19 July 2023

Lab 01

S Parameters and Pulse Response of a Channel

Intended Learning Objectives

This lab is divided into two parts:

- In Part 1 you will
  - Learn different methods to do the SP analysis for a multi-port channel and then plot the S parameters
- In Part 2 you will
  - Learn to do the pulse response for a given channel and get the precursors, main cursor, port cursors

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- Before we start, download the S parameters file of the channel from this link and copy it to your machine
- https://drive.google.com/file/d/1xys7g92T3qbKZIKTSIC2hM-CywLeIi1j/view?usp=sharing

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PART 1: Simulating S-parameters for Channel

In this part, we will have the S-parameters file (channel s4p) for a channel and we will use it to simulate the channel response

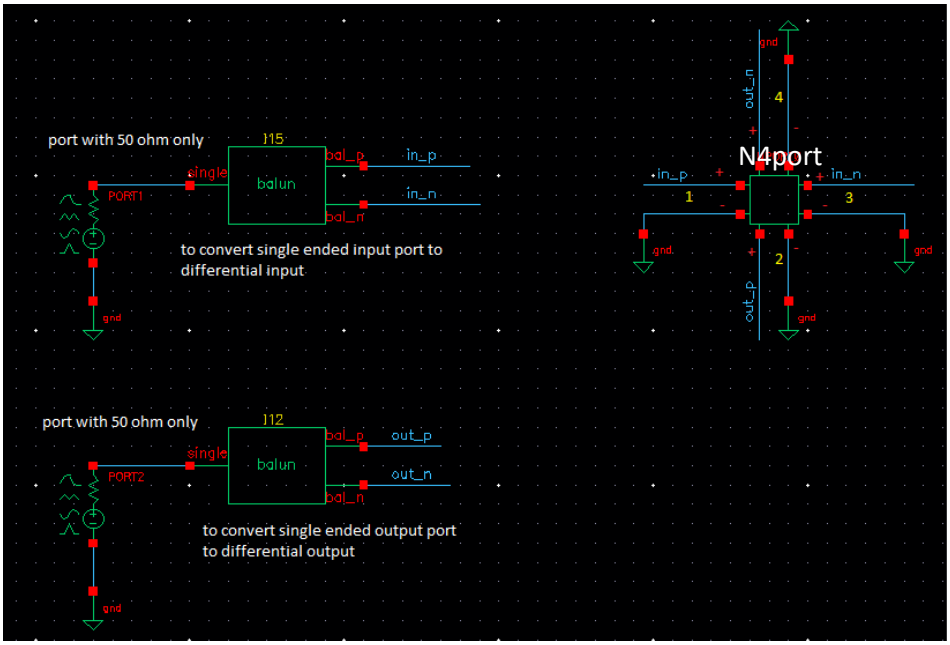
Required outputs:

- AC magnitude and phase (S21 from 0 Hz to 20 GHz)

We will have two methods to obtain the S21 for the given channel … Let's start

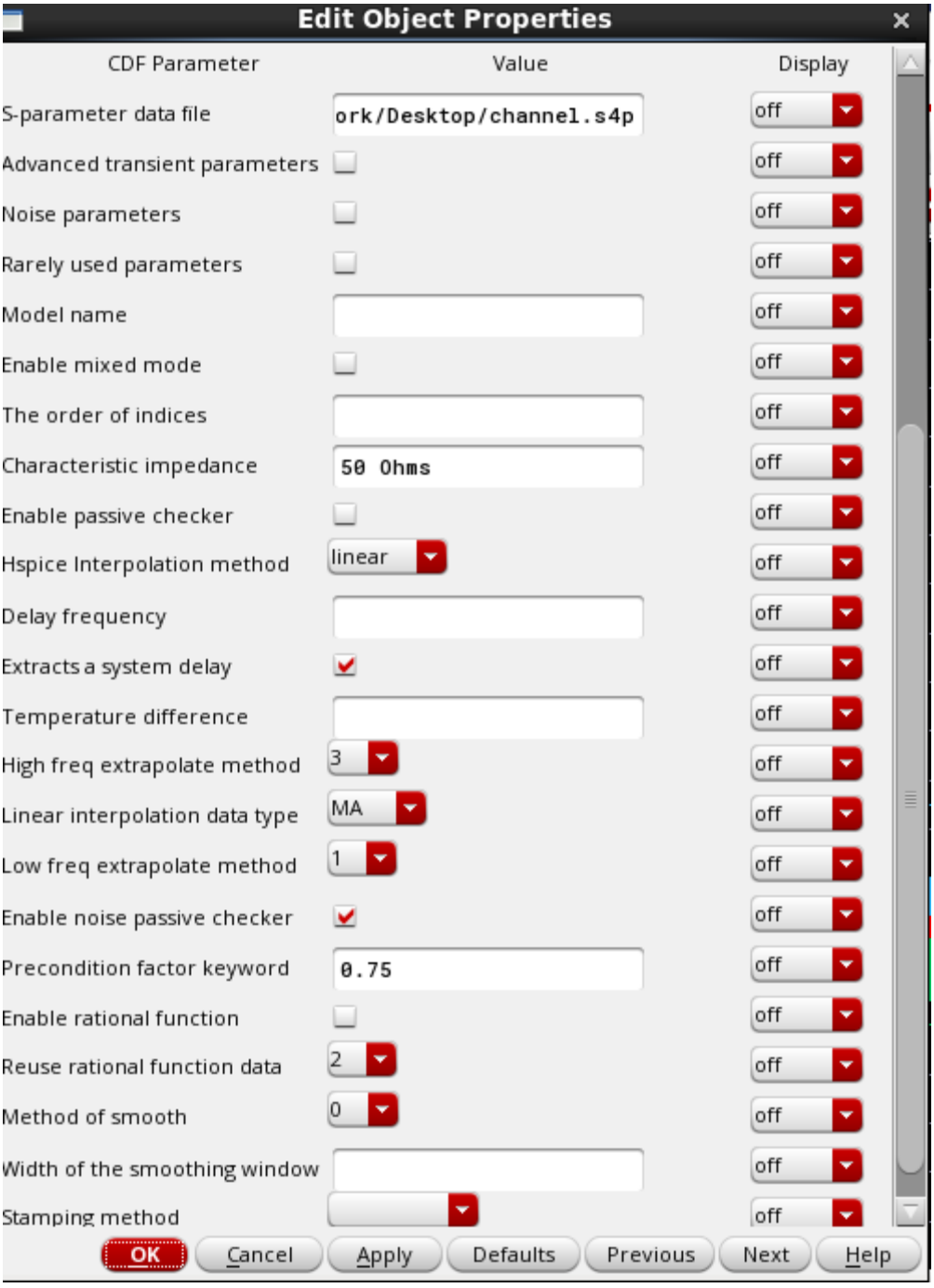
Method 1:

Overall schematic



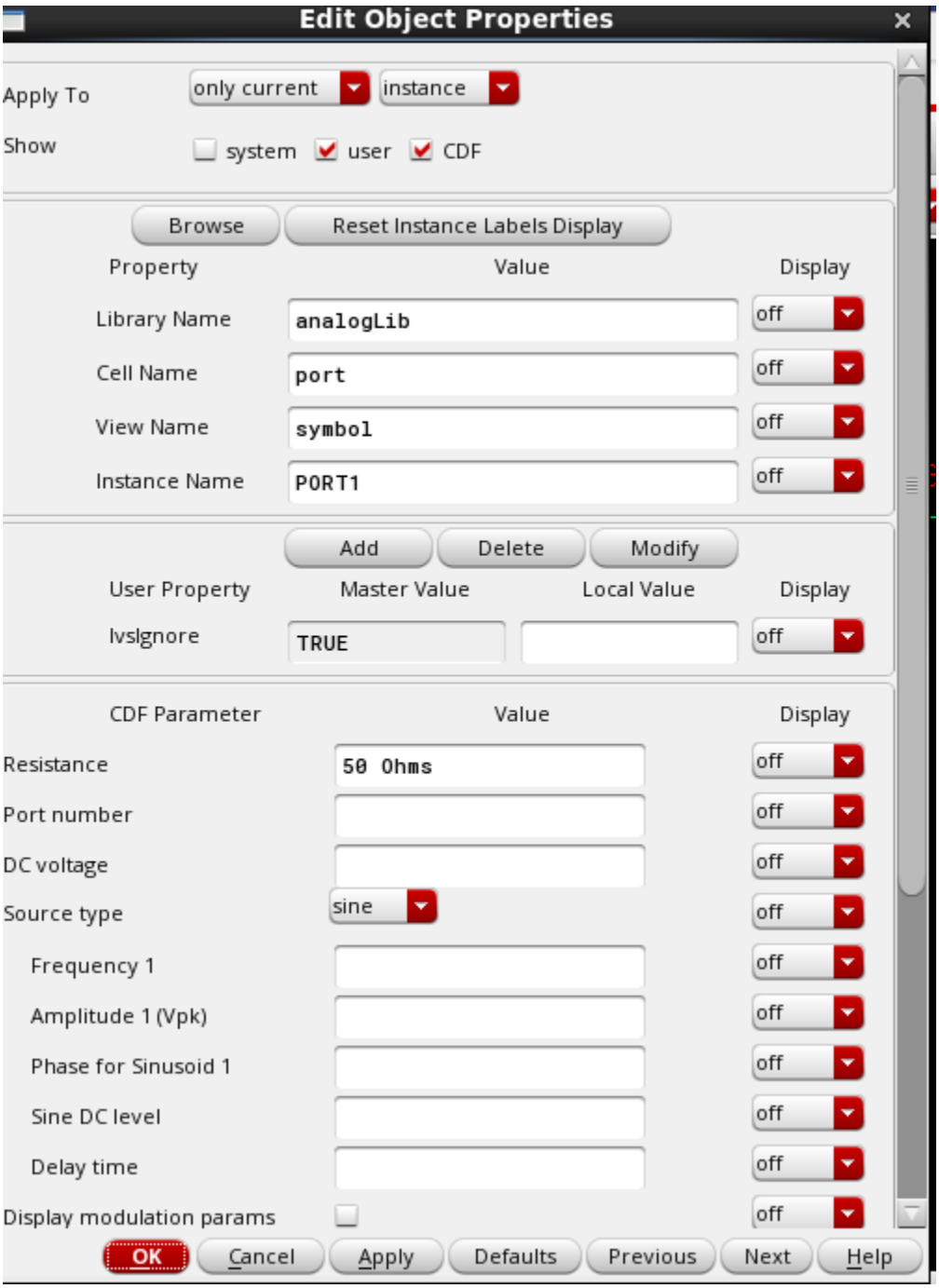
1- Placing the n4port

- Create new schematic
- Place n4port from analogLib . This is a 4 port channel symbol. We will use it to load the channel model inside it
- Open the n4port properties and load the S parameters data file by writing the path of the s4p (eg: /home/work/desktop/channel.s4p)
- Make sure that you have 50 ohm characteristic impedance in the n4port



2- Placing the ports

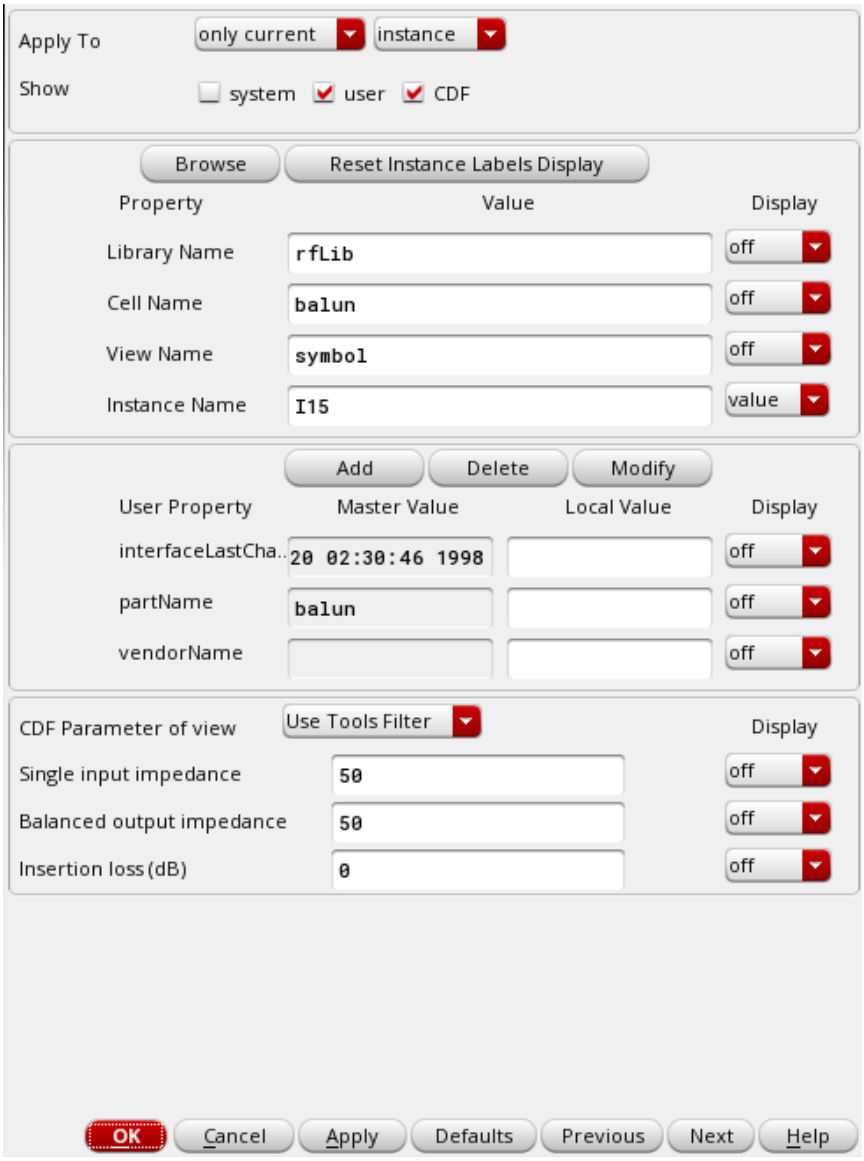
- Place two PORTS from analoglib , each one has 50 ohm (properties of the port are in the picture)
- These two PORTS will represent the input and the output of the channel



3-Placing the baluns

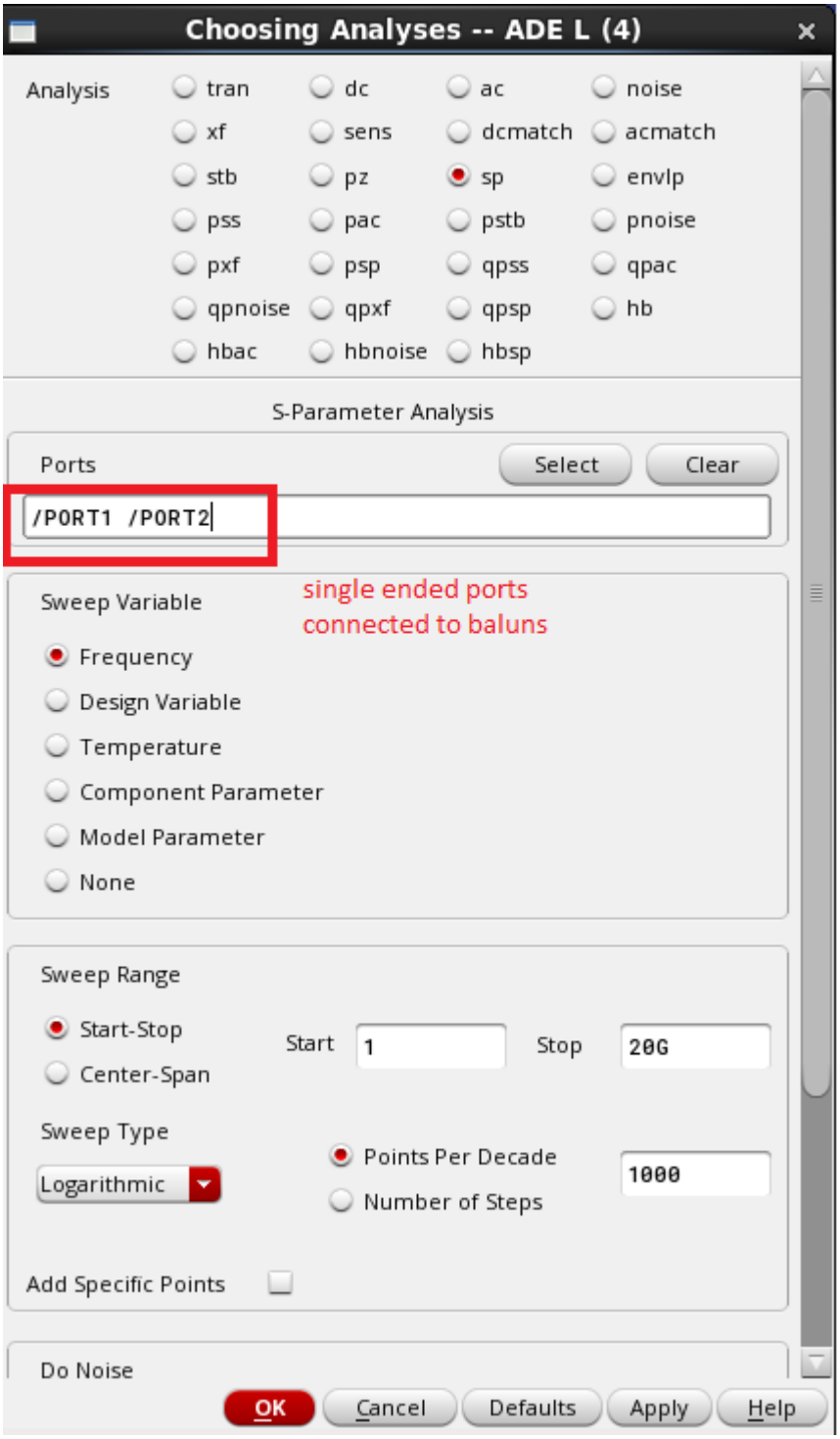
- We need baluns because we have four ports for the n4port channel
- The port 1 and 3 in the n4port are the input ports (differential + and -) , and the ports (2, 4) are the output ports (differential + and -)
- While at the same time, we need to have one input for the channel and one output for the channel , then we can measure S21 (path from input to output)
- The Balun generally converts the single ended to differential

- Place two baluns from rflib
- Open the properties of each and make sure it has input impedance = 50 ohm and output impedance = 50 ohm (properties are shown here)
- Connect the first balun to the previously placed PORT1 and the second balun to the previously placed PORT2
- The output of the first balun will represent the input differential to the n4port channel (so they will be connected to port1 and port 3 in the n4port symbol)
- The output of the second balun will represent the output differential of the n4port channel (so they will be connected to port2 and port 4 in the n4port symbol)



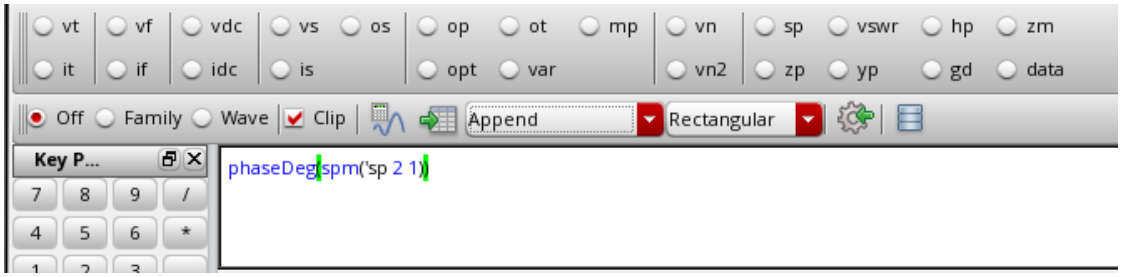
4-Create Sp analysis

- Create ADEL for the schematic
- Create SP analysis
- In the ports, select PORT1 and PORT2 in the schematic by clicking on them
- Adjust the frequency range and the number of points per decade as shown in the picture
- Run the simulation



5-plotting the outputs:

- In the ADEL, click results> Direct plot > Main form
- Select the SP
- Select plot type = rectangular
- Select S21 and plot it in dB20
- To plot the phase wrapped , write the following expression in the calculator



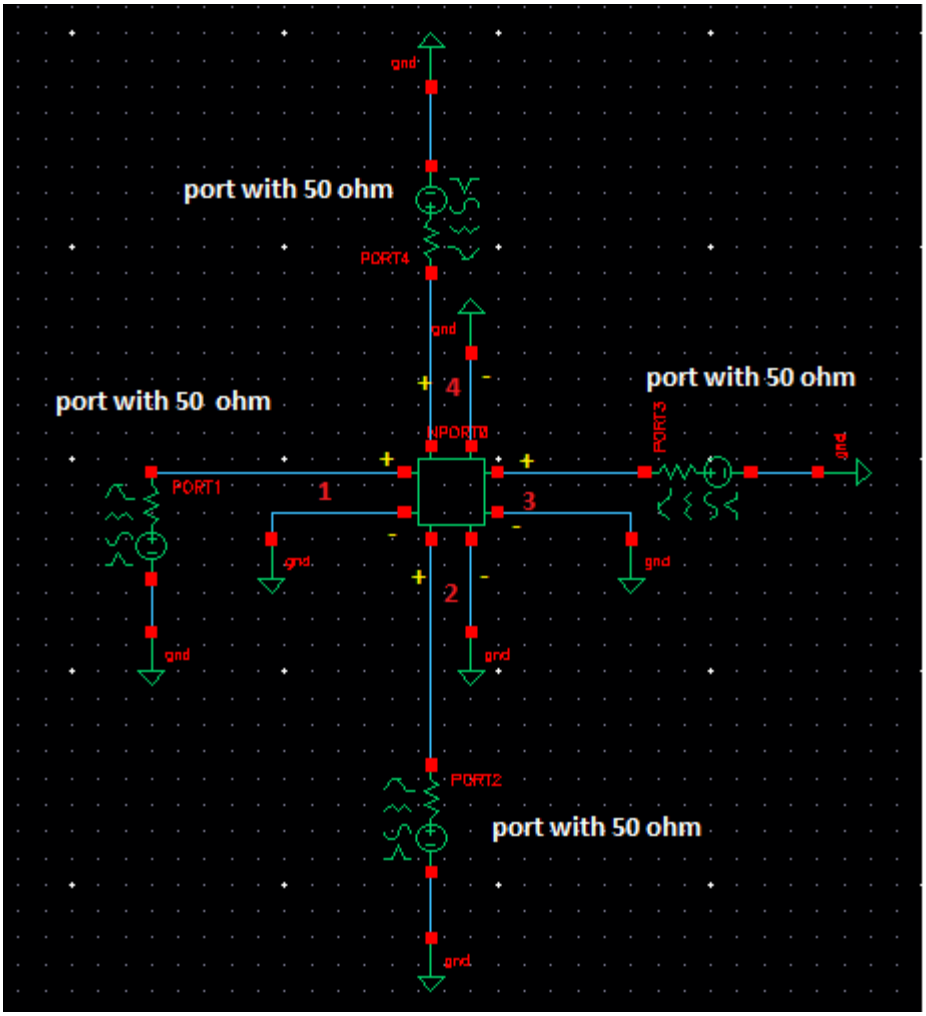
Output plots:

S21 dB

S21 phase wrapped

Method 2

Overall schematic

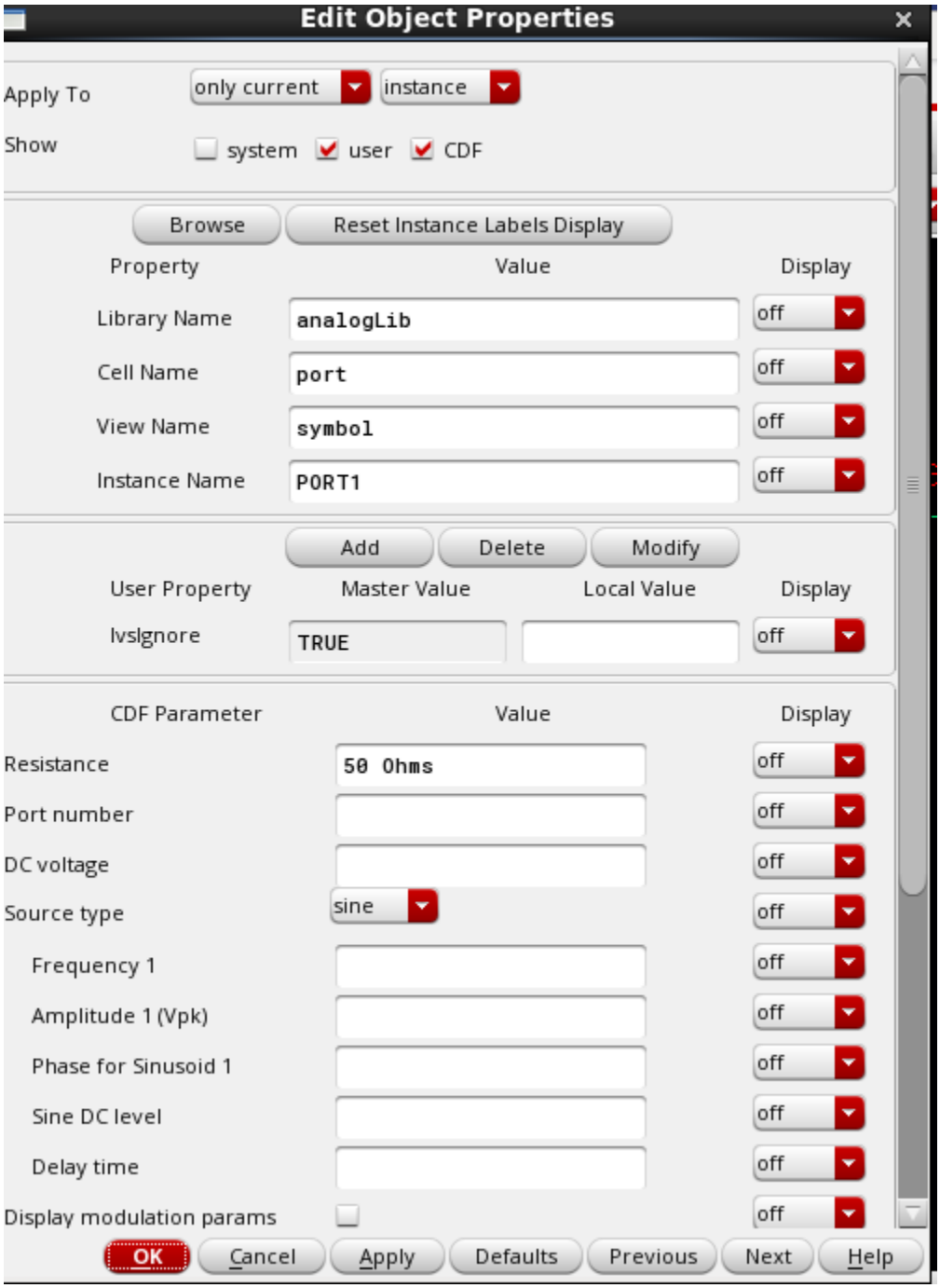


1- Placing the n4port

- Same steps of placing n4port as method 1
- Make sure that you load the s4p file correctly
- Make sure about the 50 ohm characteristic impedance

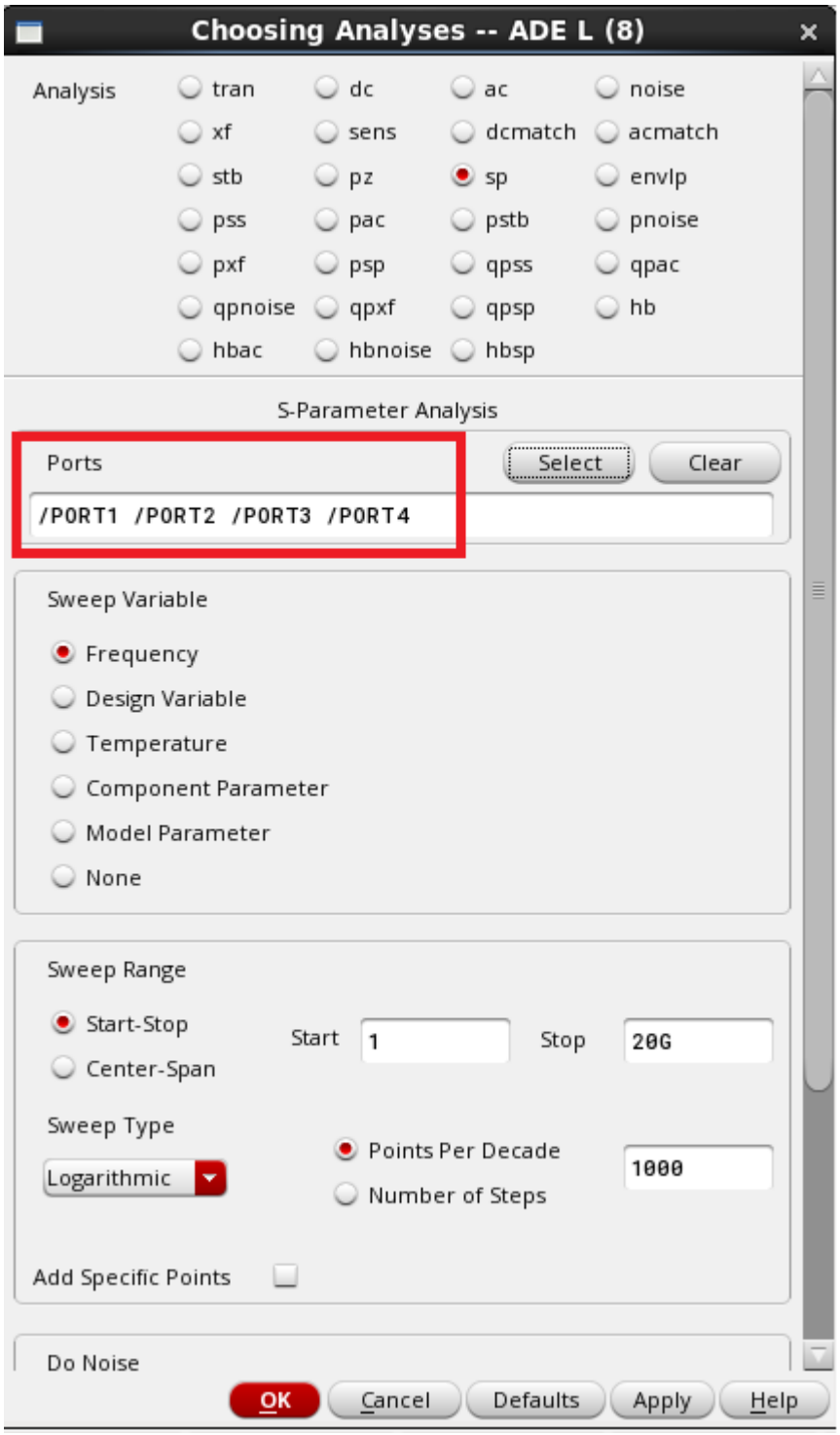
2-Placing the ports

- Place four PORTS from analoglib , each one has 50 ohm
- Connect PORT1 to port1 +ve in n4port
- Connect PORT2 to port2 +ve in n4port
- Connect PORT3 to port3 +ve in n4port
- Connect PORT4 to port4 +ve in n4port
- (make sure about port numbers please)
- Make sure about the properties of the PORT (attached in the picture again)



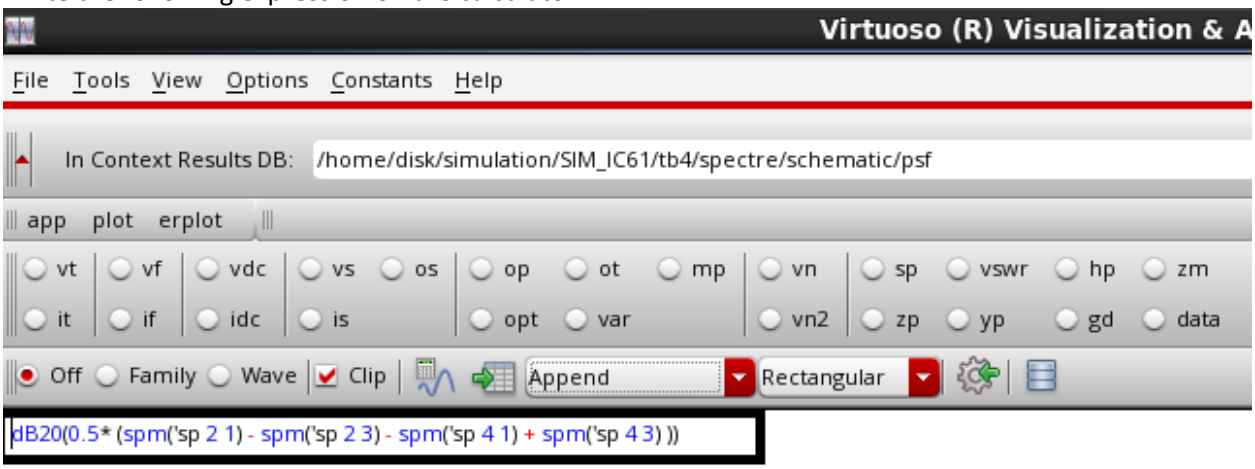
3-Create Sp analysis

- Create ADEL for the schematic
- Create SP analysis
- In the ports, select PORT1, PORT2,PORT3, PORT4 in the schematic by clicking on them
- Adjust the frequency range and the number of points per decade as shown in the picture
- Run the simulation



5-plotting the outputs:

Write the following expression on the calculator



The previous expression represents the S21

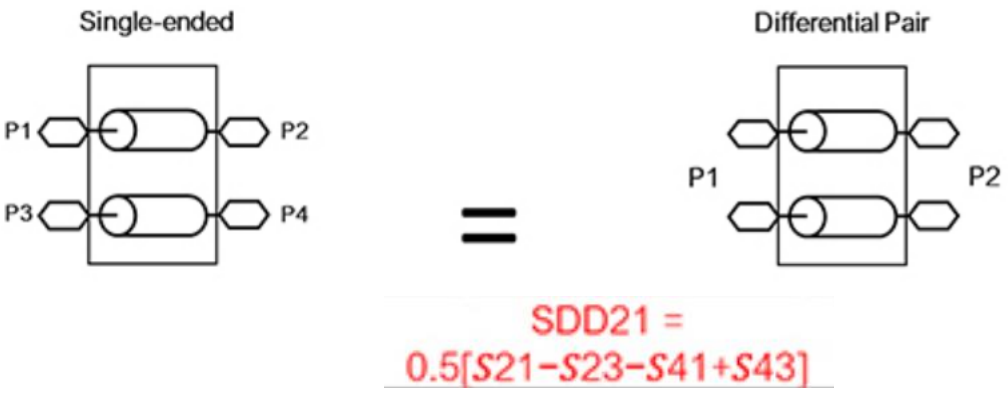
Output plots:

S21 dB

Appendix: Theory of conversion from single ended to differential (FYI)

Check the link for complete analysis:

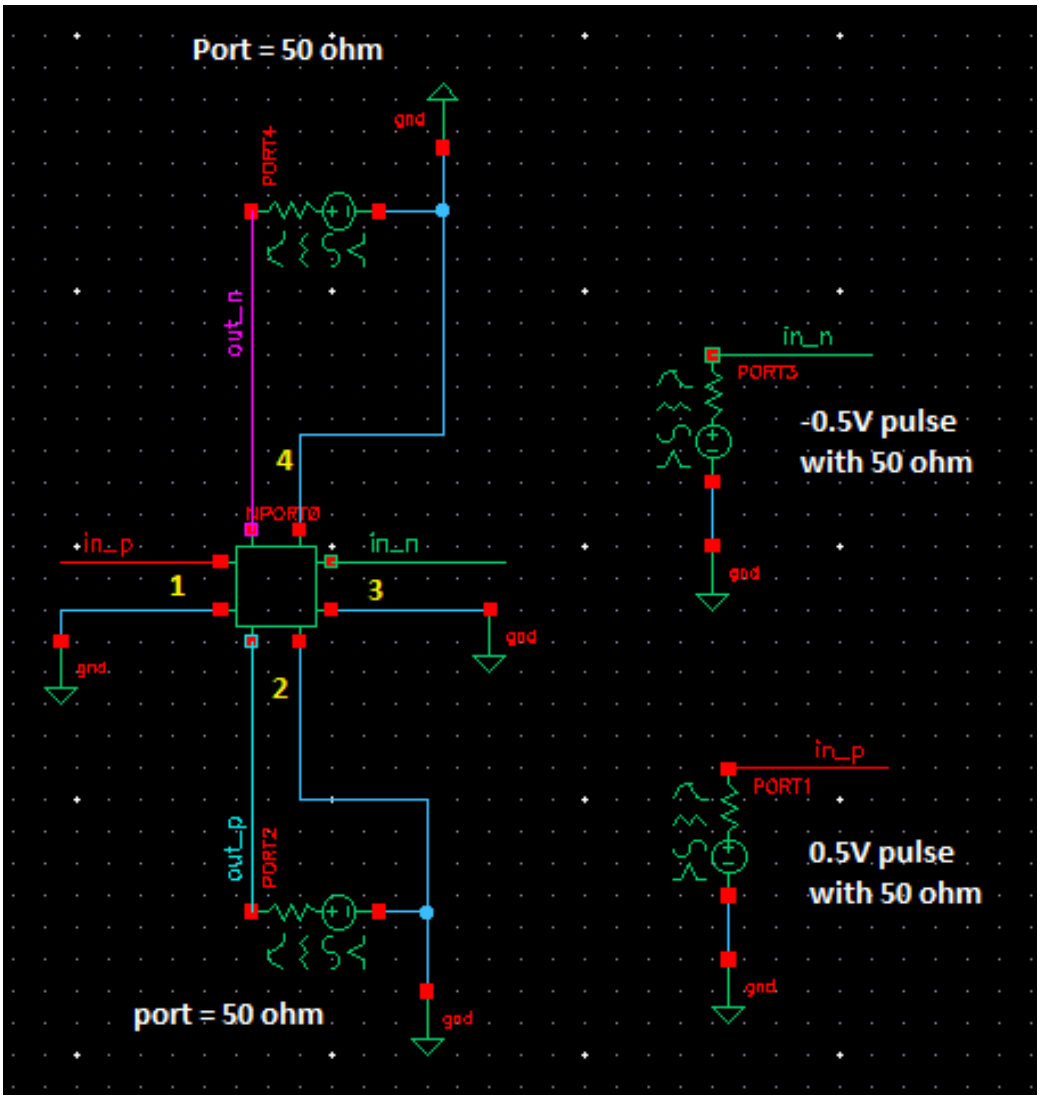
https://www.signalintegrityjournal.com/articles/1832-a-guide-for-singleended-to-mixedmode-s-parameter-conversions



PART 2: Pulse Response for Channel

In this part, we will get the pulse response at 8 Gb/s

Overall schematic:



1- Placing the n4port

- Same steps of placing n4port as part 1
- Make sure that you load the s4p file correctly
- Make sure about the 50 ohm characteristic impedance

2- Placing the PORTS

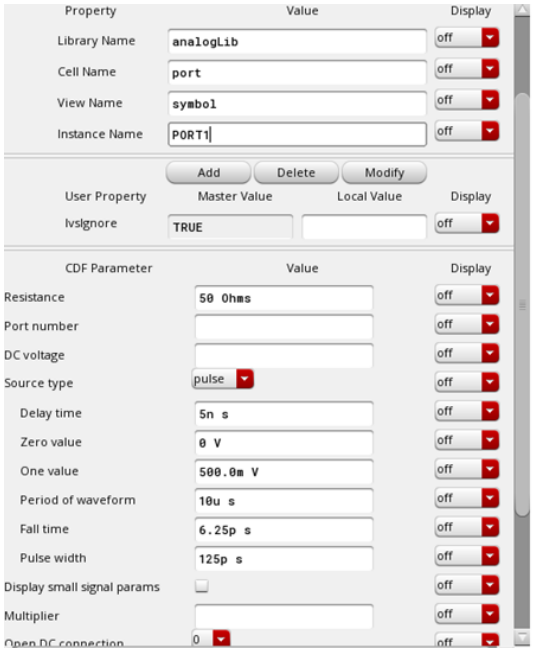
- Place PORT1 connected to port1 in the n4port as shown in previous schematic
- Place PORT2 connected to port2 in the n4port as shown in previous schematic
- Place PORT3 connected to port3 in the n4port as shown in previous schematic
- Place PORT4 connected to port4 in the n4port as shown in previous schematic

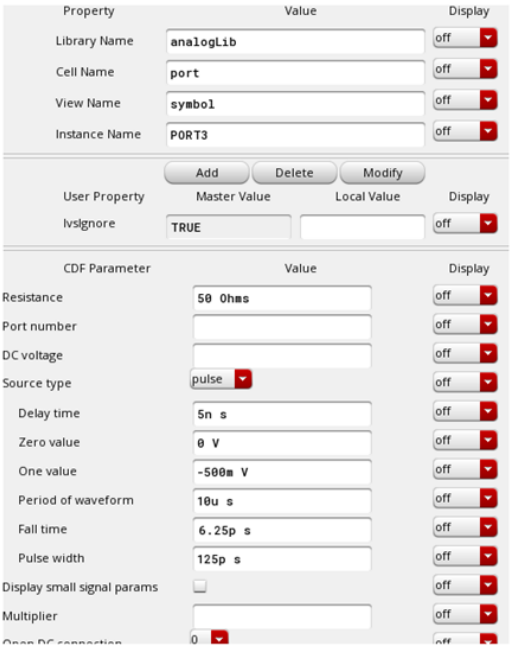
PORT1

- For PORT1, this will represent the +ve input
- Edit the properties of PORT1 to add a pulse inside it
- The pulse width is 125 ps (corresponds to 8 Gb/S)
- The fall time is 6.25ps (corresponds to 5% of the pulse width)
- The one value = 0.5V and zero value =0
- Note: the input pulse is shifted to start from 5ns

PORT3

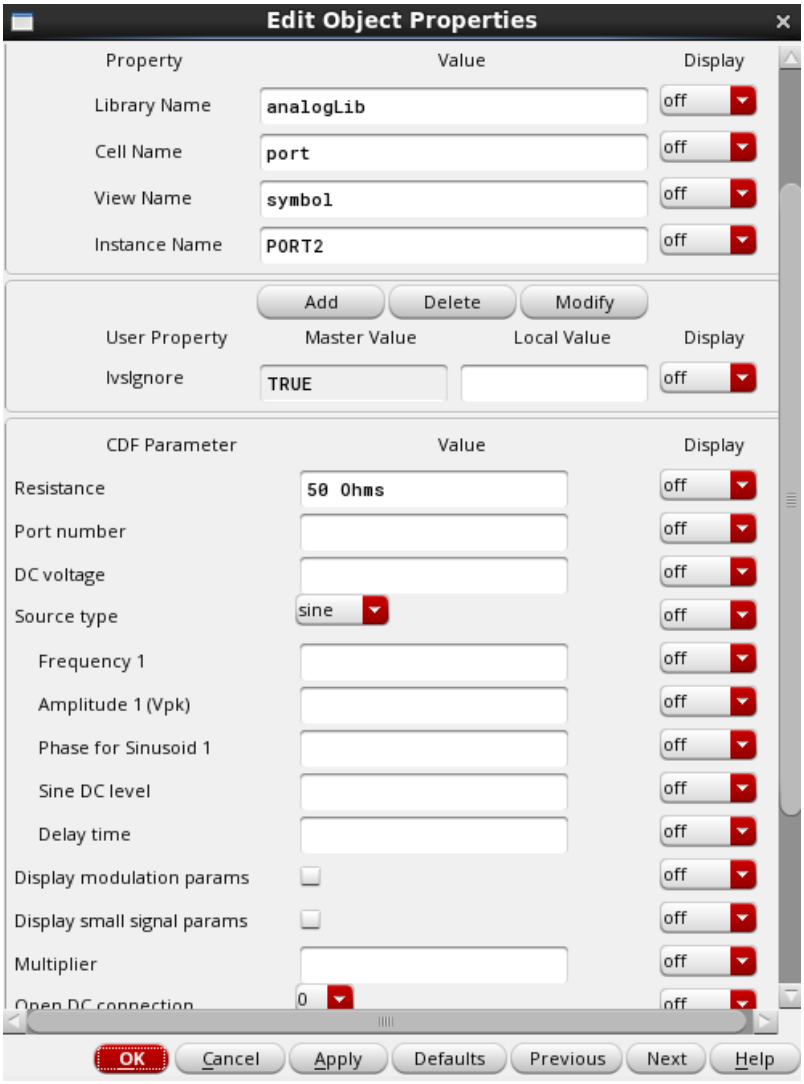
- For PORT3, this will represent the -ve input
- Edit the properties of PORT3 to add a pulse inside it
- The pulse width is 125 ps (corresponds to 8 Gb/S)
- The fall time is 6.25ps (corresponds to 5% of the pulse width)
- The one value =- 0.5V and zero value =0
- Note: the input pulse is shifted to start from 5ns





PORT2 and PORT4

- They represent the output
- We just put 50 ohm inside PORT2 and PORT4



3- Create Transient analysis

- Create ADEL for the schematic
- Create transient analysis
- Let the stop time = 15ns
- Click options in the transient simulation, set the maxstep = 1ps to get high accurate
- Make sure that you select conservative
- Run the simulation

4- Plotting the output

- Plot the output differential of the channel (out_p – out_n)
- Determine the main cursor (highest point)
- Start moving by UI and record the post cursors and pre cursors
- Record your data in a table

Required Outputs
Transient Output plot of the channel

Table including main cursor, post cursors, precursors (include at least 10 cursors)

Time	Cursor type (pre or post or main)	Value

Appendix: Cursors example

Pulse Response	
Time (UI)	Sample (V)
-3	0.02
-2	-0.03
-1	0.03
0	0.33
1	0.25
2	0.15
3	0.06
4	0
5	-0.05
6	0.03
7	-0.02
8	0.02
9	0.01