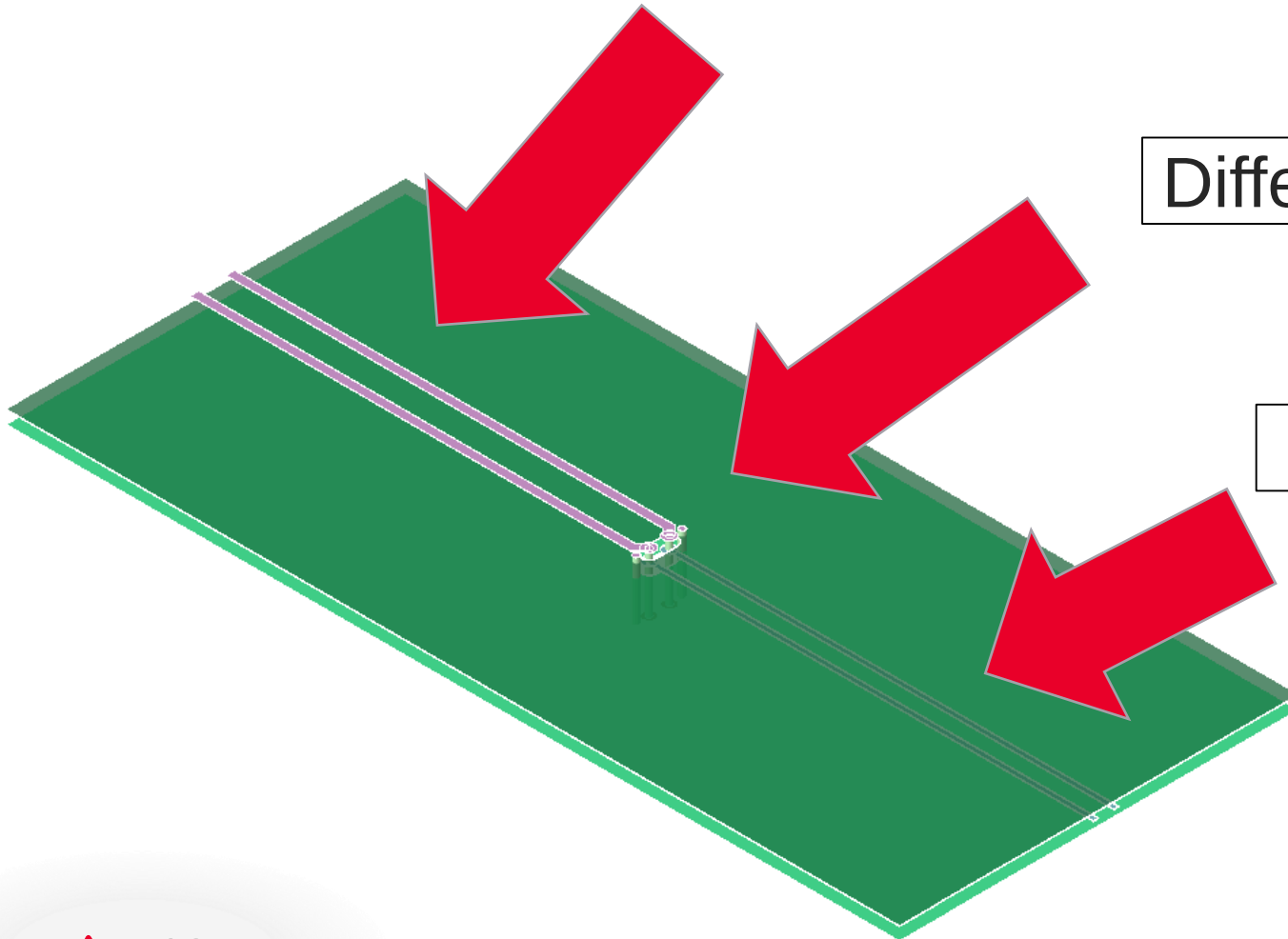
S_{DC21} Mode-conversion: EM susceptibility.

First Glimpse of the Virtual Channel

3-inch microstrip differential pair

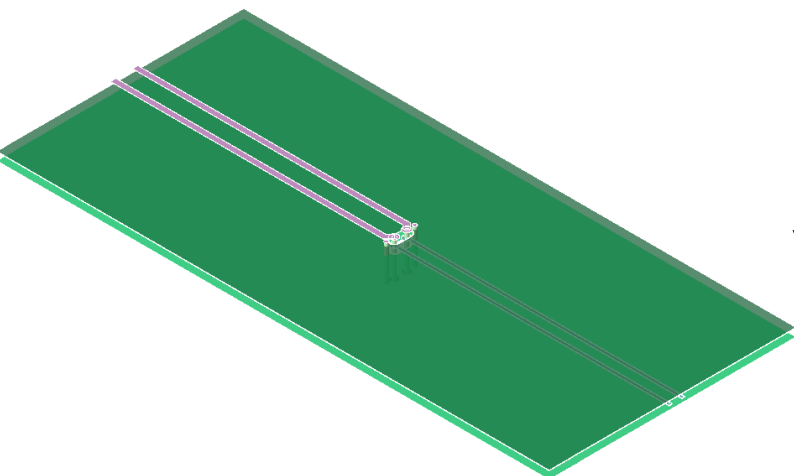
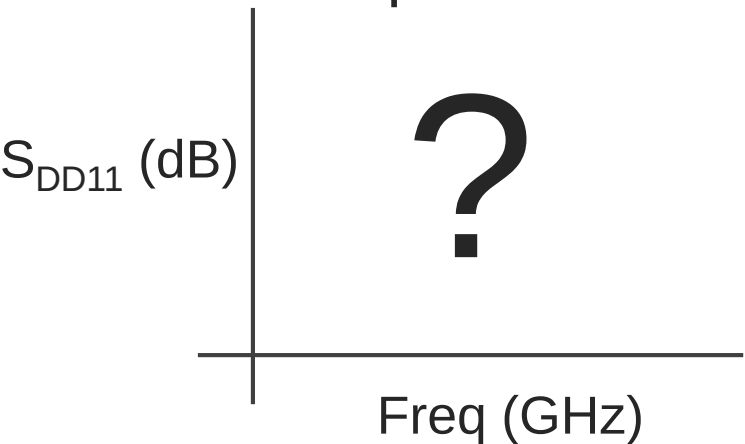
Differential Via structure

3-inch stripline differential pair

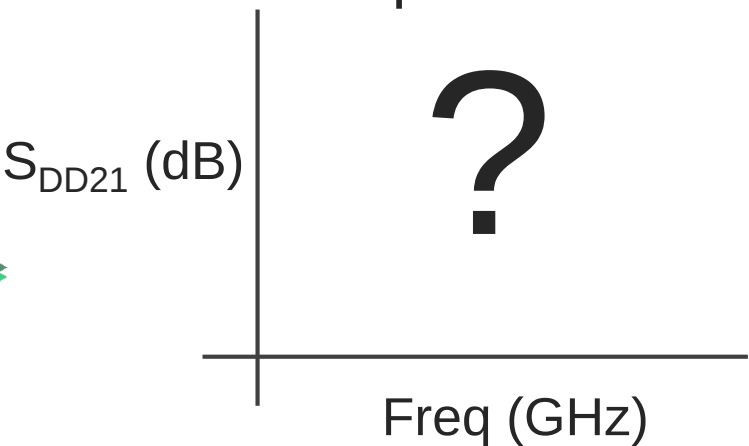


ABS*: What Do We Expect with Given Channel?

Expectation

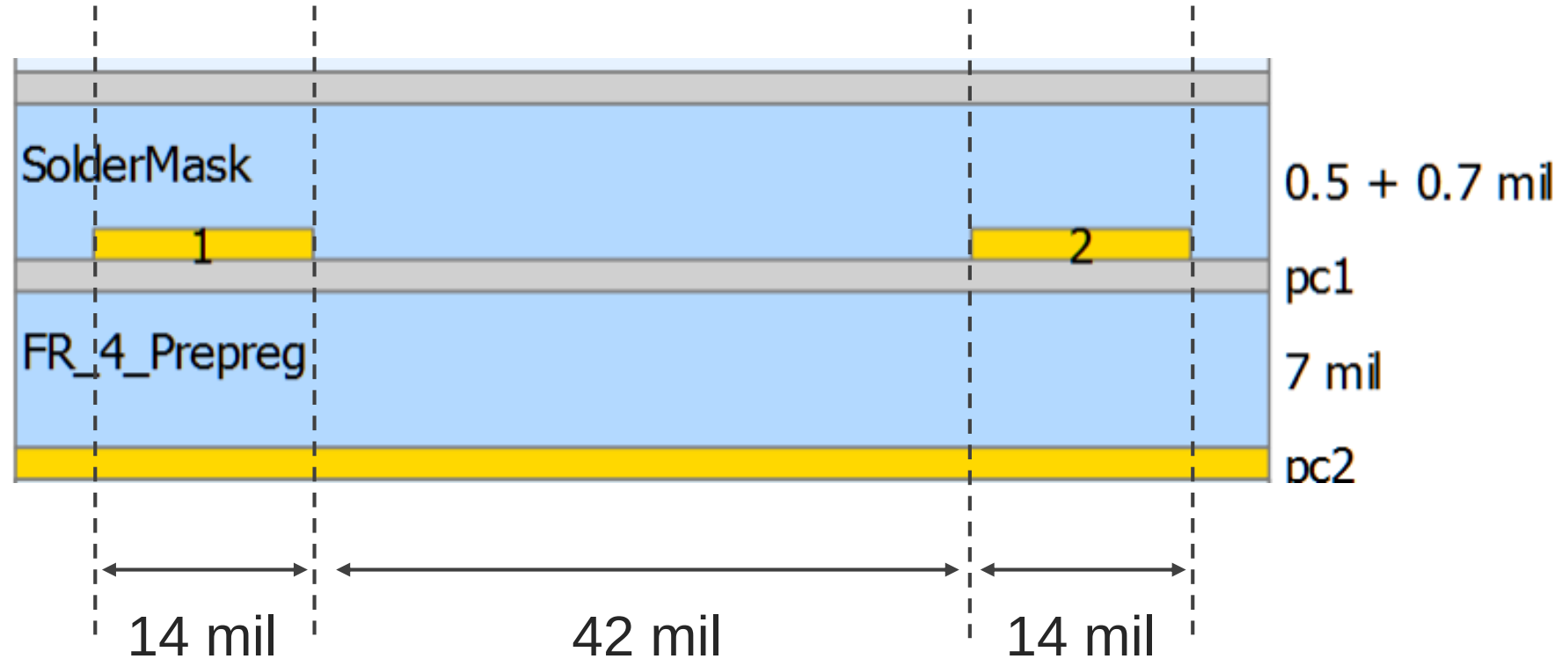


Expectation



Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)			
Impedance (Ohm)			

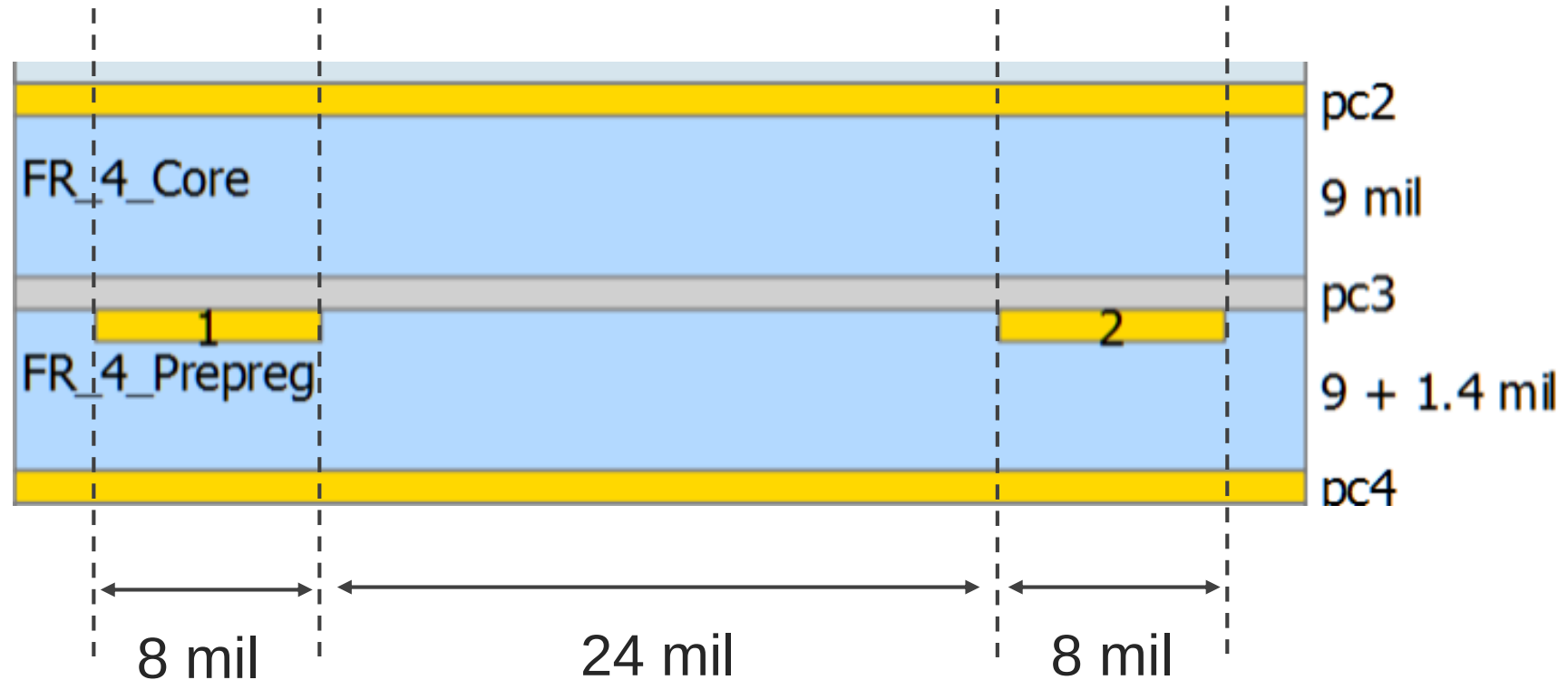
Cross-section of the Microstrip Differential Pair



Single-ended Microstrip Impedance
Rule of Thumb: $W/H = 2 \rightarrow Z = 50 \text{ Ohm}$

Because of solder mask, we expect:
differential impedance $< 100 \text{ Ohm}$

Cross-section of the Stripline Differential Pair



Single-ended Stripline Impedance

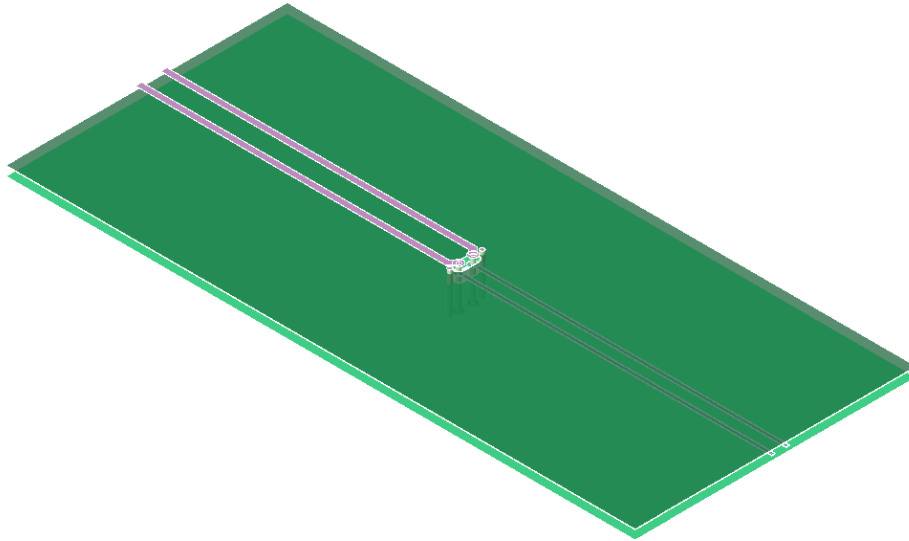
Rule of Thumb:

$0.8 < W/H < 1 \rightarrow Z \sim 50 \text{ Ohm}$

We expect:

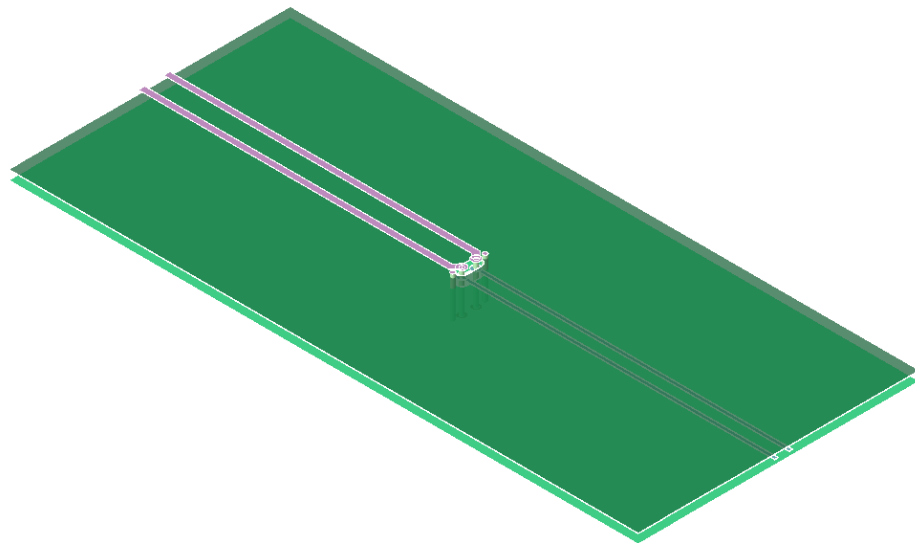
differential impedance $\sim 100 \text{ Ohm}$

ABS: What Loss Do We Expect with Given Channel?



Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)			
Impedance (Ohm)	<100		~100

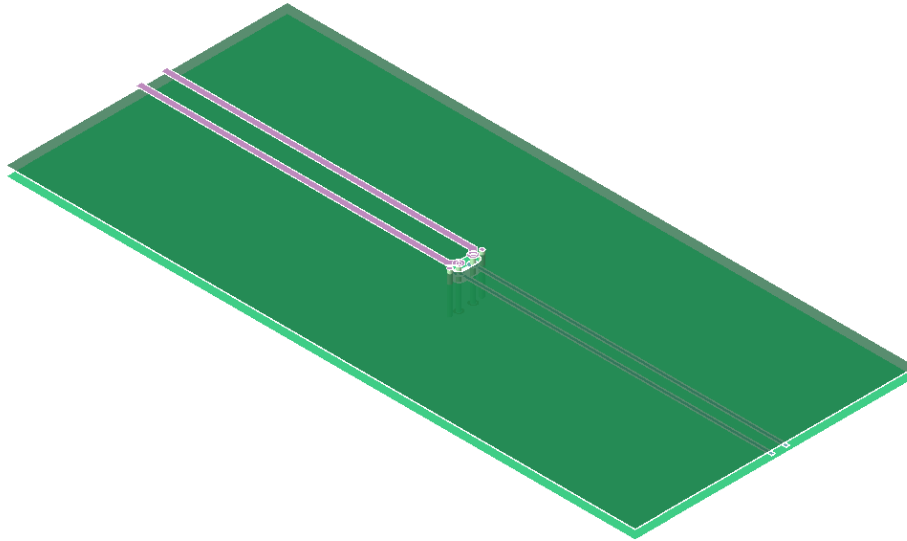
ABS: What Loss Do We Expect with Given Channel?



Date Rate: 32 Gbps
Nyquist Frequency: 16 GHz
Estimated Loss: ~ 0.1 dB/in/GHz

Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)			
Impedance (Ohm)	<100		~100

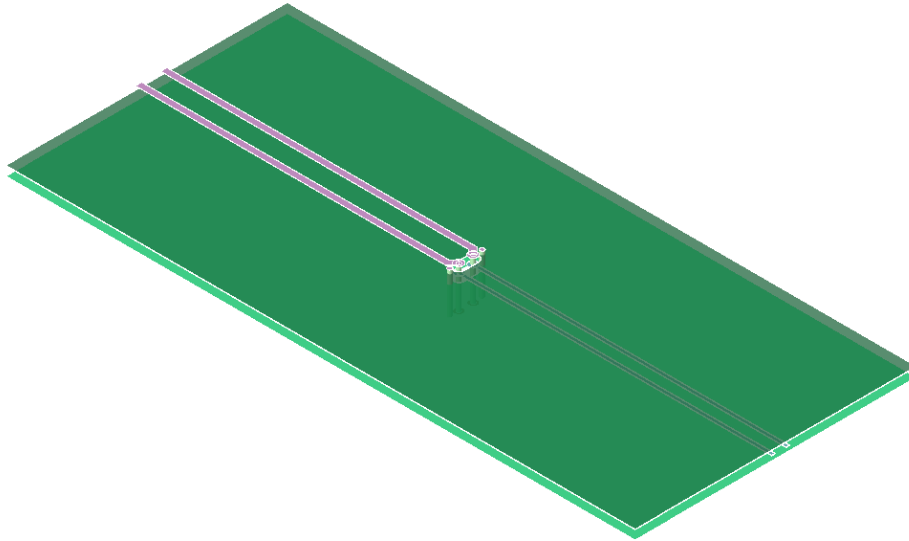
ABS: What Loss Do We Expect with Given Channel?



Date Rate: 32 Gbps
Nyquist Frequency: 16 GHz
Estimated Loss: ~ 0.1 dB/in/GHz

Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)	5 dB		5 dB
Impedance (Ohm)	<100		~ 100

ABS: What Loss Do We Expect with Given Channel?



Date Rate: 32 Gbps
Nyquist Frequency: 16 GHz
Estimated Loss: ~ 0.1 dB/in/GHz

Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)	5 dB	small	5 dB
Impedance (Ohm)	<100	?	~ 100

Mode of Operation and Impedances

Even Mode of Operation



- Each T-line has an Even Mode Impedance
- Common signal sees the Common Impedance

Odd Mode of Operation



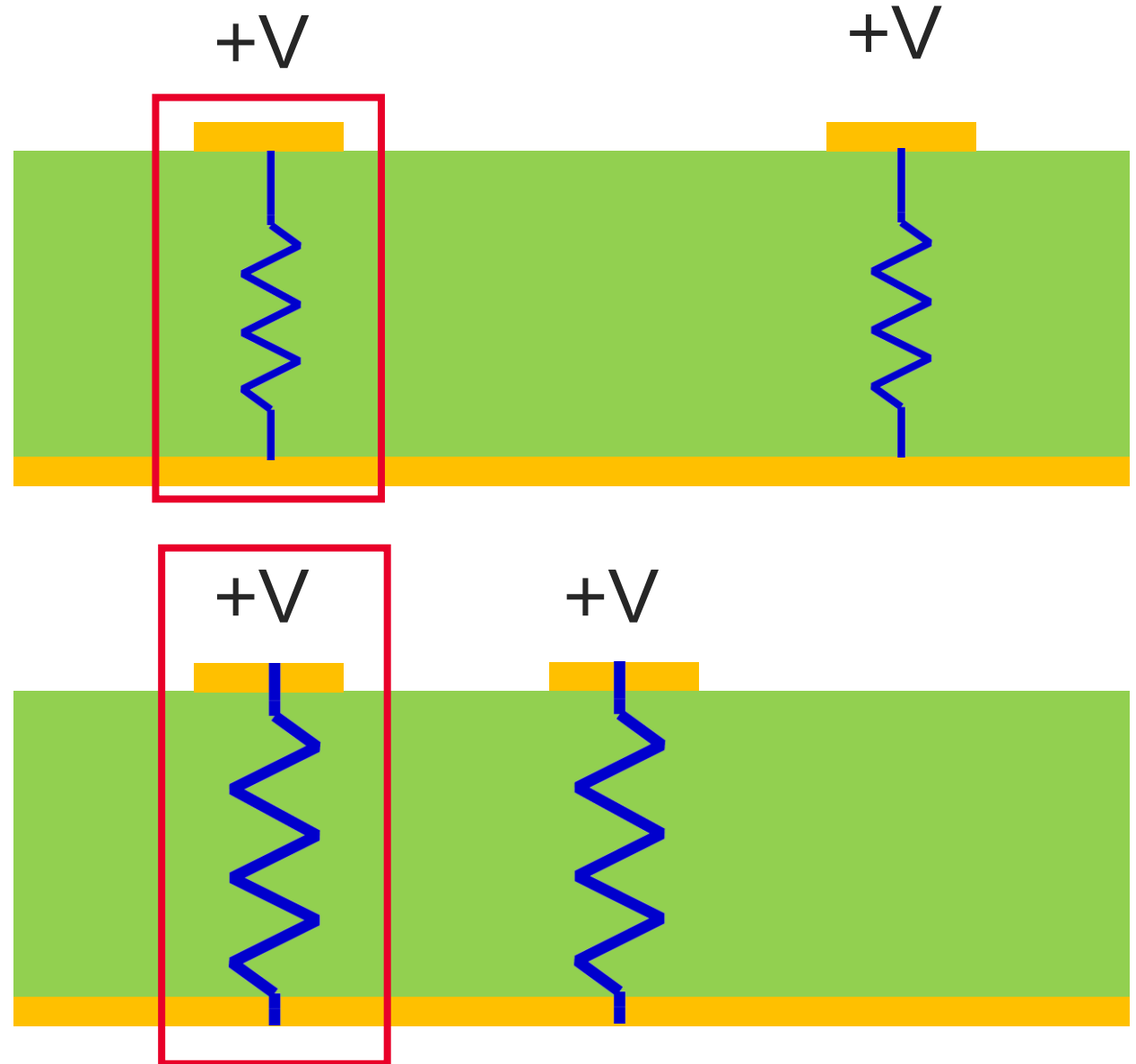
- Each T-line has an Odd mode Impedance
- Differential signal sees the Differential Impedance

Even Mode Impedance Increases as Spacing Decreases

Even Mode

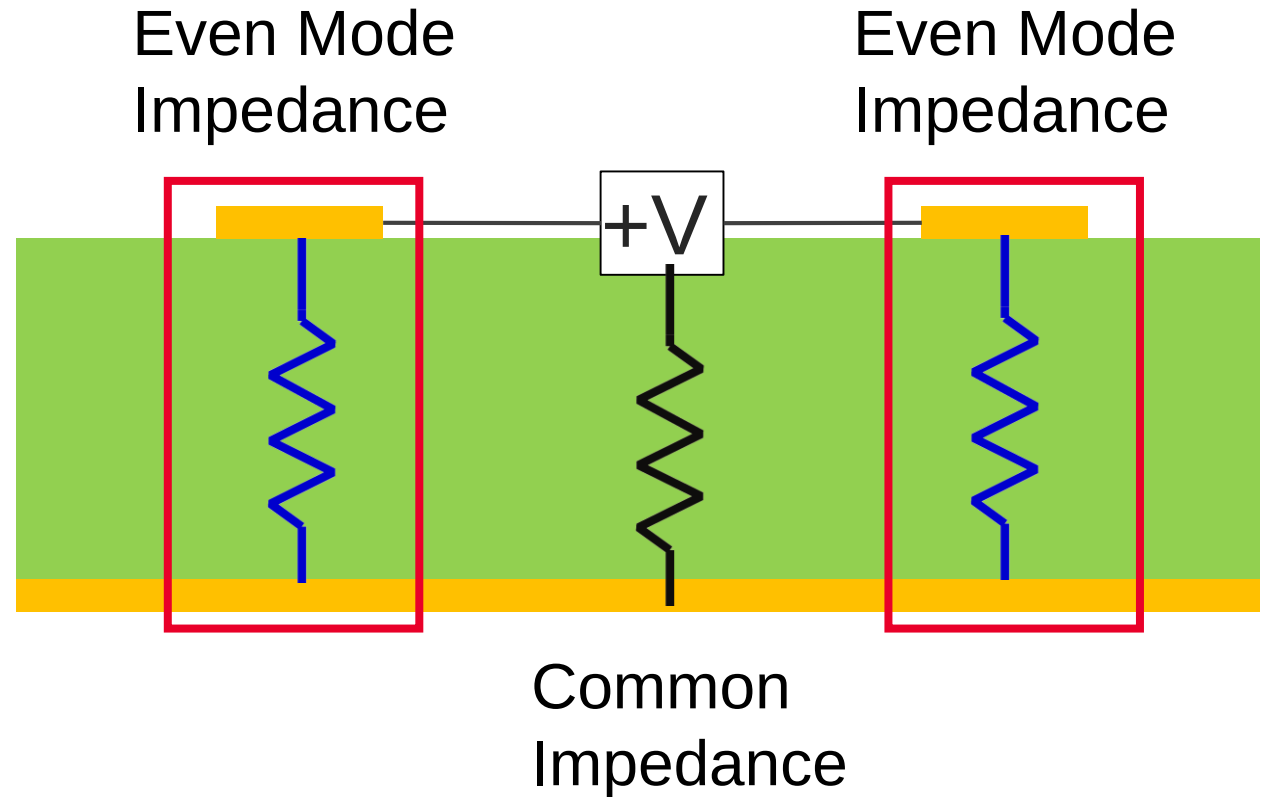


$$Z_{\text{even}} \propto \frac{1}{C} \propto \frac{V}{q}$$



Common Impedance Increases as Spacing Decrease

Common signal sees the
Common Impedance



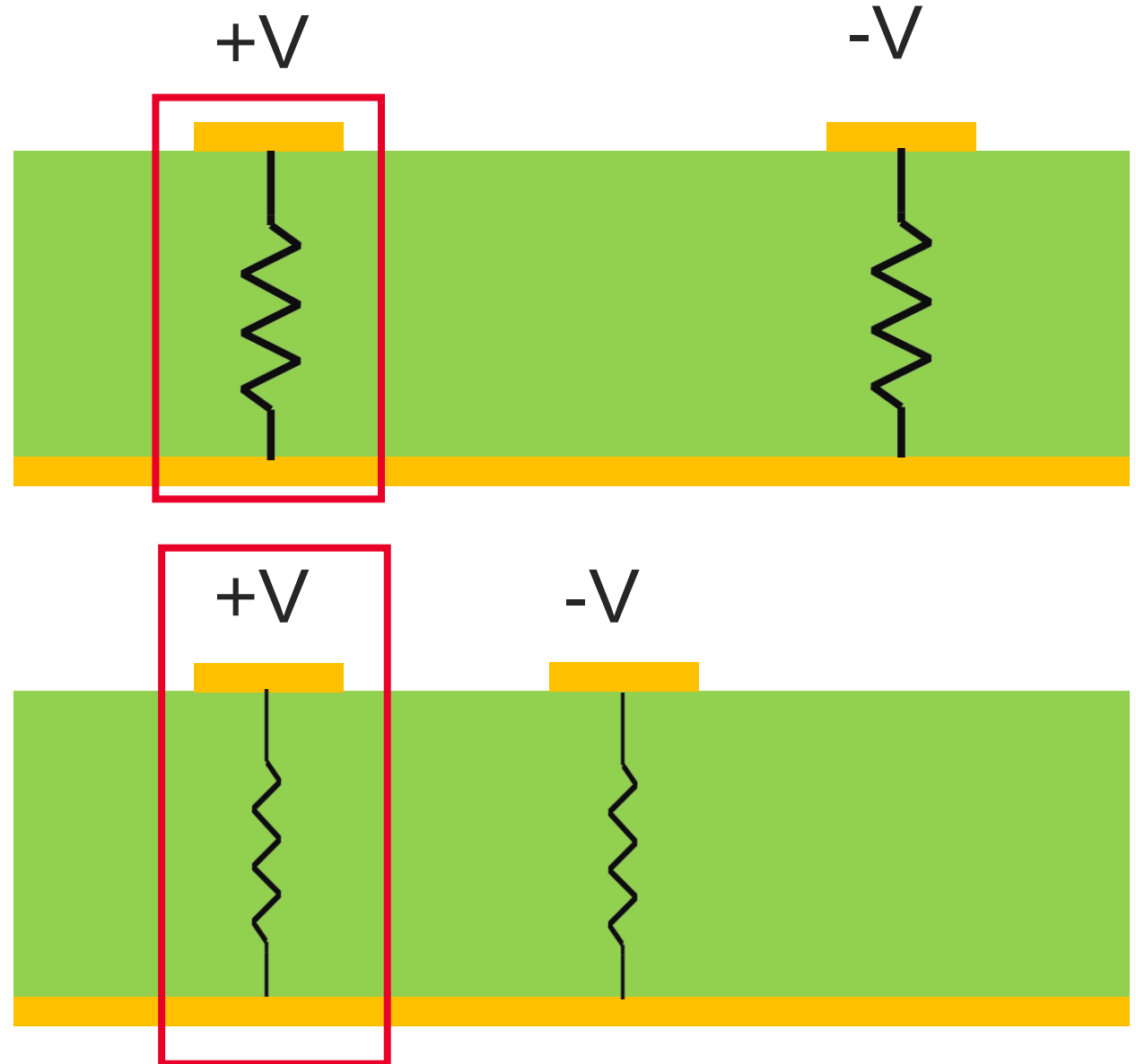
$$Z_{common} = \frac{1}{2} Z_{even}$$

Odd Mode Impedance Decreases as Spacing Decrease

Odd Mode

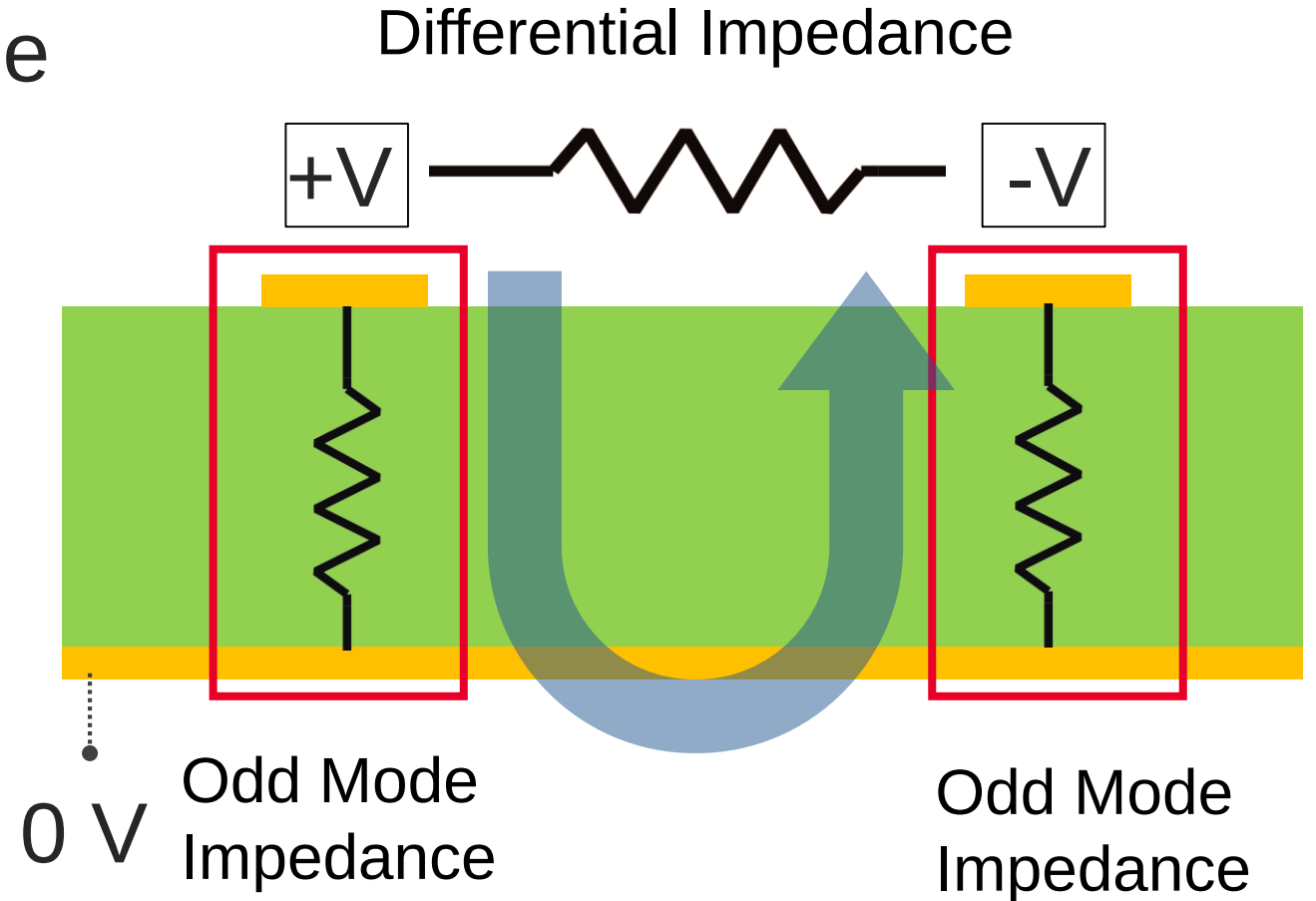


$$Z_{odd} \propto \frac{1}{C} \propto \frac{V}{q}$$



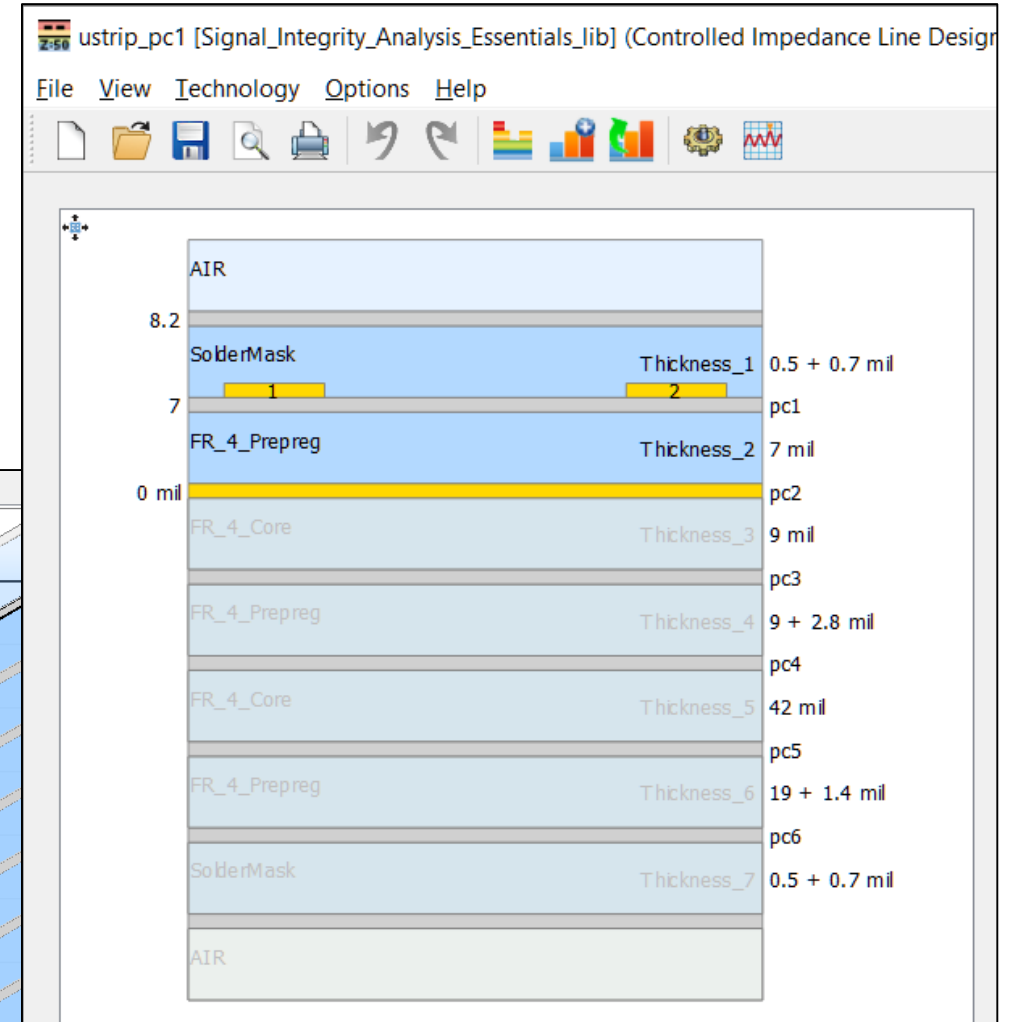
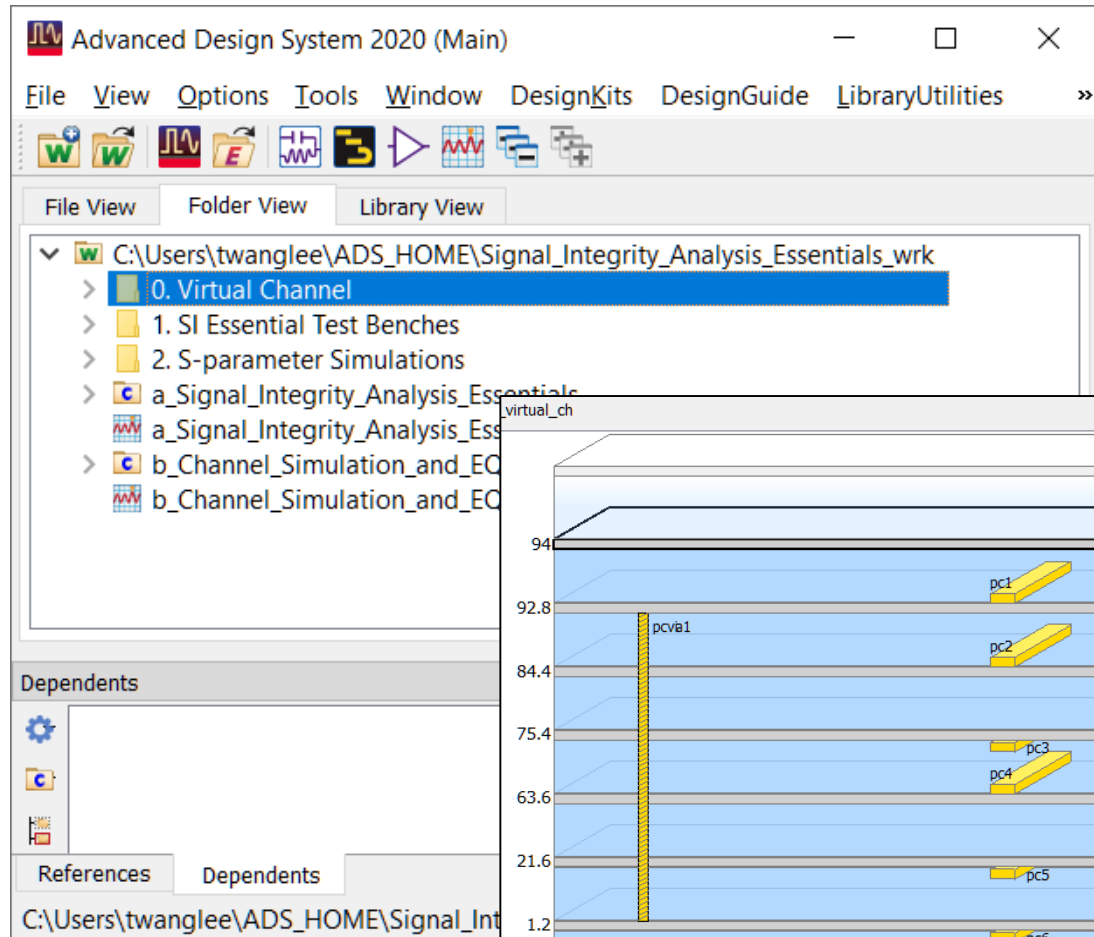
Differential Impedance Decreases as Spacing Decrease

Differential signal sees the
Differential Impedance

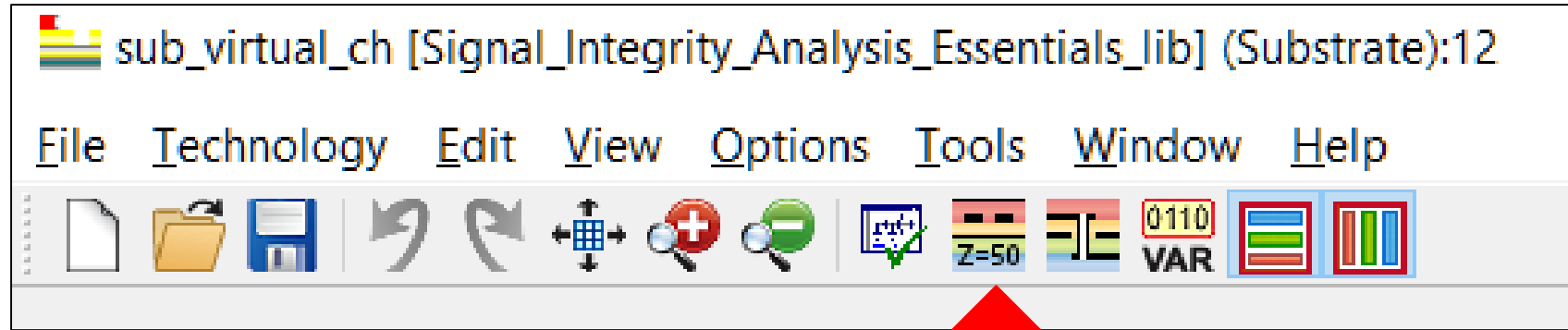
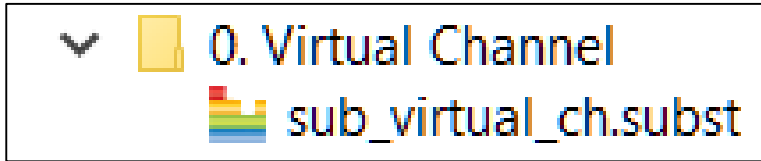


$$Z_{diff} = 2Z_{odd}$$

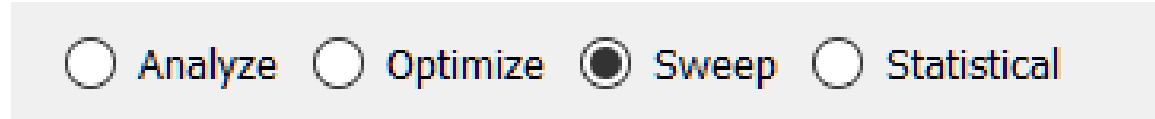
Lab 2: Use Controlled-Impedance Line Designer to Investigate Virtual Channel



Lab 2 Exercises



1. Open substrate window in folder:
0. Virtual Channel/sub_virtual_ch
2. Use Controller Impedance Line Designer, open:
ustrip_pc1.cild
3. In CILD, sweep **ONLY** spacing from 10 mil to 42 mil: **How do you expect the differential impedance to change?**



Lab 2 Exercises Continued

4. In CILD, open:

stripline_pc3.cild

Simulate 1 inch of the structure.

What's the attenuation per inch?

5. With **stripline_pc3.cild**:

change spacing to 12 mils, and optimize the width for 100 Ohm Z_{diff} .

How do you expect the width to change?

Name	Nominal
freq	1 GHz
Length	3 in
Width	8 mil
Space	24 mil

Change to 1
inch

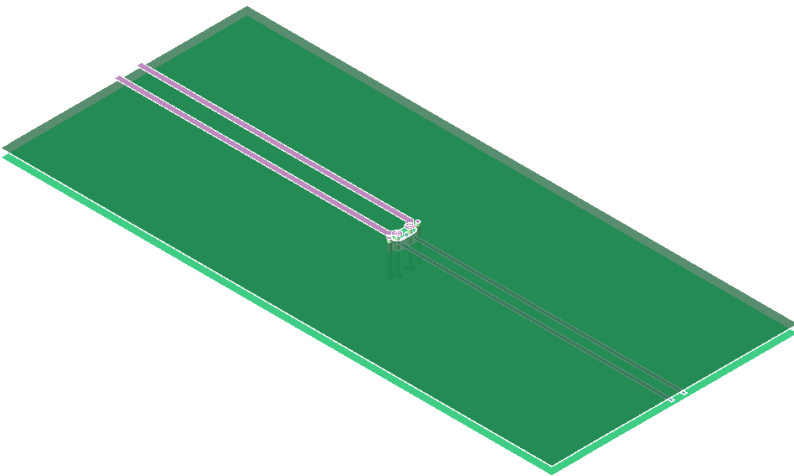
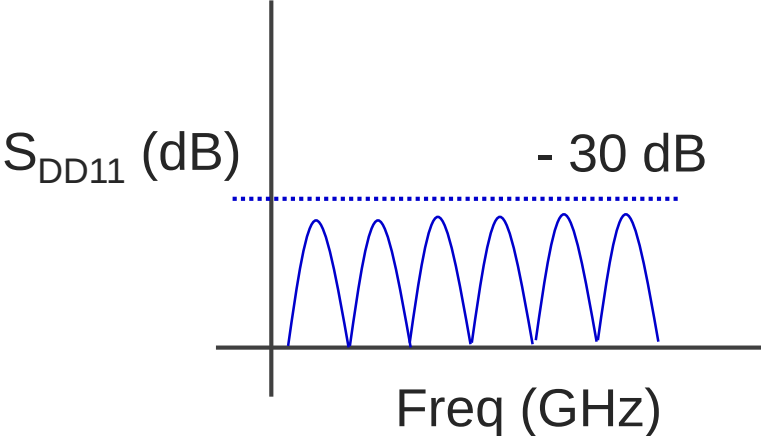
☐ Analyze ☒ Optimize ☐ Sweep

Goal

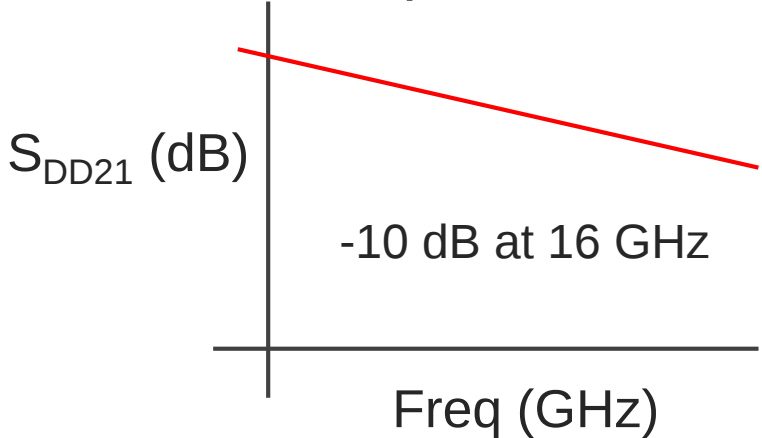
Zc Differential ▼ 100

Compare Expectation to S-Parameters Result

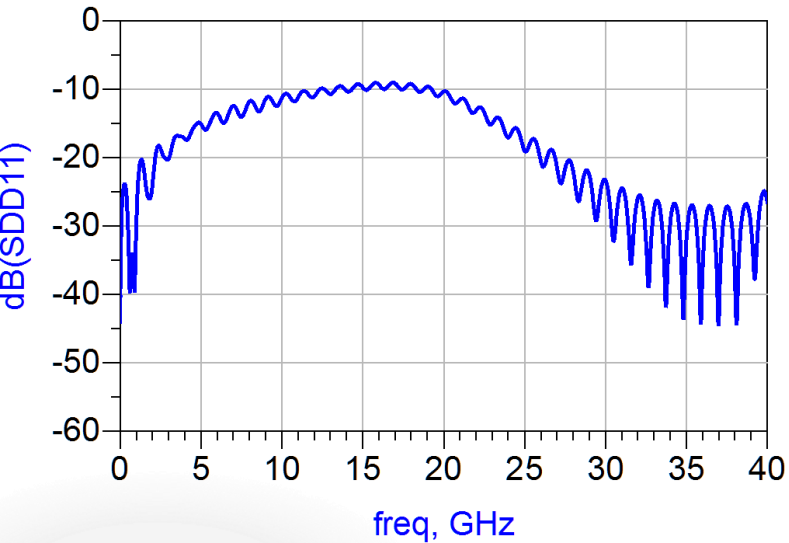
Expectation



Expectation



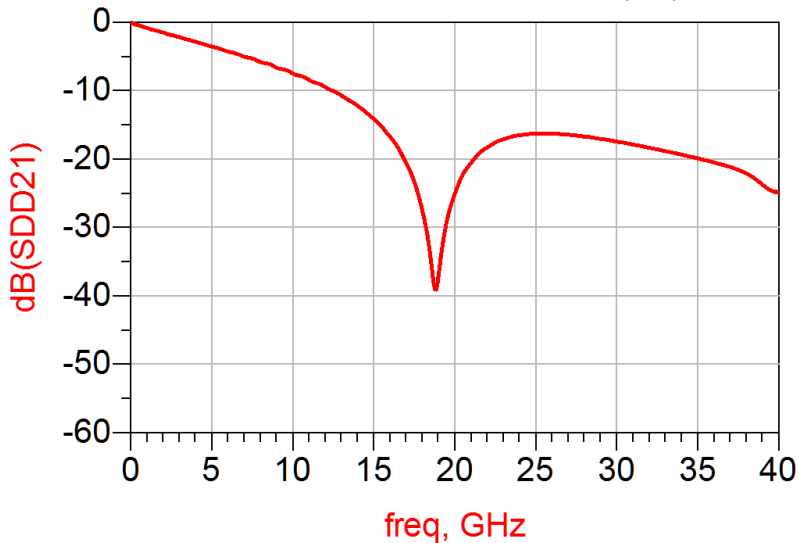
Differential Return Loss (dB)



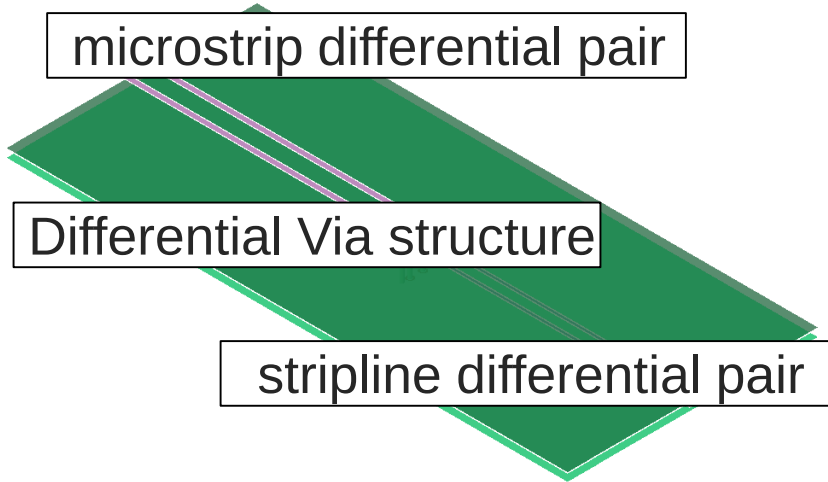
Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)	5	Small	5
Impedance (Ohm)	<100	?	~100

Not what we expect!

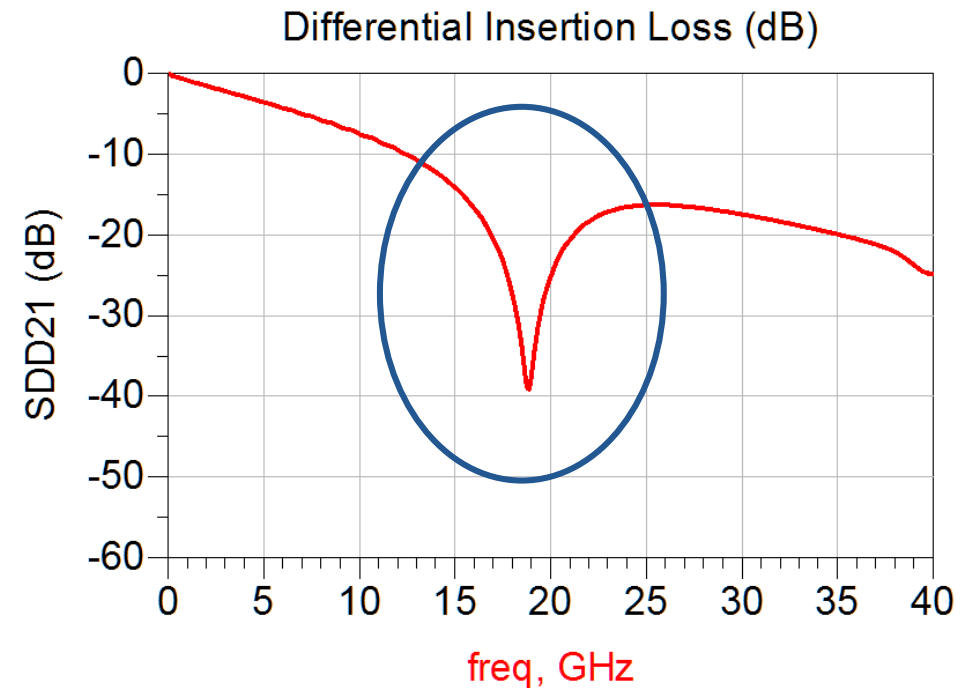
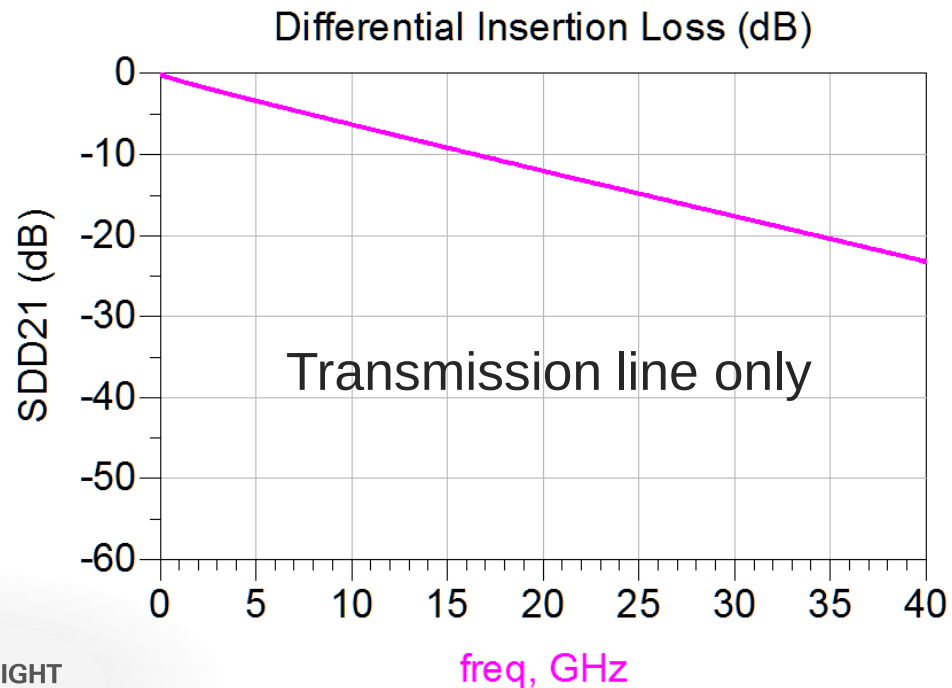
Differential Insertion Loss (dB)



Simulate Only the Transmission Lines



Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)	5	Small	5



Lab 3 Exercises Data Display and S-parameter Equations

1. Open cell:

a_Signal_Integrity_Analysis_Essentials

2. Push into (Shift+E) or right click:

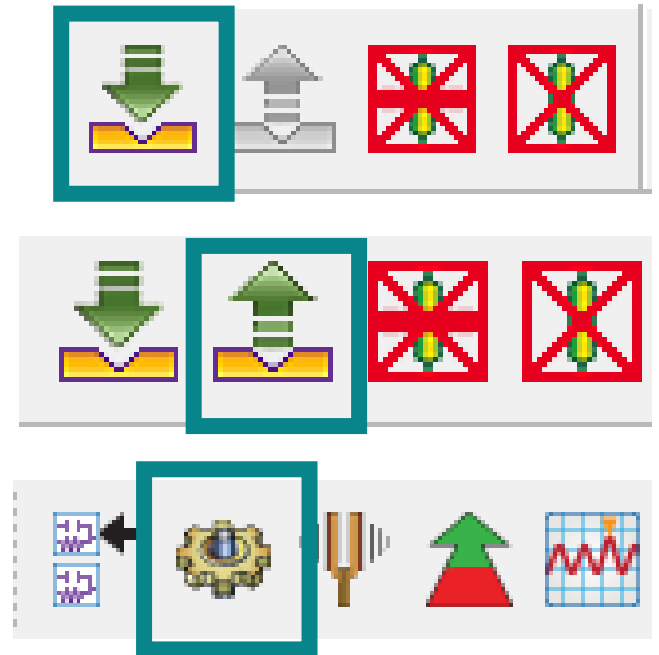
TB2_S_parameter_analysis

3. Pop out of:

TB2_S_parameter_analysis

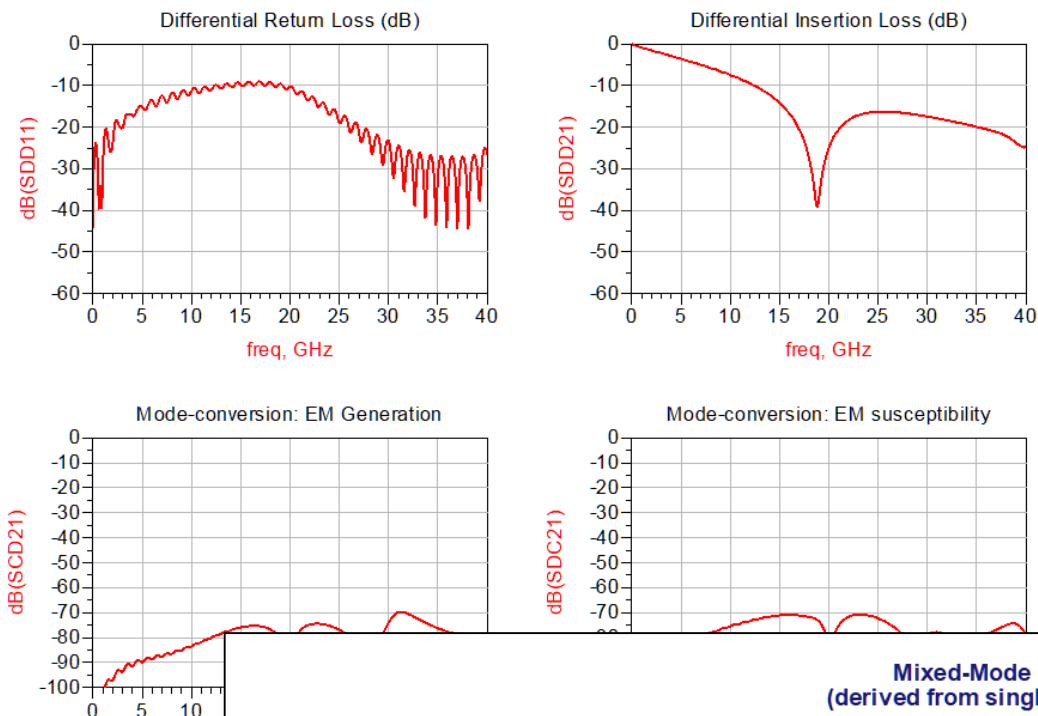
4. Simulate

5. Investigate the Mixed-Mode S-parameters in data display



Lab 3 Exercises

Differential S-parameters



Mixed-Mode S-Matrix (derived from single-ended S-Matrix)

DD Quadrant

Eqn $\text{SDD11} = 0.5 \cdot (\text{S}(1,1) - \text{S}(1,3) - \text{S}(3,1) + \text{S}(3,3))$	Eqn $\text{SDD12} = 0.5 \cdot (\text{S}(1,2) - \text{S}(1,4) - \text{S}(3,2) + \text{S}(3,4))$
Eqn $\text{SDD21} = 0.5 \cdot (\text{S}(2,1) - \text{S}(2,3) - \text{S}(4,1) + \text{S}(4,3))$	Eqn $\text{SDD22} = 0.5 \cdot (\text{S}(2,2) - \text{S}(2,4) - \text{S}(4,2) + \text{S}(4,4))$

CD Quadrant

Eqn $\text{SCD11} = 0.5 \cdot (\text{S}(1,1) - \text{S}(1,3) + \text{S}(3,1) - \text{S}(3,3))$	Eqn $\text{SCD12} = 0.5 \cdot (\text{S}(1,2) - \text{S}(1,4) + \text{S}(3,2) - \text{S}(3,4))$
Eqn $\text{SCD21} = 0.5 \cdot (\text{S}(2,1) - \text{S}(2,3) + \text{S}(4,1) - \text{S}(4,3))$	Eqn $\text{SCD22} = 0.5 \cdot (\text{S}(2,2) - \text{S}(2,4) + \text{S}(4,2) - \text{S}(4,4))$

DC Quadrant

Eqn $\text{SDC11} = 0.5 \cdot (\text{S}(1,1) + \text{S}(1,3) - \text{S}(3,1) - \text{S}(3,3))$	Eqn $\text{SDC12} = 0.5 \cdot (\text{S}(1,2) + \text{S}(1,4) - \text{S}(3,2) - \text{S}(3,4))$
Eqn $\text{SDC21} = 0.5 \cdot (\text{S}(2,1) + \text{S}(2,3) - \text{S}(4,1) - \text{S}(4,3))$	Eqn $\text{SDC22} = 0.5 \cdot (\text{S}(2,2) + \text{S}(2,4) - \text{S}(4,2) - \text{S}(4,4))$

CC Quadrant

Eqn $\text{SCC11} = 0.5 \cdot (\text{S}(1,1) + \text{S}(1,3) + \text{S}(3,1) + \text{S}(3,3))$	Eqn $\text{SCC12} = 0.5 \cdot (\text{S}(1,2) + \text{S}(1,4) + \text{S}(3,2) + \text{S}(3,4))$
Eqn $\text{SCC21} = 0.5 \cdot (\text{S}(2,1) + \text{S}(2,3) + \text{S}(4,1) + \text{S}(4,3))$	Eqn $\text{SCC22} = 0.5 \cdot (\text{S}(2,2) + \text{S}(2,4) + \text{S}(4,2) + \text{S}(4,4))$

Plot Traces & Attributes

Plot Type Plot Options Plot Title

1234 5678

Datasets and Equations

Equations

Search List

SCC11 SCC12 SCC21 SCC22 SCD11 SCD12 SCD21 SCD22

< >

Enter any Equation >> Add >>

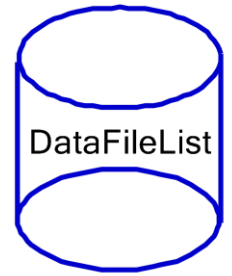
Trace Options...

OK Cancel Help

Lab 3 Exercises

6. Browse and change S-parameter file to:

channel_with_tlines_only.s4p

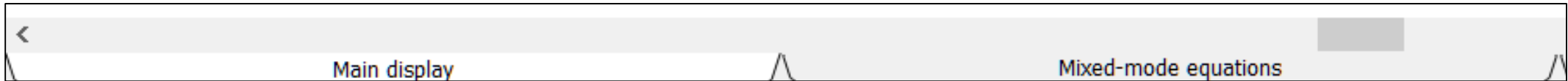


DataFileList
SParameter

7. Simulate

8. Investigate the data display (bottom tab)

find the equations for Mixed mode S-parameters

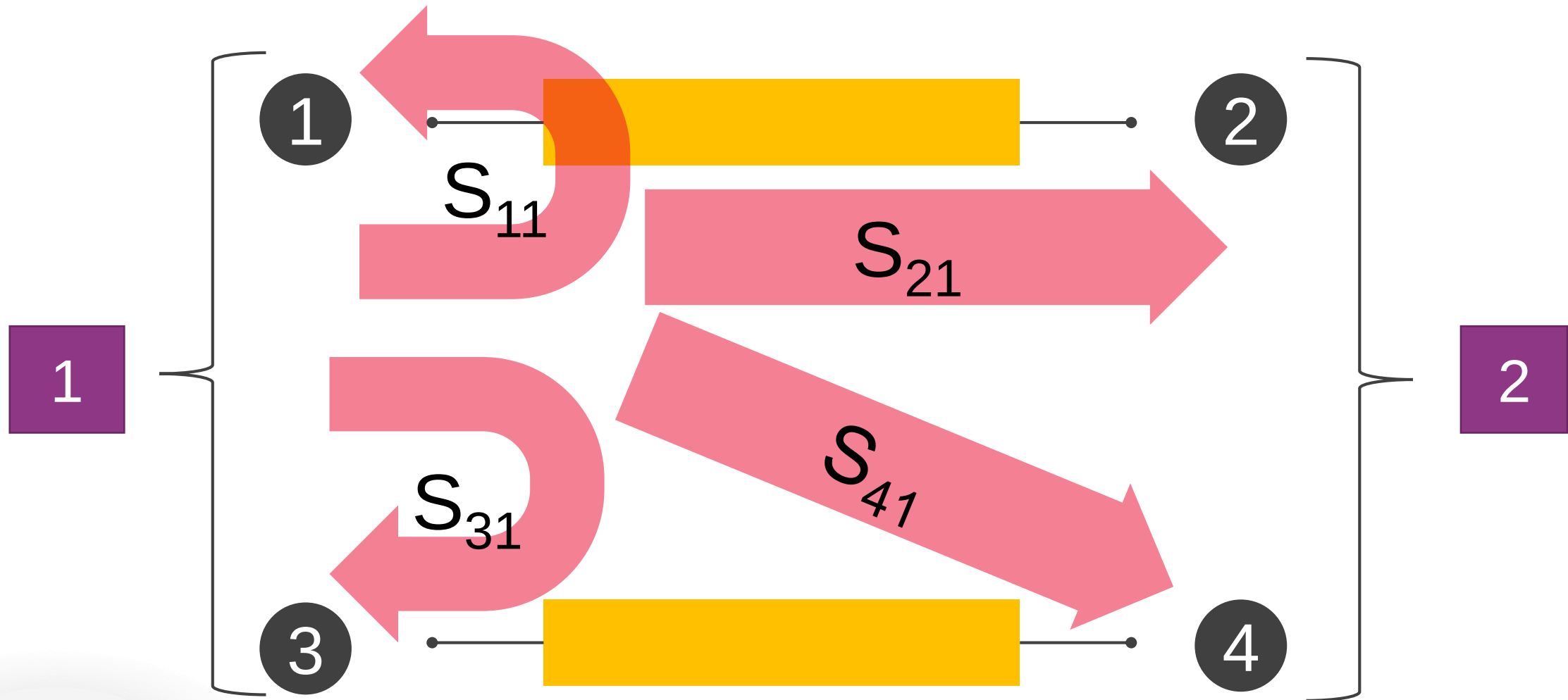


9. Browse and change S-parameter file back to:

a_failing_channel.s4p

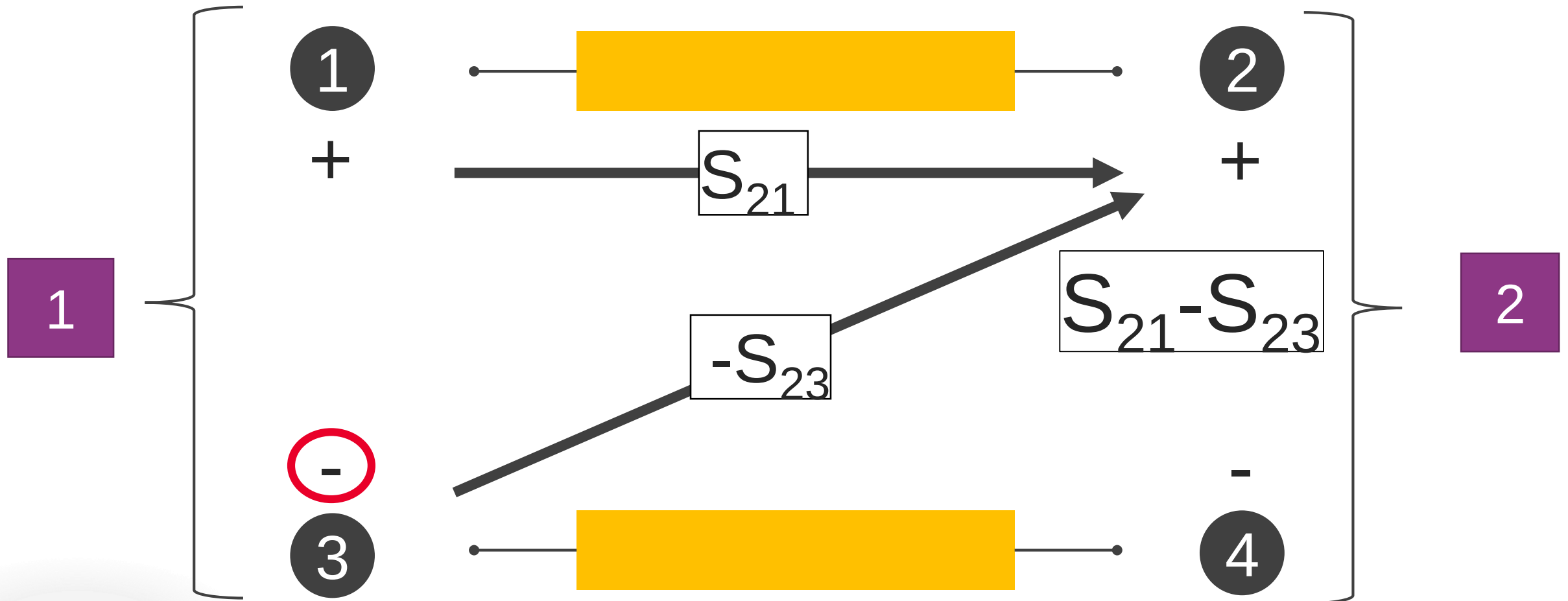
Converting Single-ended S-parameters to Mixed-mode

Port Assignment



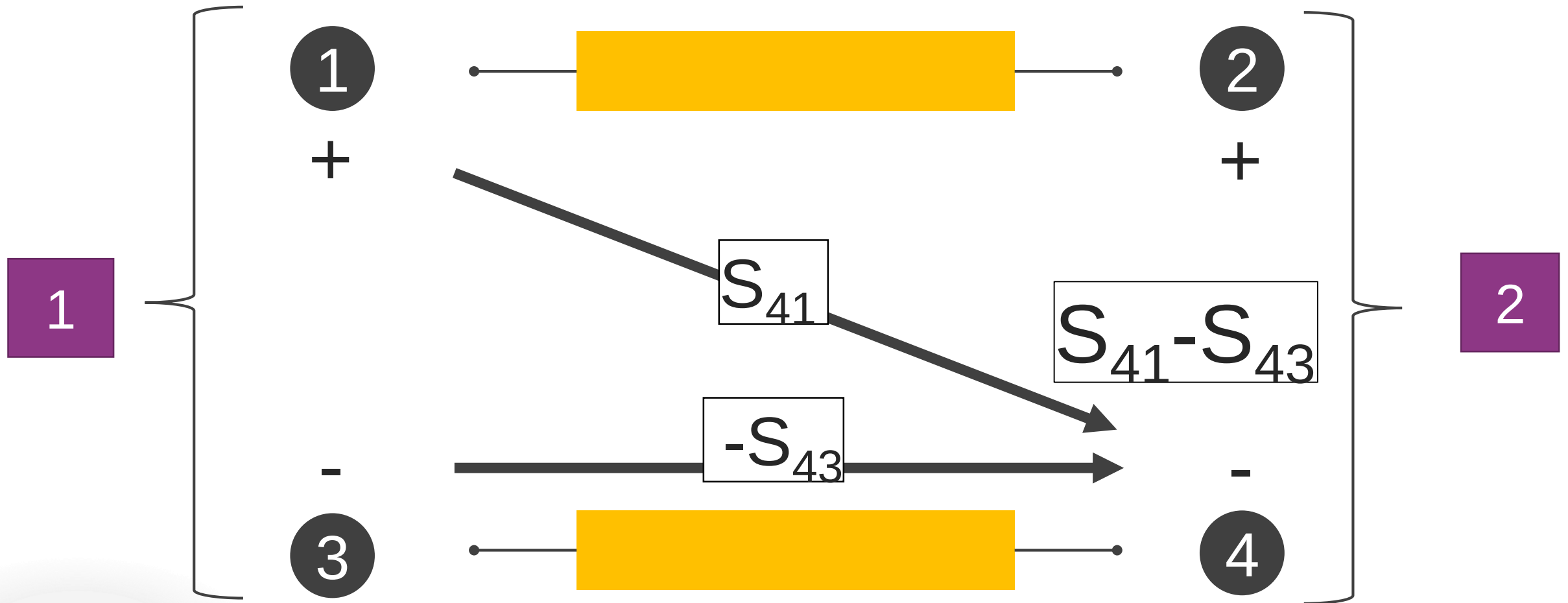
Converting Single-ended S-parameters to Mixed-mode

S_{DD21} Example



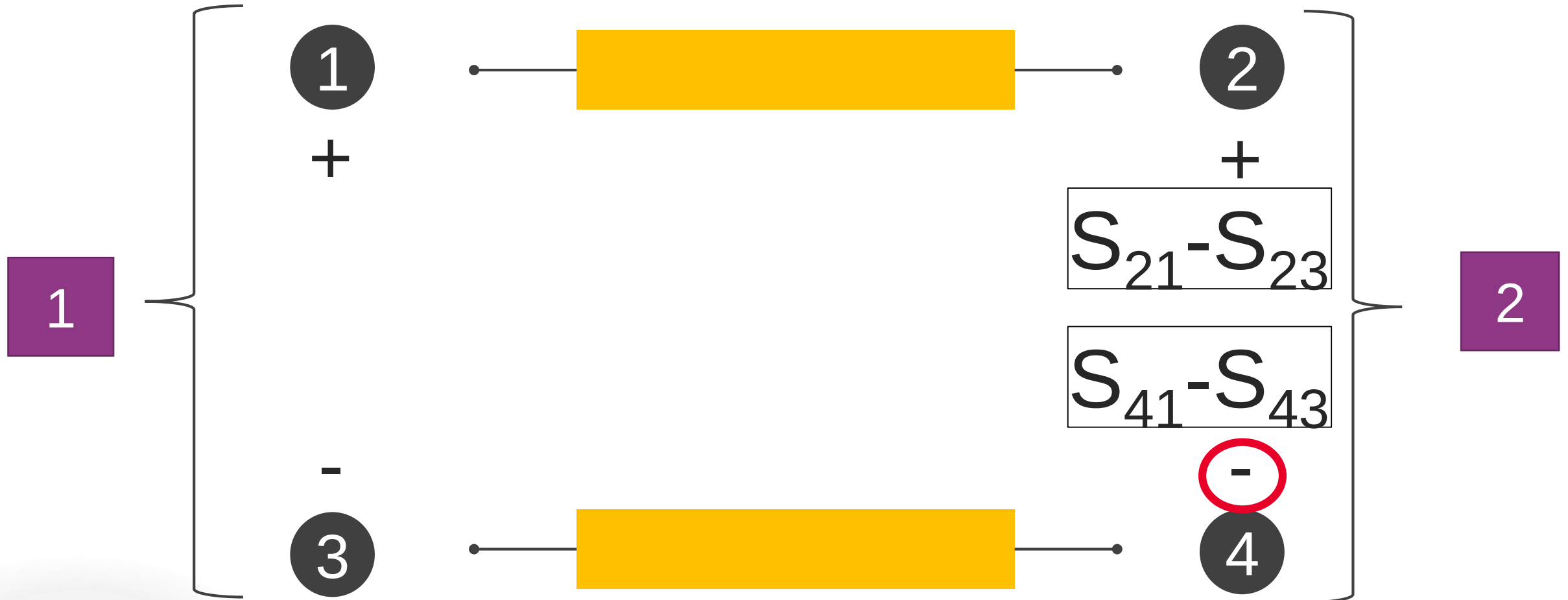
Converting Single-ended S-parameters to Mixed-mode

S_{DD21} Example



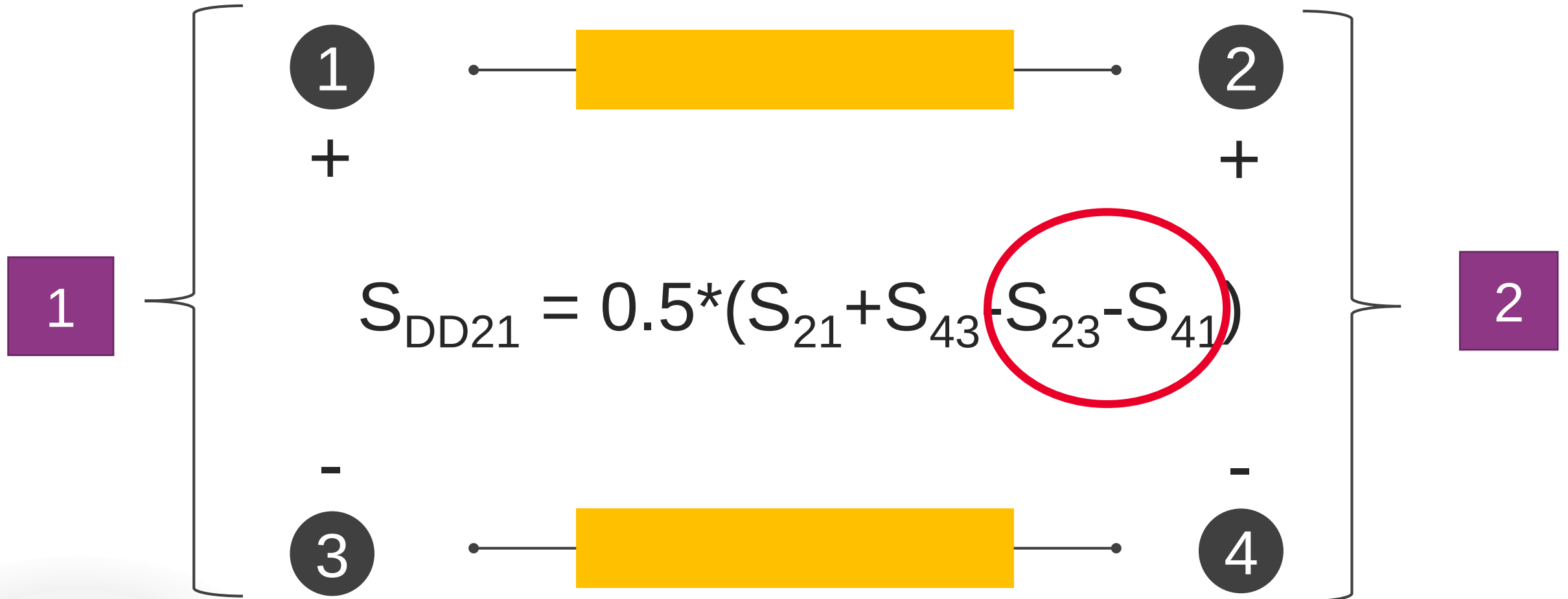
Converting Single-ended S-parameters to Mixed-mode

S_{DD21} Example

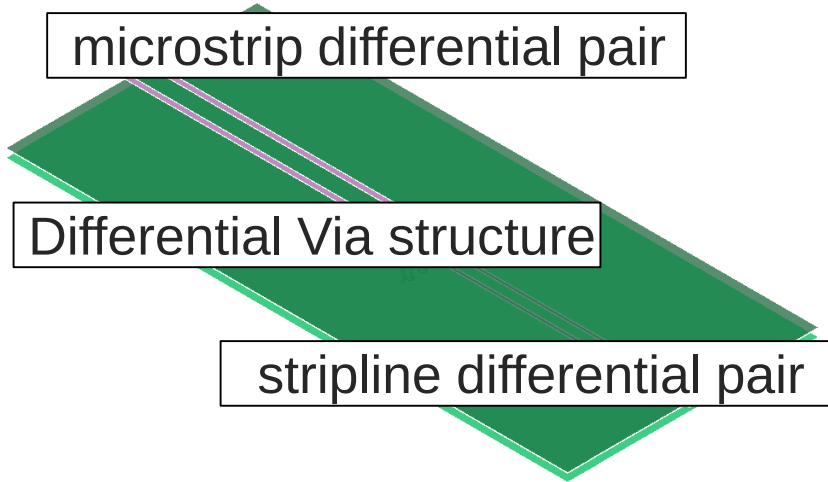


Converting Single-ended S-parameters to Mixed-mode

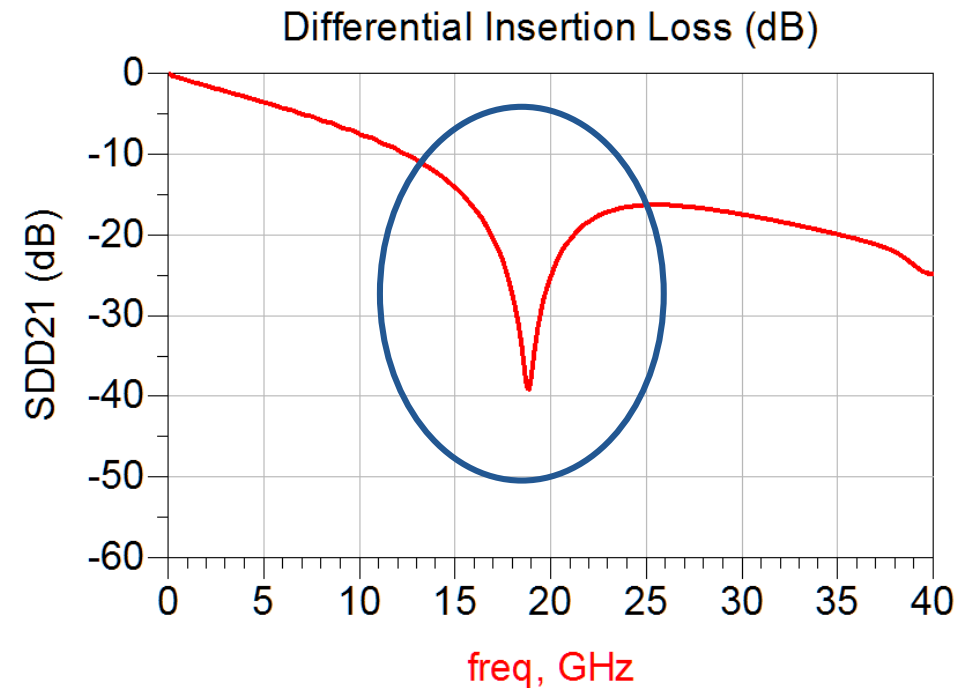
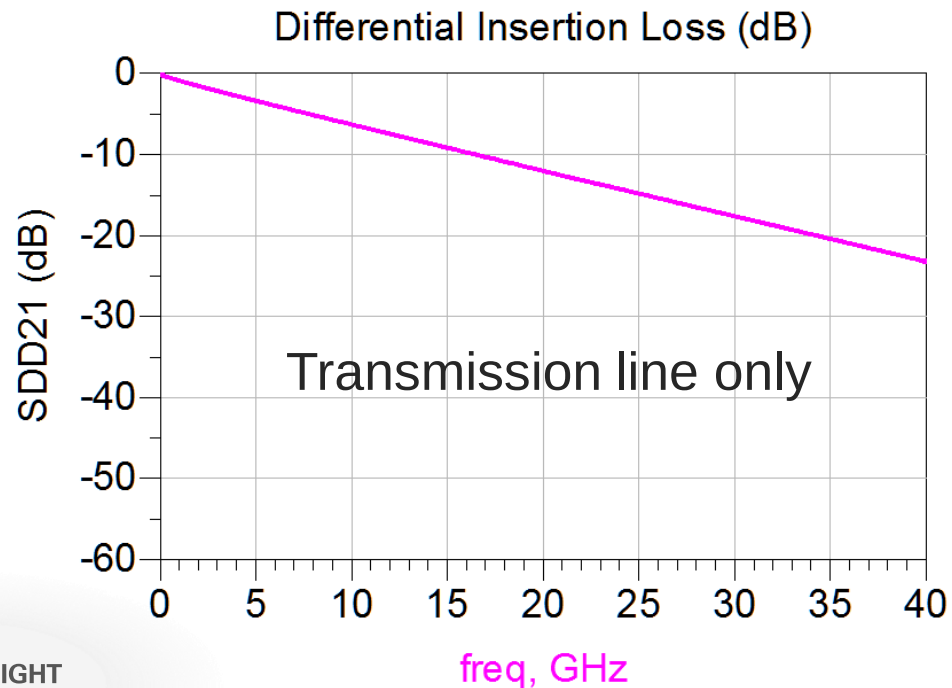
S_{DD21} Example



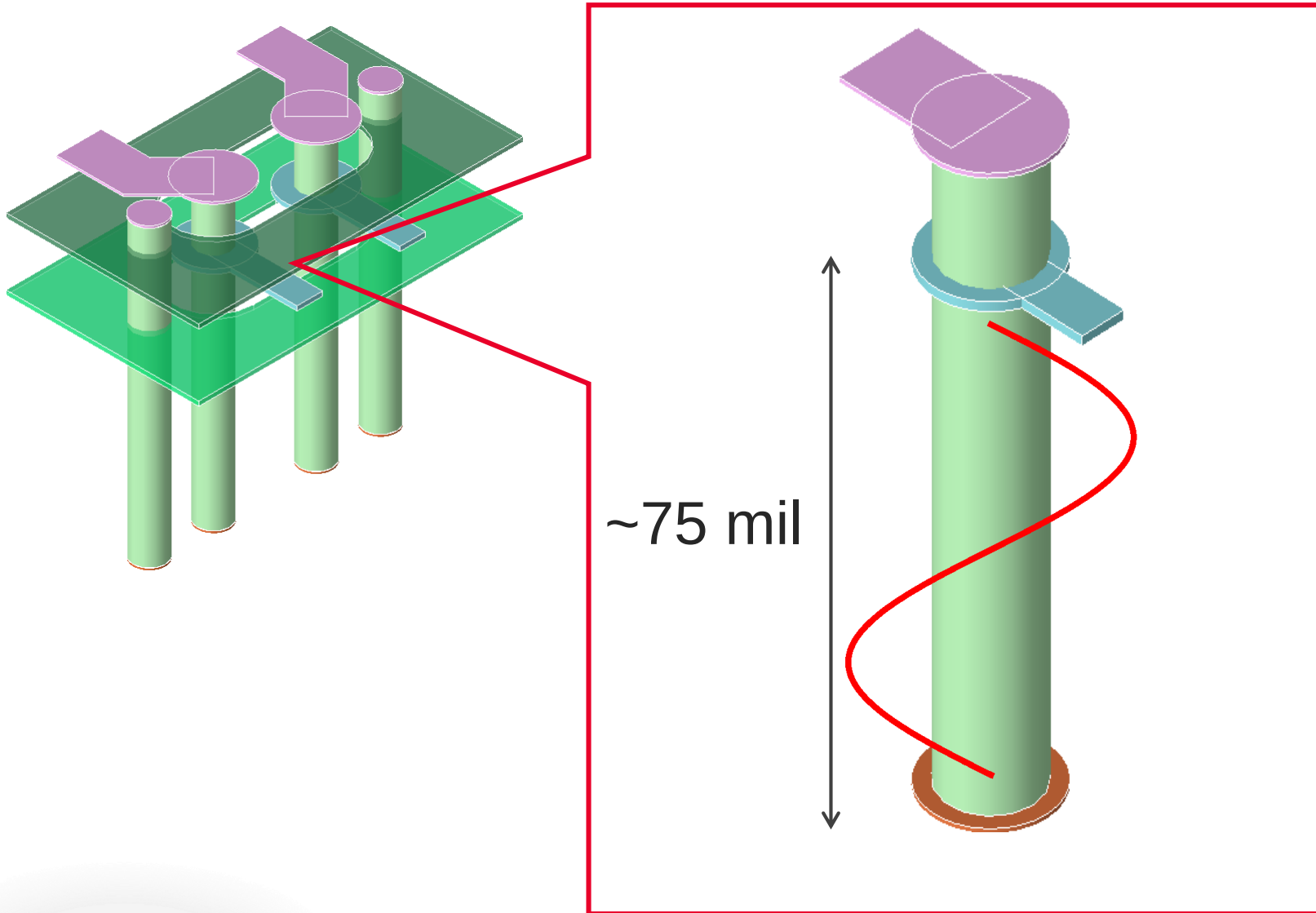
Simulate Only the Transmission Lines



Structure	3-inch microstrip	Via	3-inch stripline
Estimated Loss (dB at Nyquist)	5	Small	5



Via Structure Consists of Transmission Line

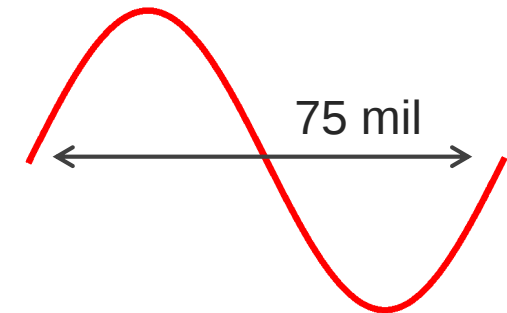


Data rate: 32 Gbps

Nyquist: 16 GHz

Bandwidth: $5 \times 16 = 80$ GHz

Wavelength: $6 \text{ in/nsec} / 80 \sim 75 \text{ mil}$

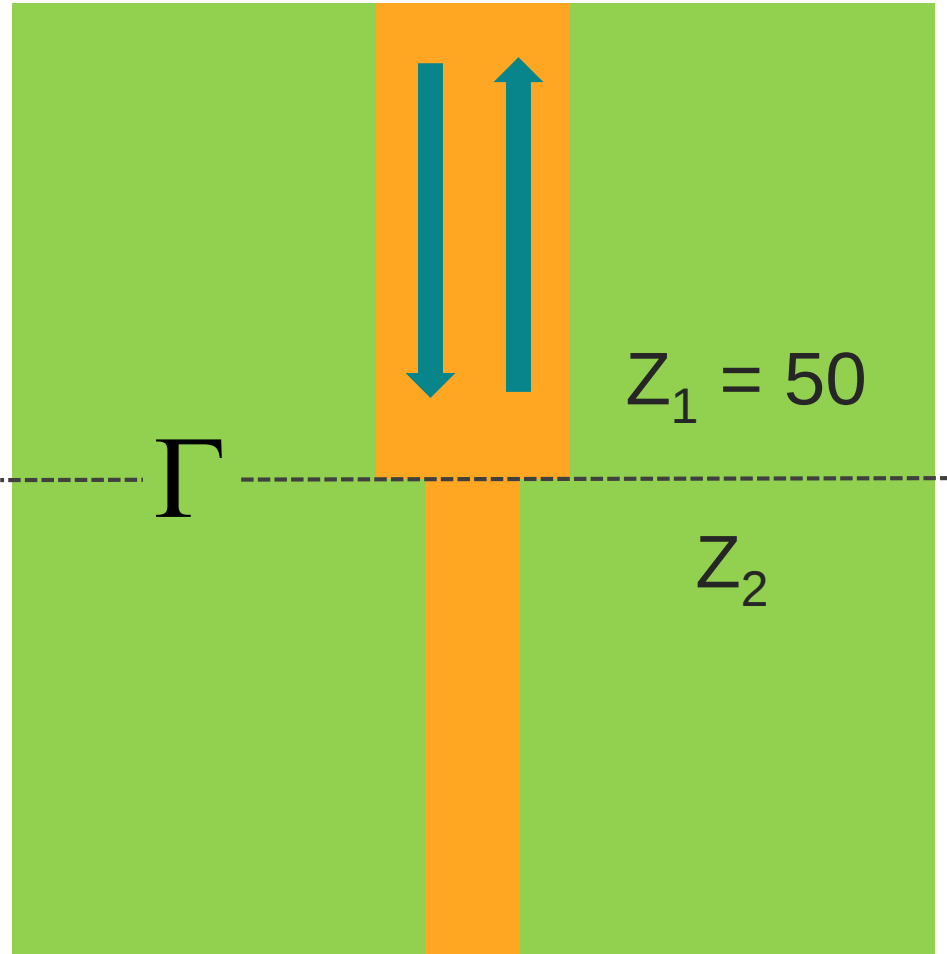


Transmission line:

Voltages and currents vary in magnitude and phase over physical length.

Impedance Discontinuity Creates Reflection in TLine

Top View



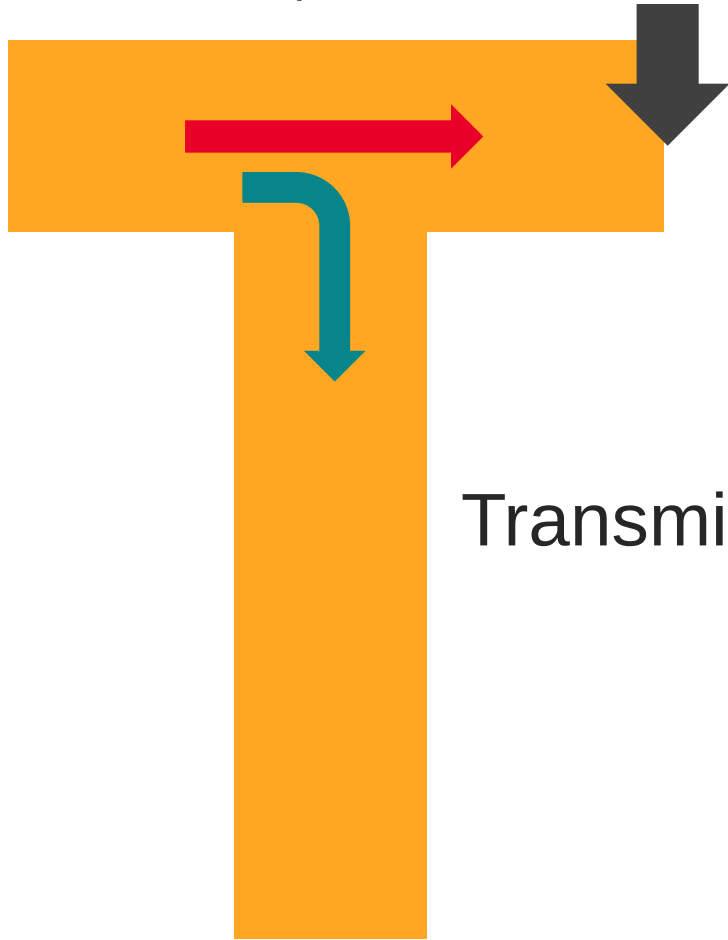
Γ : Reflection Coefficient

$$\Gamma = \frac{Z_2 - Z_1}{Z_1 + Z_2}$$

Z_2 (Ohm)	Z_2 short	$Z_2 < 50$	$Z_2 = 50$	$Z_2 > 50$	Z_2 open
Γ	-1	$-1 < \Gamma < 0$	0	$0 < \Gamma < 1$	1

What Can Reflected Waves Do?

Top View

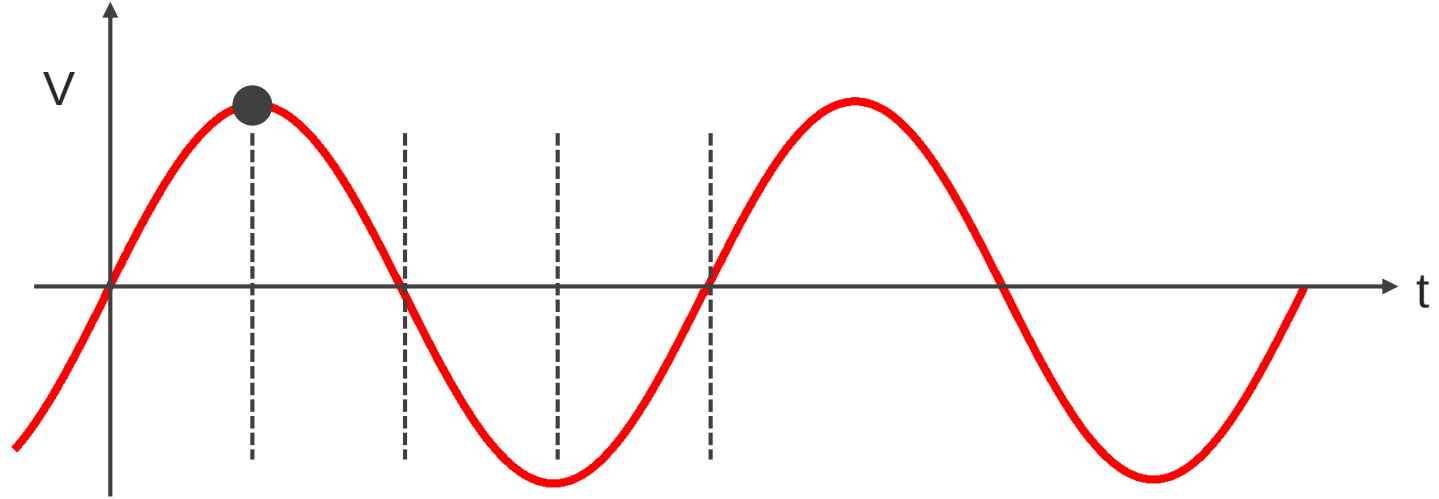
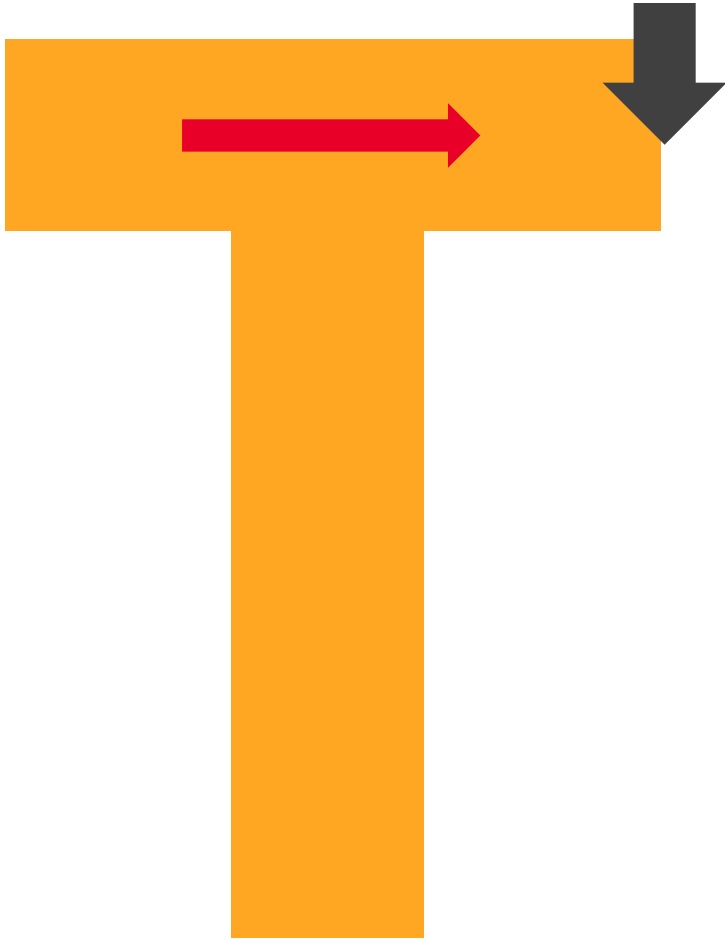


Transmission line stub

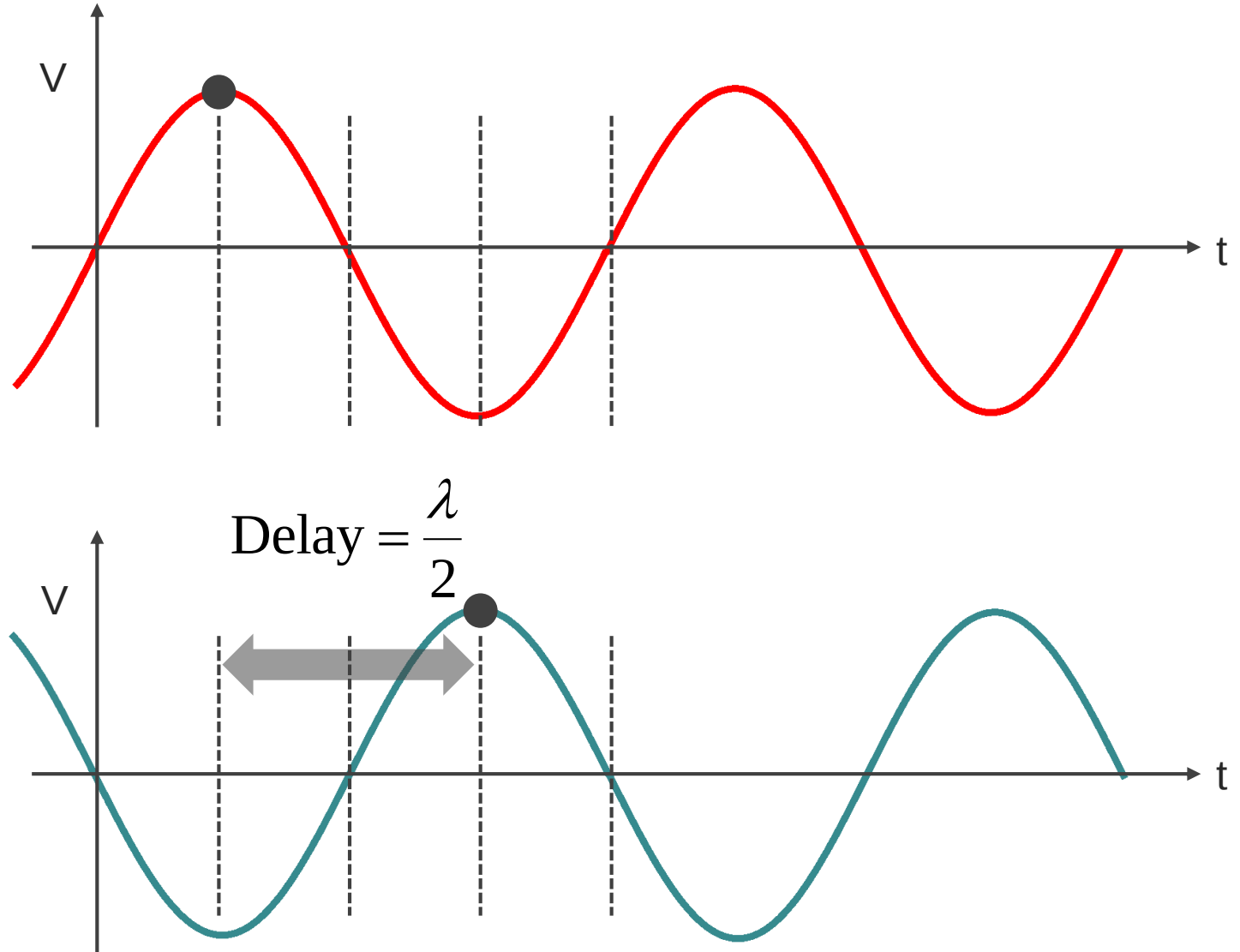
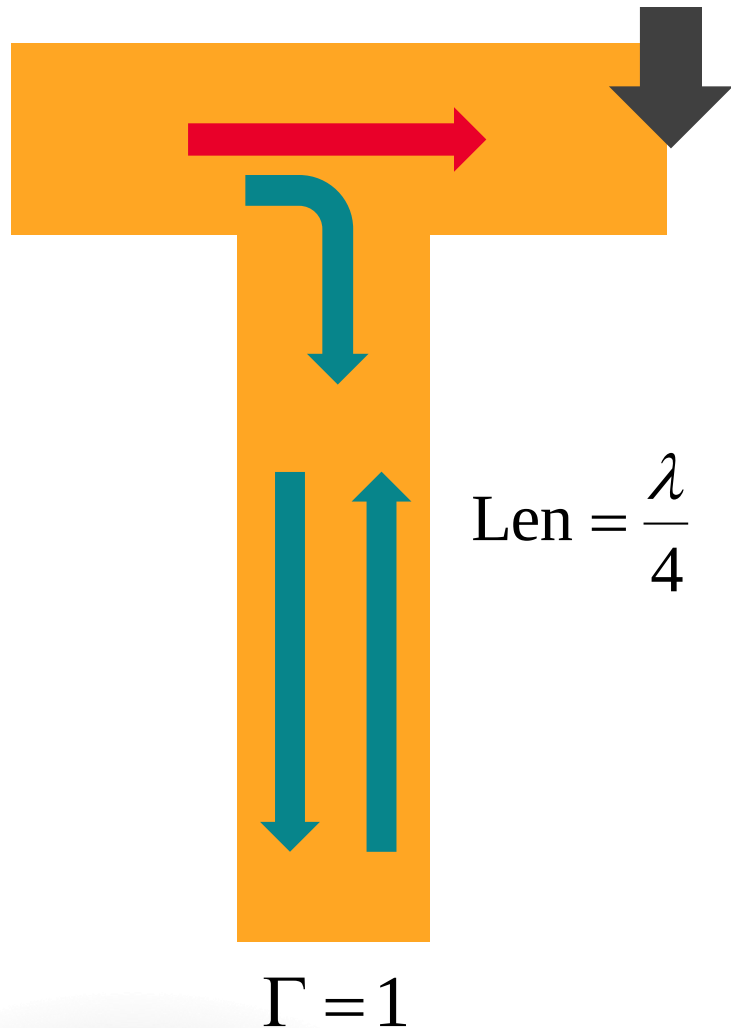
Open

Wave Propagation Path Not Through Stub

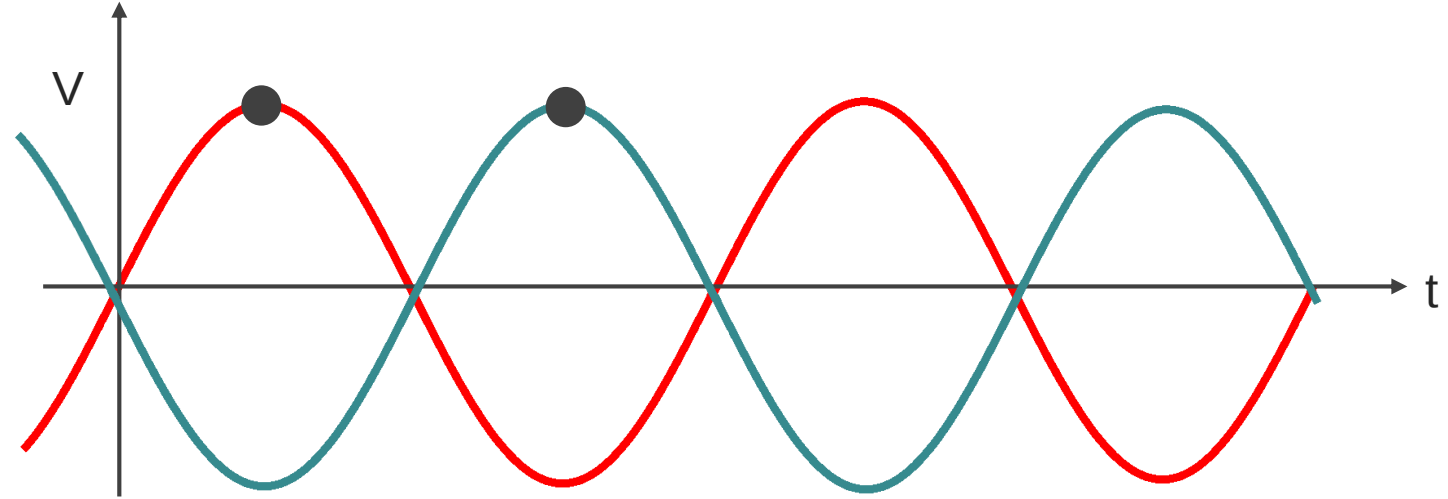
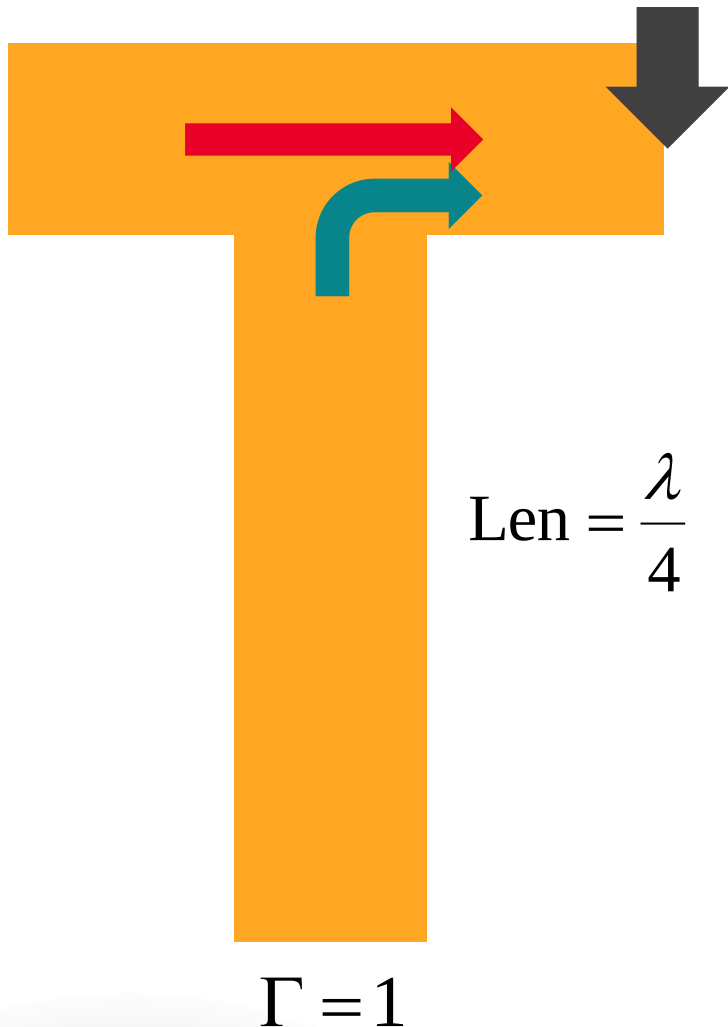
Top View



Wave Propagation in the Stub Direction



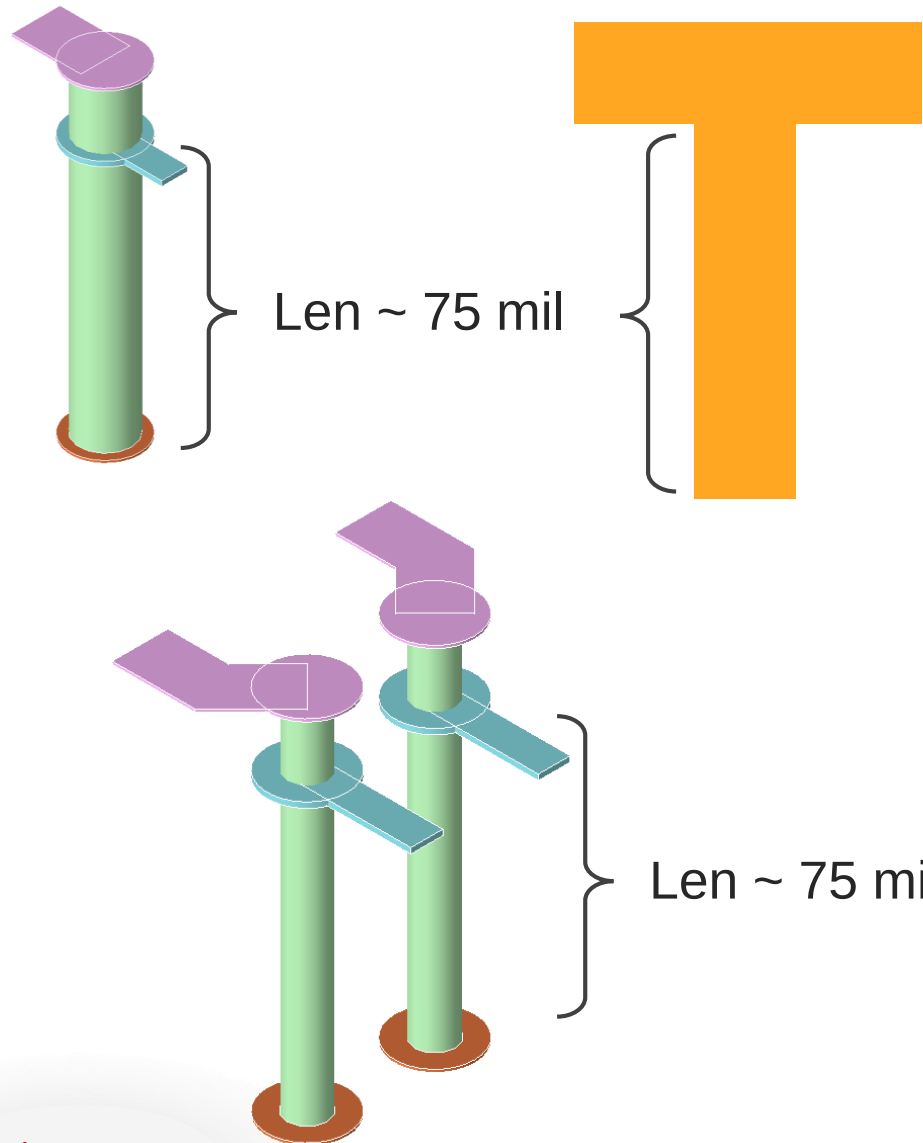
Quarter-wave Stub Resonance Minimizes Transmission



Quarter-wave stub resonance

At frequency where the physical length of the stub is a quarter of a wave length, it seems like nothing is being transmitted (virtual short).

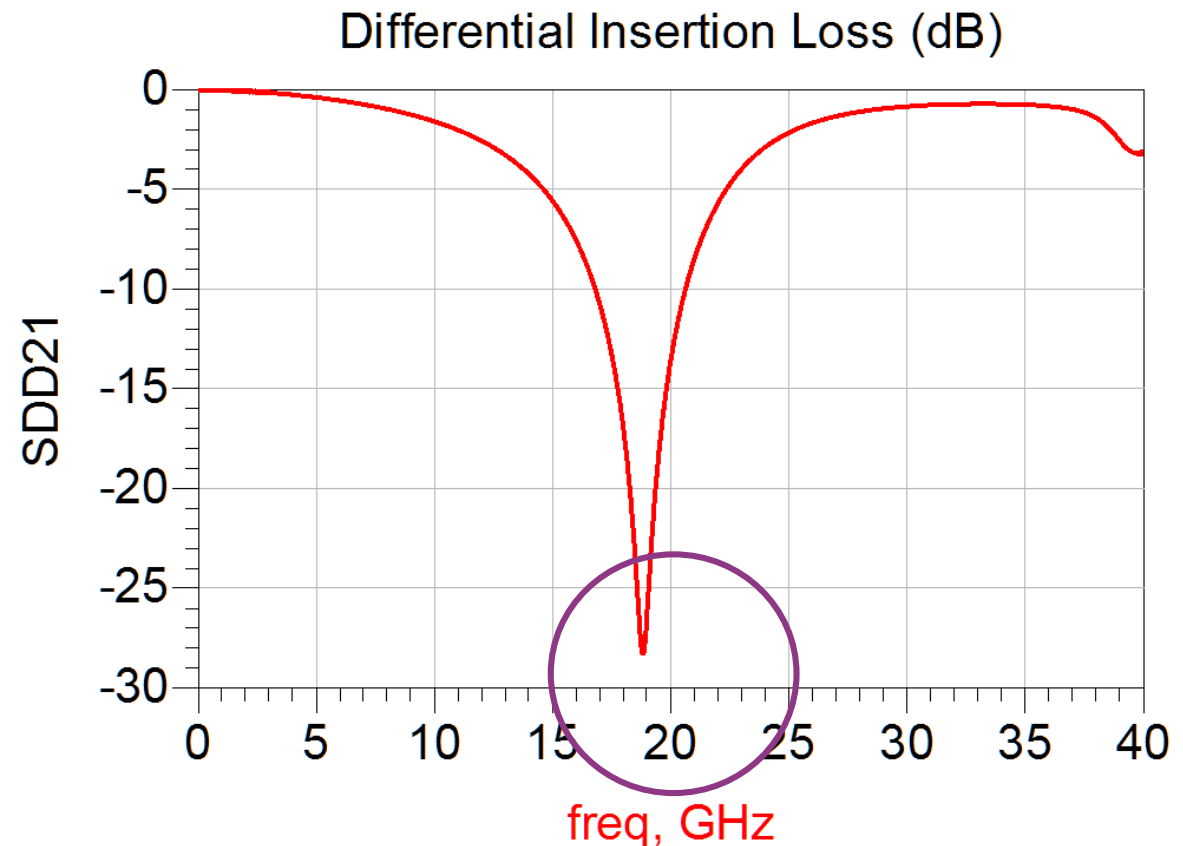
Transmission Line Resonance Example



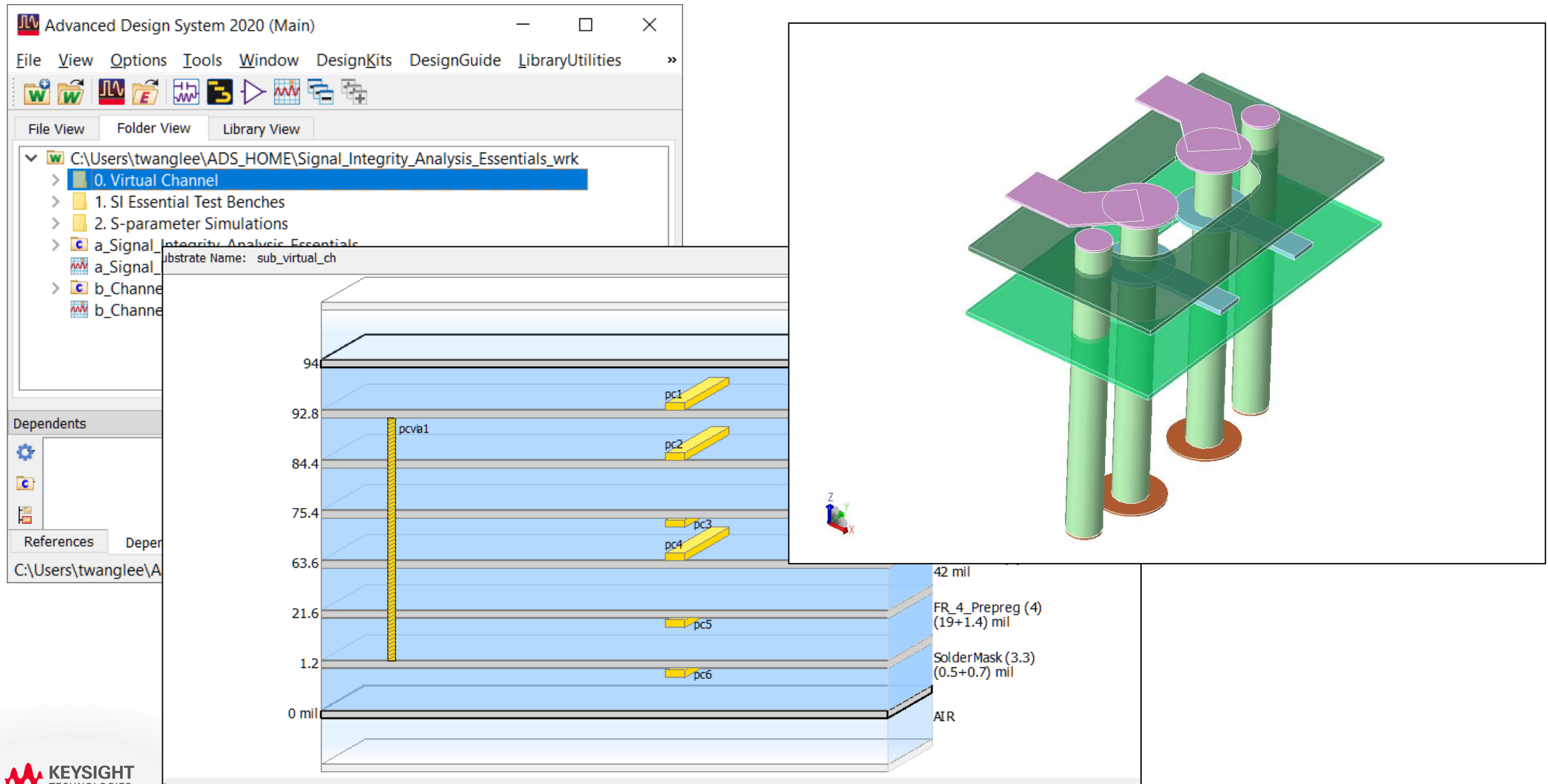
$$len = \frac{\lambda}{4} \rightarrow \lambda = 4 \cdot len \quad f_{res} = \frac{v}{\lambda} = \frac{v}{4 \cdot len} \quad v \approx 6 \frac{\text{in}}{\text{nsec}}$$

$$f_{res} (\text{GHz}) = \frac{1.5}{len (\text{in})}$$

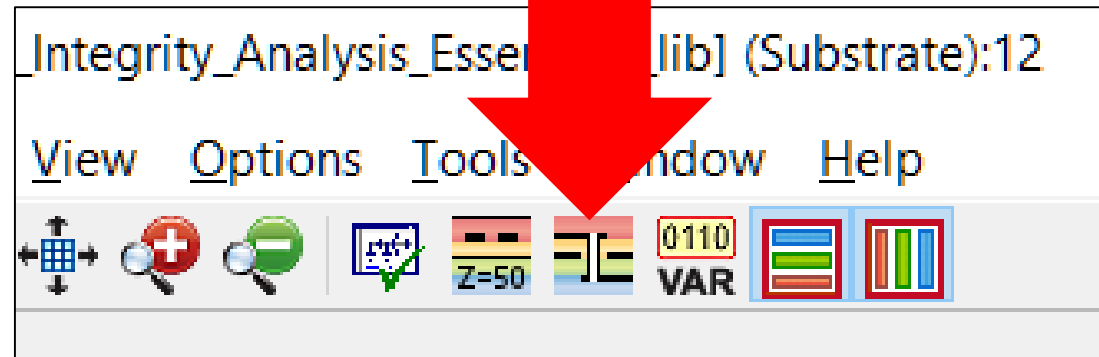
For FR4, expect $f_{res} = 20 \text{ GHz}$



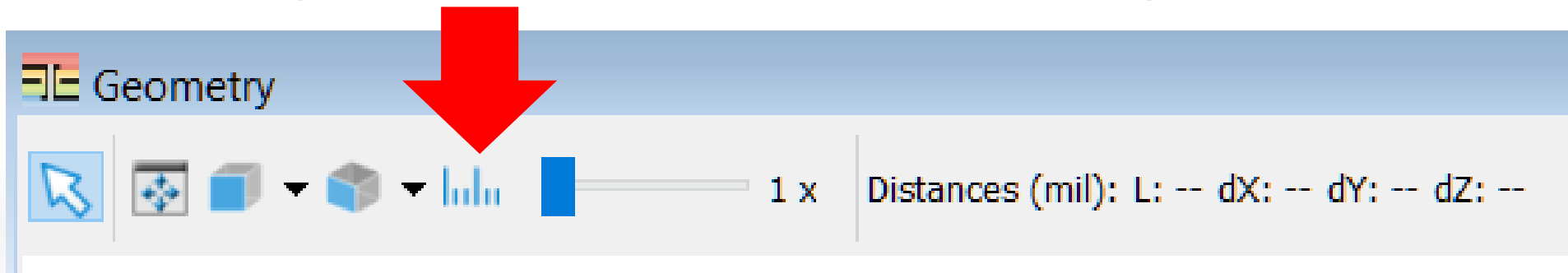
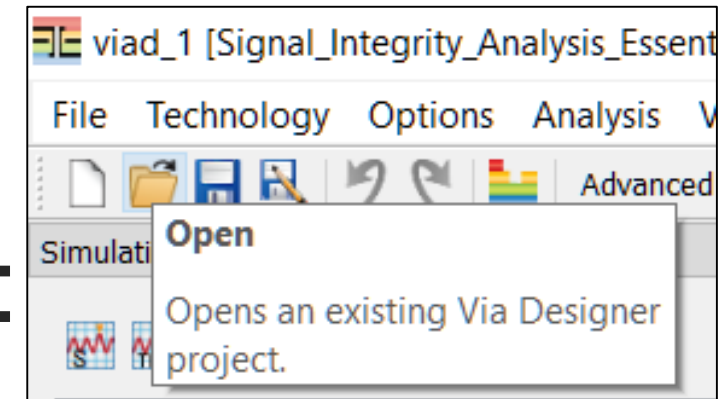
Lab 4: Use Via Designer to Explore Stub Resonance



Lab 4 Exercises



1. Open substrate window in folder:
0. Virtual Channel/sub_virtual_ch
2. Use Via Designer, go to File/open/:
via_w_stub.viad
3. In Via Designer, measure the length of the stub:

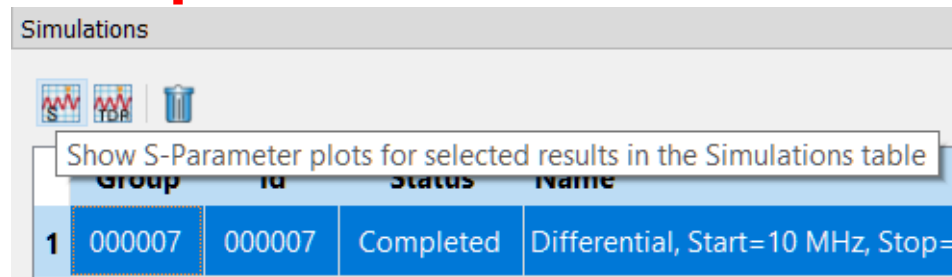


Lab 4 Exercises Continued

4. Answer the following questions:

What is the length of the Stub?

What do you expect the resonance frequency to be?



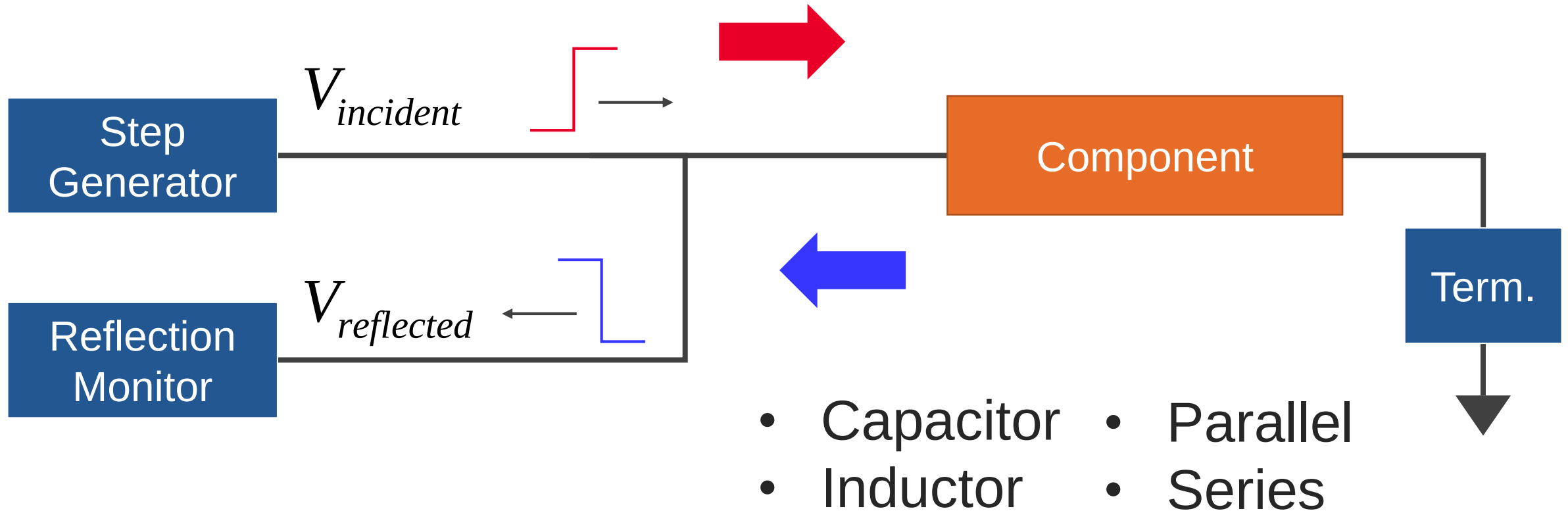
The screenshot shows a 'Simulations' window with a table of simulation results. A tooltip is visible over the table, stating 'Show S-Parameter plots for selected results in the Simulations table'. The table has columns for Group, Id, Status, and Name. One row is visible with the following data:

Group	Id	Status	Name
1	000007	Completed	Differential, Start=10 MHz, Stop=4

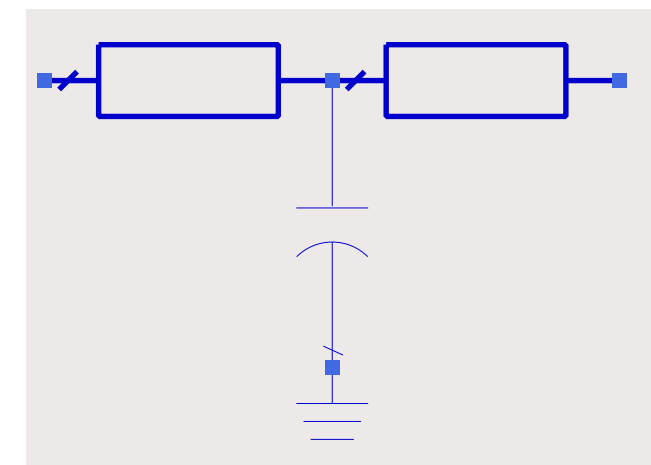
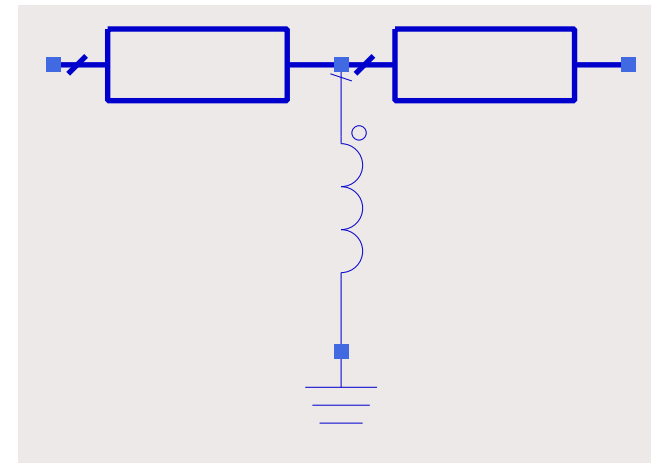
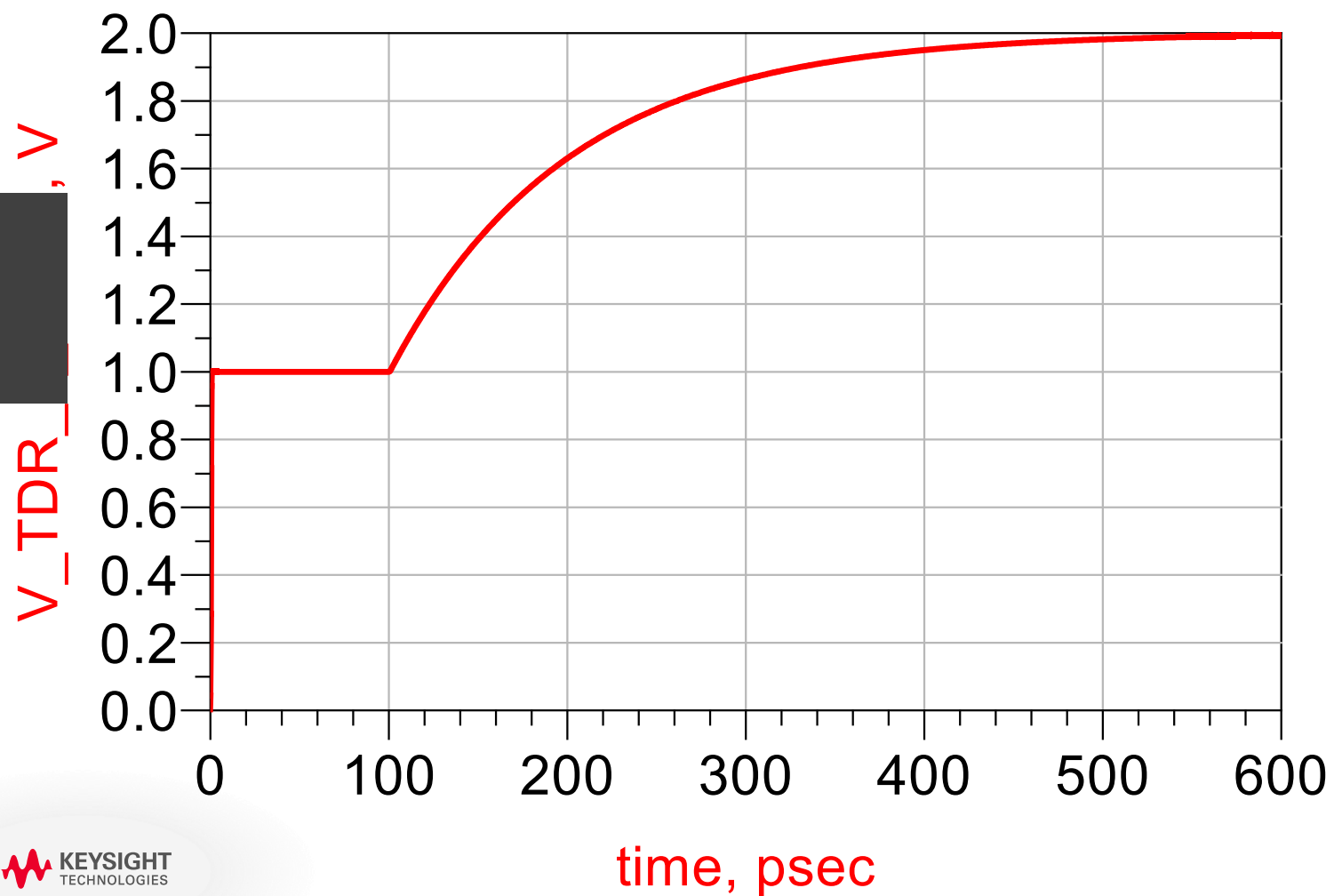
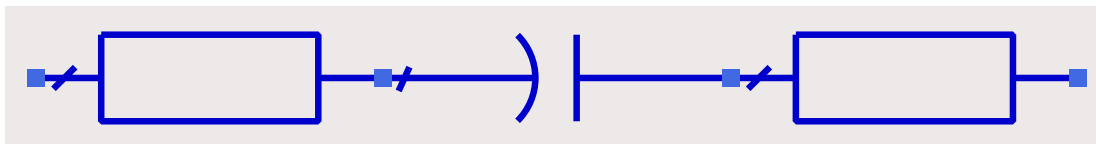
5. Look at the S-parameter results of the via:

Is the Insertion loss of single ended S-parameter the same as differential? Why and Why not?

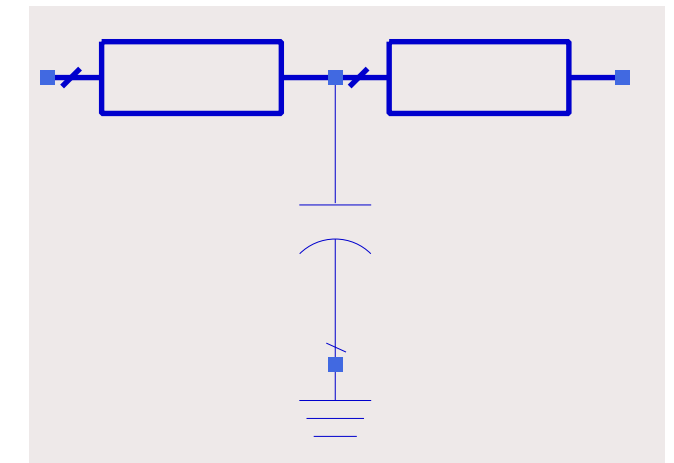
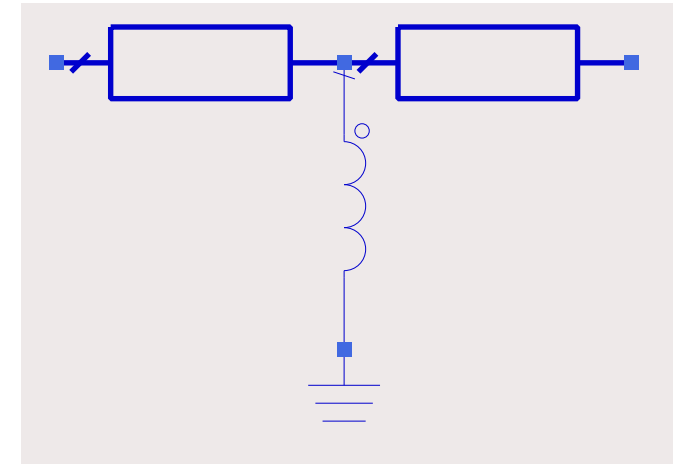
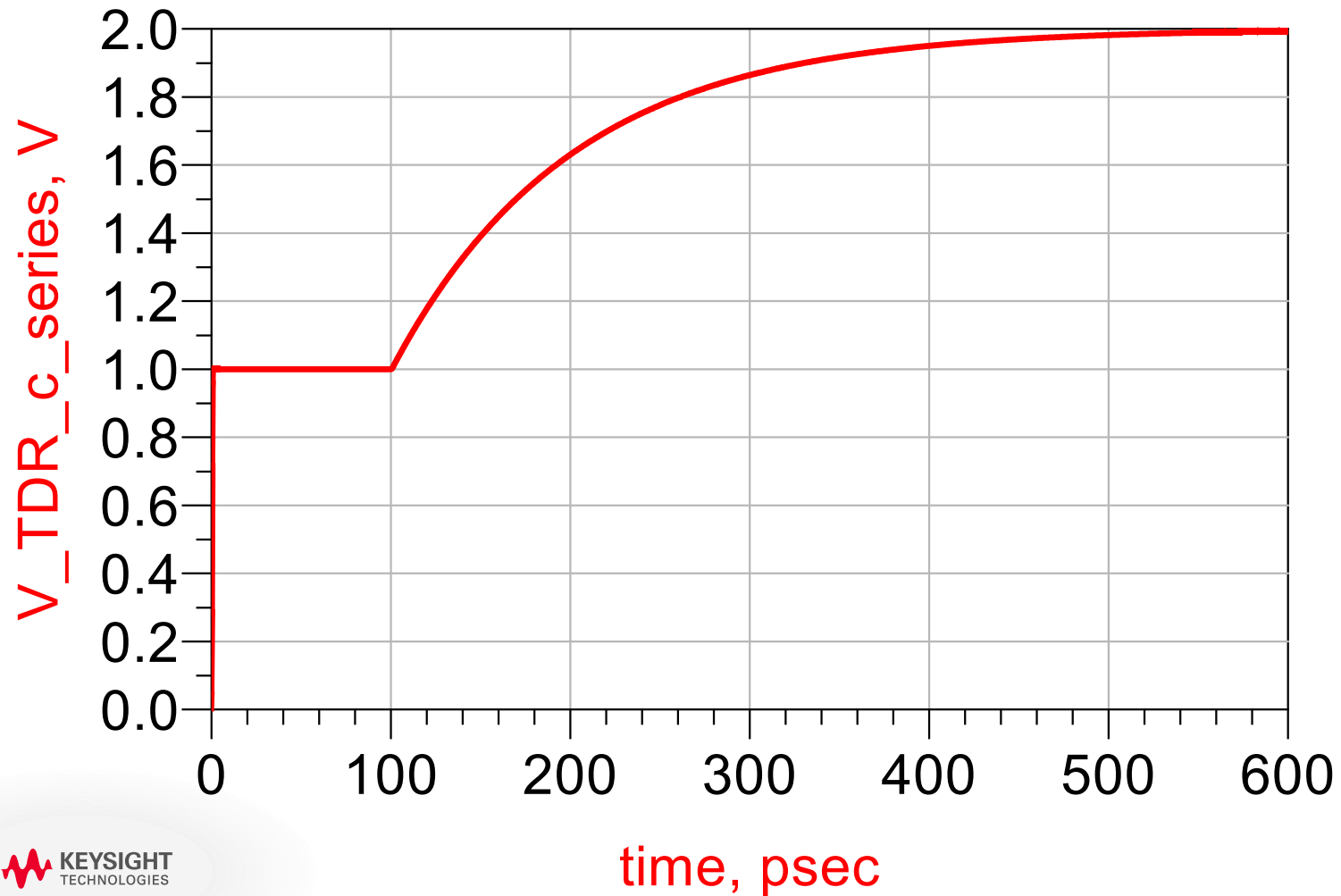
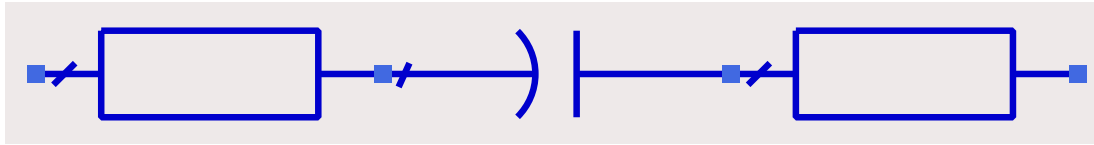
TDR Voltage Signatures for Inductor and Capacitor



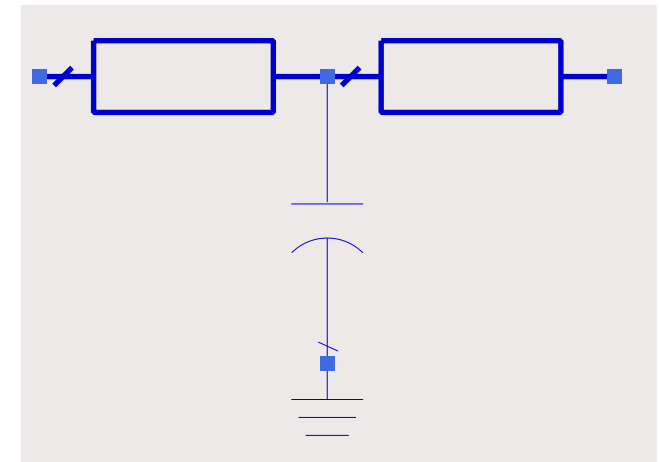
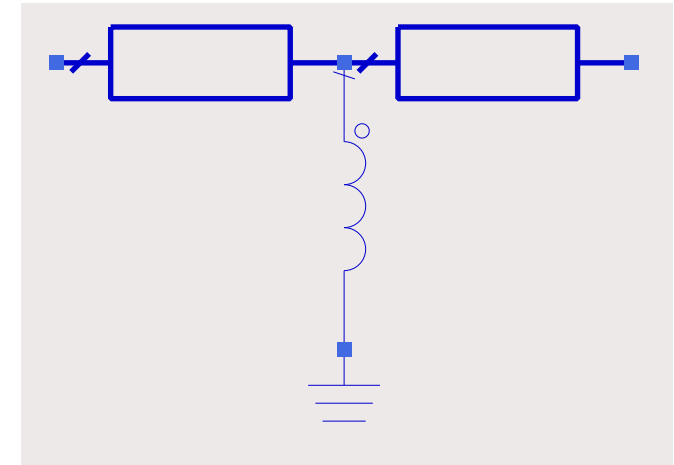
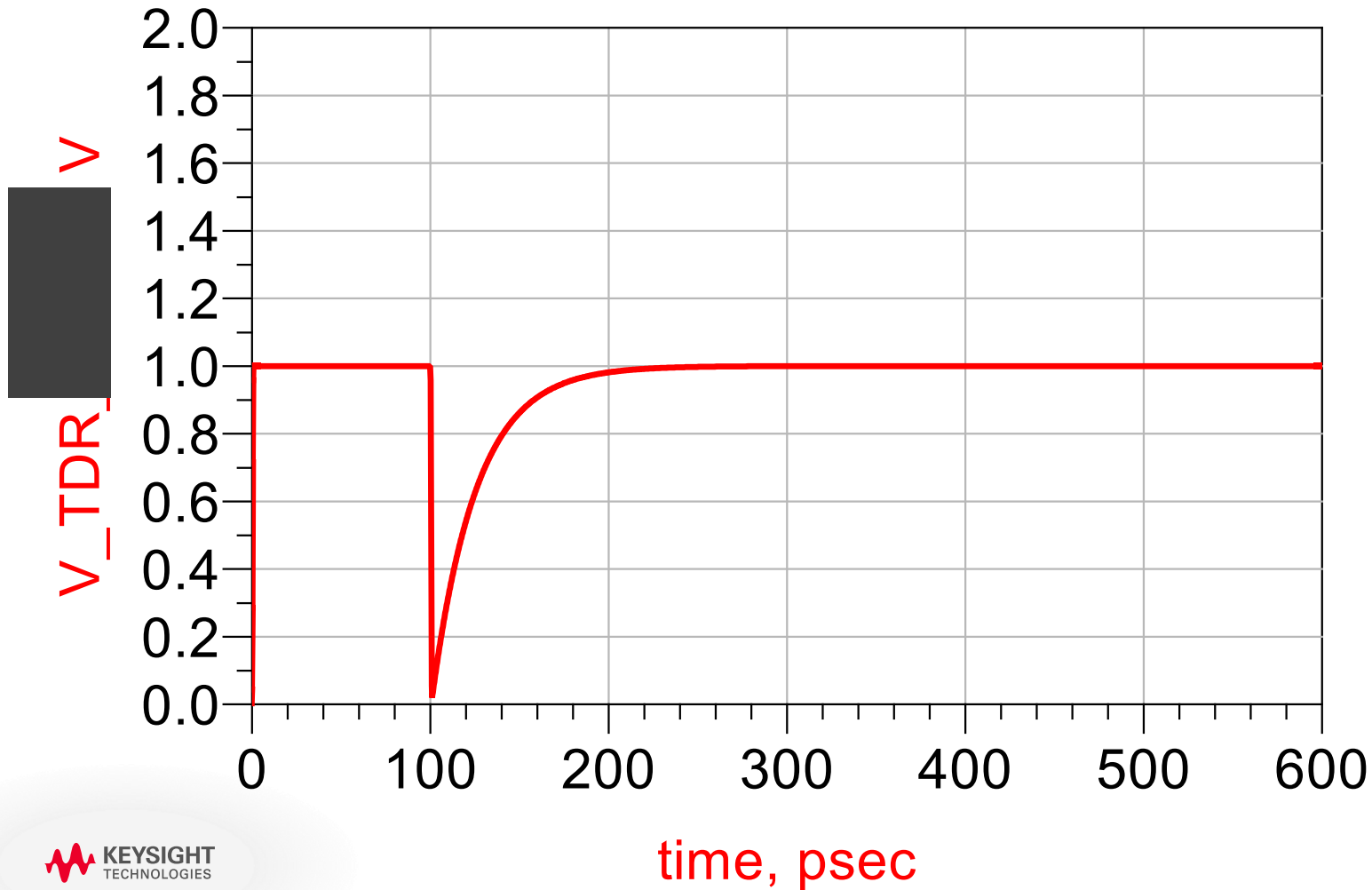
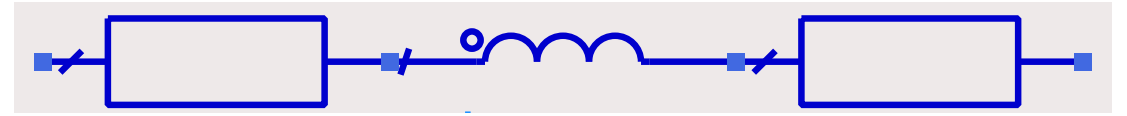
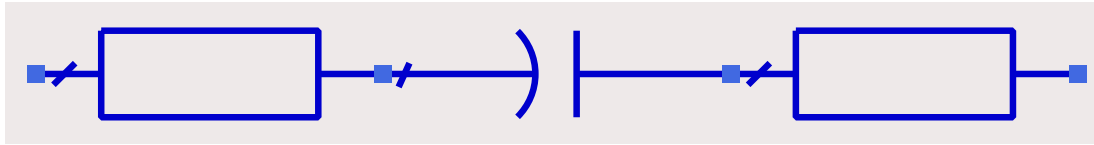
Quiz 1



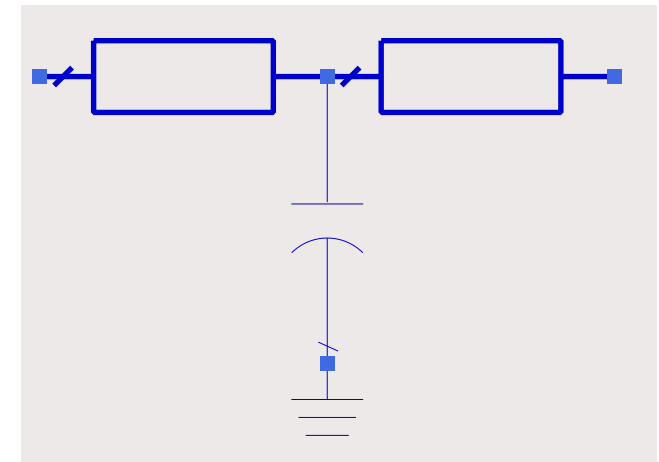
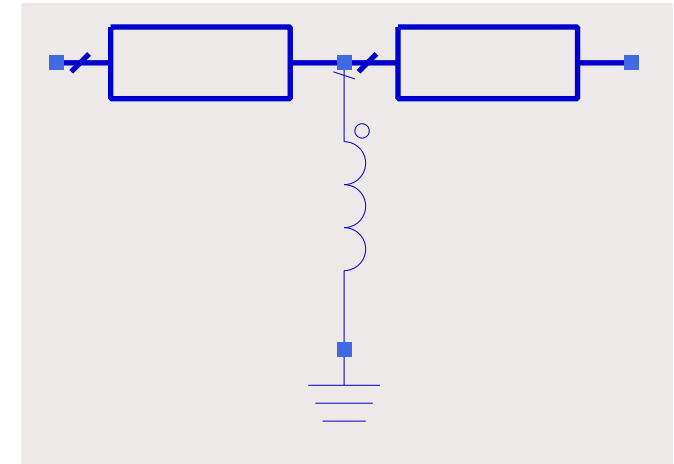
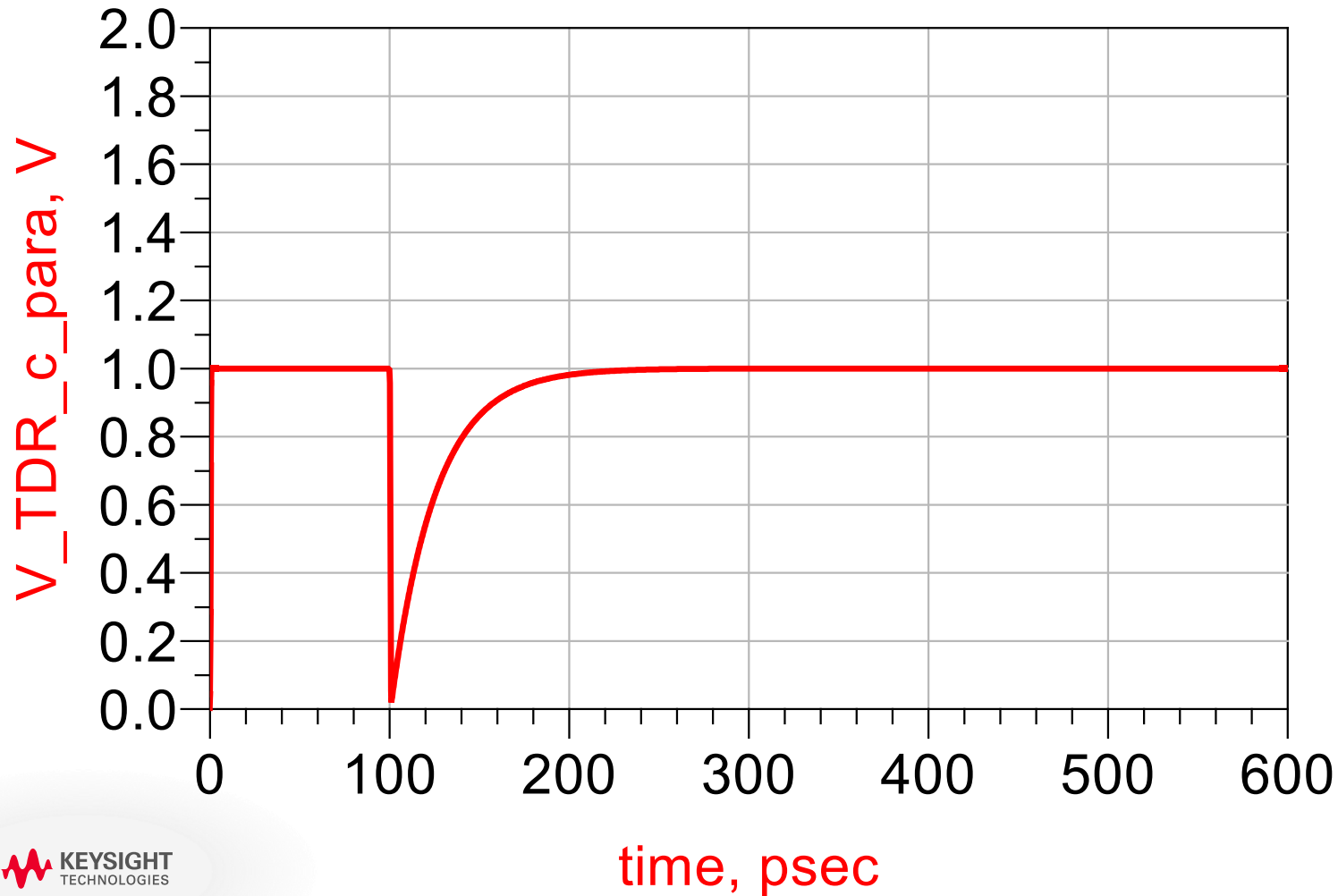
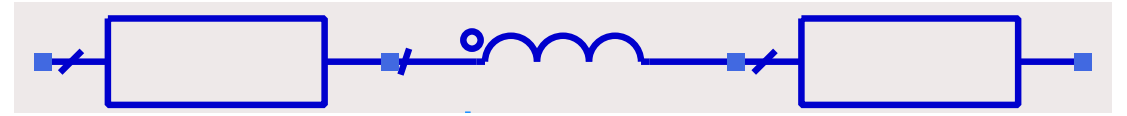
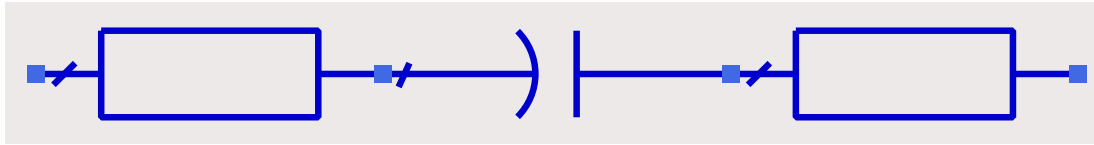
Quiz 1



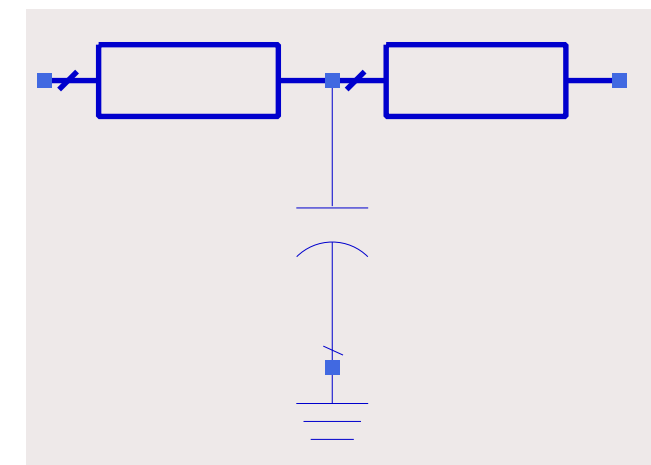
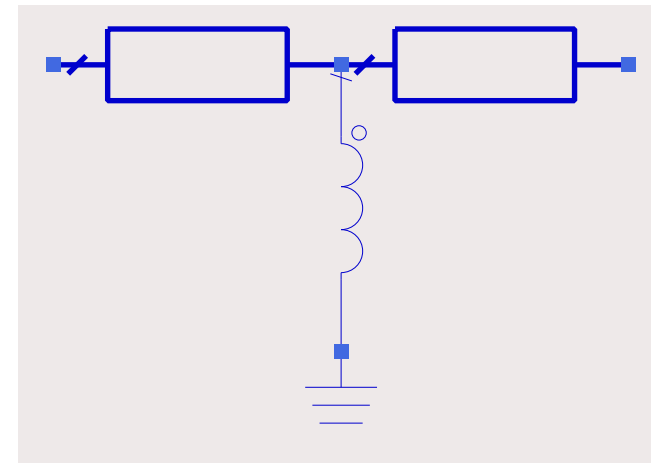
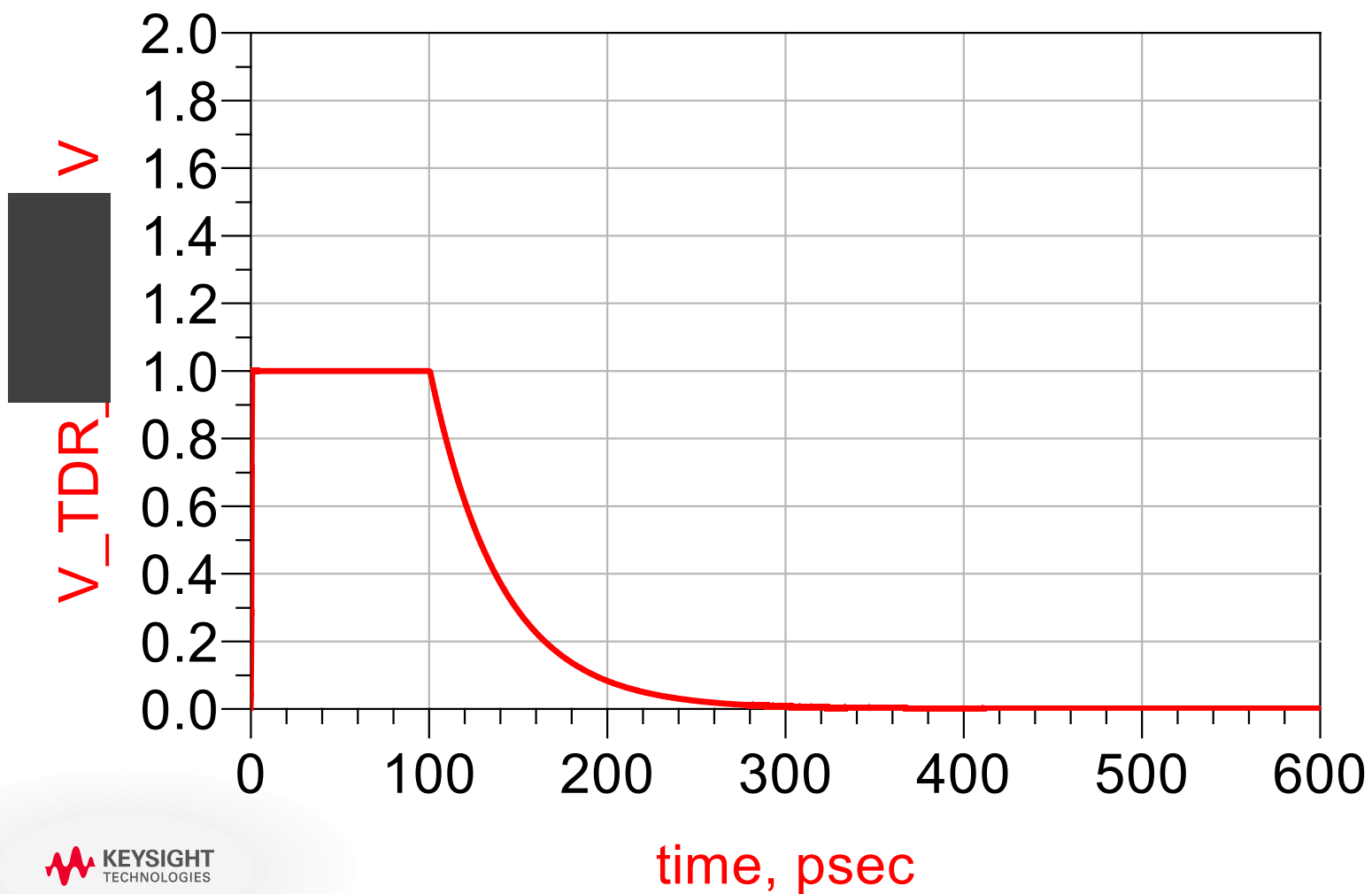
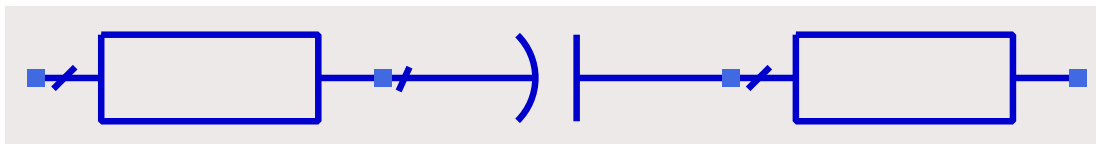
Quiz 2



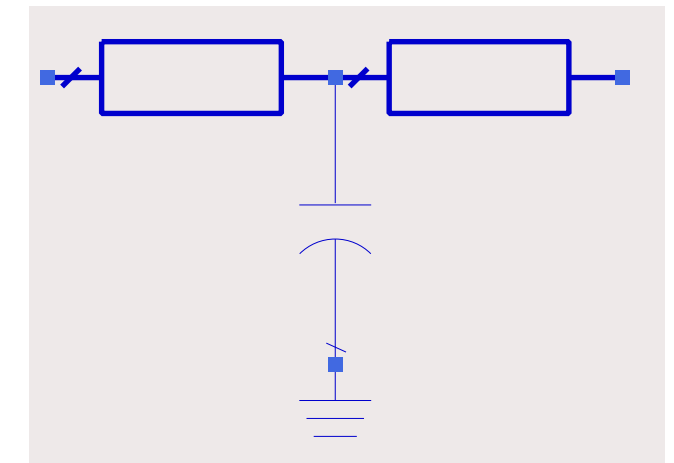
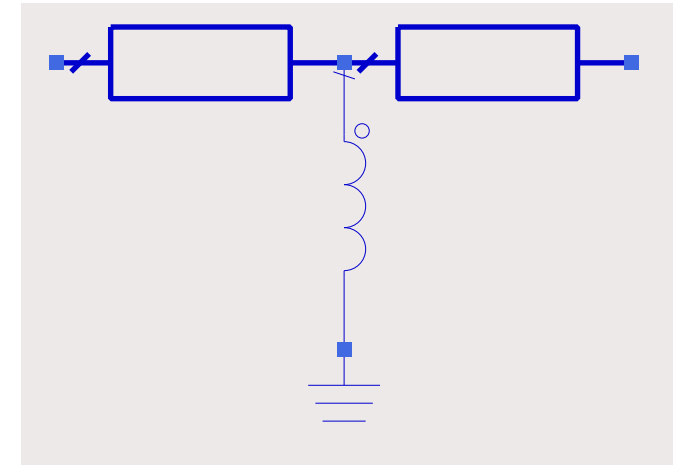
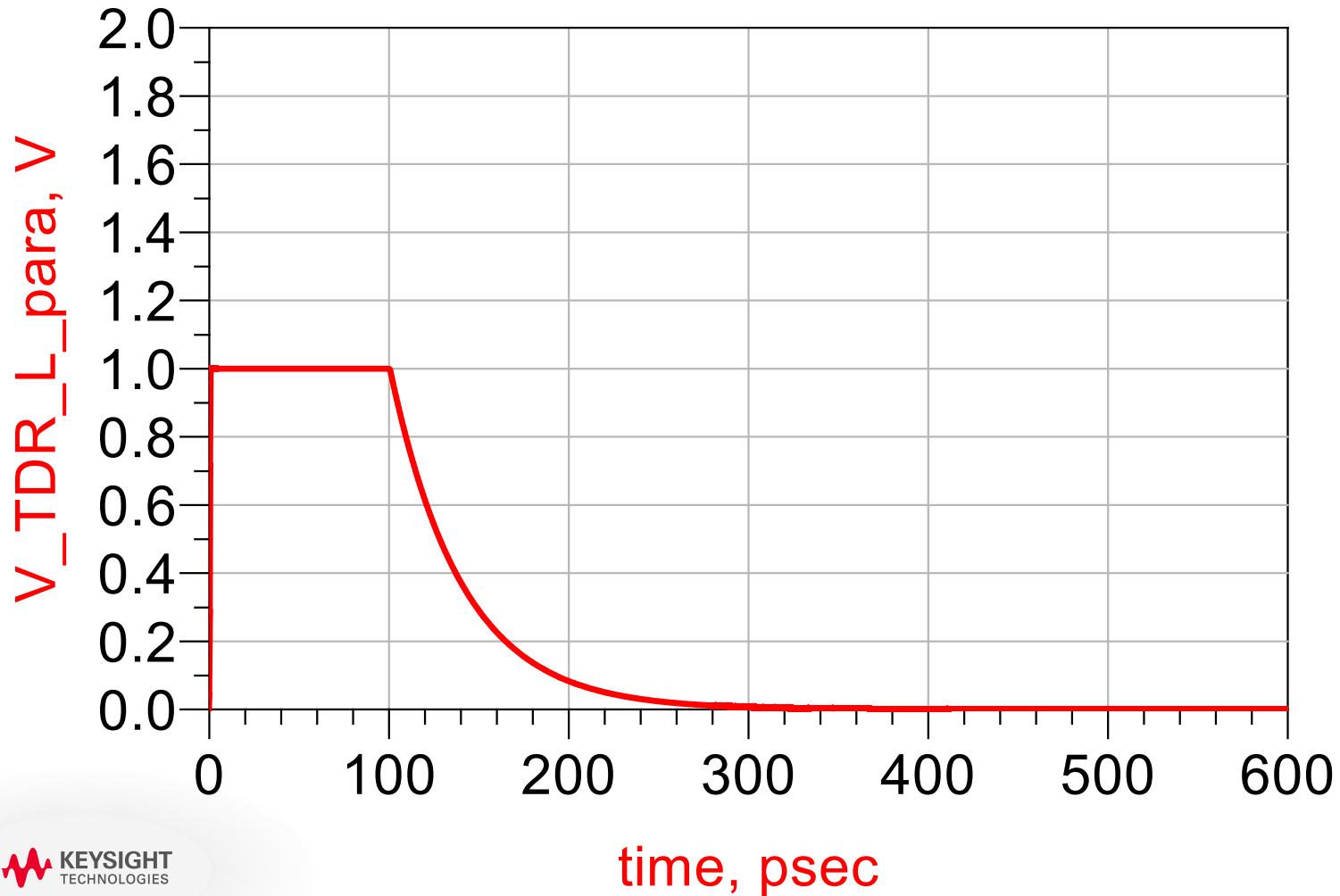
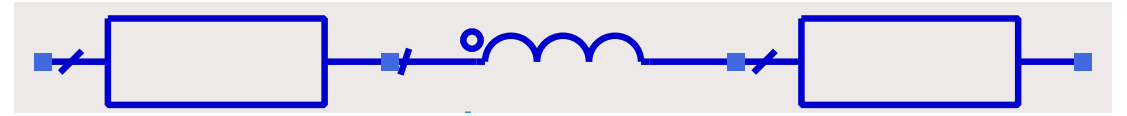
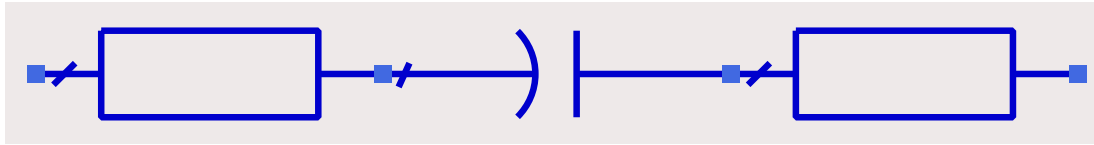
Quiz 2



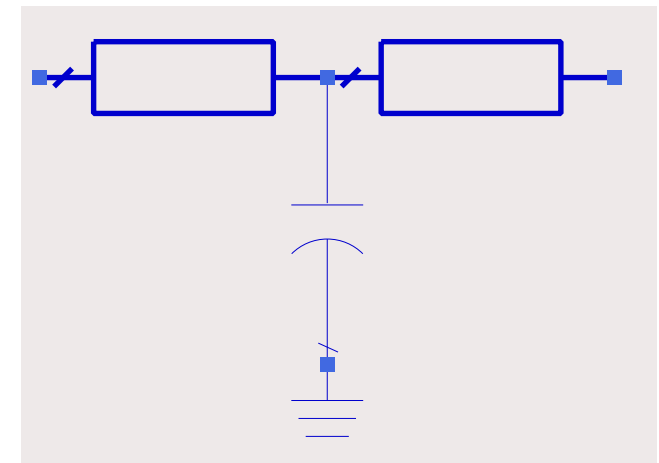
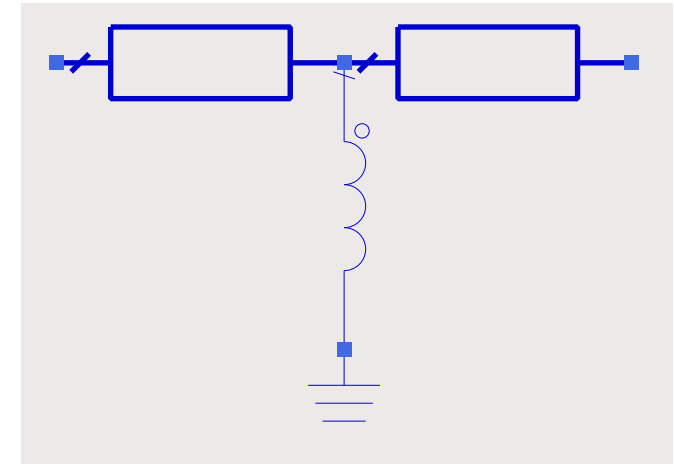
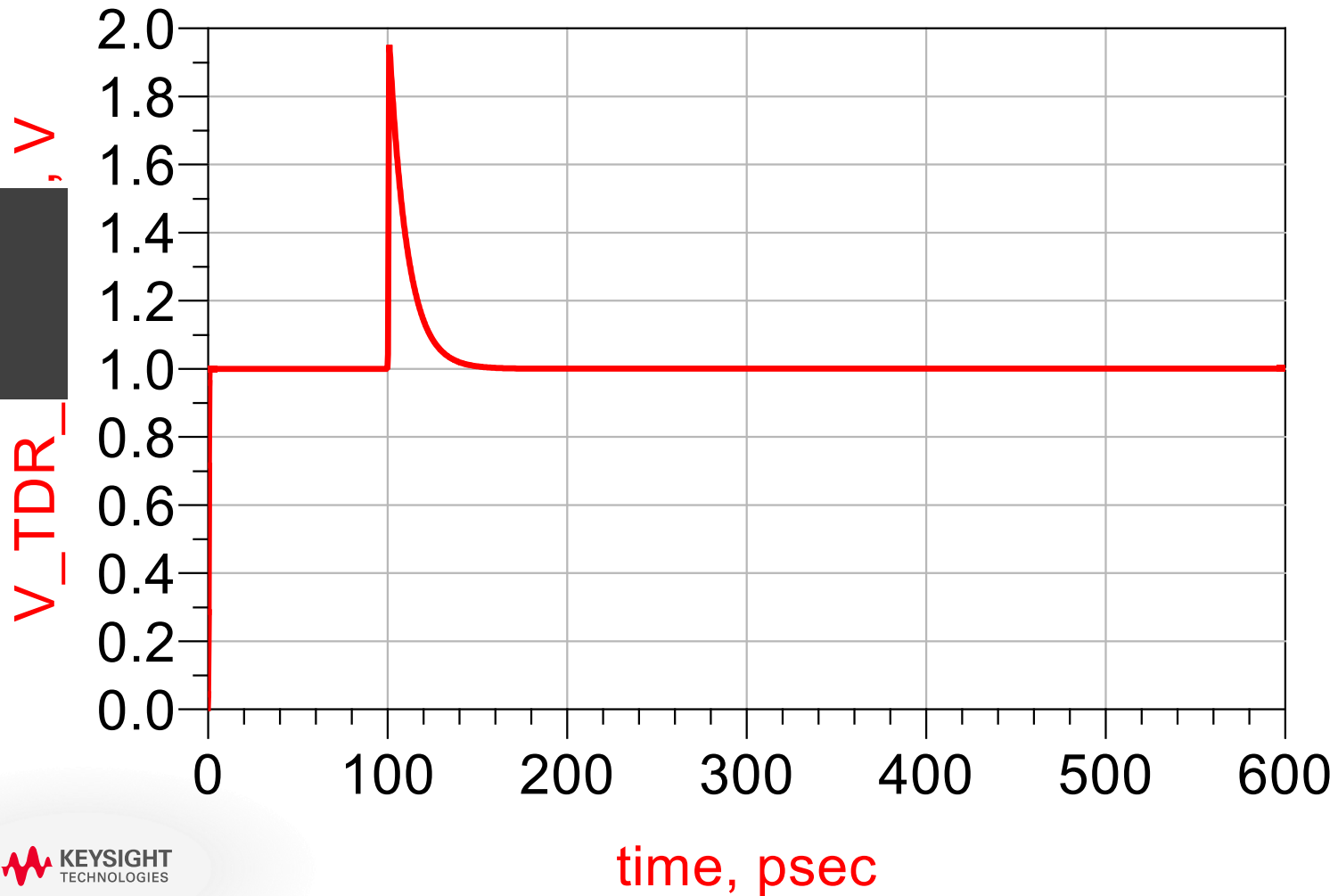
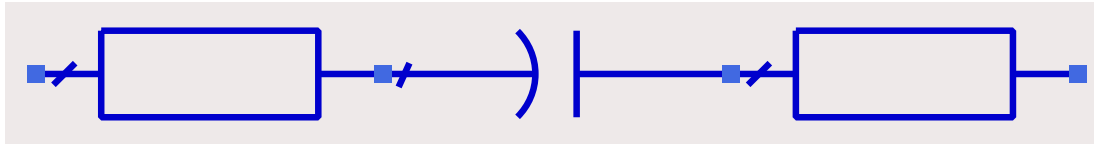
Quiz 3



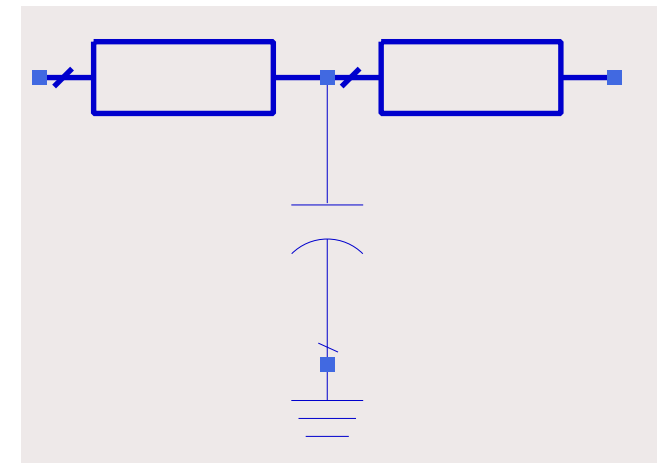
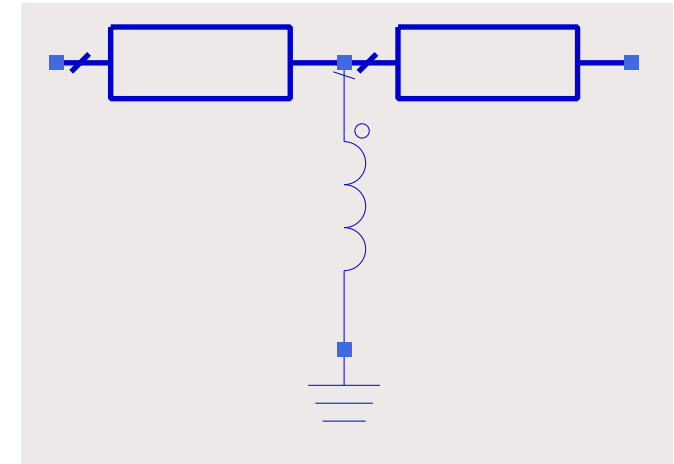
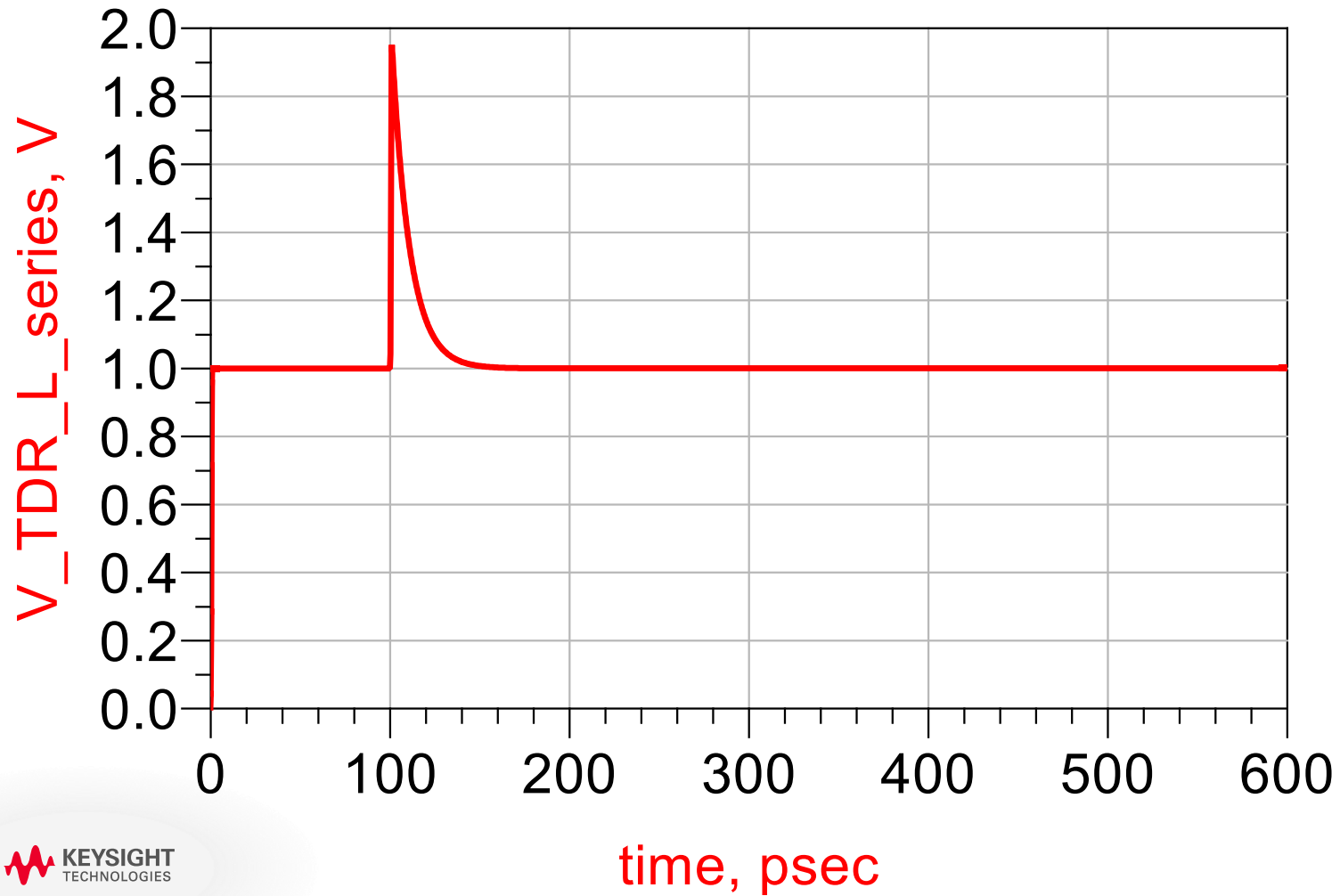
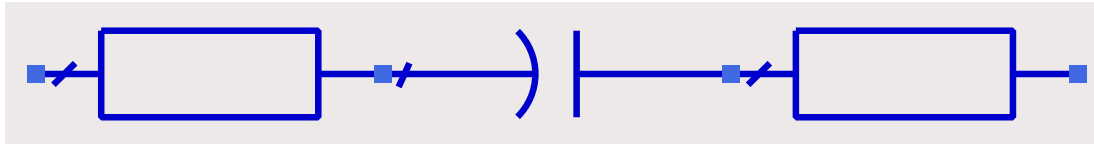
Quiz 3



Quiz 4

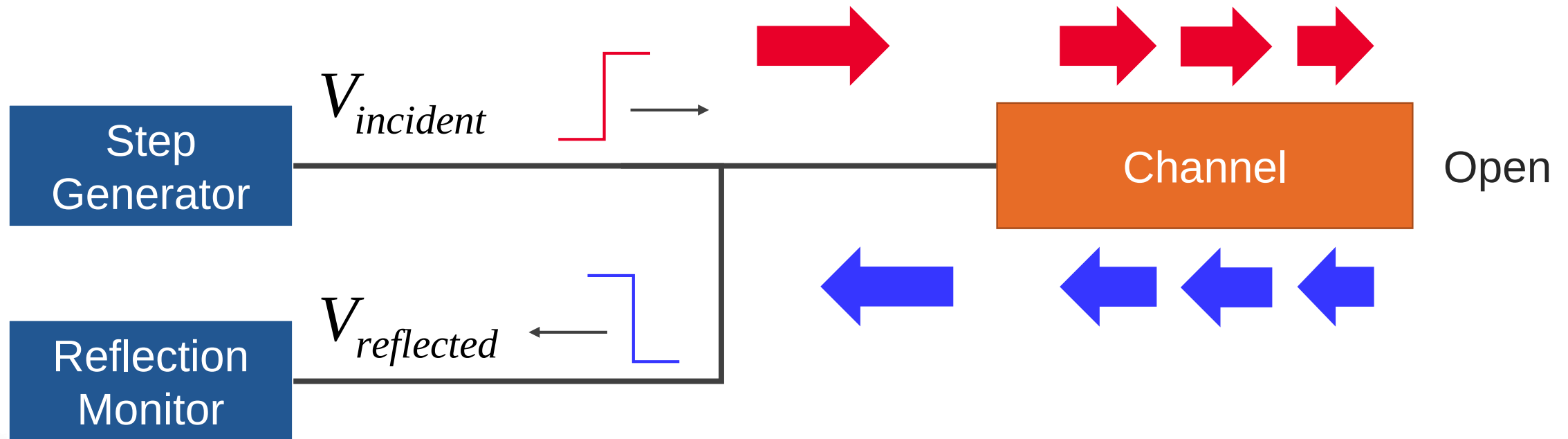


Quiz 4

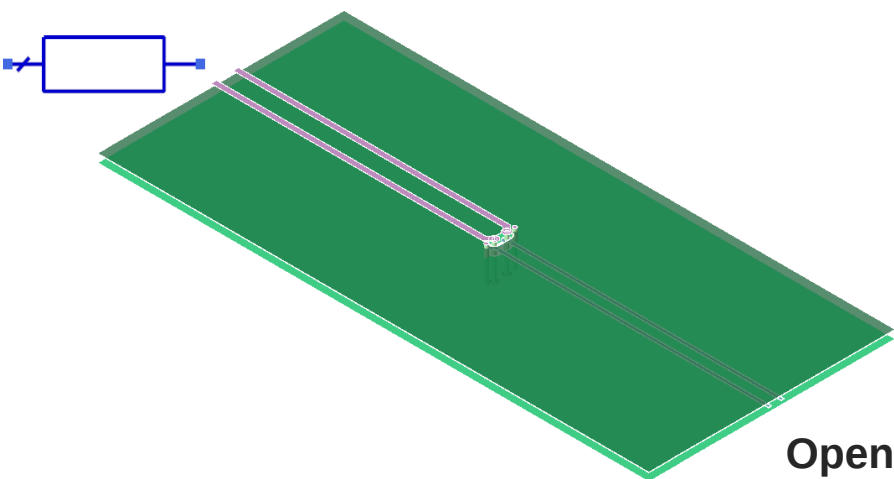


Perform Consistency Test with TDR Impedance Plot

$$Z_{DUT}(t) = Z_0 \frac{1 + \Gamma(t)}{1 - \Gamma(t)} \quad \Gamma(t) = \frac{V_{reflected}(t)}{V_{incident}(t)}$$



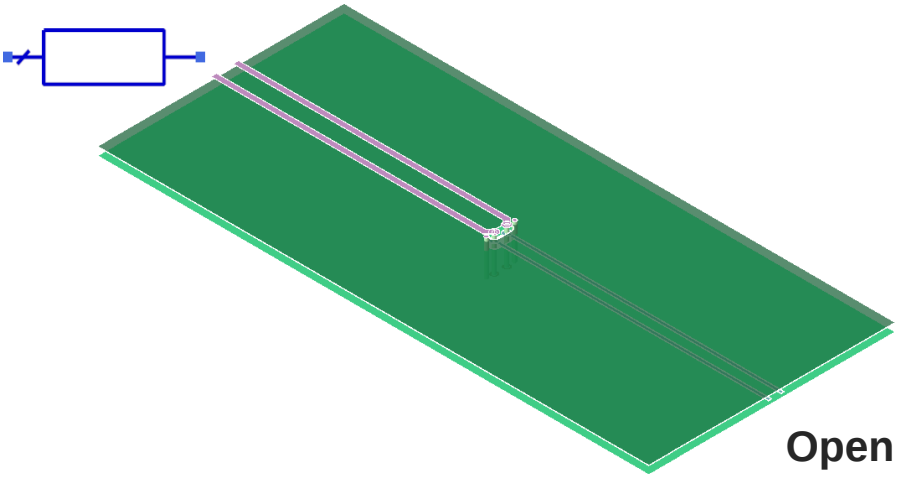
Expectation of Impedance Profile Before Simulation



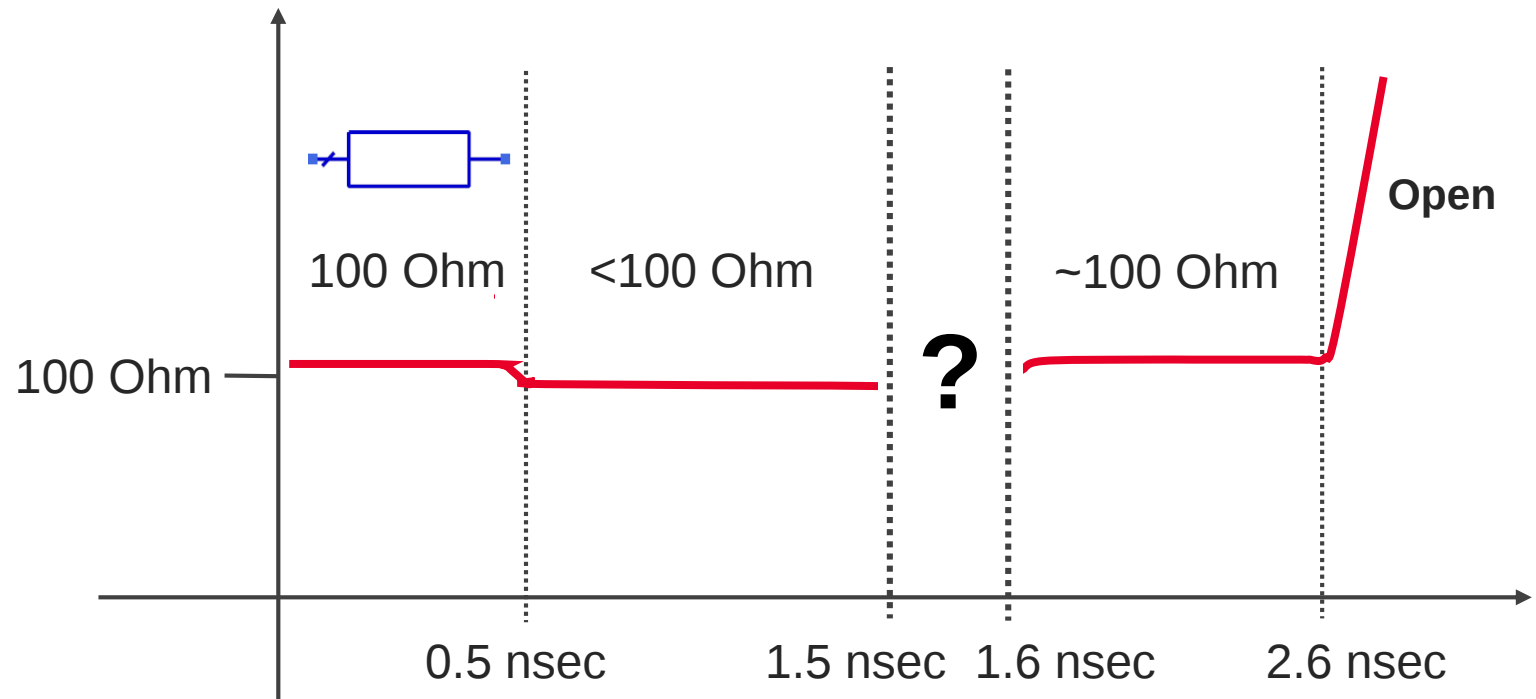
Estimated Delay (FR4): 6 in/nsec

Structure	3-inch microstrip	Via	3-inch stripline
Round Trip Delay (nsec)		Small	
Impedance (Ohm)	<100	?	~100

Expectation of Impedance Profile Before Simulation

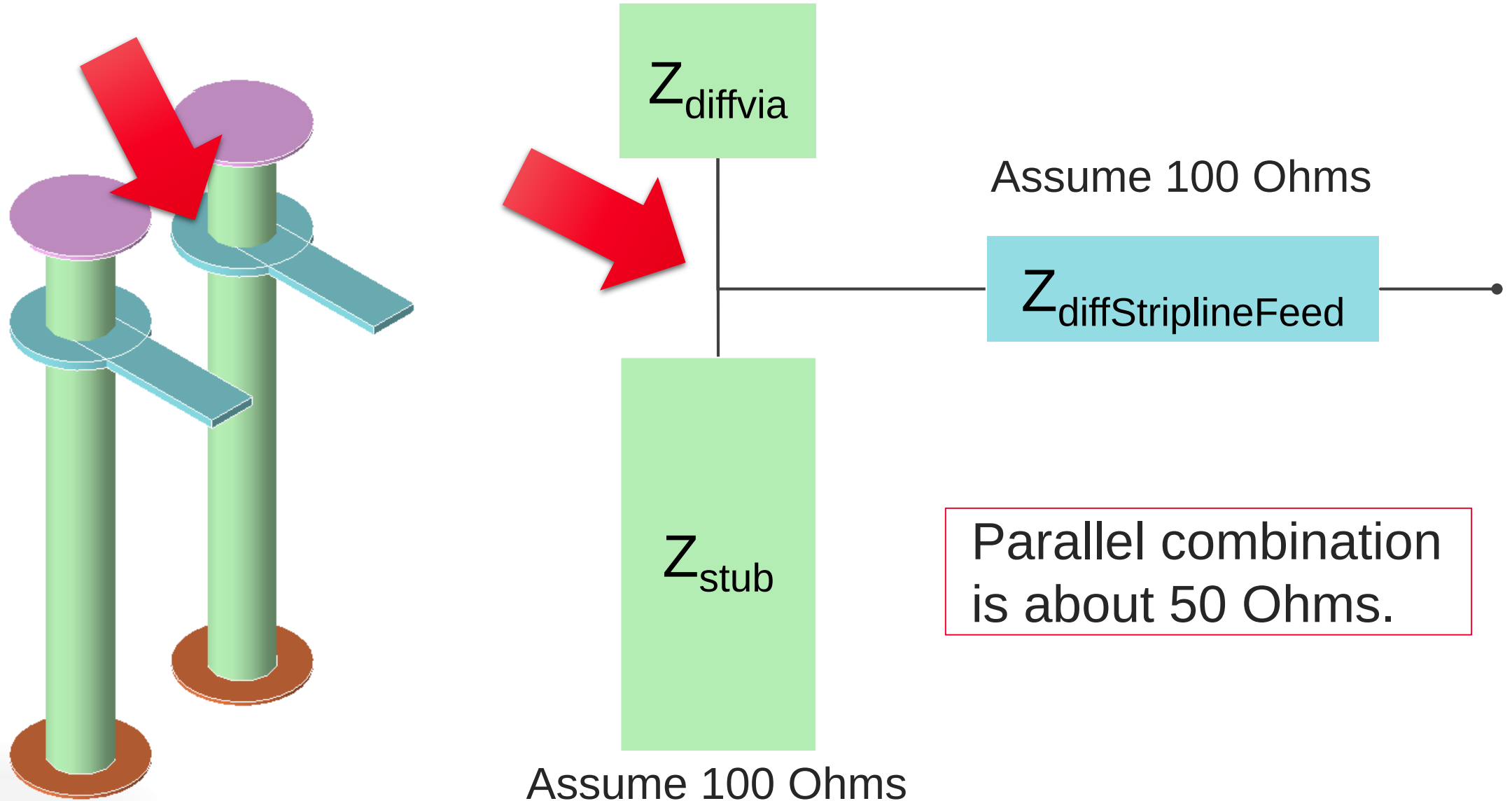


Estimated Delay (FR4): 6 in/nsec

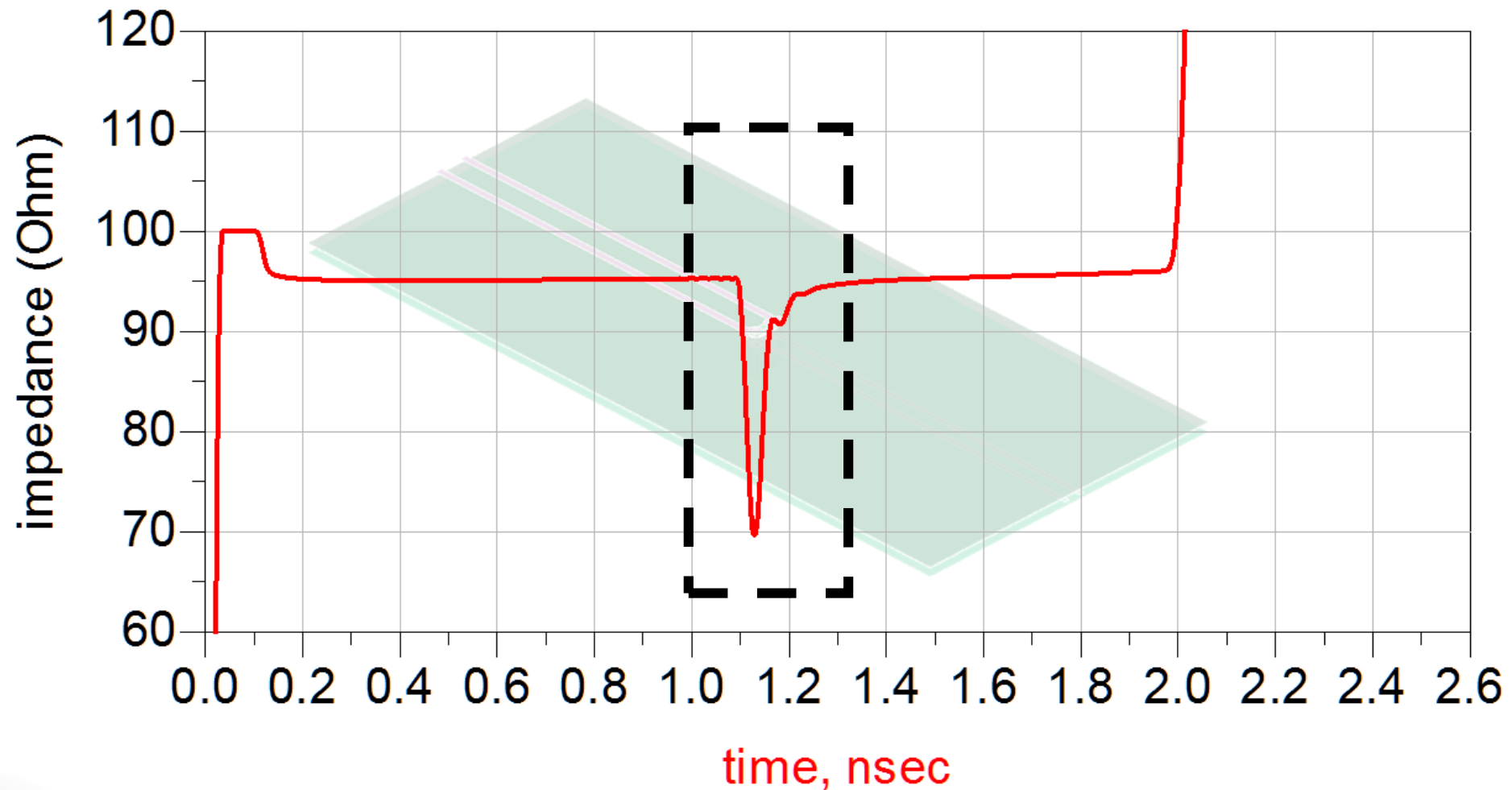


Structure	3-inch microstrip	Via	3-inch stripline
Round Trip Delay (nsec)	1	Small	1
Impedance (Ohm)	<100	?	~100

Examine Via Structure to Estimate Impedance



Low Impedance Shown in TDR is Consistent



Lab 5 Exercises TDR Equations and Data Display

1. Open cell:

a_Signal_Integrity_Analysis_Essentials

2. Push into (Shift+E) or right click:

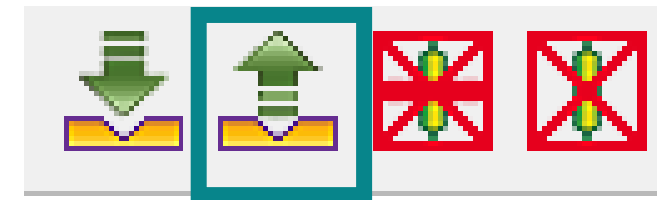
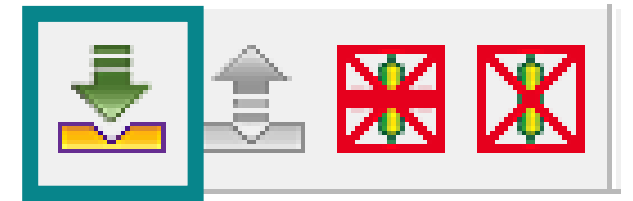
TB3_TDR_analysis

3. Pop out of:

TB3_TDR_analysis

4. Simulate

5. Investigate the TDR data display

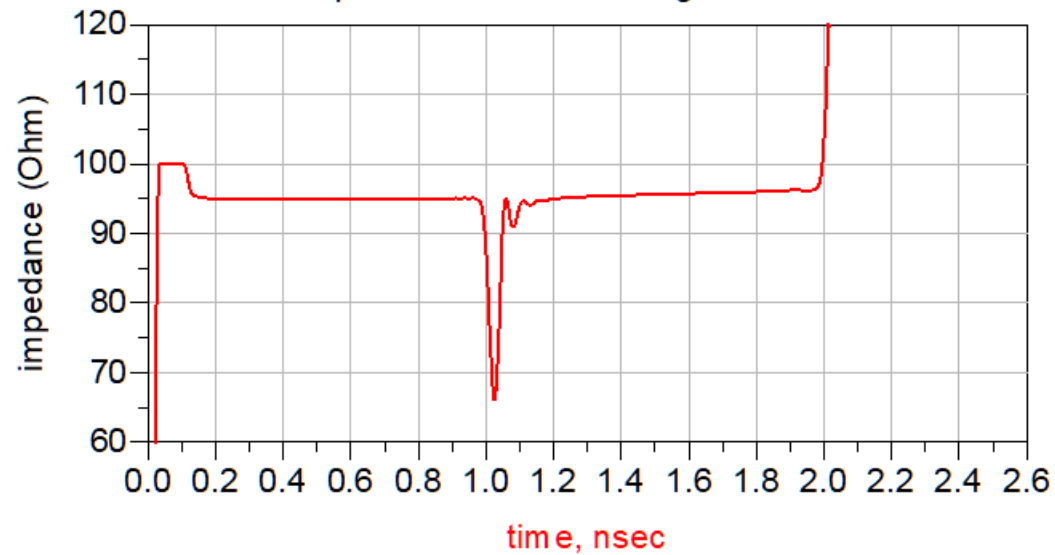


Lab 5 Exercises

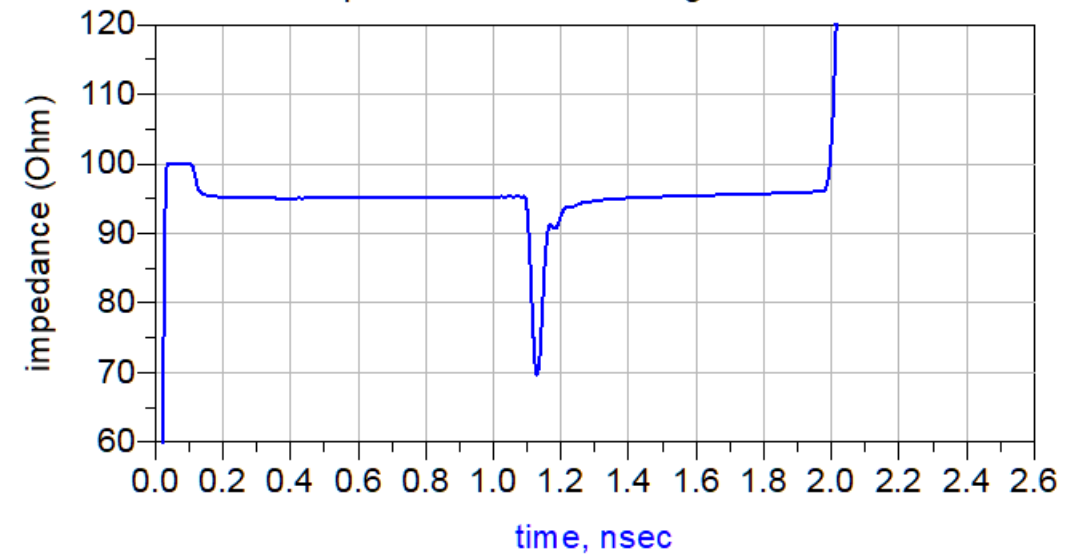
TDR Impedance Analysis

Device under test starts at 0.100 nsec

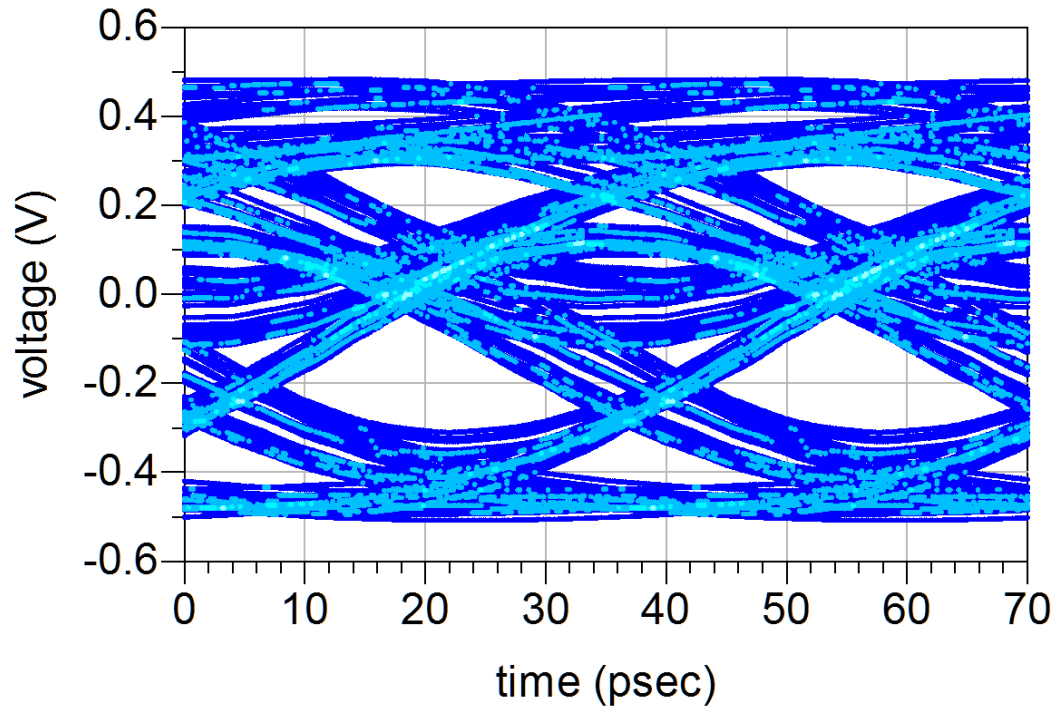
Impedance Profile looking from Port 1



Impedance Profile looking from Port 2

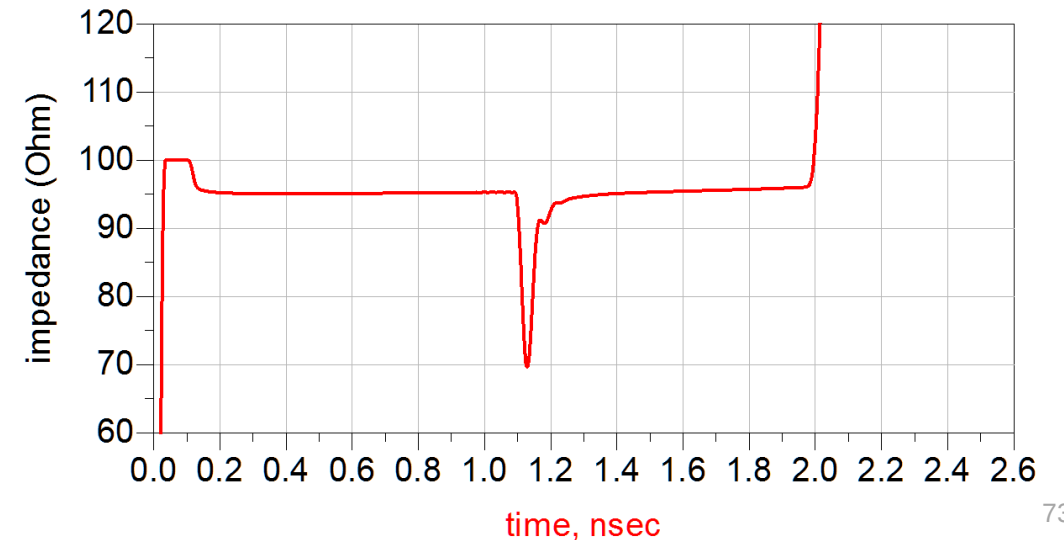
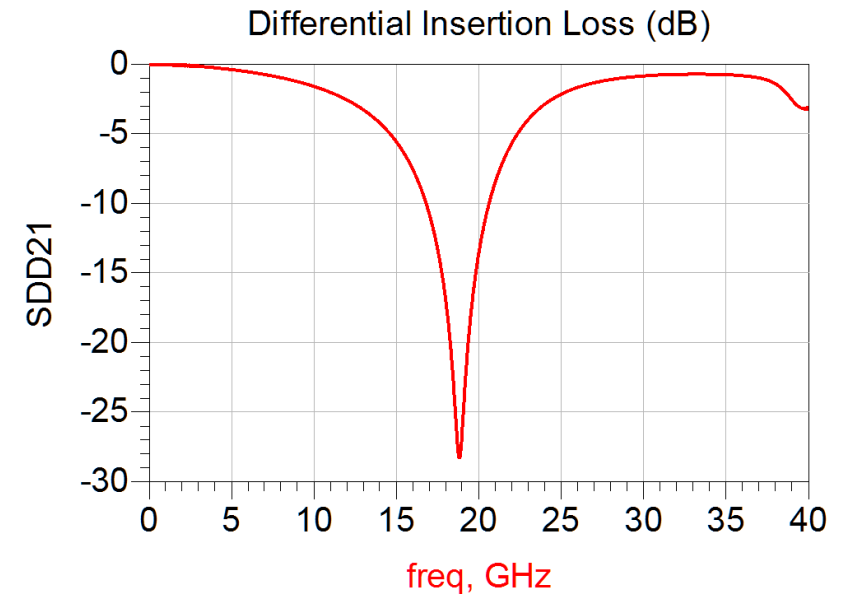
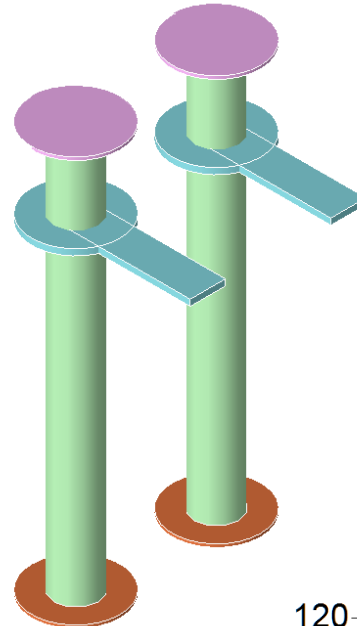


Via Stub is The Root Cause of Eye Closure



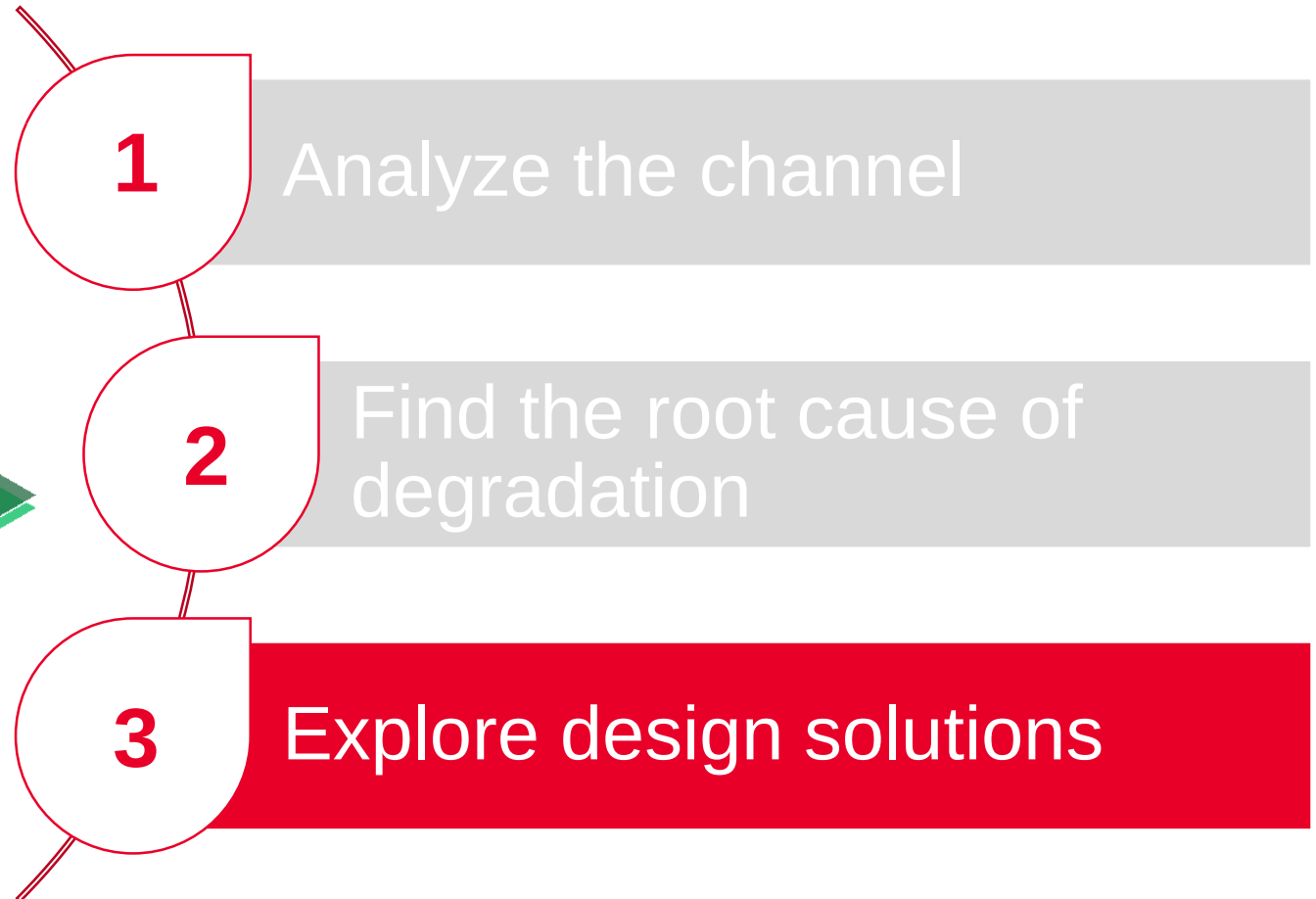
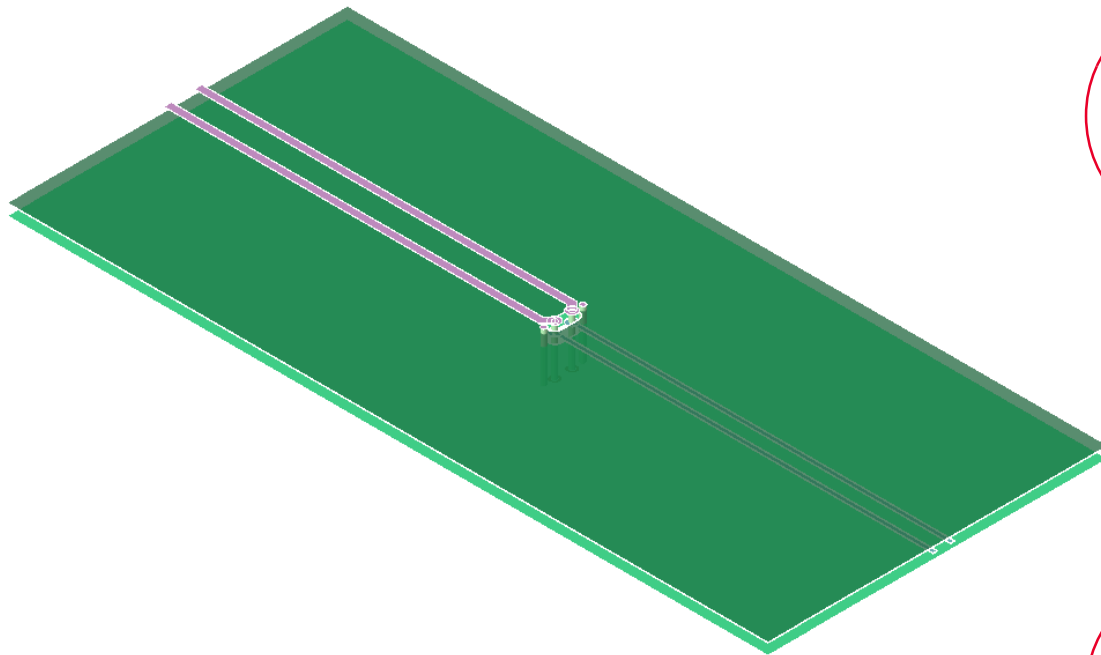
The Root Cause:

The via stub is resonating at frequency close to Nyquist and degrading the frequency spectrum of the input signal.

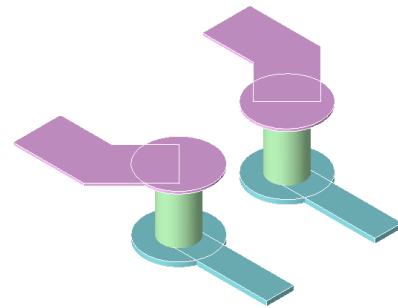
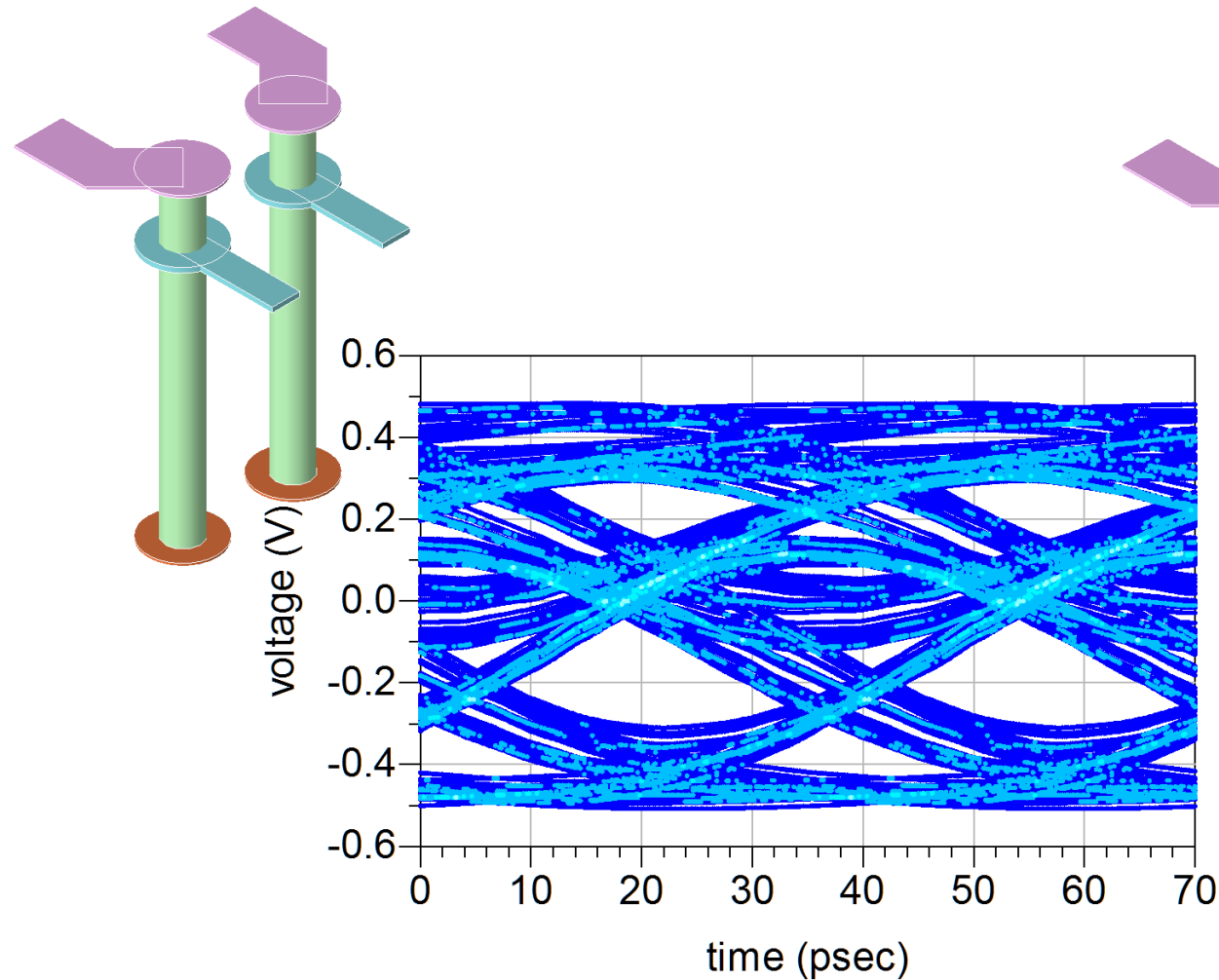


Understand Signal Integrity Analyses with a Case Study

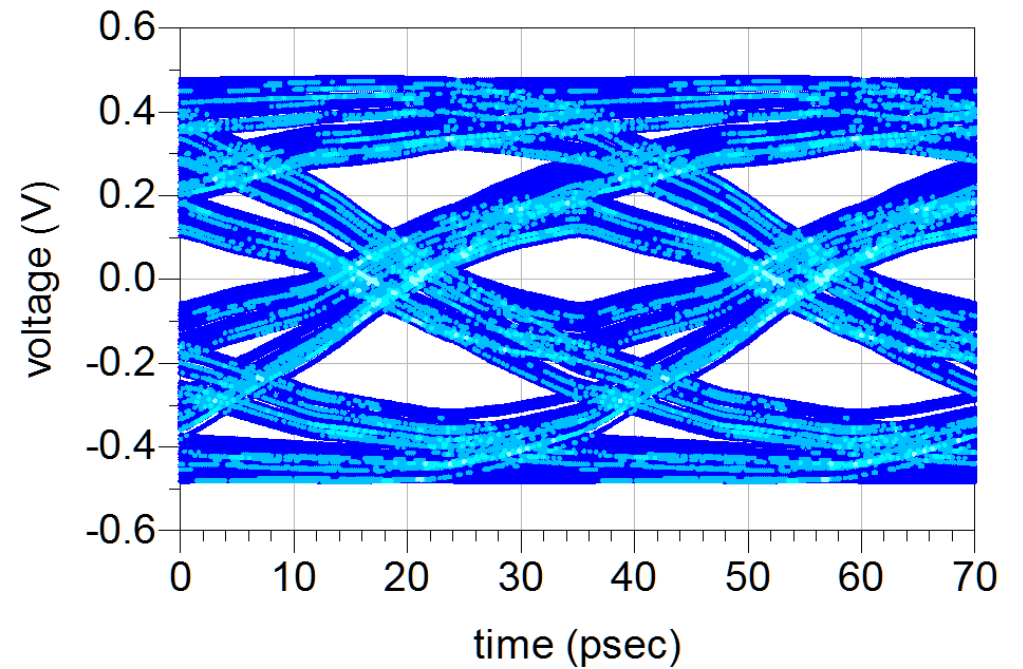
The case of the failing virtual channel



Solution 1: Remove Stub with Back-drilling



Expect eye to be more open.



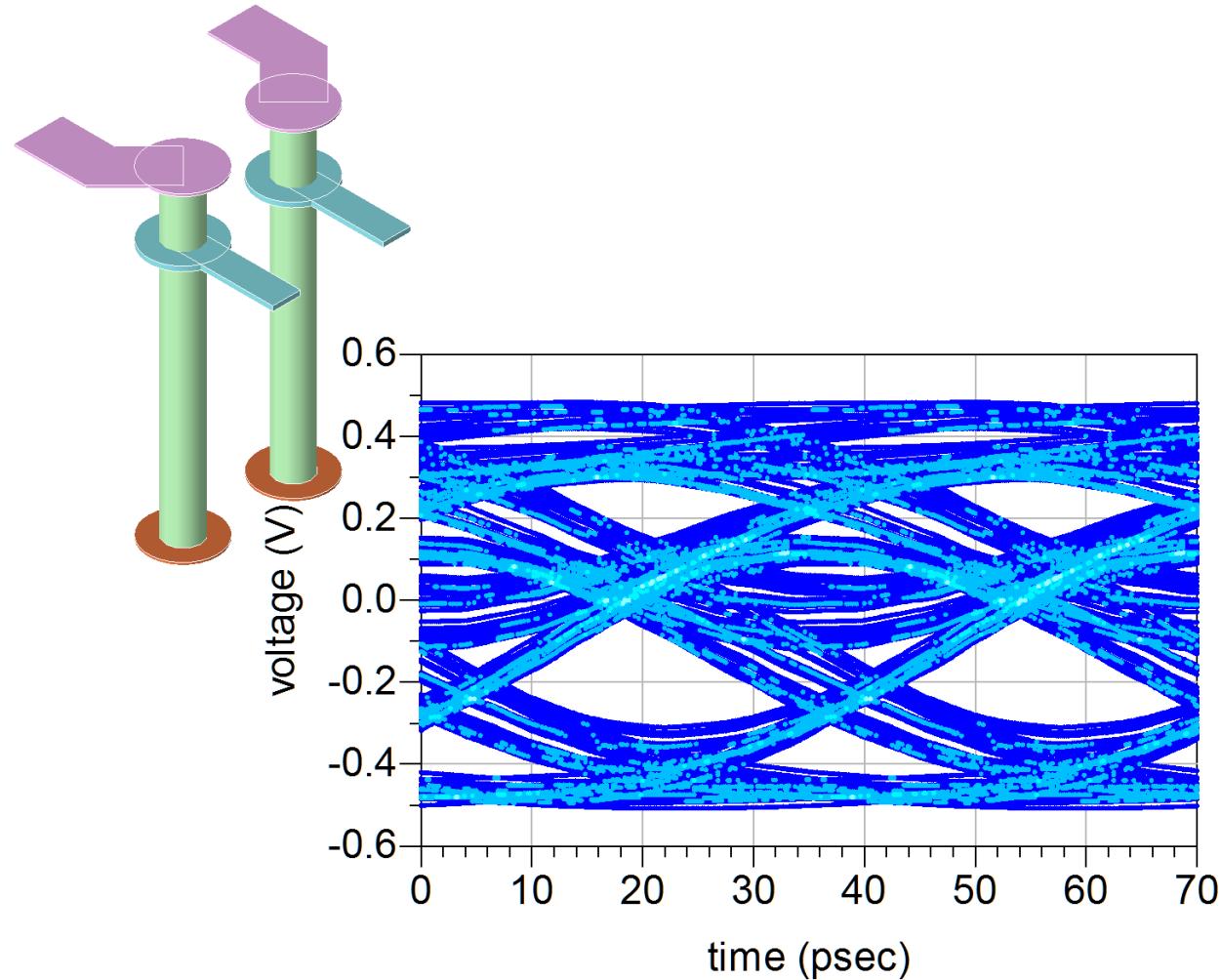
Lab 6 Exercises

1. Browse and change S-parameter file to:
channel_without_via_stubs.s4p
2. Simulate
3. Investigate the data display
4. Browse and change S-parameter file back to:
a_failing_channel.s4p



DataFileList
SParameter

Solution 2: Add Equalization at the Receiver



Decision Feedback
+ Equalization

But... How many taps?

Use Single Pulse to Identify Number of Taps Needed

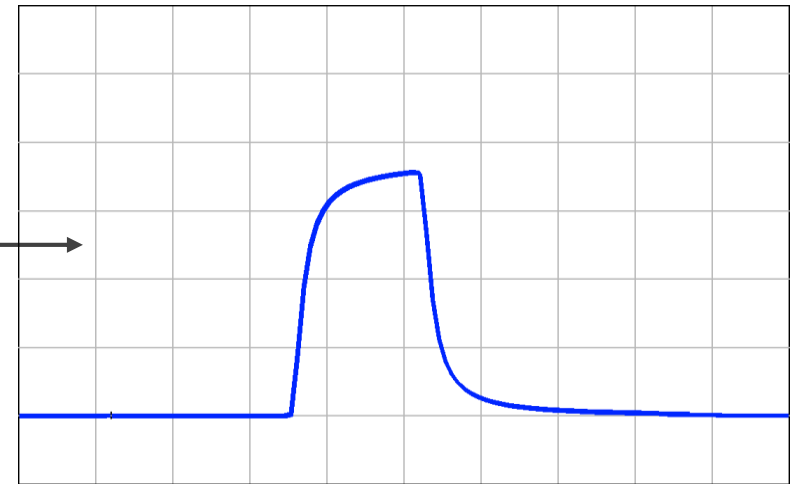
Single pulse



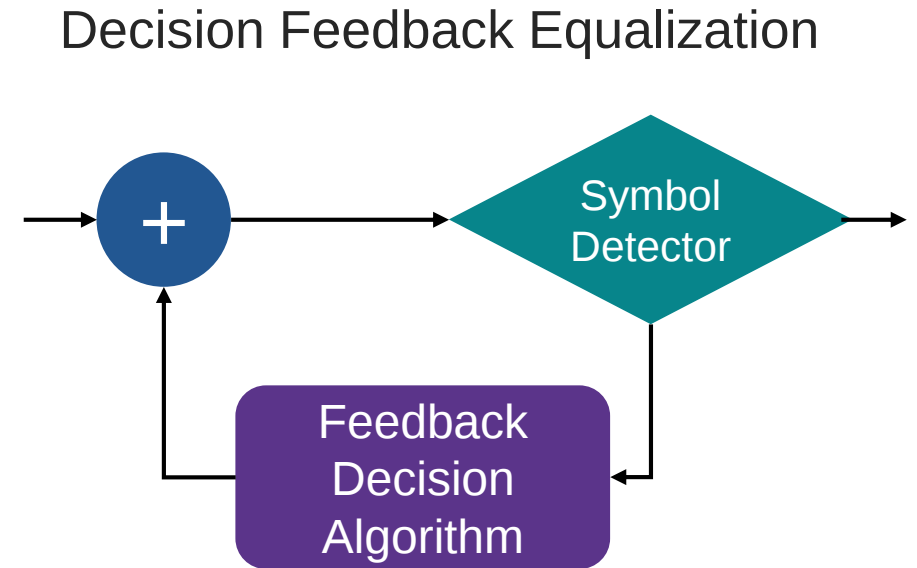
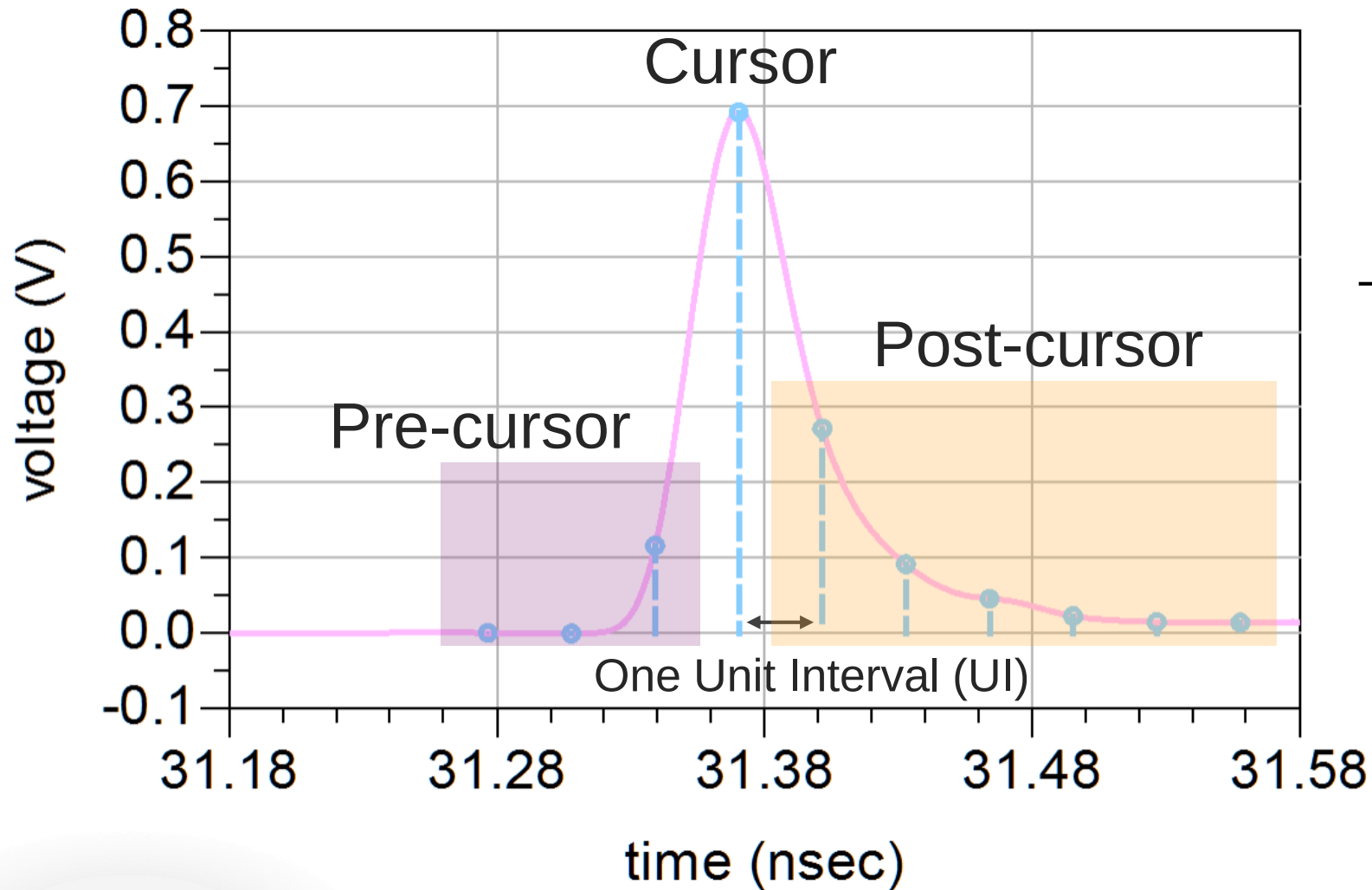
- Rise Time
- Data rate (Unit Interval)

Channel

Single pulse response



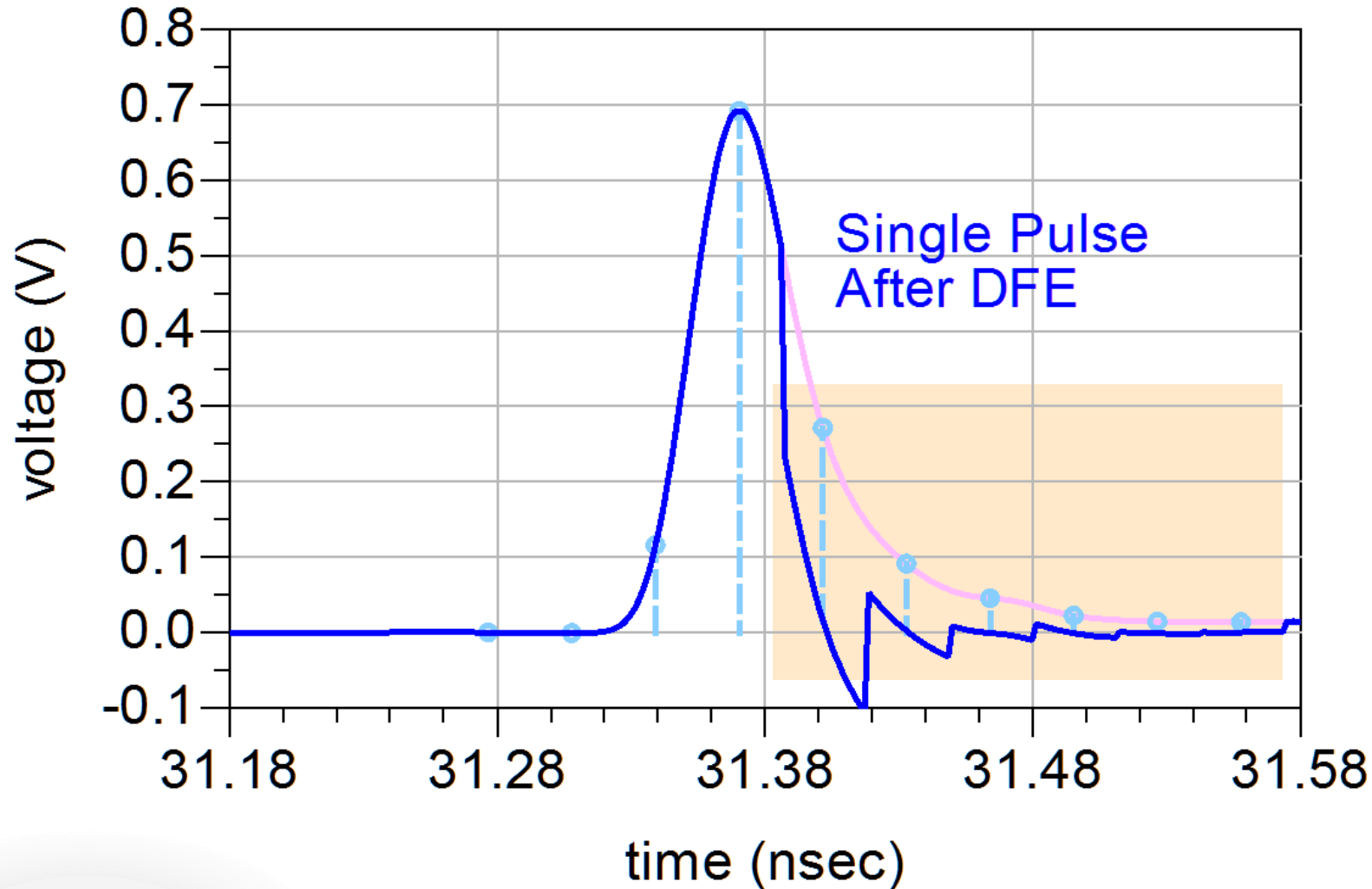
Select Number of Taps for Decision Feedback Equalization



If I detect a “1”,
emphasize the next “0”.

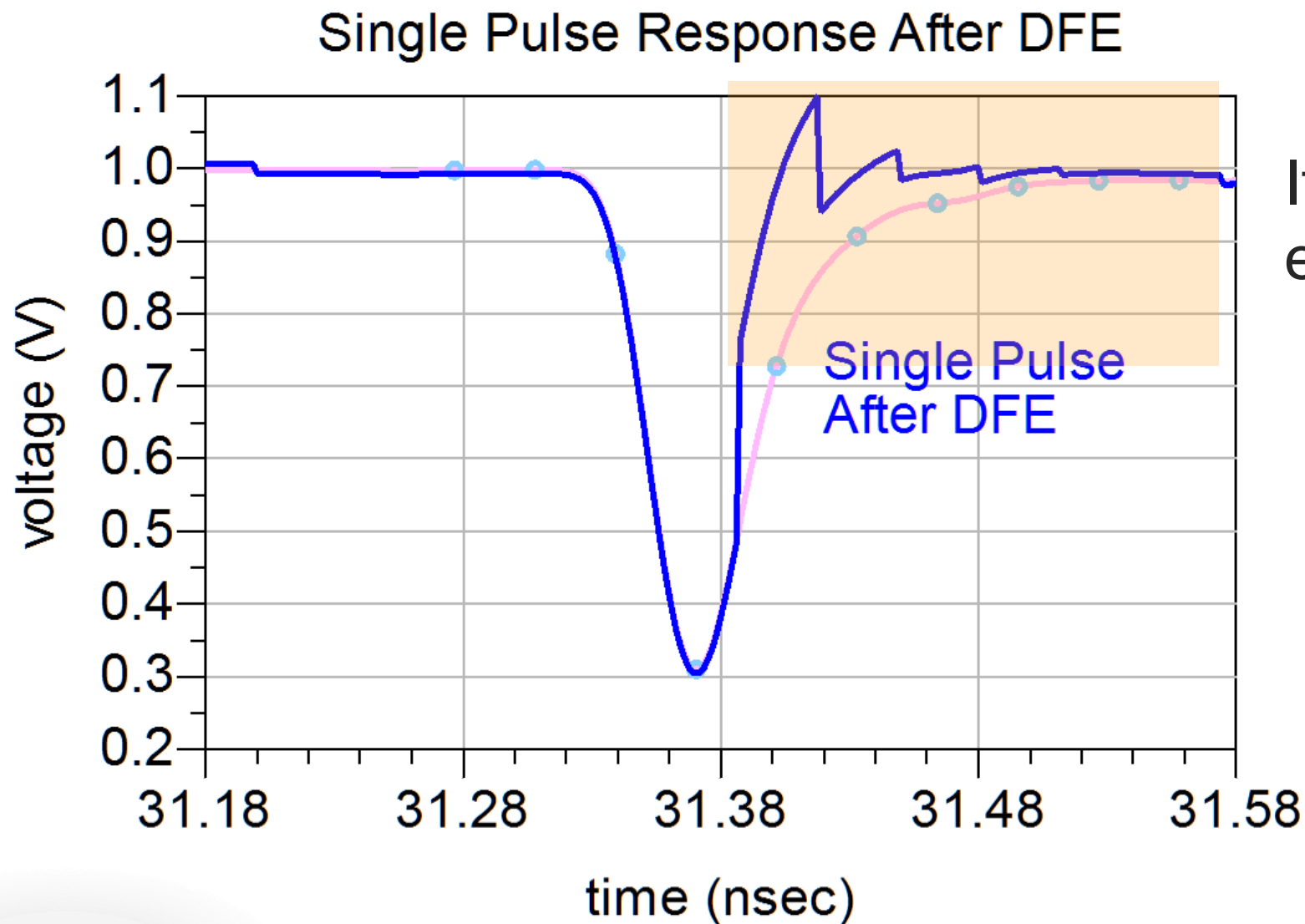
Decision Feedback Equalization in Time Domain

Single Pulse Response After DFE



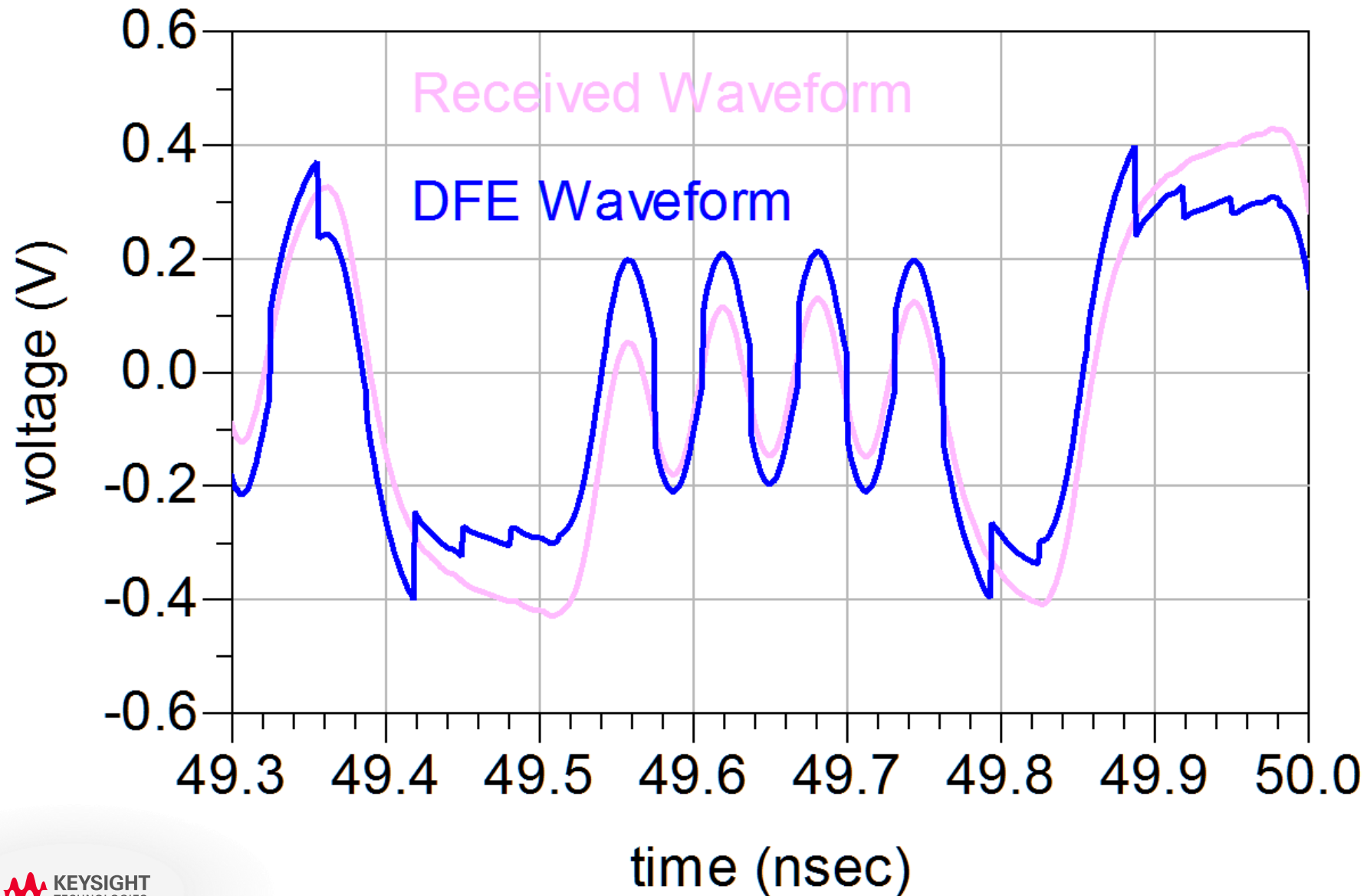
If I detect a "1",
emphasize the next "0".

Decision Feedback Equalization in Time Domain



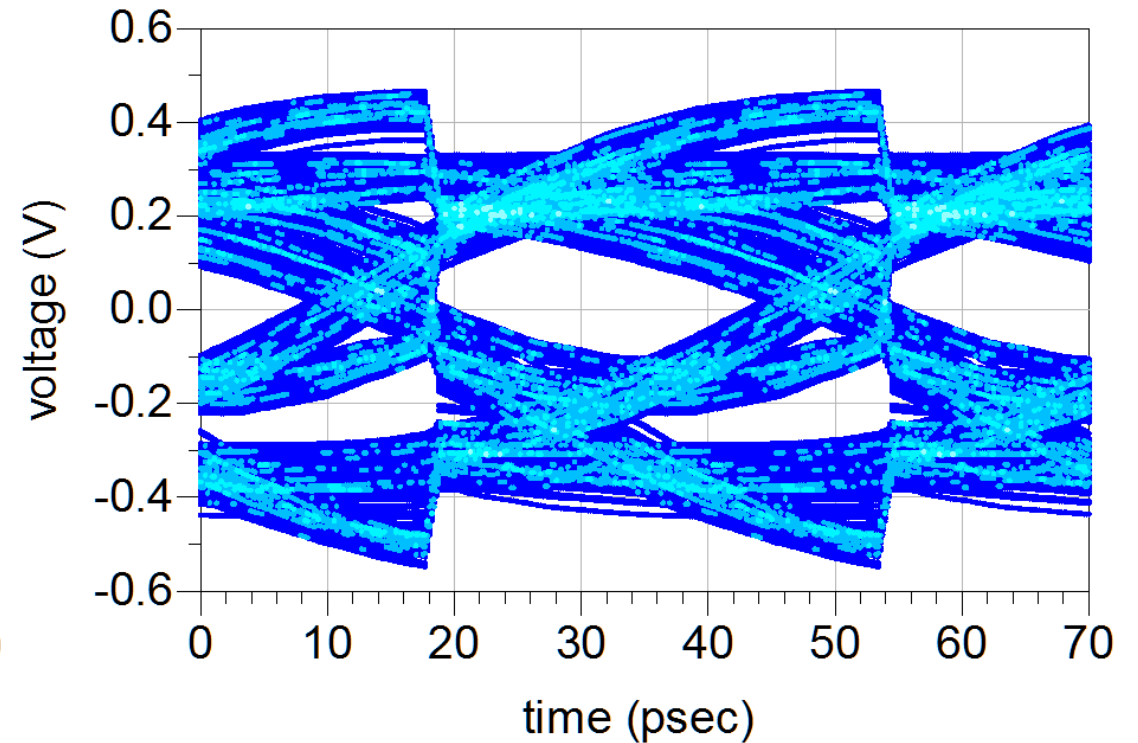
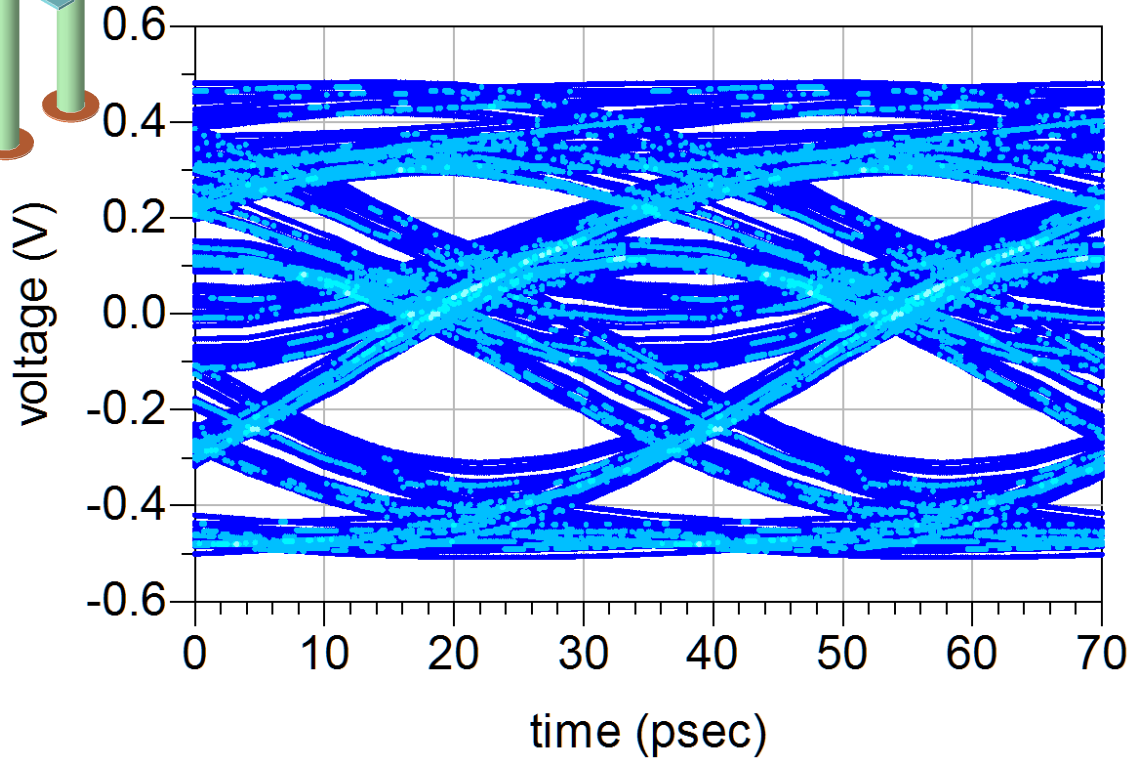
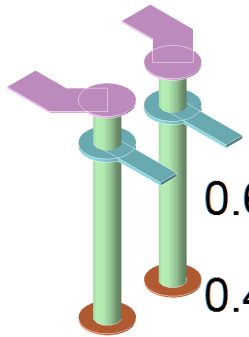
If I detect a “0”,
emphasize the next “1”.

Decision Feedback Equalization in Time Domain

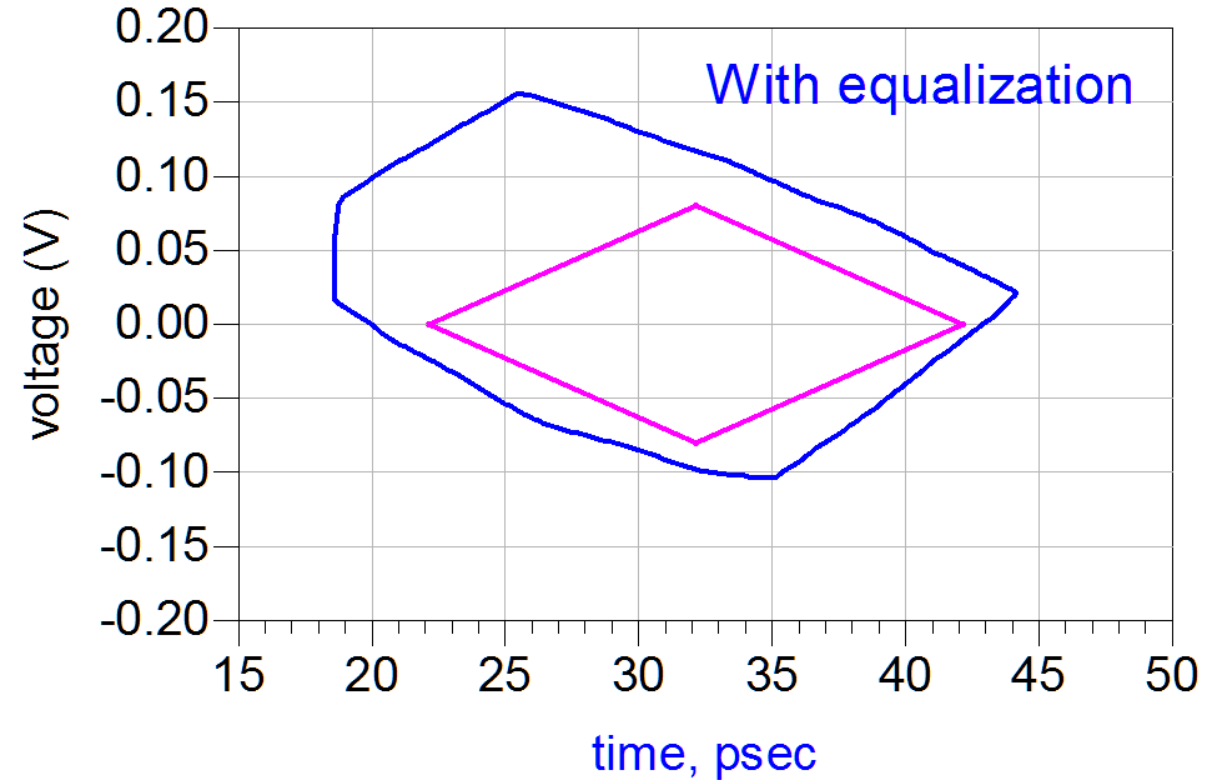
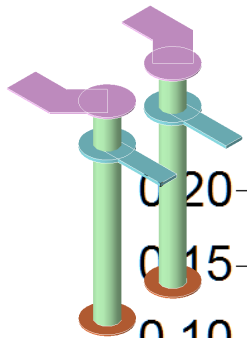


Solution 2: Add Equalization at the Receiver

Decision Feedback
+ Equalization



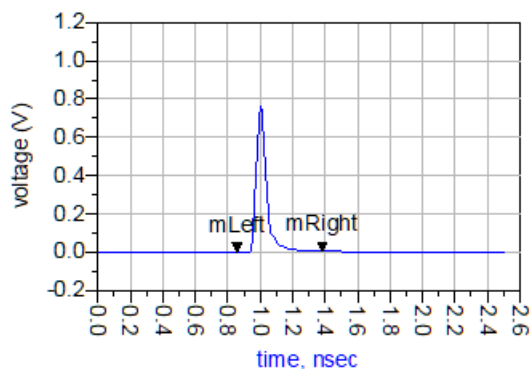
Eye Mask Comparison Before and After DFE



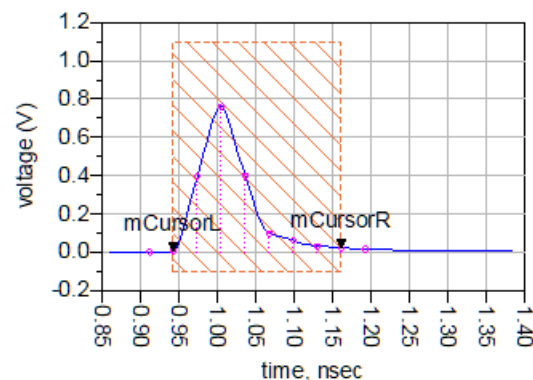
Lab 7 Using Single Pulse Response

Single Pulse Response Analysis

Interactive zooming tool
-move the left and right marker to zoom



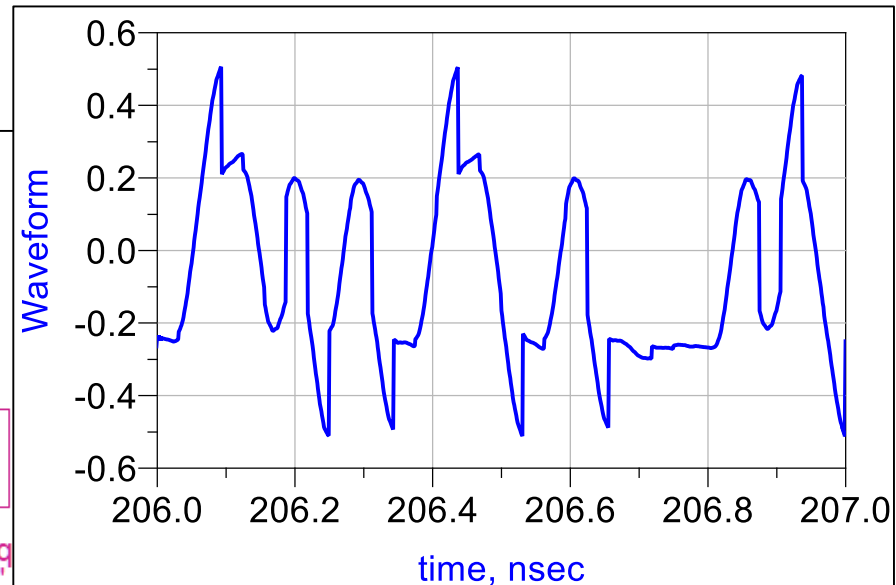
Interactive pre- and post- cursor selection tool
-move the left and right marker to select
number of pre- and post- cursors to equalize



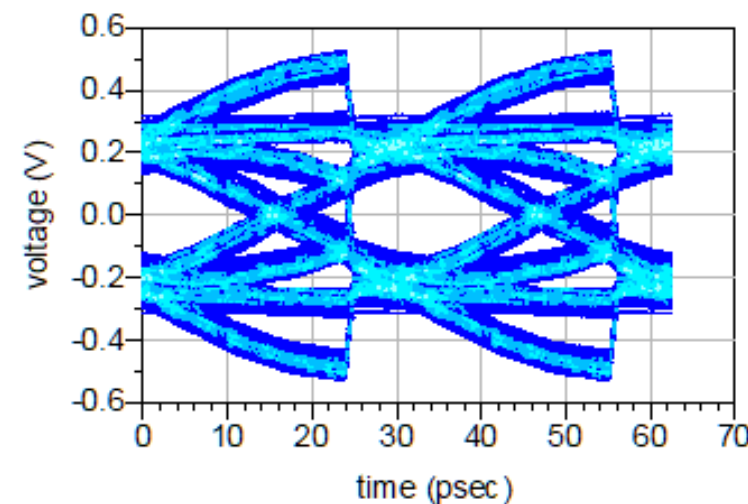
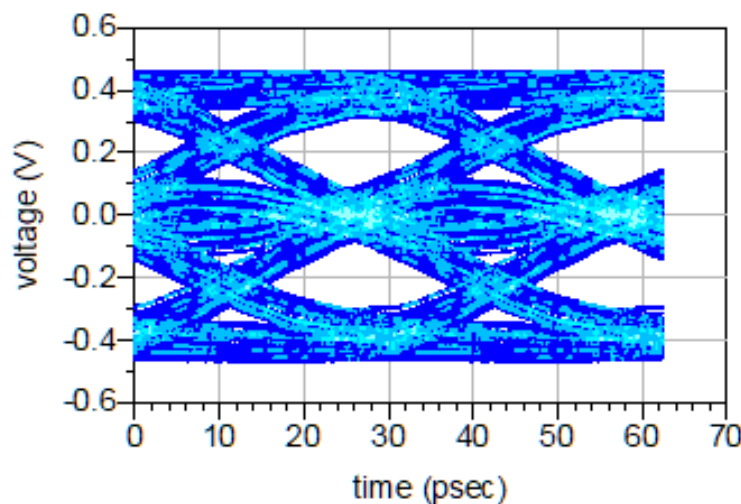
numPreCursor	numPostCursor
2.000	5.000

Right-click on below eq and "Toggle Activation"
pre- and post- cursor information

Eqn writeToDiscrete = write_var(writeFileName,"



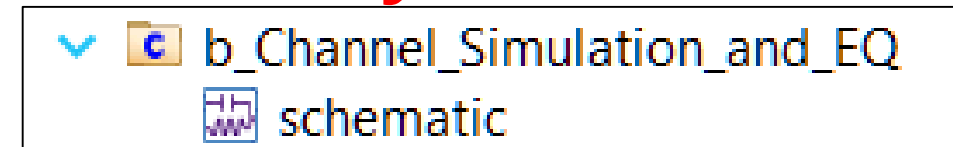
Number of Precursor Taps: n/a
Number of Postcursor Taps: 5.000



Lab 7 Exercises

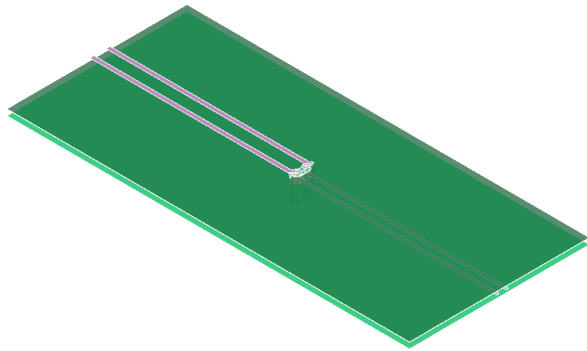
numPreCursor	numPostCursor
2.000	4.000

1. Use interactive cursor in data display:
a_Signal_Integrity_Analysis_Essentials.dds
2. based on the SPR
Specify number of taps you want for your DFE
3. Investigate the data display
4. Open and investigate the Schematic:
b_Channel_Simulation_and_EQ
5. Simulate and watch the eye opens up.

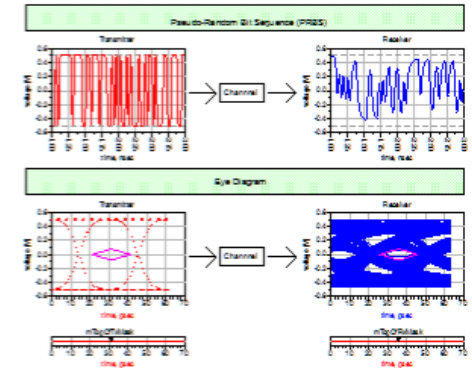


Summary

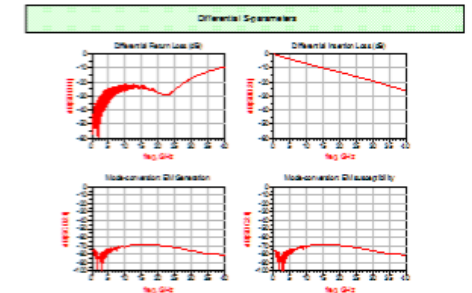
The case of the failing virtual channel



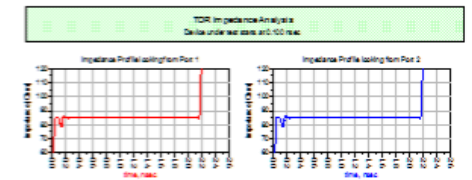
Eye diagrams



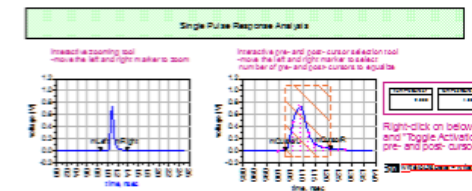
Mixed-mode S-parameters



Time domain reflectometry

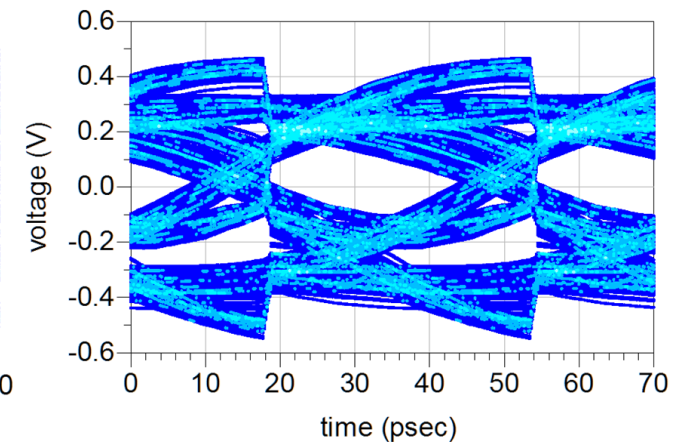
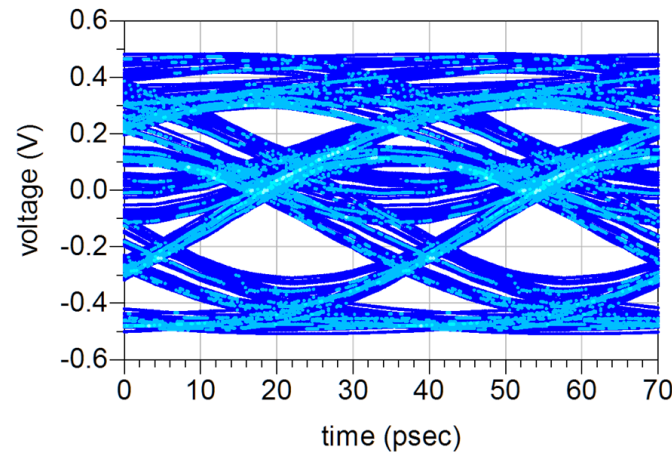
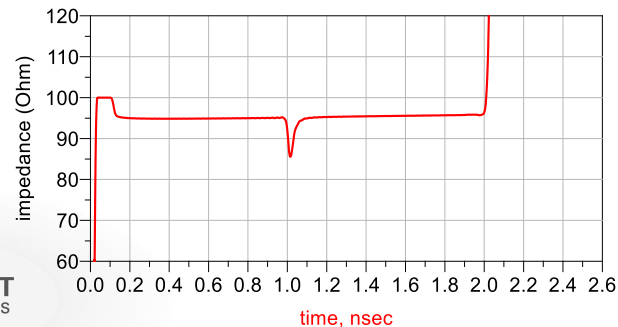
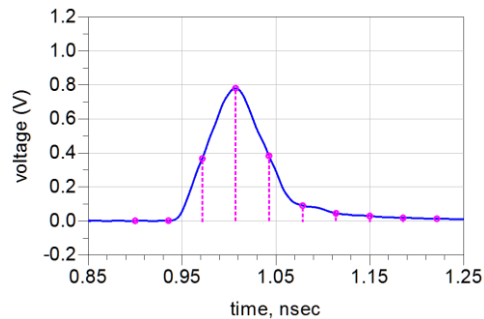
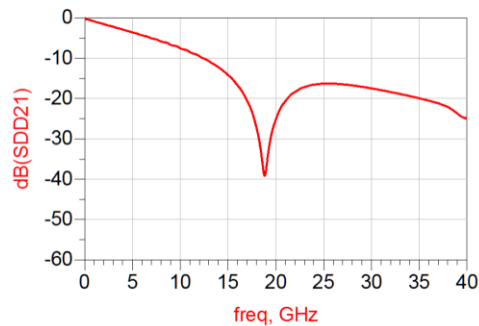
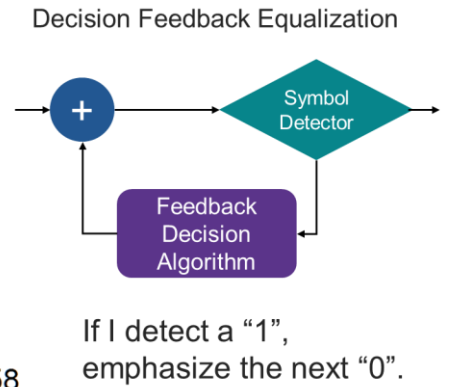
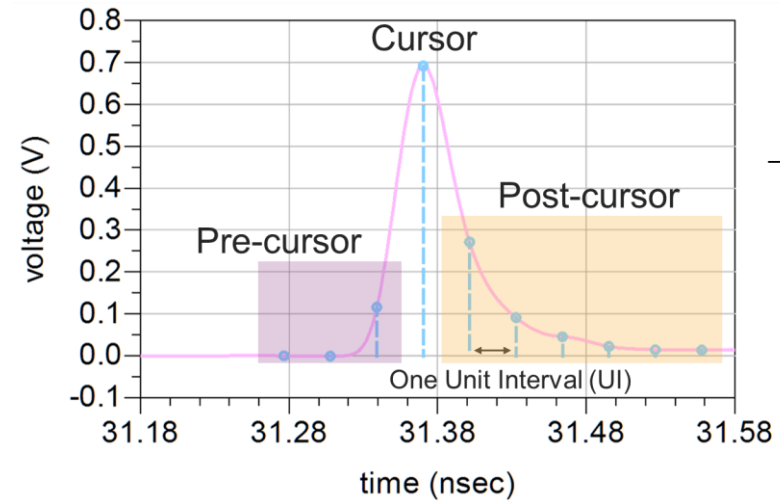
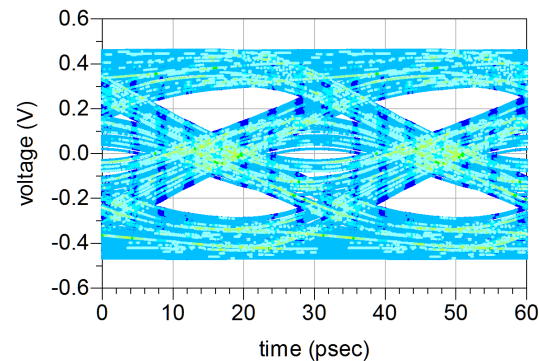
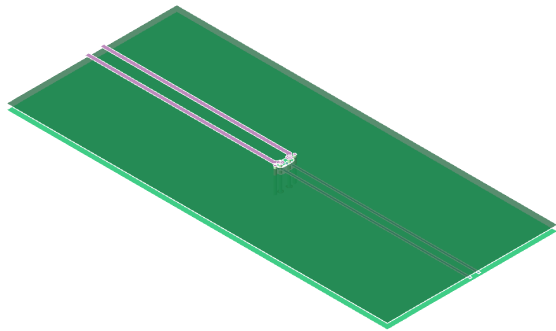


Single pulse response

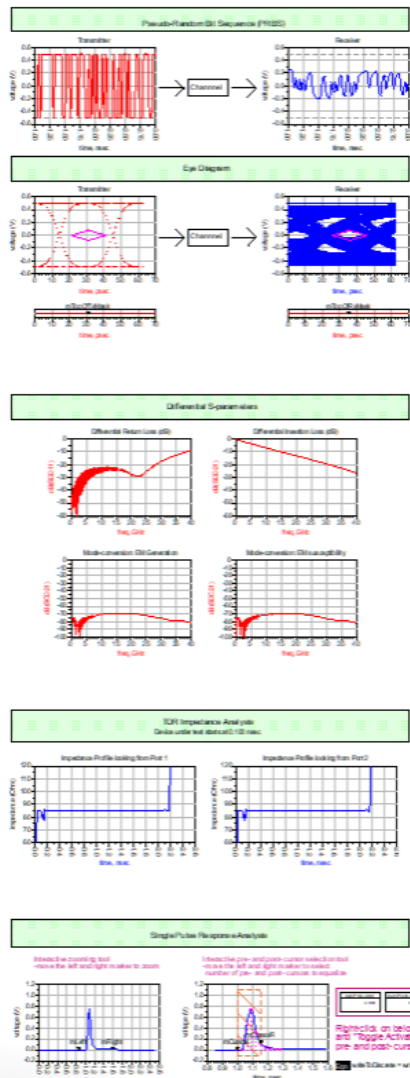


Understand Signal Integrity in the Ideal World

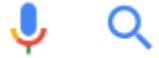
The case of the failing virtual channel



Review of Today's Content and Workspace for Colleague



youtube: signal integrity



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About 10,600,000 results (0.37 seconds)

How to Solve Signal Integrity Problems: The Basics - YouTube

<https://www.youtube.com/watch?v=mpyMWuVrKKc>



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Keysight EEsof EDA. ... This video shows you how to use basic **signal integrity** (SI) analysis techniques ...

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Published on Sep 24, 2018

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This video shows you how to use basic signal integrity (SI) analysis techniques such as eye diagrams, S-parameters, time-domain reflectometry (TDR) and single pulse response to solve signal integrity problems. Click this link, <http://www.keysight.com/find/eesof-ho...>, to request a .zip file that includes all of the analyses and more!