Hacking a 100-ohm Differential Pair

Shrinithi Venkatesan
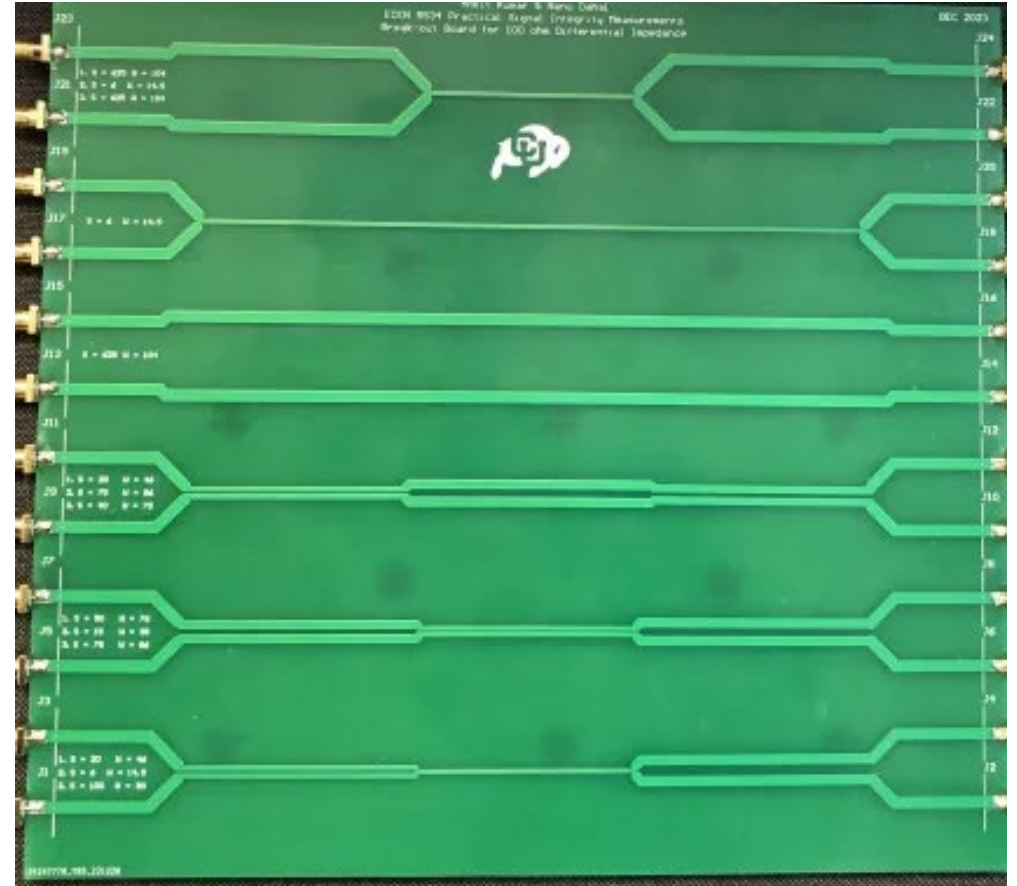
Sonal Tamrakar

03/21/2024
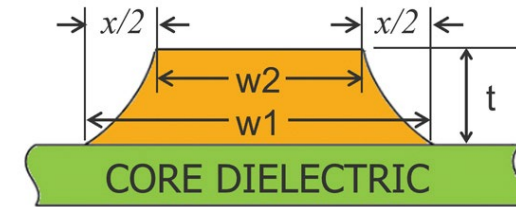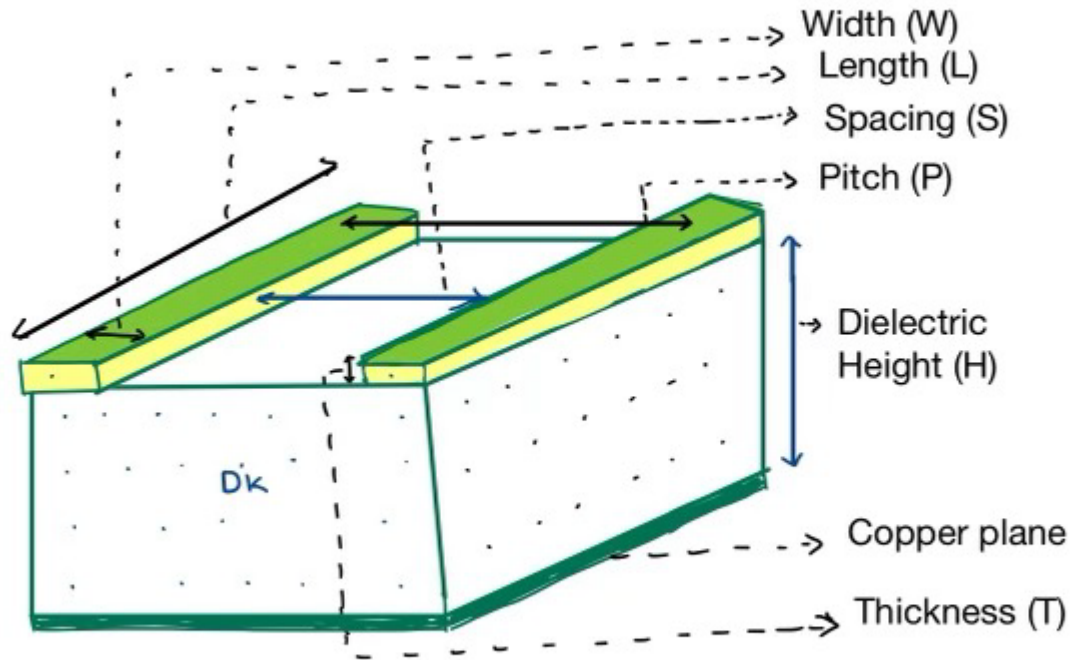
University of Colorado **Boulder**

High Speed Digital Engineering Group

Agenda
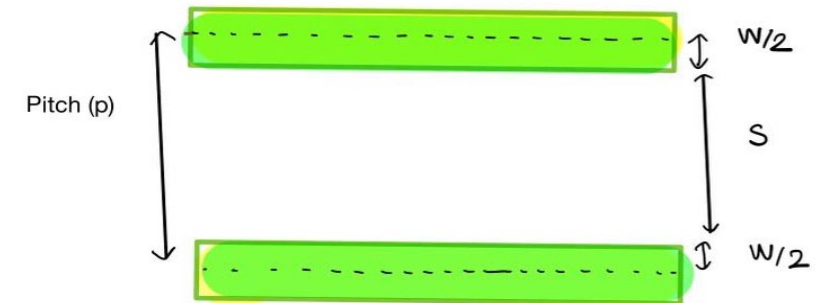
- Transmission Line Parameters

- Differential Pair Setup (DUT)

- Parameters

- Measured Data

- Hacking the circuit

- Observations

- Key Takeaways

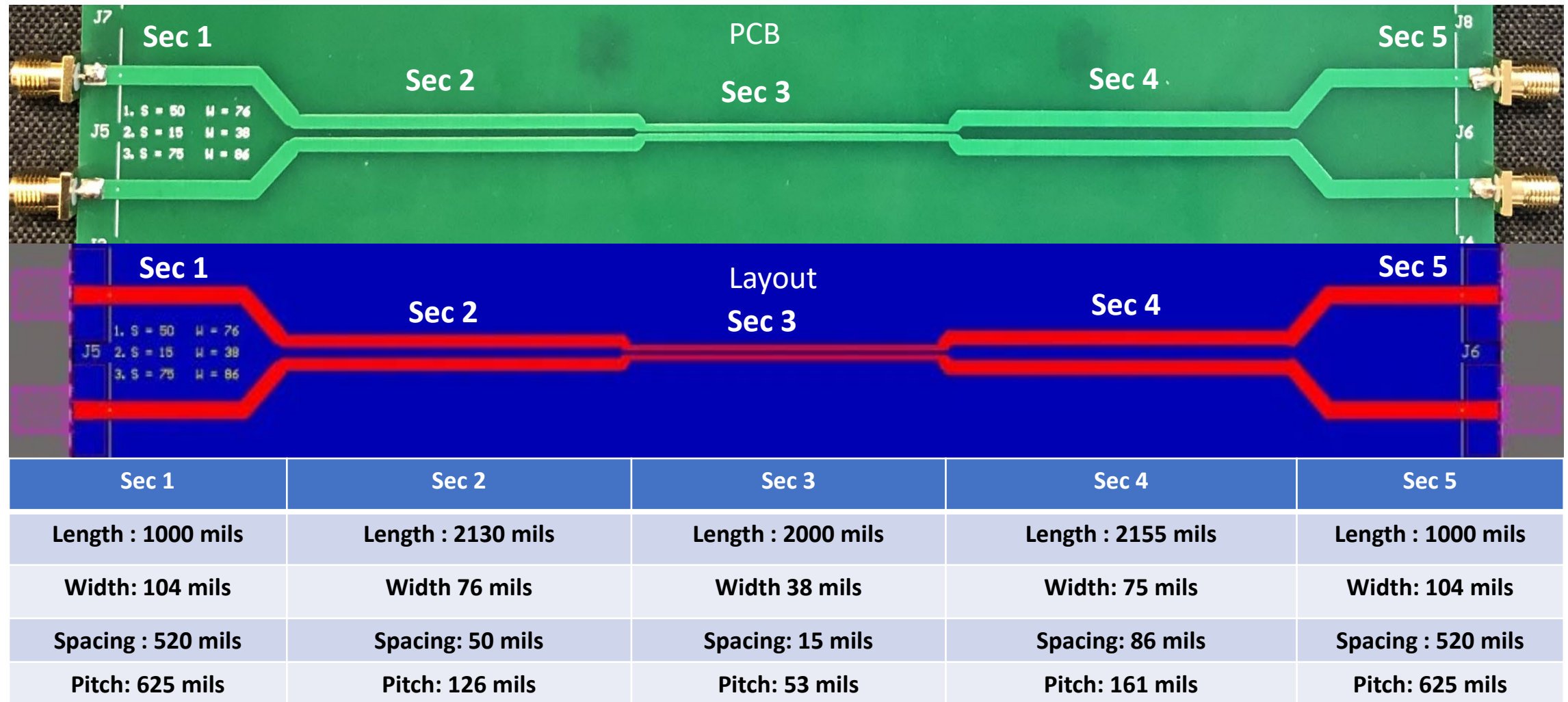University of Colorado **Boulder**

High Speed Digital Engineering Group

Background

$$Etchback\ (x) = w1 - w2$$

Pitch = S + 2*(W/2)

University of Colorado **Boulder**

High Speed Digital Engineering Group

DUT – 100-ohm Differential pair

Sec 1	Sec 2	Sec 3	Sec 4	Sec 5
Length : 1000 mils	Length : 2130 mils	Length : 2000 mils	Length : 2155 mils	Length : 1000 mils
Width: 104 mils	Width 76 mils	Width 38 mils	Width: 75 mils	Width: 104 mils
Spacing : 520 mils	Spacing: 50 mils	Spacing: 15 mils	Spacing: 86 mils	Spacing : 520 mils
Pitch: 625 mils	Pitch: 126 mils	Pitch: 53 mils	Pitch: 161 mils	Pitch: 625 mils

University of Colorado **Boulder**

High Speed Digital Engineering Group

Consistency Check

Known Parameters:

Solder Mask: 0.0254 mm (1 mil)

Copper Thickness: 0.03048 mm (1.2 mils) (Measured w and w/o trace)

Dielectric Height (H) = 1.615mm – 2(0.03556mm) – 2(0.0254mm) = **1.491mm (58.7 mils)**

Tolerance factor = +/- 0.8 mils

1.615mm +/- 0.010mm

| Solder Mask |
| Copper |
| FR4 / Dielectric |
| Copper |
| Solder Mask |

What is the expected data?

University of Colorado **Boulder**

High Speed Digital Engineering Group

Parameters

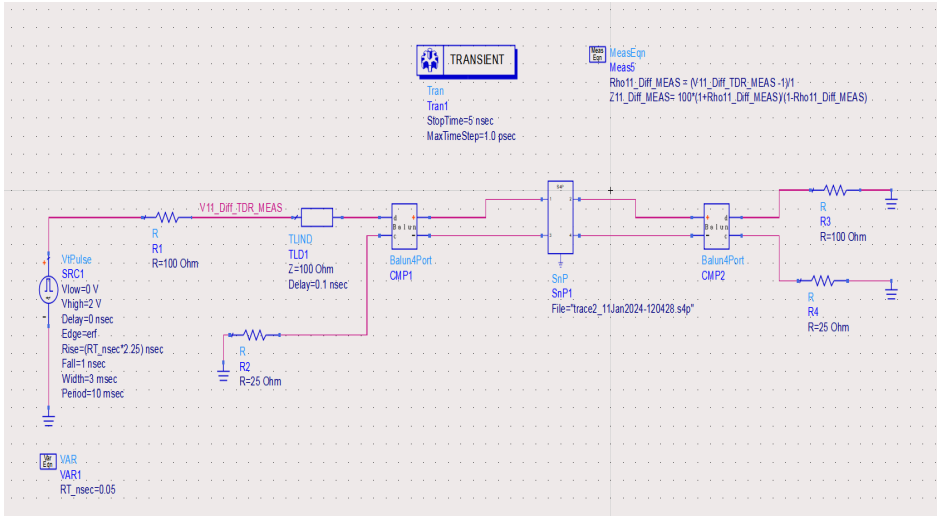| Parameters	Sec I (Uncoupled)	Sec 2	Sec 3	Sec 4	Sec 5 (Uncoupled)
ΔW (Etch)	Variable - Unknown	Variable - Unknown	Variable - Unknown	Variable - Unknown	Variable - Unknown
Pitch	625 mils	126 mils	53 mils	161 mils	625 mils
Spacing (S_{mfg})	X	$S_{des} + 2 * \Delta W$	$S_{des} + 2 * \Delta W$	$S_{des} + 2 * \Delta W$	X
Trace Width (W_{mfg})	$W_{des} - 2 * \Delta W$	$W_{des} - 2 * \Delta W$	$W_{des} - 2 * \Delta W$	$W_{des} - 2 * \Delta W$	$W_{des} - 2 * \Delta W$
Dk_{mfg}	4.5	4.5	4.5	4.5	4..5
Copper Thickness	1.2 mils	1.2 mils	1.2 mils	1.2 mils	1.2 mils
Dielectric Height	58.7 mils	58.7 mills	58.7 mils	58.7 mils	58.7 mills
Trace Length	1000 mils	2130 mils	2000 mils	2155 mils	625 mils

What are the variable parameters and how far can we alter these parameters?

Parameter	Variability factor
Dielectric Constant (Dk)	+/- 0.4
Dielectric height (H)	+/- 2 mils
Etch (del W)	+/- 1 mil

University of Colorado **Boulder**

High Speed Digital Engineering Group

Measured Data

CIRCUIT

TDR PLOT
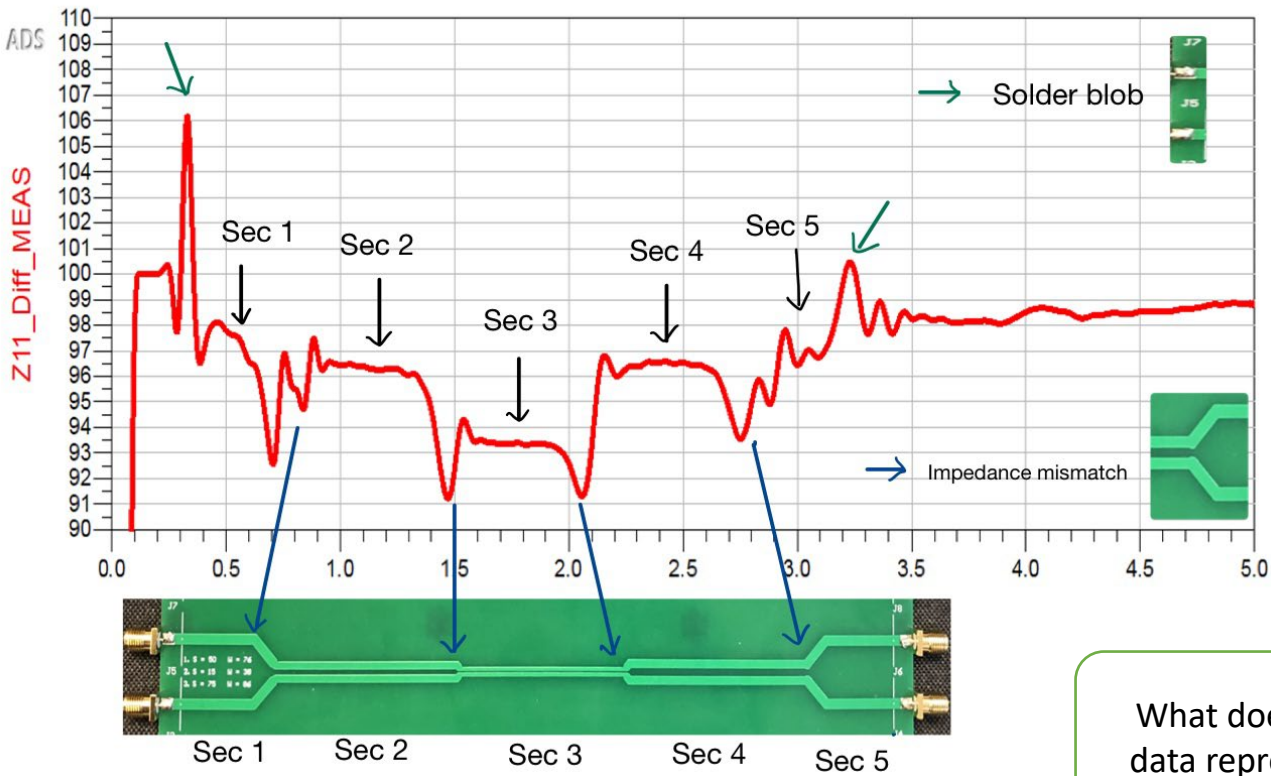
What does this data represent?

University of Colorado **Boulder**

High Speed Digital Engineering Group

Simulated Data
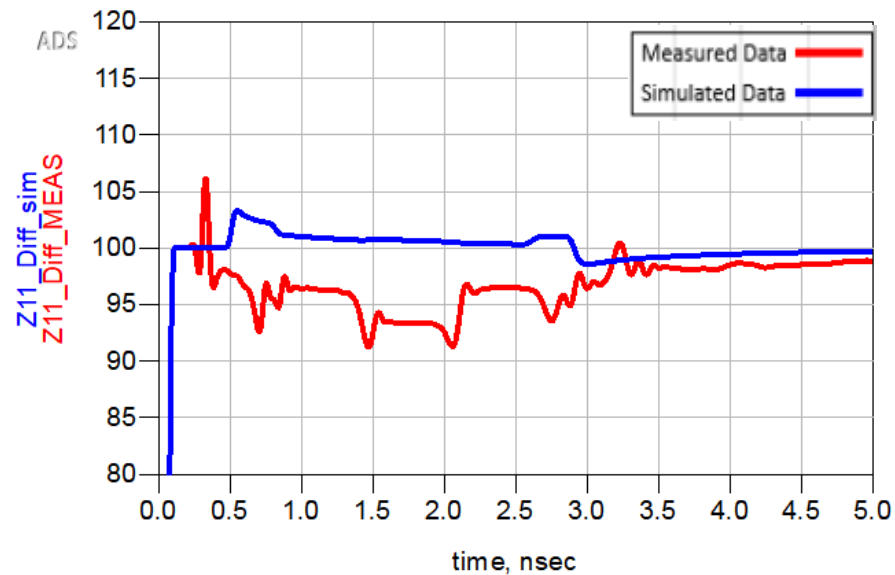
TDR PLOT

Parameters	Simulated
Dielectric Constant (Dk)	4.5
Dielectric height (H)	58.7 mils
Etch (del W)	0 mil

CIRCUIT

How do we hack?

University of Colorado **Boulder**

High Speed Digital Engineering Group

TDR plots Meas vs Sim Data
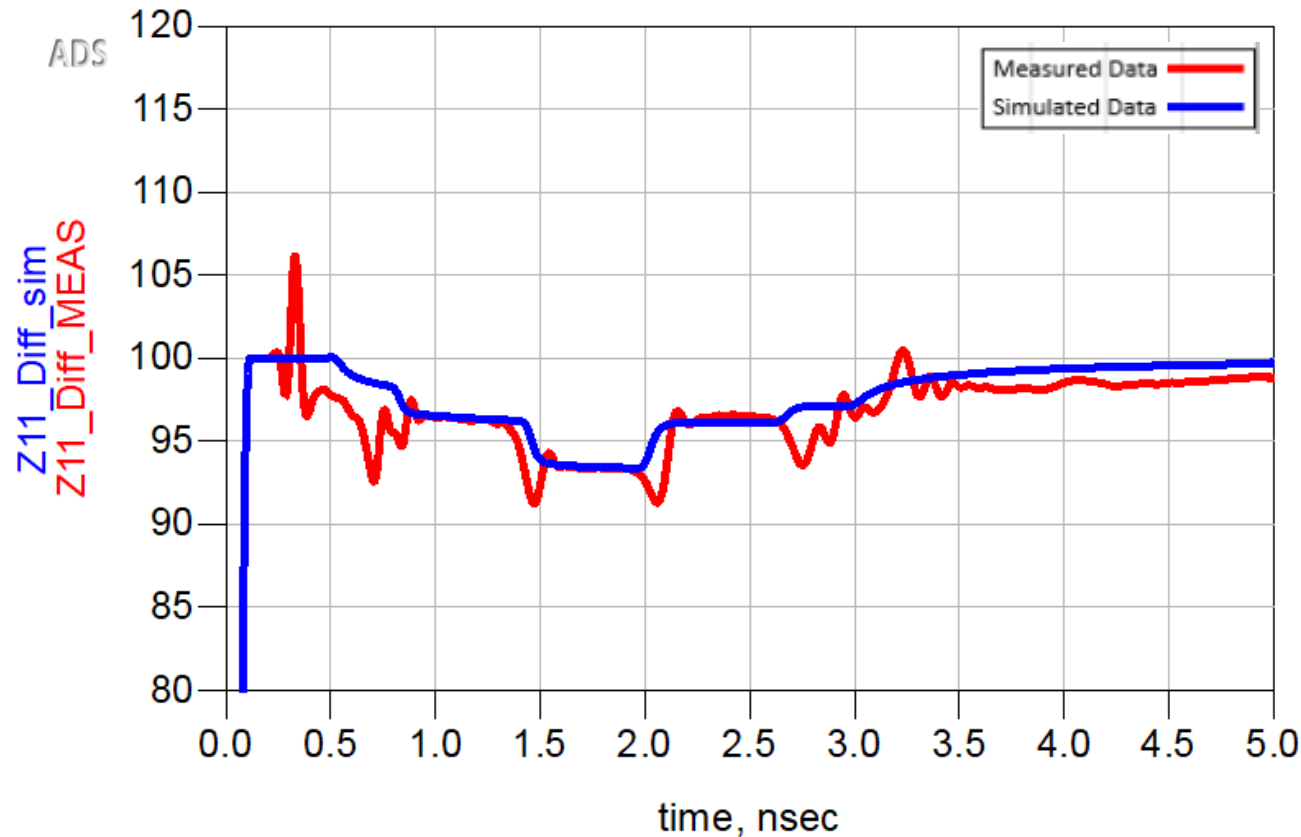
Parameters	Measured	Simulated
Dielectric Constant (Dk)	4.5	4.82
Dielectric height (H)	58.7 mills	58.9 mills
Etch (del W)	0 mil	-0.9 mils (Over etched)

How good can we match?

Key Takeaways

- Understanding the behavior of interconnects and parameters of PCB stack-up.

- Board designs with specific parameters may not always be consistent with what the fabrication vendor produced.

- Hacking the simulation data to fit the measured data allowed a bigger transparency of the parameter values.

University of Colorado **Boulder**

High Speed Digital Engineering Group

Questions?

University of Colorado **Boulder**

High Speed Digital Engineering Group