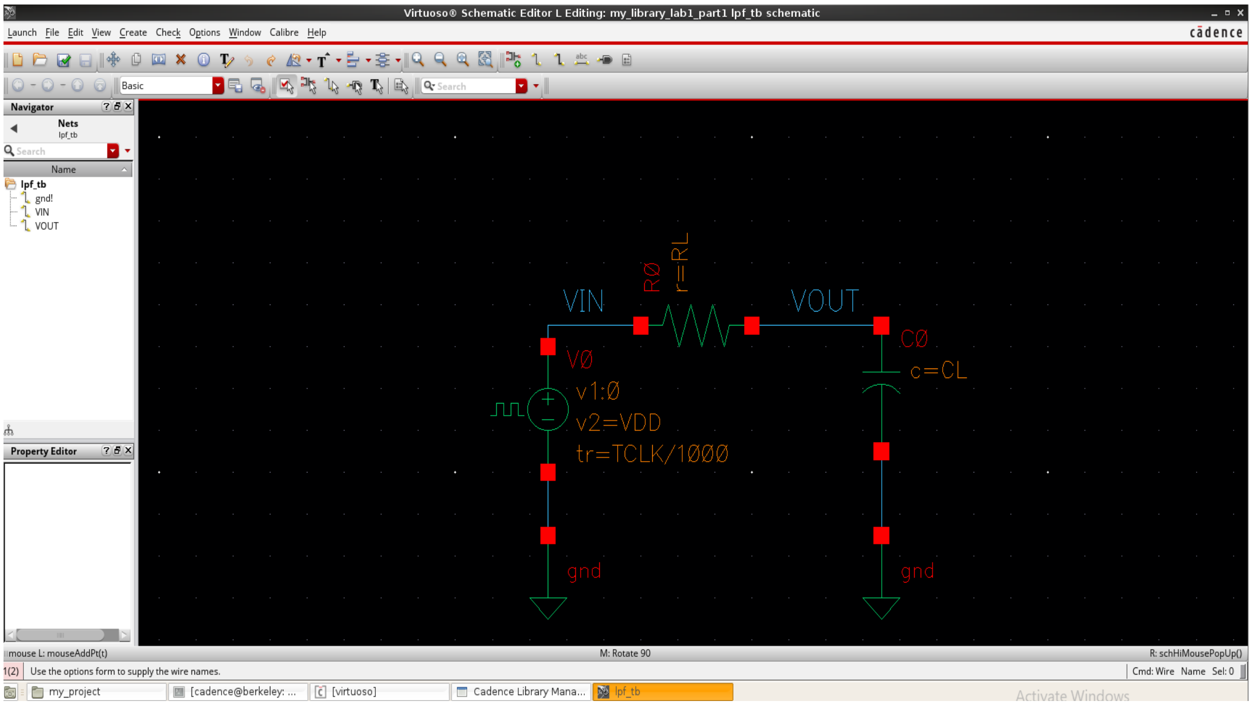
LAB 01

PART 1 (LPF SIMULATION):

1^{ST}: Transient simulation:

Low pass filter circuit:

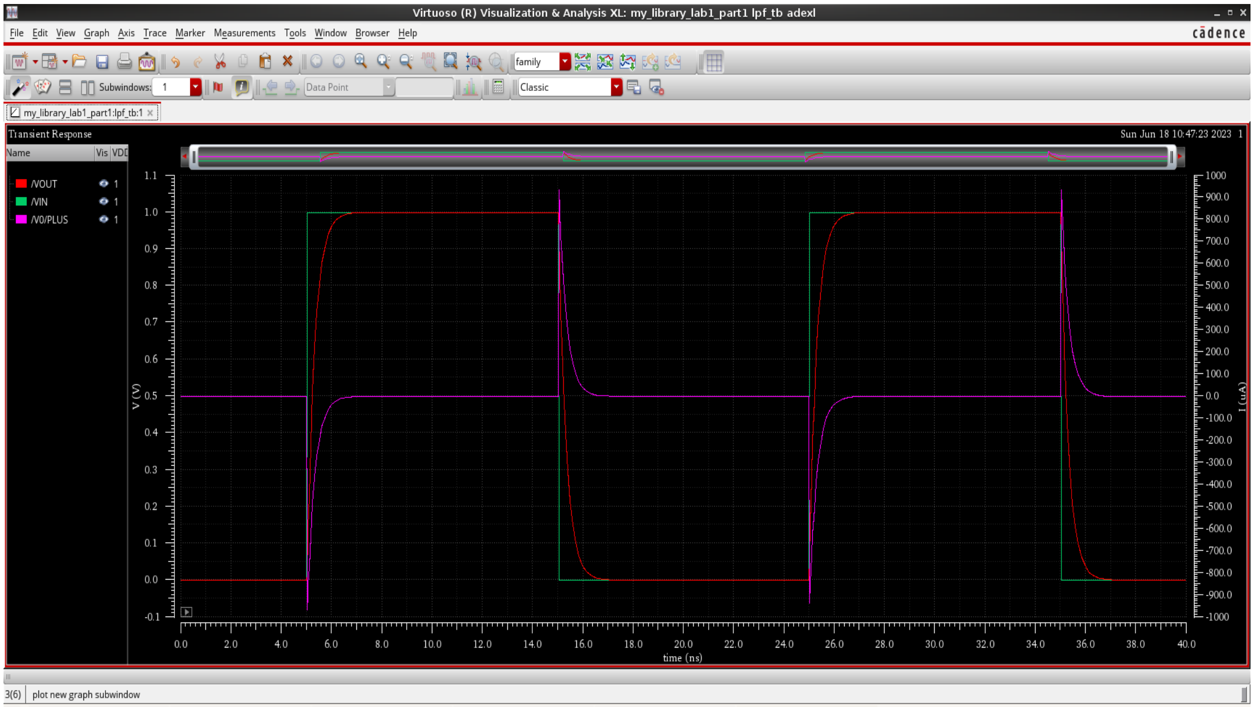


//comments:

for transient analysis :

- a square wave voltage input is used [1,VDD]
- period = TCLK
- r = RL , c = CL , Trise = Tfall = TCLK/1000
- delay = TCLK/4
- pulsewidth = TCLK/2

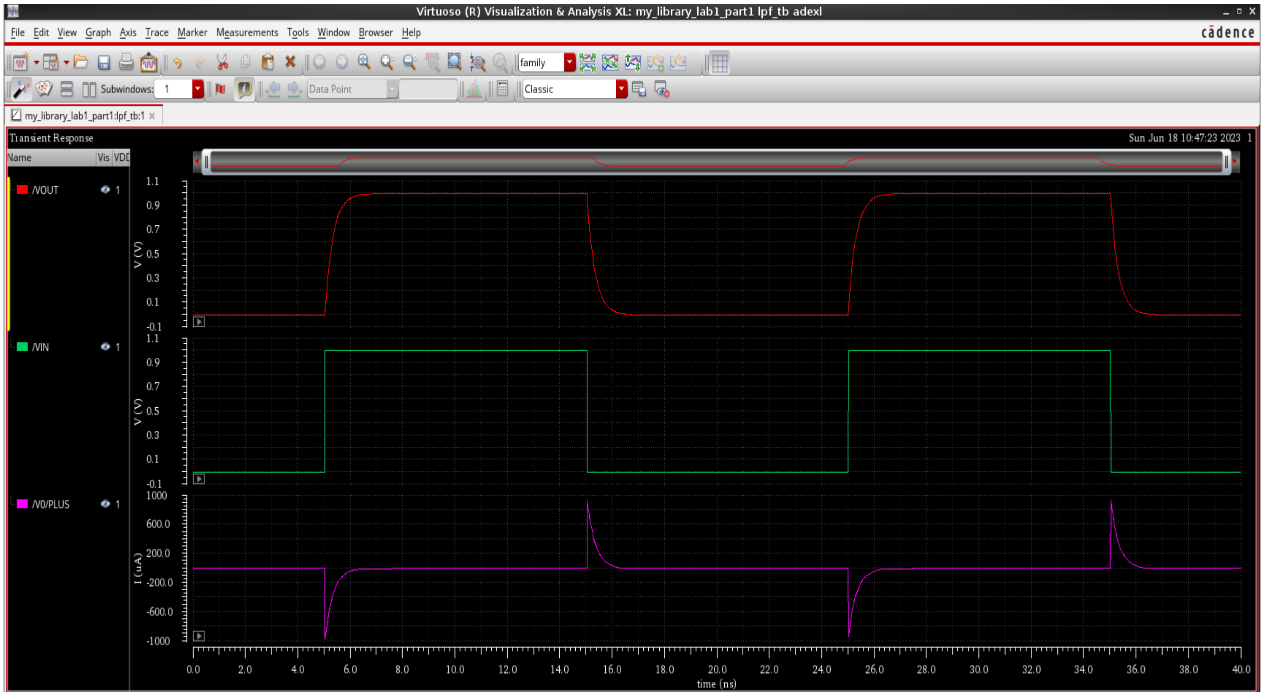
Low pass filter transient simulation:



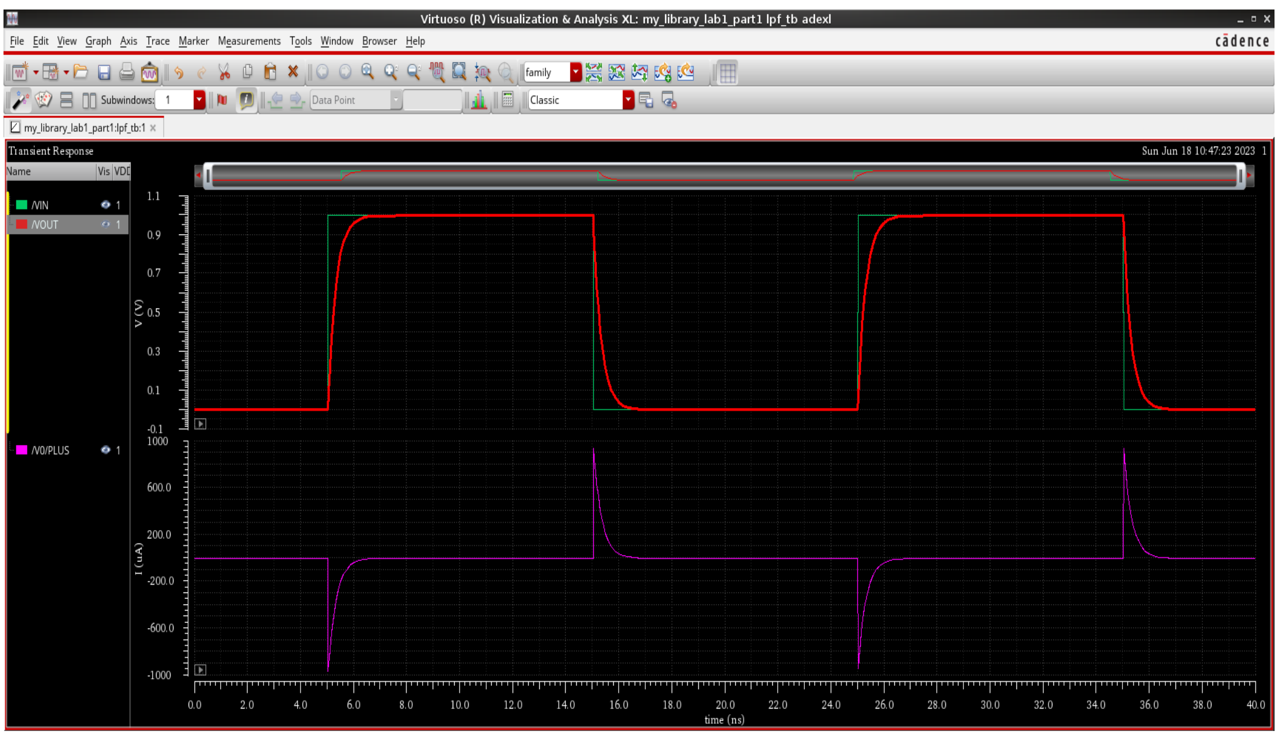
VOUT, VIN, Current {not separated}

//comments:

- For launching ADE XL is used for its simplicity and better interface.
- A moderate analysis is used.
- A graph is plotted for VOUT, VIN, Current is plotted.
- 0 Errors occurred with 1 warning.

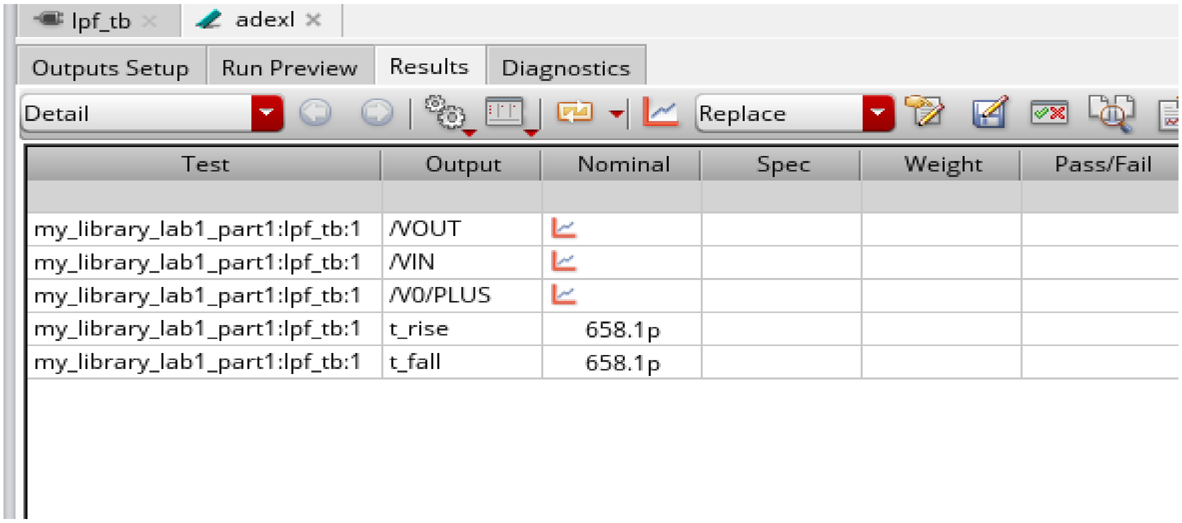


VOUT, VIN, Current {separated}



(VOUT verses VIN) & Current

Rise time & Fall time:



Test	Output	Nominal	Spec	Weight	Pass/Fail
my_library_lab1_part1:lpf_tb:1	/VOUT				
my_library_lab1_part1:lpf_tb:1	/VIN				
my_library_lab1_part1:lpf_tb:1	/V0/PLUS				
my_library_lab1_part1:lpf_tb:1	t_rise	658.1p			
my_library_lab1_part1:lpf_tb:1	t_fall	658.1p			

	Rise time	Fall time
Calculated	658.1p	658.1p
Analyical	2.2*T = 0.66p	2.2*T = 0.66p

//comments:

- For calculating the rise time using cadence calculator Y-initial value is set = 0 & Y-final value is set = 1
  & Percentage low = 10%, percentage high = 90%
- A function for calculating rise time is built.
- Buffer expression is sent to ADE XL outputs to perform the calculations.
  For calculating the fall time using cadence calculator Y-initial value is set = 1 & Y-final value is set = 0 & Percentage low = 10%, percentage high = 90%
- function for calculating rise time is built.
- Buffer expression is sent to ADE XL outputs to perform the calculations
  table including all values will be included in next page.

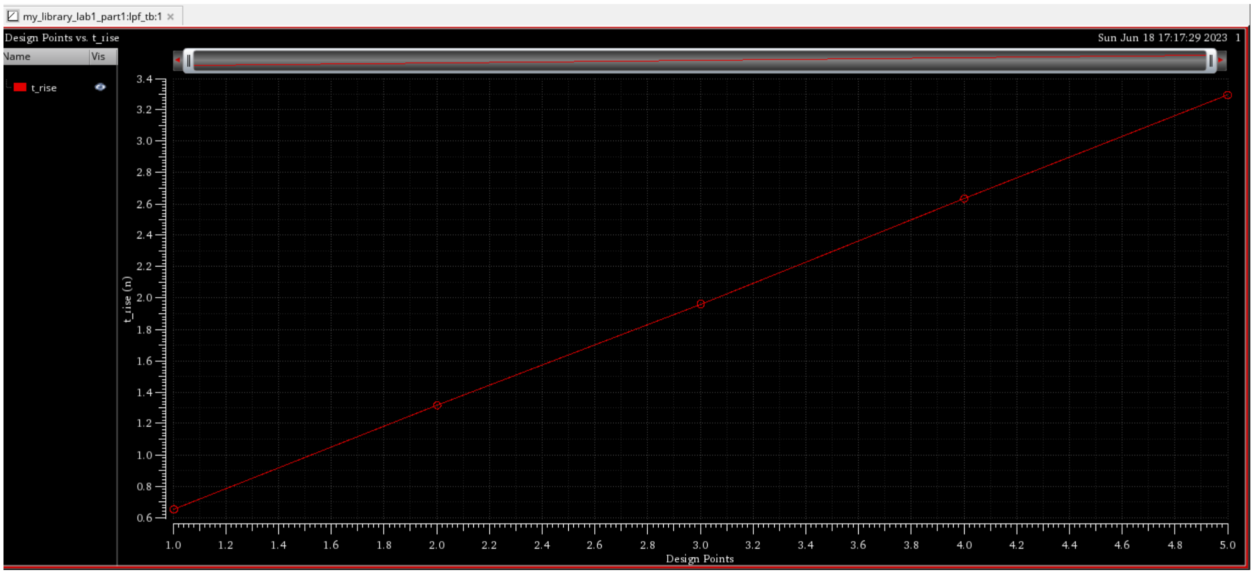
Parametric sweeps:

	RL	riseTim...time")
1	1.000E3	658.1E-12
2	2.000E3	1.320E-9
3	3.000E3	1.967E-9
4	4.000E3	2.638E-9
5	5.000E3	3.300E-9

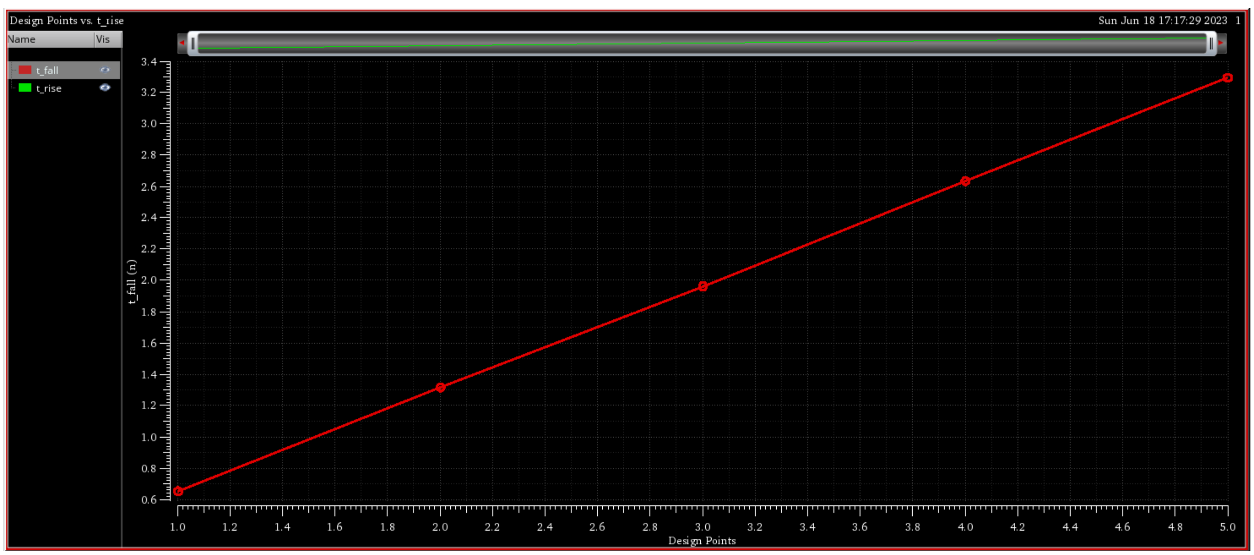
	RL	fallTim...time")
1	1.000E3	658.1E-12
2	2.000E3	1.320E-9
3	3.000E3	1.967E-9
4	4.000E3	2.638E-9
5	5.000E3	3.300E-9

//comments:

- After doing a parametric sweep for R = 1: 1: 5kΩ.
- This means that it will start with 1 k and step by 1K till reaching 5k.
- In the status: finished with no errors.
- It is obvious that the rise time and fall time have a linear relation with the resistance _*and this will be clearer in the trise and tfall plotting graph*_.



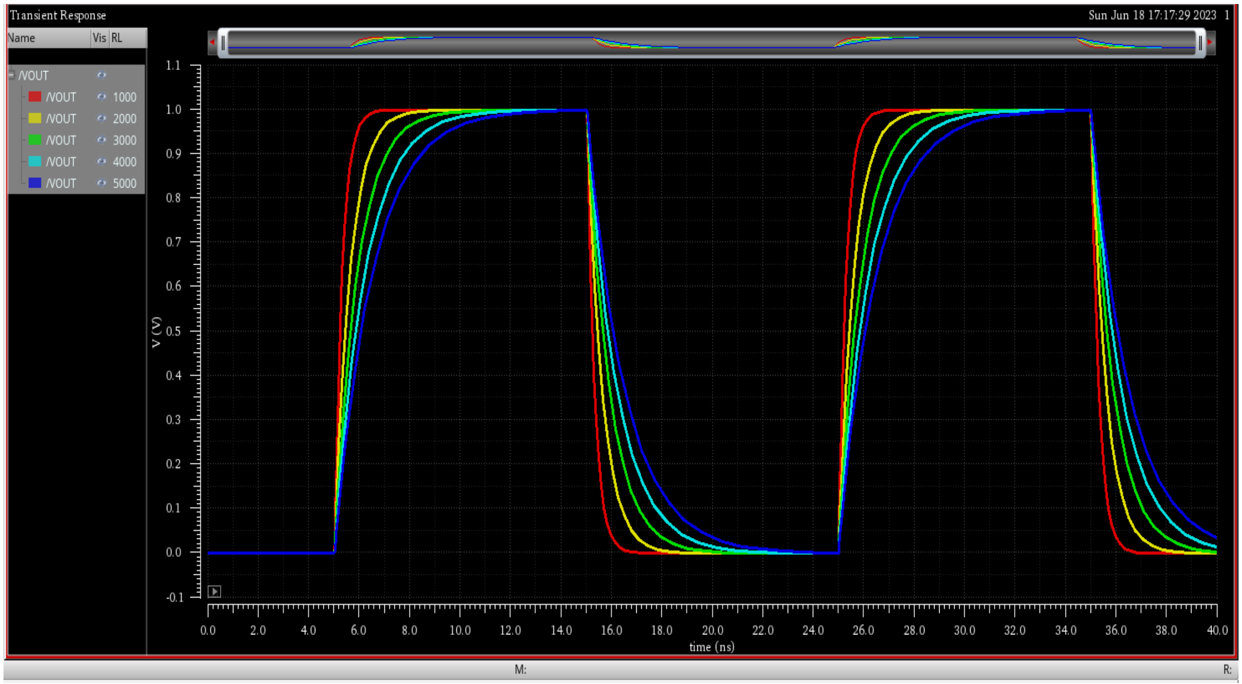
Rise time plotting with respect to resistance values.



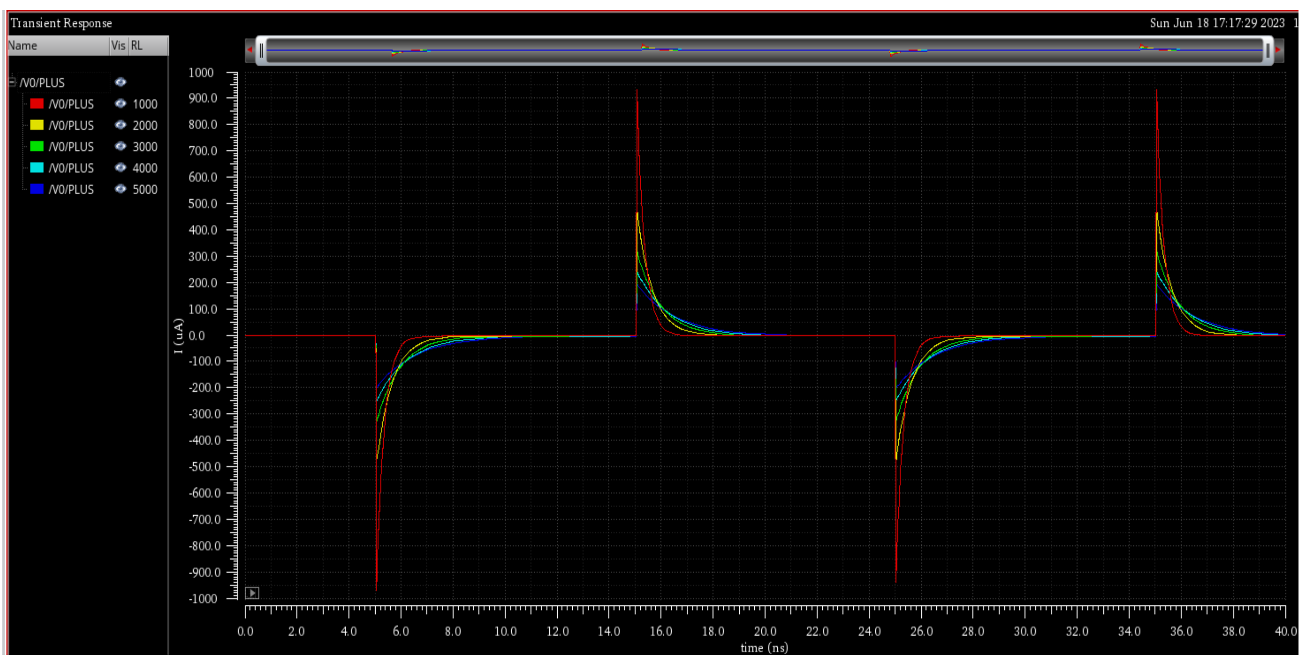
Fall time plotting with respect to resistance values.

//comments:

- Plot across all design points is done for both trise and tfall.
- Then, it is very clear that the rise time and fall time has a linear relation with the Resistance.



VOUT plotting with changing resistance values. (Transient response)



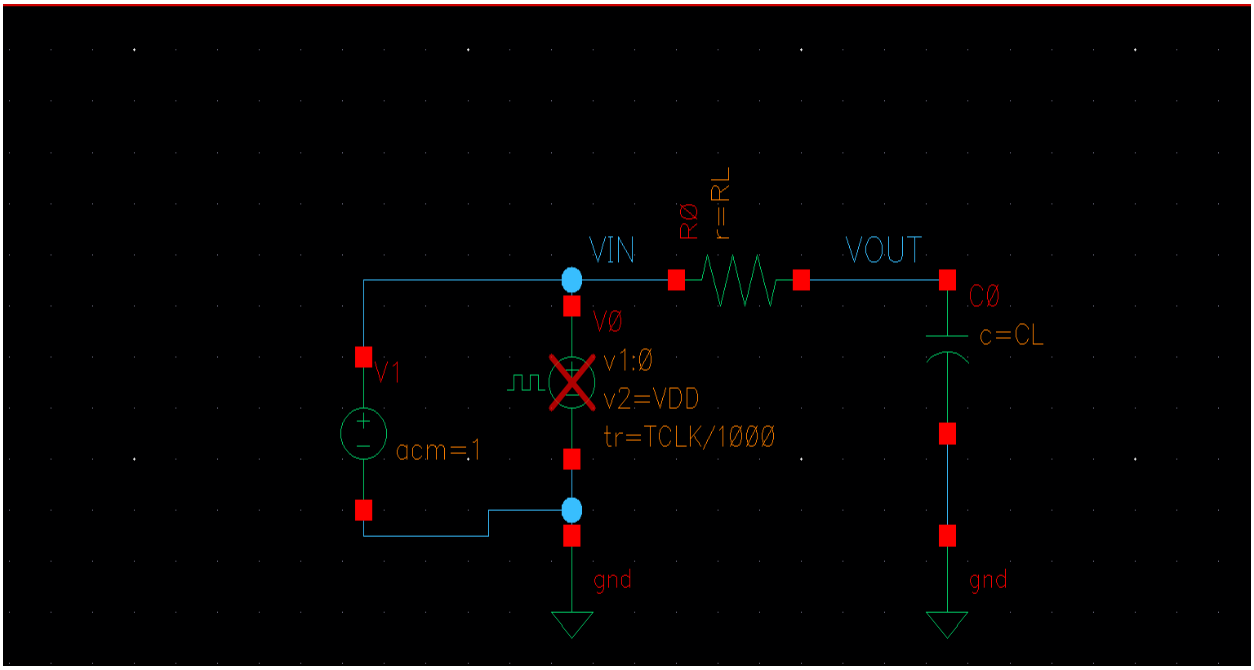
current plotting with changing resistance values.

//comments:

- To plot the outputs “plot all” is done.

2nd: AC Analysis:

Low pass filter circuit:

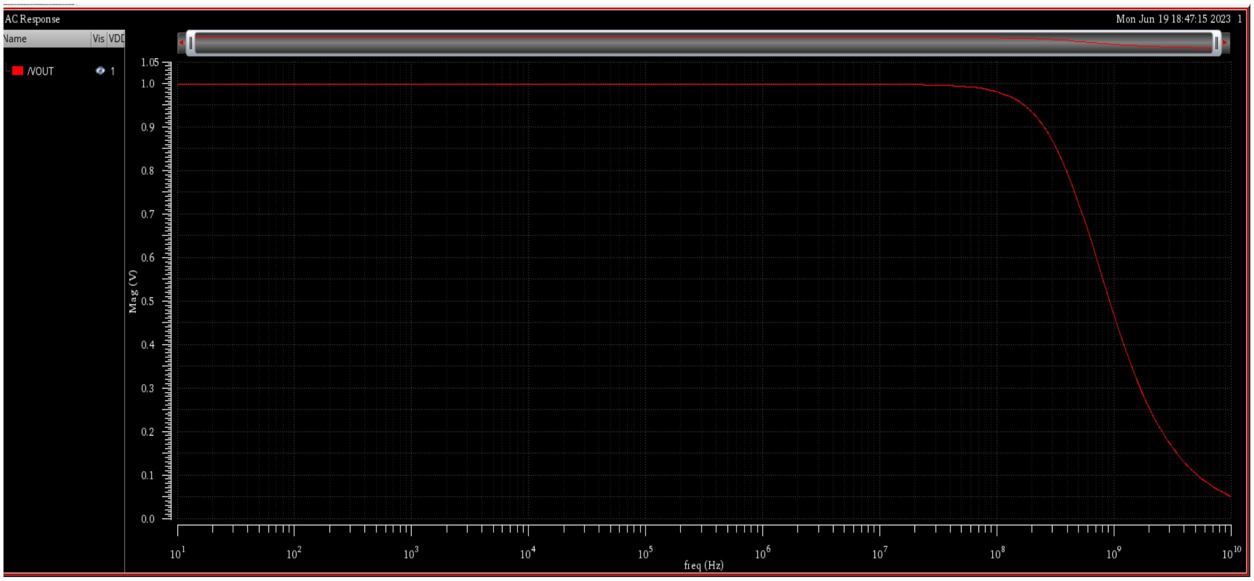


//comments:

For Ac analysis:

- Vpulse can't be used for AC analysis, so VDC is added from magnitude equal 1 volt.
- For avoiding the short circuit, the Vpulse voltage source is ignored using "shift + del".

LPF AC simulation _magnitude plot(BODE plot):

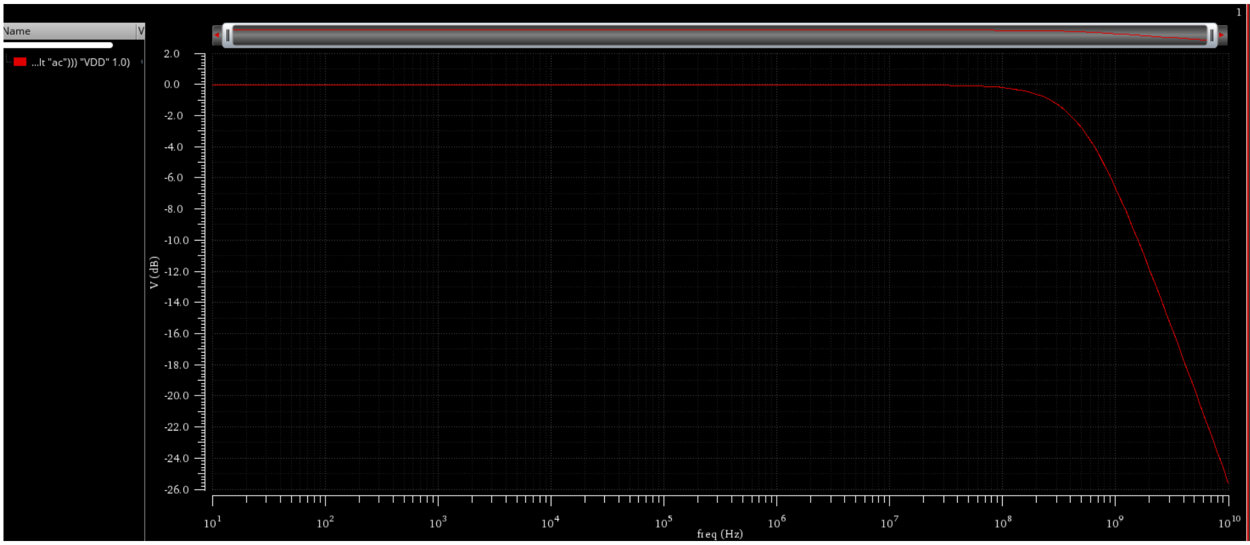


//comments:

- A new analysis is made after disabling the transient analysis, of sweep range starting from 10 HZ to 10G HZ.
- The sweep type is set to be logarithmic and points per decade is set to be equal 20 points.
- Points per decade is used as we have a large range.
- RL is set to be 1k again after canceling the old parametric sweeps.
- After running it will be finished with errors as we trise and tfall can’t be calculated as no transient.
- So trise and tfall plot is cancelled to ignore the error.

- Then VOUT is plotted.

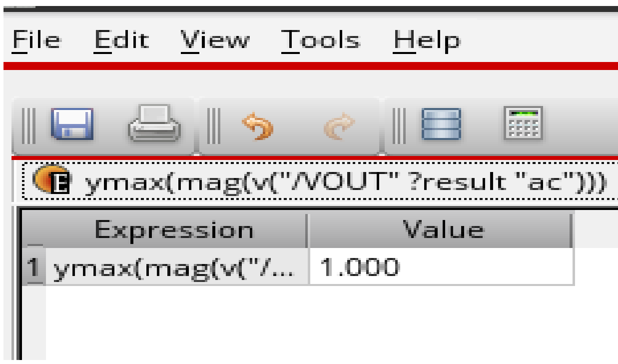
Low pass filter AC simulation in log scale:

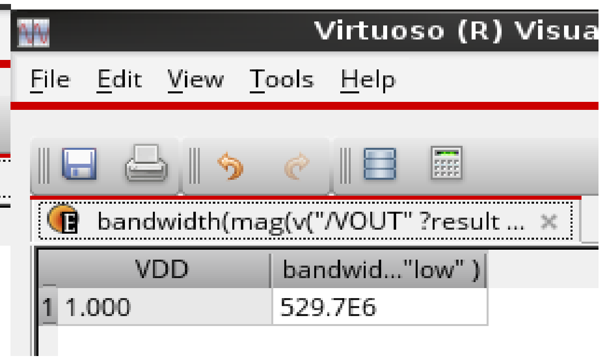


//comments:

- After sending VOUT to calculator and selecting dB20 from all functions and the plotting the function we get the VOUT in log scale.
- And by using AB cursor it is obvious that slope = 20 dB per decade,
- Then, it is obvious from the plot in log scale that the slope is 20 dB per decade.

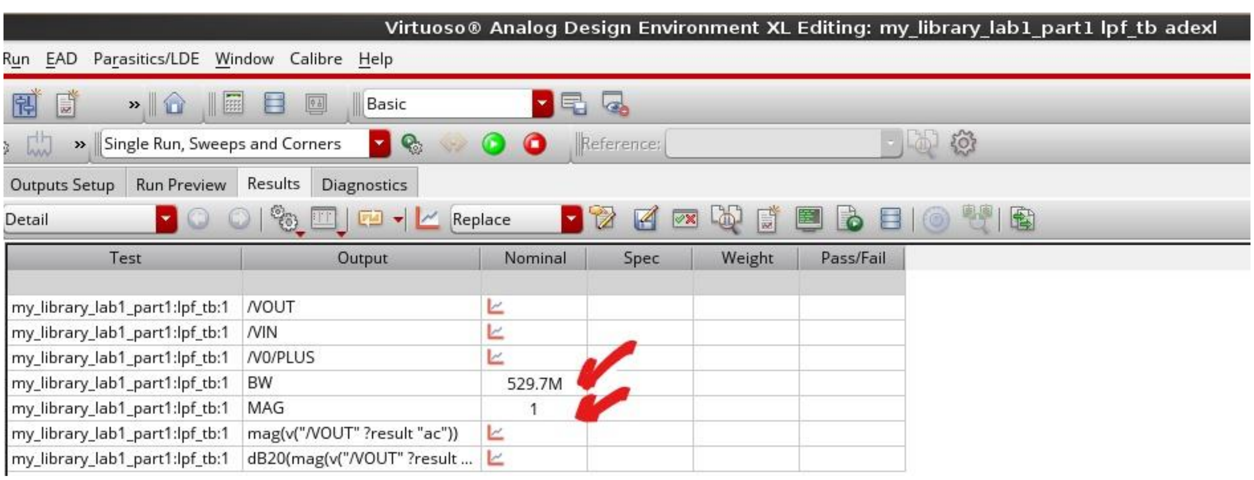
Bandwidth and magnitude calculations:





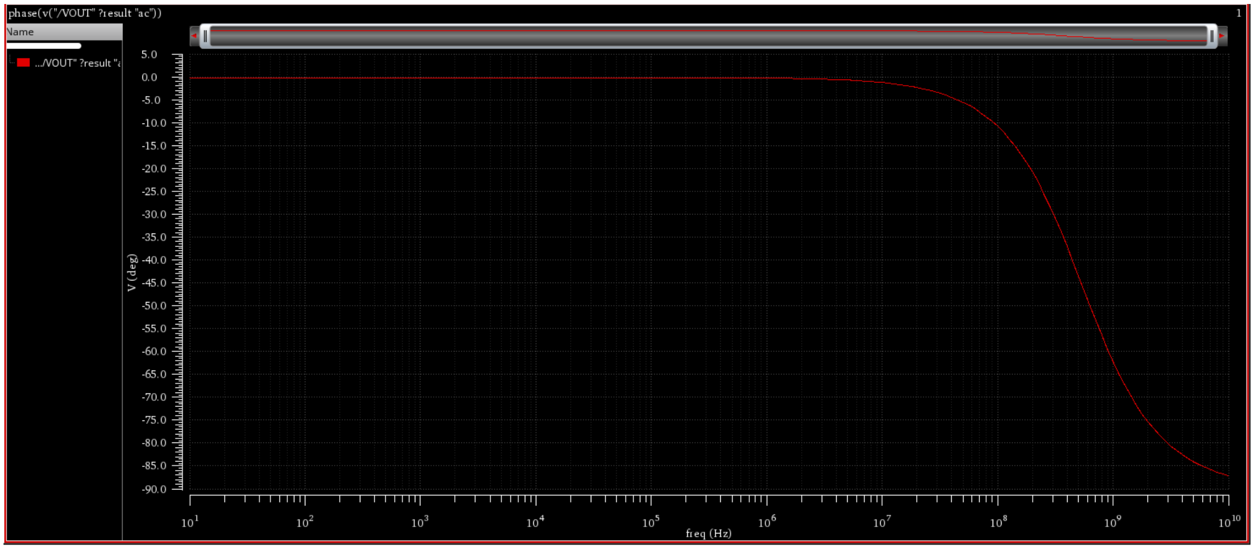
//comments:

- From the calculator bandwidth is selected from all functions to calculate the "bandwidth" till <u>3dB</u> with type "low" then, it is viewed in a table.
- The same steps are done to calculate the magnitude of the VOUT "max magnitude" by selecting "ymax" from all functions.
- Then bandwidth and magnitude are sent to testbench adexl <u>*as shown in the next picture*</u>.



Test	Output	Nominal	Spec	Weight	Pass/Fail
my_library_lab1_part1:lpf_tb:1	/VOUT				
my_library_lab1_part1:lpf_tb:1	/VIN				
my_library_lab1_part1:lpf_tb:1	/V0/PLUS				
my_library_lab1_part1:lpf_tb:1	BW	529.7M			
my_library_lab1_part1:lpf_tb:1	MAG	1			
my_library_lab1_part1:lpf_tb:1	mag(v("/VOUT" ?result "ac"))				
my_library_lab1_part1:lpf_tb:1	dB20(mag(v("/VOUT" ?result ...				

LPF AC simulation _phase plot (BODE plot):



//comments:

- Phase plot is done by sending the VOUT to the calculator and removing “mag()” from the function then adding the “phase ”from all functions.

Hand analysis and simulation comparisons:

1st: bandwidth:

Hand analysis	simulation
BW=1/(2*π*R*C) BW=1/(2*3.14*1k*0.3p) BW=530M	From the simulation calculations we get that BW=529.7M *And this is shown in the previous pages.*

2nd: gain:

Gain will be equal 1.

Parametric sweeps:

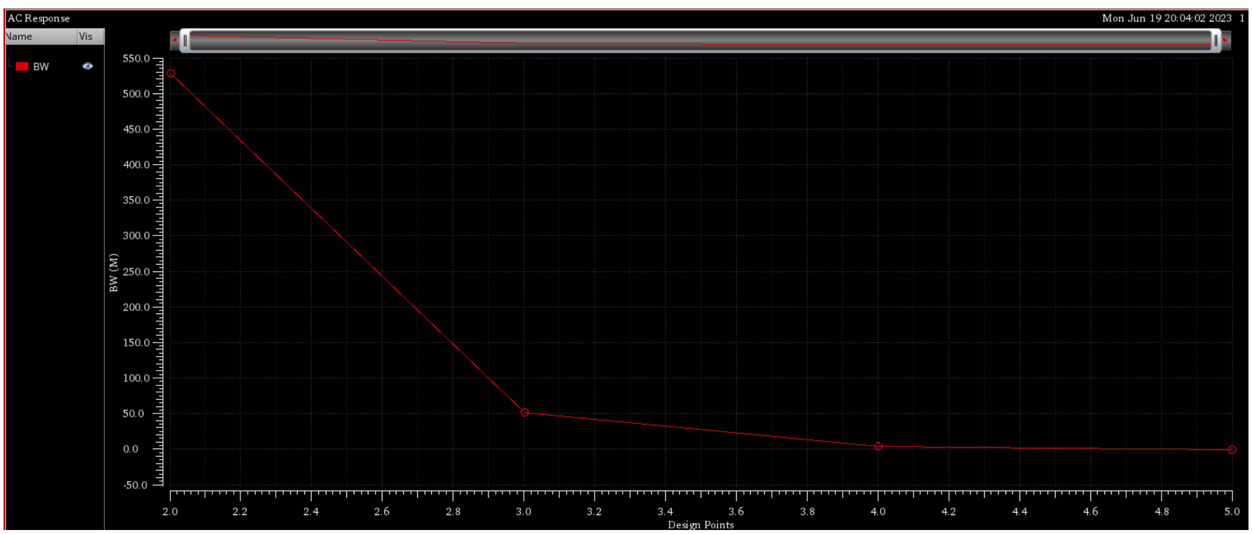
Parameters: RL=1k			
2	my_library_lab1_part1:lpf_tb:1	/VOUT	
2	my_library_lab1_part1:lpf_tb:1	/VIN	
2	my_library_lab1_part1:lpf_tb:1	/V0/PLUS	
2	my_library_lab1_part1:lpf_tb:1	BW	529.7M
2	my_library_lab1_part1:lpf_tb:1	MAG	1
Parameters: RL=10k			
3	my_library_lab1_part1:lpf_tb:1	/VOUT	
3	my_library_lab1_part1:lpf_tb:1	/VIN	
3	my_library_lab1_part1:lpf_tb:1	/V0/PLUS	
3	my_library_lab1_part1:lpf_tb:1	BW	52.97M
3	my_library_lab1_part1:lpf_tb:1	MAG	1
Parameters: RL=100k			
4	my_library_lab1_part1:lpf_tb:1	/VOUT	
4	my_library_lab1_part1:lpf_tb:1	/VIN	
4	my_library_lab1_part1:lpf_tb:1	/V0/PLUS	
4	my_library_lab1_part1:lpf_tb:1	BW	5.297M
4	my_library_lab1_part1:lpf_tb:1	MAG	1
Parameters: RL=1M			
5	my_library_lab1_part1:lpf_tb:1	/VOUT	
5	my_library_lab1_part1:lpf_tb:1	/VIN	
5	my_library_lab1_part1:lpf_tb:1	/V0/PLUS	
5	my_library_lab1_part1:lpf_tb:1	BW	529.7k
5	my_library_lab1_part1:lpf_tb:1	MAG	1

//comments:

- It is required to do parametric sweep for R = 1, 10, 100, 1000 kΩ.
- For doing parametric sweeps old values for RL are deleted then, “parametrize” window is opened and select “from/to” sweep and determine a “logarithmic step” from 1k to 1M with 4 steps.
- After running, no errors occurred. “finished with no errors”

//follow comments on parametric sweeps:

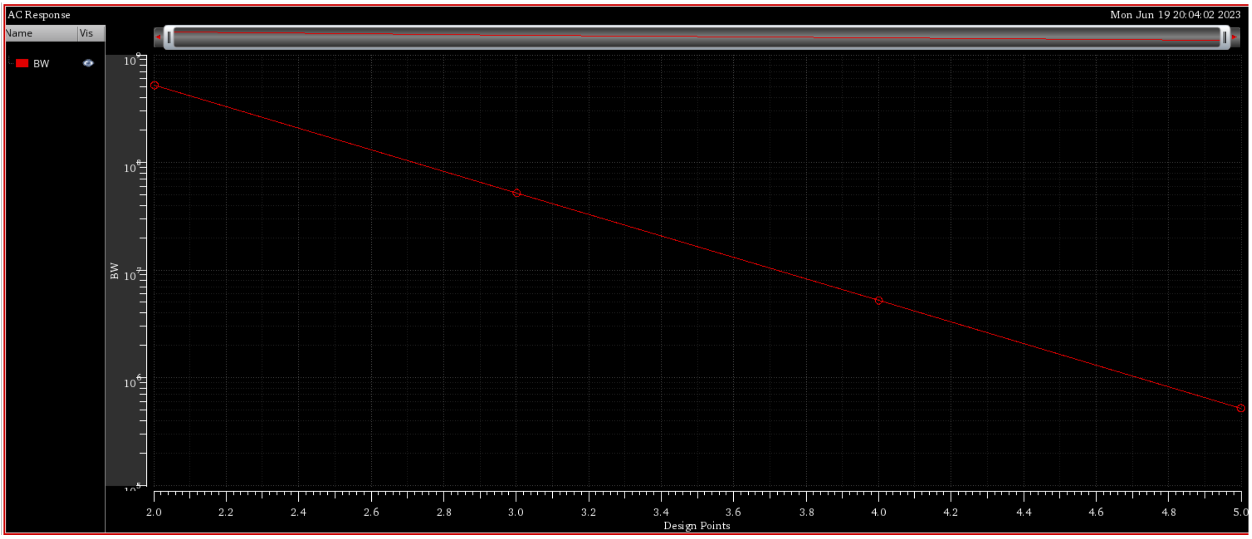
- After multiplying the R with 10 every step it is obvious that the bandwidth is divided by 10 every step.
- And the gain is constant despite changing the R values.



Bandwidth plot with parametric sweeps verses R

//comments:

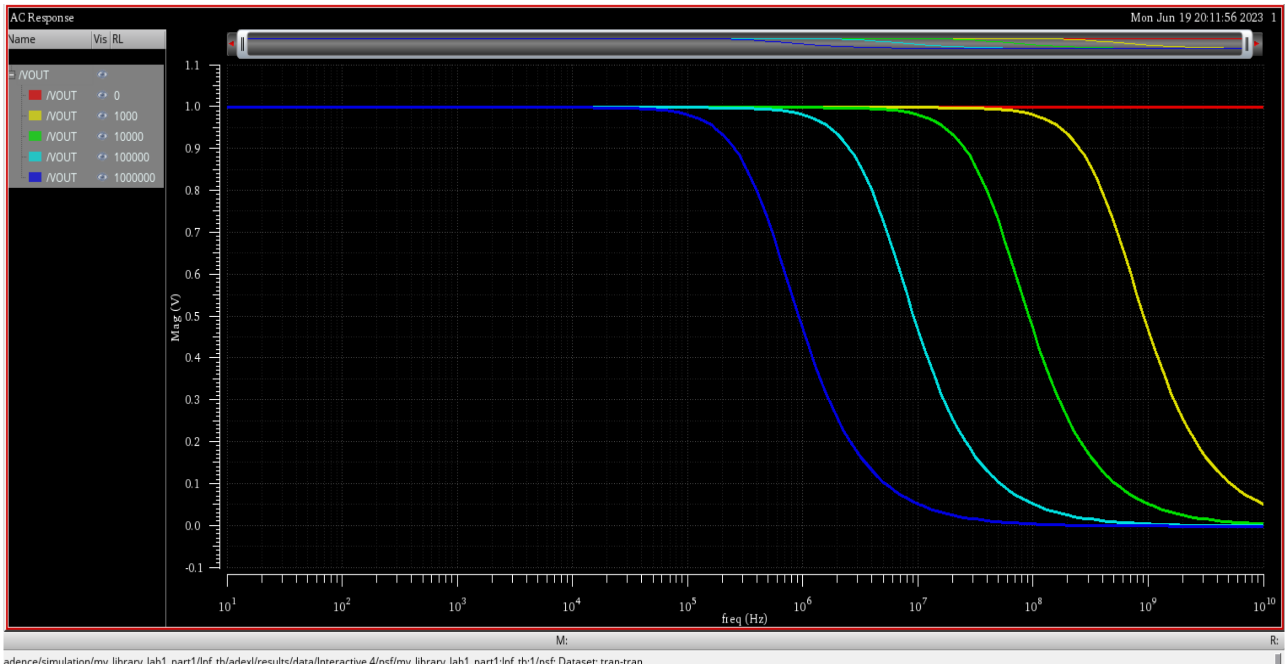
- Bandwidth is plotted by using “plot across design points.”
- R is on the x-axis.



Bandwidth plot with parametric sweeps in log scale

//comments:

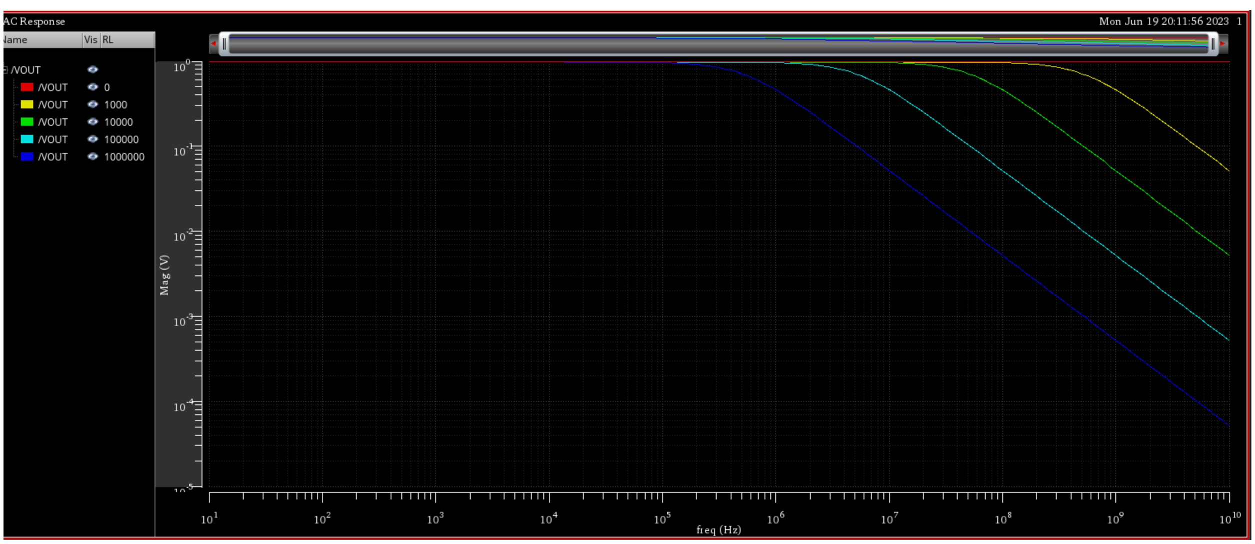
- After enabling log scale from the bandwidth plot we have a bandwidth plot in log scale
- The x-axis determines the design points not the R.



VOUT plot with parametric sweeps

//comments:

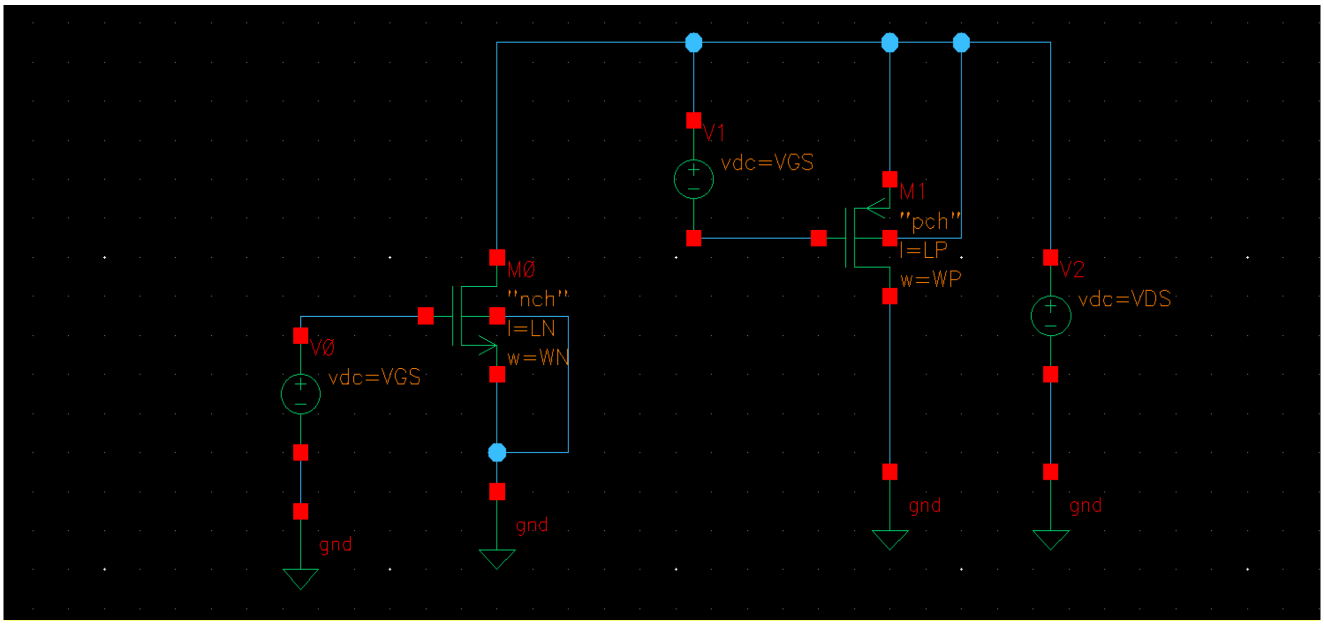
- VOUT with parametric sweeps is plotted using “plot all”.
- As R increases the voltage decreases.



VOUT plot with parametric sweeps in log scale

PART 2 (MOSFET Characteristics):

MOSFET circuit (NMOS and PMOS):



//comments:

- NMOS4 and PMOS4 are added from the analoglib with model names nch and pch respectively.
- NMOS body is connected to the ground while PMOS body is connected to high voltage (source terminal).
- Since vsp = zero, then there is no body effect for both NMOS and PMOS.
- Then, the circuit is launched on ADEXL.

1ST: ID vs VGS:

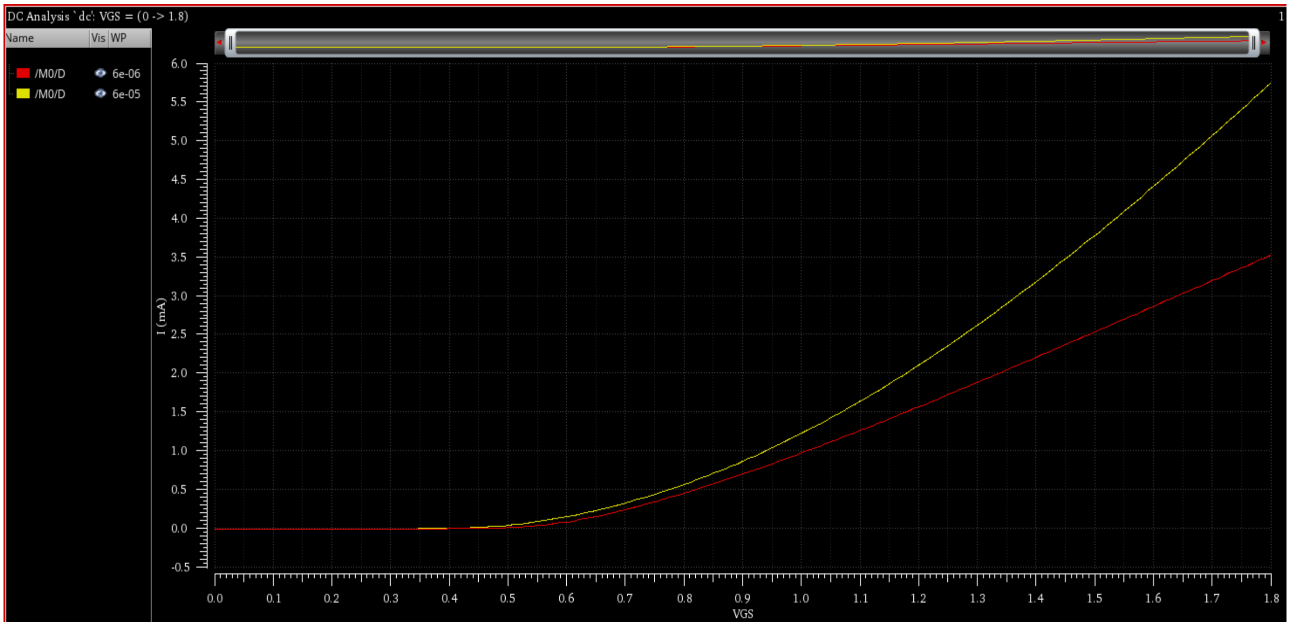
//comments:

- Circuit variables are added in design variables, and it will be strikethrough because variables are overridden in the global variables.
- A new analysis is made of type DC analysis, and sweep design variable: VGS, with linear sweep range [0,1.8] with step 10m V.
- Variables values are added in global variable for both long and short channels as follows:

Short channel	Long channel
LN = 200n LP = 200n VDS = 1.8 V VGS = 0 (the sweep) WN = 6u WP = 6u	LN = 2u LP = 2u VDS = 1.8 V VGS = 0 (the sweep) WN = 60u WP = 60u

- To add the drain current, it is added manually for both NMOS and PMOS from the output setup by using add signal, and analyses is modified to save DC operating point to save the transistor information.

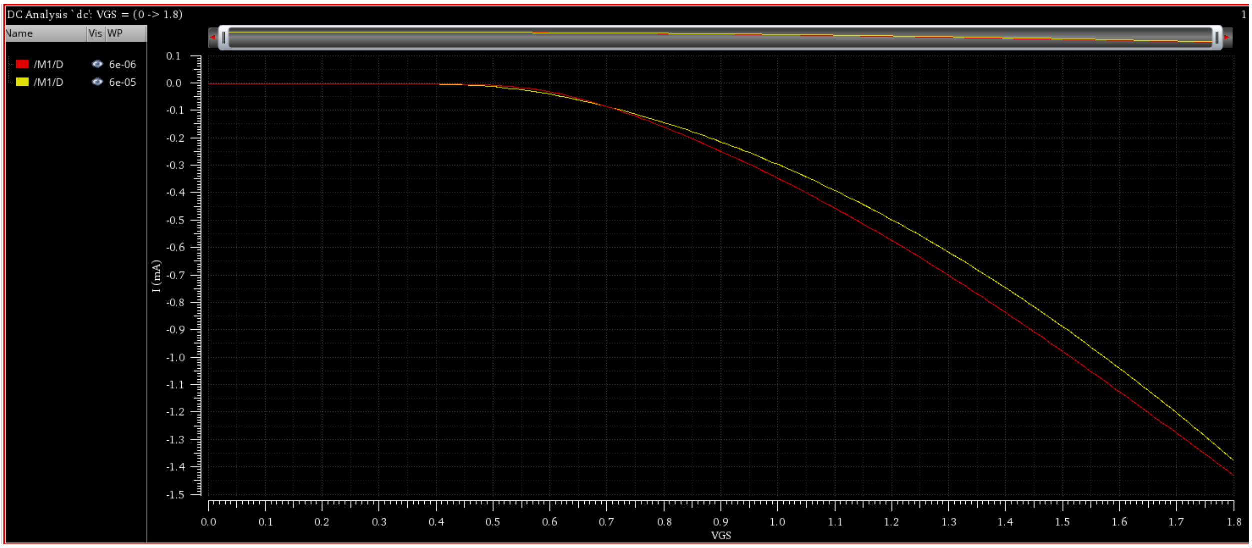
ID & VGS plot _ NMOS_***short channel vs long channel***:



//comments:

- Short channel starts smilar to quadritix curve but continues as lineardue to velocitysat.
- Long channel results is nearly quadritic.
- Long channel expect higher current dueto velocitysat.

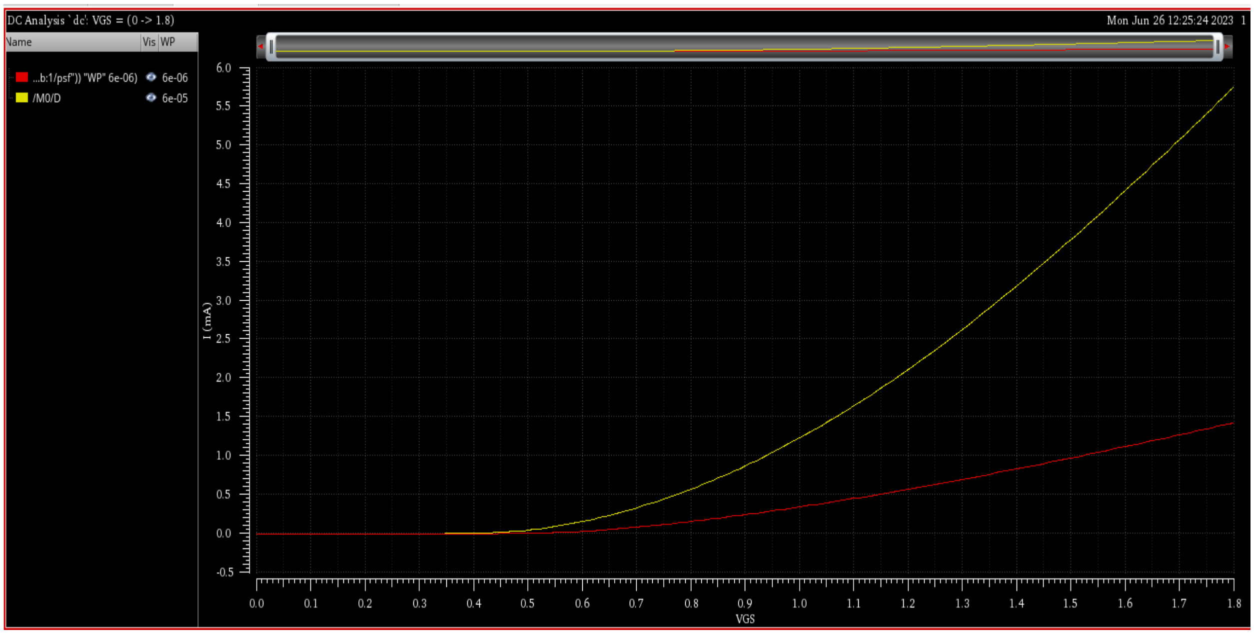
ID & VGS plot _ PMOS_***short channel vs long channel***:



//comments:

- In Long and short channel current is nearly equal because PMOS is less effective by velocitysat as it has low mobility, so it doesn't reach velocitysat.

NMOS and PMOS comparison:



//comments:

- PMOS current is sent to calculator to get it absolute value using abs function.
- It is obvious that the current in NMOS is much larger due to the difference in mobility ratio between NMOS and PMOS where PMOS has lower mobility.

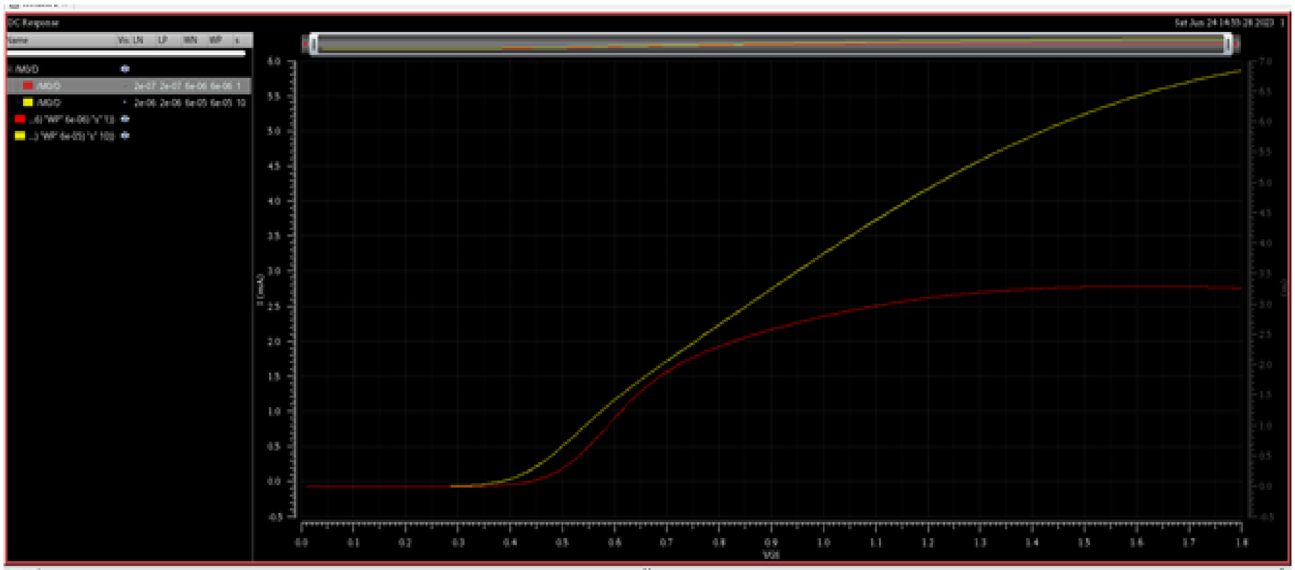
//REQUIRED COMMENTS:

1) Long channel is expected to have higher current.
2) Short channel (NMOS) starts a bit like quadratic but continues as linear due to velocitysat.
3) Long channel (NMOS) is nearly equal to quadratic chs sue to velocitysat.
4) While in (PMOS) long and short channel is nearly equal as PMOS is less effective by velocitysat as it has low mobility, so it doesn’t reach velocitysat.
5) NMOS current is higher than PMOS absolute current due to the difference between mobility of electrons and holes.
6) Ratio between NMOS and PMOS:

LONG channel	Short channel
5.75/1.373 = 4.19	3.531/1.43 = 2.47

7) PMOS is more affected by short channel effects.

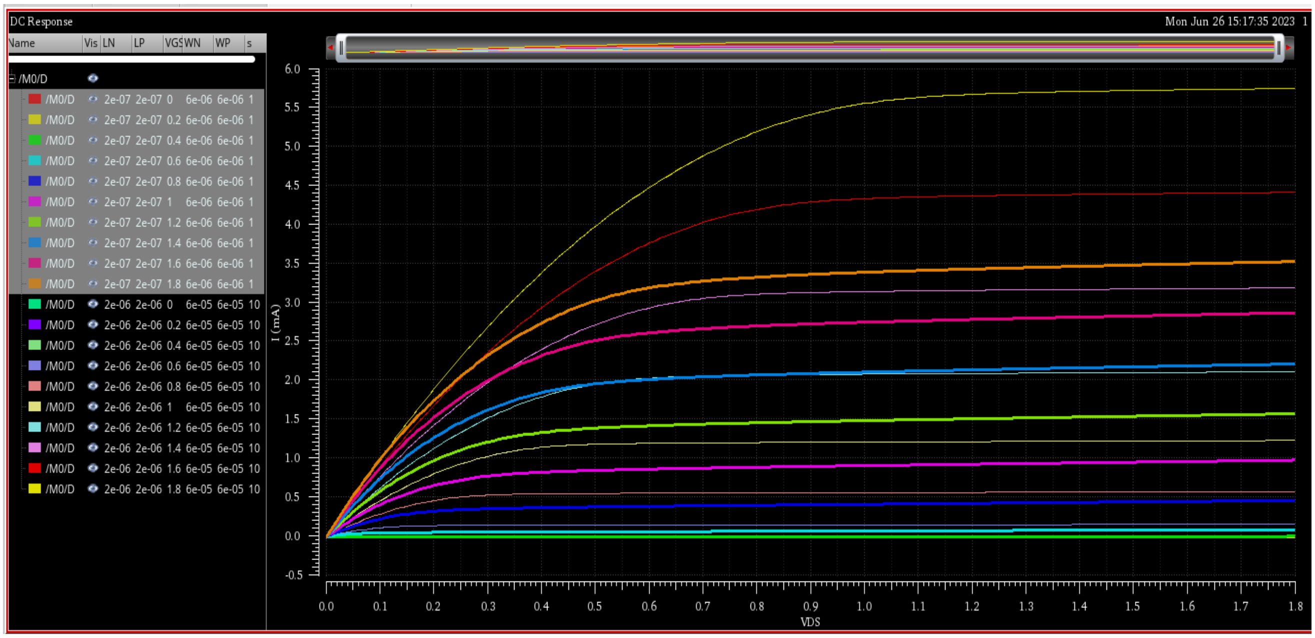
2nd: gm vs VGS:



//REQUIRED COMMENTS:

1) Short channel length devices provide higher performance than longer channel length devices, but the longer channel length has significantly reduced subthreshold leakage current.
2) gm increases linearly as a result, the inflection point on gm-VGS curves, which corresponds to the maximum d gm /d VGS.
3) Yes, gm saturate as gm is slightly affected by drain voltage and tends to saturate with VGS.

3rd: ID vs VDS:



//REQUIRED COMMENTS:

1) In analysis, variable name is changed to VDS.
2) In global variable sweep VGS → 0:0.2:1.8
3) A new variable s is created with two values 1 and 10 to make my sweep with short and long channel.
4) Linearity chs in short channel is clear.
5) Quadratic chs in long channel is clear.
6) Current is higher in long channel due to quadratic relation.
7) Due to linearity in short channel then current is lower.
8) The slope of short channel is higher due to the linearity.