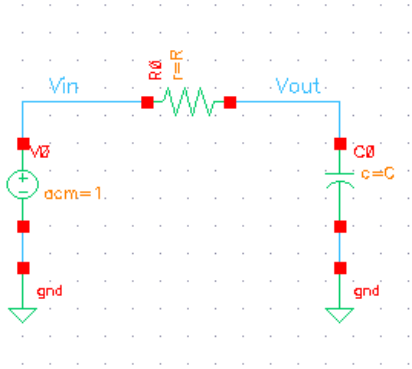
Lab 10

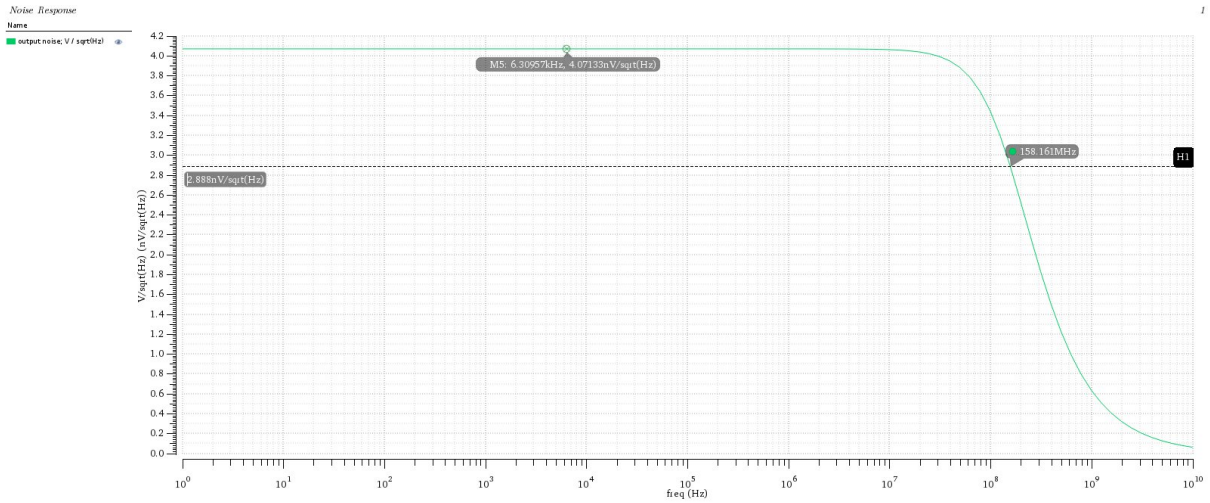
Noise Simulation

PART 1: LPF AC Noise Analysis



Circuit schematic for low pass filter

1) Report output noise vs frequency. Annotate voltage noise density and bandwidth in the plot.



Noise versus frequency plot from simulation results

2) Calculate rms output noise using rms noise function in the calculator.

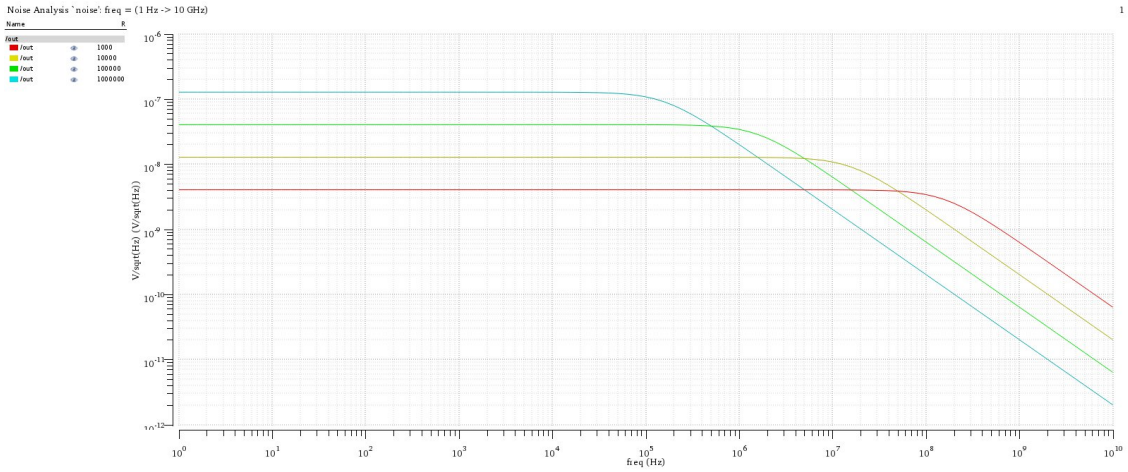
Test	Output	Nominal	Spec	Weight	Pass/Fail
TrainLAB:Lab10_Noise:1	rms Output Noise	64.32u			
TrainLAB:Lab10_Noise:1	BW	158.8M			
TrainLAB:Lab10_Noise:1	Noise Density	4.071n			

Calculator results for bandwidth and noise density

3) Compare the simulation results (noise density, bandwidth, and rms) with hand analysis.
   - Noise Density: $\overline{V^2} = \frac{KT}{C} = 4.14\ nV^2/Hz$.
   - Rms Output Noise: $\sigma = \sqrt{\overline{V^2}} = 64.34\ uV/\sqrt{Hz}$.

- Bandwidth: $f_c = \frac{1}{2\pi RC} = 159.15MHz$.

4) Plot output noise overlaid on the same plot. Using log-scale for y-axis.



Sweep of resistance versus noise analysis from cadence

Comment on the results.

As shown from previous analysis that by increasing resistance noise density increases also due to increasing thermal noise value but bandwidth decreases.

5) Calculate the rms noise using the calculator.

Point	Test	Output	Nominal	Spec	Weight	Pass/Fail
Parameters: R=1k						
1	TrainLAB:Lab10_Noise:1	rms Output Noise	64.32u			
1	TrainLAB:Lab10_Noise:1	BW	158.8M			
1	TrainLAB:Lab10_Noise:1	Noise Density	4.071n			
Parameters: R=10k						
2	TrainLAB:Lab10_Noise:1	rms Output Noise	64.62u			
2	TrainLAB:Lab10_Noise:1	BW	15.88M			
2	TrainLAB:Lab10_Noise:1	Noise Density	12.87n			
Parameters: R=100k						
3	TrainLAB:Lab10_Noise:1	rms Output Noise	64.65u			
3	TrainLAB:Lab10_Noise:1	BW	1.588M			
3	TrainLAB:Lab10_Noise:1	Noise Density	40.71n			
Parameters: R=1M						
4	TrainLAB:Lab10_Noise:1	rms Output Noise	64.66u			
4	TrainLAB:Lab10_Noise:1	BW	158.8k			
4	TrainLAB:Lab10_Noise:1	Noise Density	128.7n			

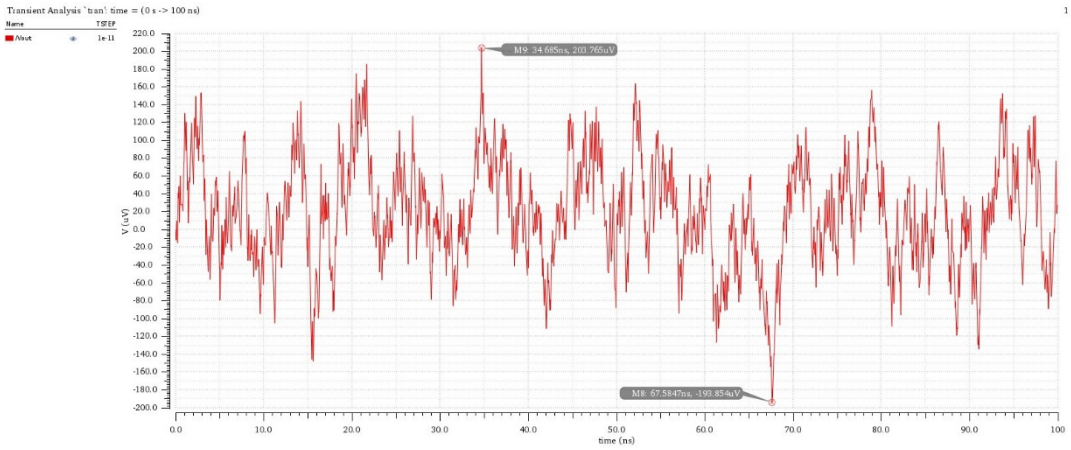
Rms output noise results after sweeping resistance

Comment on the results.

As shown that value of rms output voltage noise is nearly constant and not affected by changing resistance value because RC-circuits depend on value of capacitance and not affected by resistors.

PART 2: LPF Transient Noise Analysis

1) Report the noise output waveform. Annotate the min and max values.



Noise waveform from transient analysis

2) Use the rms function in the calculator to calculate the rms noise.

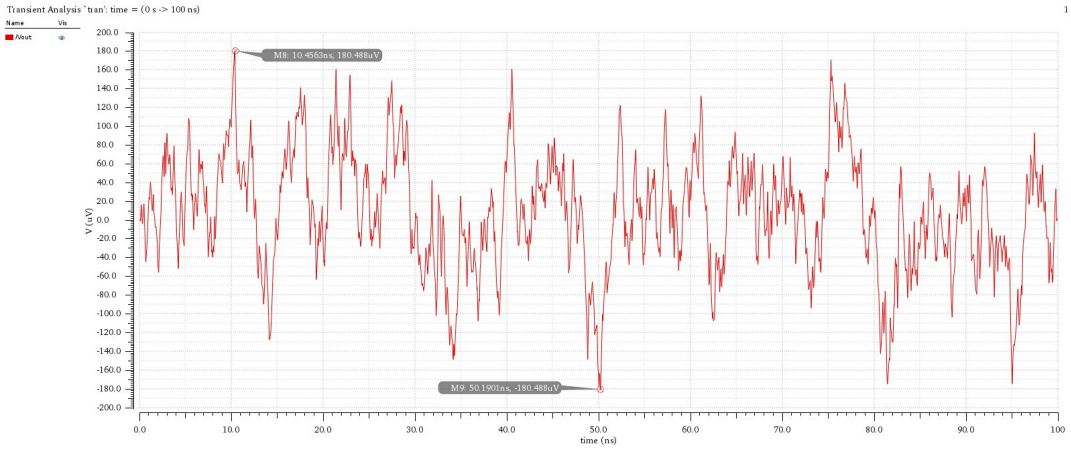
Test	Output	Nominal	Spec	Weight	Pass/Fail
TrainLAB:Lab10_Noise:1	Max Noise AMP	203.8u			
TrainLAB:Lab10_Noise:1	Min Noise AMP	-194.2u			
TrainLAB:Lab10_Noise:1	rms Noise	60.88u			

Rms output voltage from ADEL cadence

Compare it to the value calculated in Part 1.

As shown that rms output voltage is the same results we get from part 1. “noise-analysis”

3) Repeat the simulation with TSTEP = TAU/10.



Waveform of output voltage at tsep=tau/10

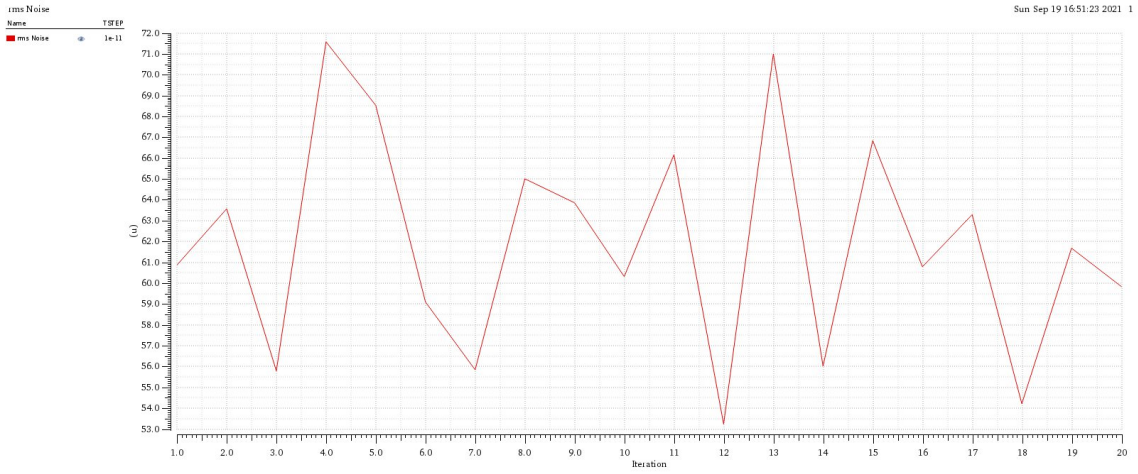
Test	Output	Nominal	Spec	Weight	Pass/Fail
TrainLAB:Lab10_Noise:1	Max Noise AMP	180.2u			
TrainLAB:Lab10_Noise:1	Min Noise AMP	-181u			
TrainLAB:Lab10_Noise:1	rms Noise	61.59u			

Rms output voltage from ADEL cadence @ TSTEP=tau/10

Does the calculated rms noise increase or decrease? Why?

As shown that rms noise increased slightly because of increasing step size which increases noise rms value.

4) Report the rms noise vs iteration.



Rms output voltage versus iterations

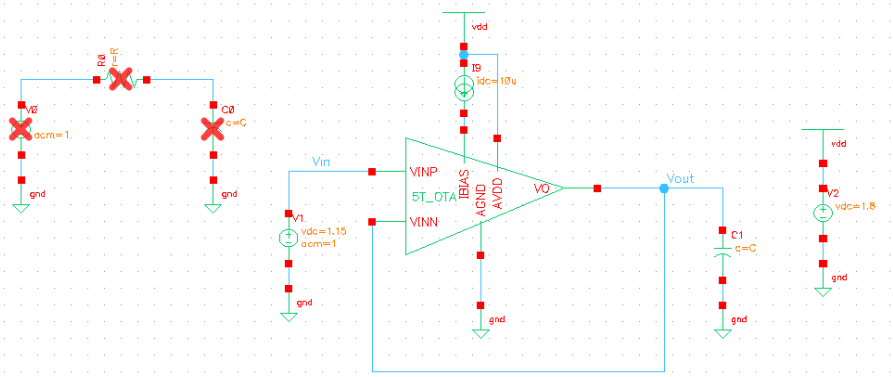
5) Use the calculator to calculate the average rms noise. Compare the calculated value with the rms noise previously obtained in Part 1 and Part 2.

Test	Output	Nominal	Spec	Weight	Pass/Fail
TrainLAB:Lab10_Noise:1	rms Noise				
TrainLAB:Lab10_Noise:1	Average rms Noise	61.97u			

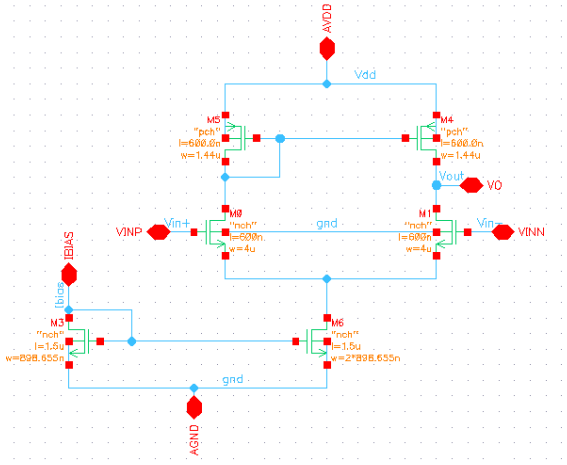
Rms noise value from cadence simulation

As shown from previous analysis that rms output voltage is the same in part 1 and part 2.

PART 3: 5T OTA AC Noise Analysis

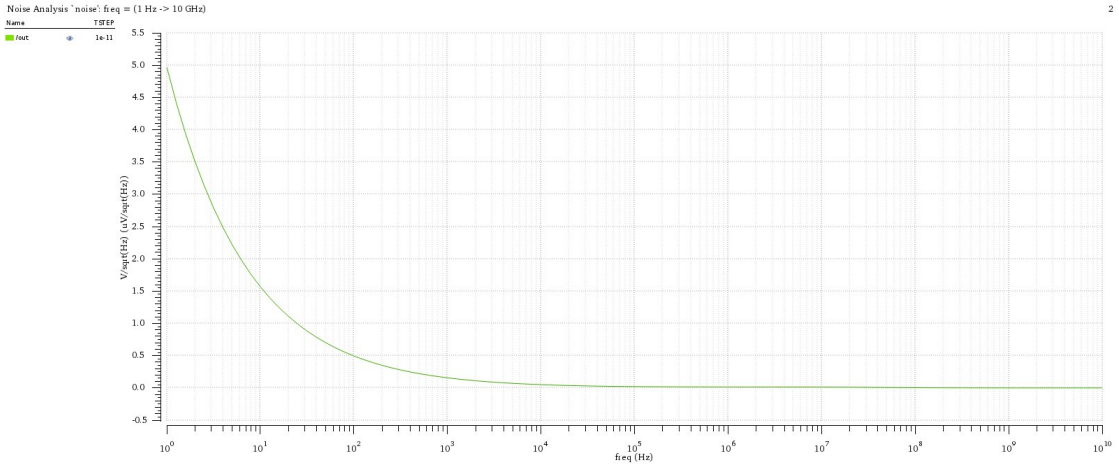


Circuit schematic for OTA symbol from cadence



Circuit schematic for MOSFETs from cadence

1) Report output noise vs frequency. Annotate noise density and bandwidth in the plot.

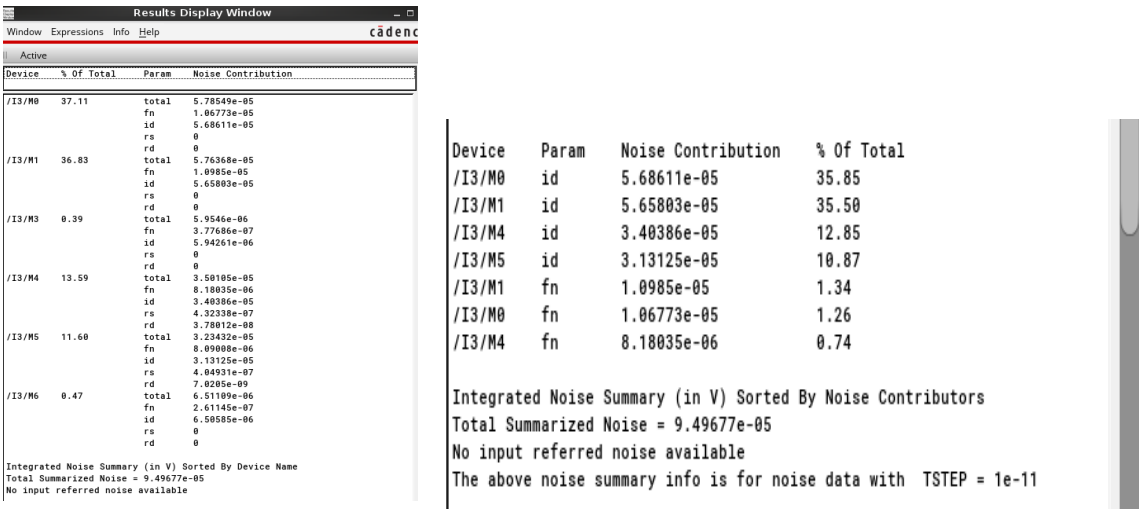


Noise versus frequency from AC noise analysis

Test	Output	Nominal	Spec	Weight	Pass/Fail
TrainLAB:Lab10_Noise:1	rms Output Noise	95.27u			
TrainLAB:Lab10_Noise:1	BW	1.995			
TrainLAB:Lab10_Noise:1	Noise Density	4.964u			

Bandwidth and noise density results from ADEL

2) Calculate rms output noise (calculate the rms noise due to thermal noise only using Noise Summary).



Results Display Window

Window Expressions Info Help

Active

Device	% Of Total	Param	Noise Contribution
/I3/M0	37.11	total	5.78549e-05
		fn	1.06773e-05
		id	5.68611e-05
		rs	0
		rd	0
/I3/M1	36.83	total	5.76368e-05
		fn	1.0985e-05
		id	5.65803e-05
		rs	0
		rd	0
/I3/M3	0.39	total	5.9546e-06
		fn	3.77686e-07
		id	5.94261e-06
		rs	0
		rd	0
/I3/M4	13.59	total	3.58105e-05
		fn	8.18035e-06
		id	3.40386e-05
		rs	4.32338e-07
		rd	3.78012e-08
/I3/M5	11.60	total	3.23432e-05
		fn	8.09008e-06
		id	3.13125e-05
		rs	4.04931e-07
		rd	7.0205e-09
/I3/M6	0.47	total	6.51109e-06
		fn	2.61145e-07
		id	6.50585e-06
		rs	0
		rd	0

Integrated Noise Summary (in V) Sorted By Device Name
Total Summarized Noise = 9.49677e-05
No input referred noise available

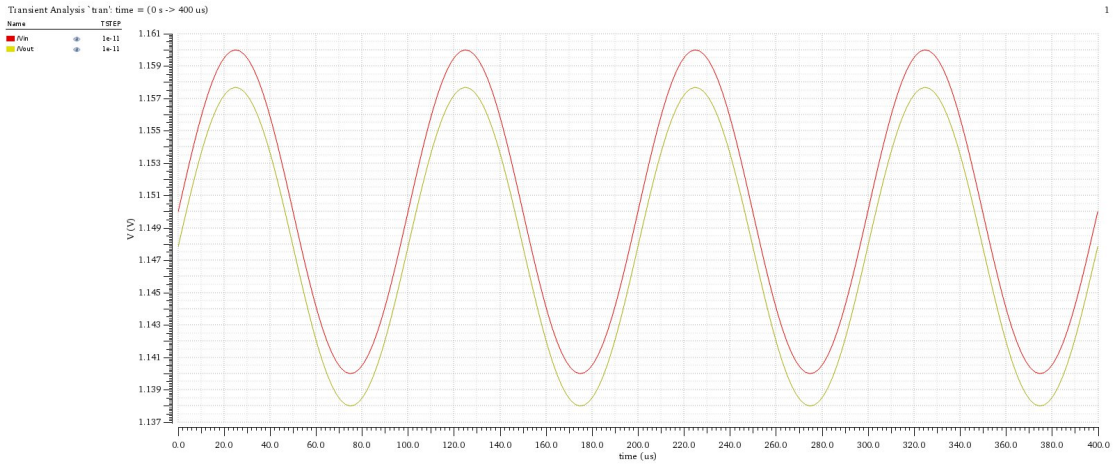
Device	Param	Noise Contribution	% Of Total
/I3/M0	id	5.68611e-05	35.85
/I3/M1	id	5.65803e-05	35.50
/I3/M4	id	3.40386e-05	12.85
/I3/M5	id	3.13125e-05	10.87
/I3/M1	fn	1.0985e-05	1.34
/I3/M0	fn	1.06773e-05	1.26
/I3/M4	fn	8.18035e-06	0.74

Integrated Noise Summary (in V) Sorted By Noise Contributors
Total Summarized Noise = 9.49677e-05
No input referred noise available
The above noise summary info is for noise data with TSTEP = 1e-11

Noise summary results from cadence

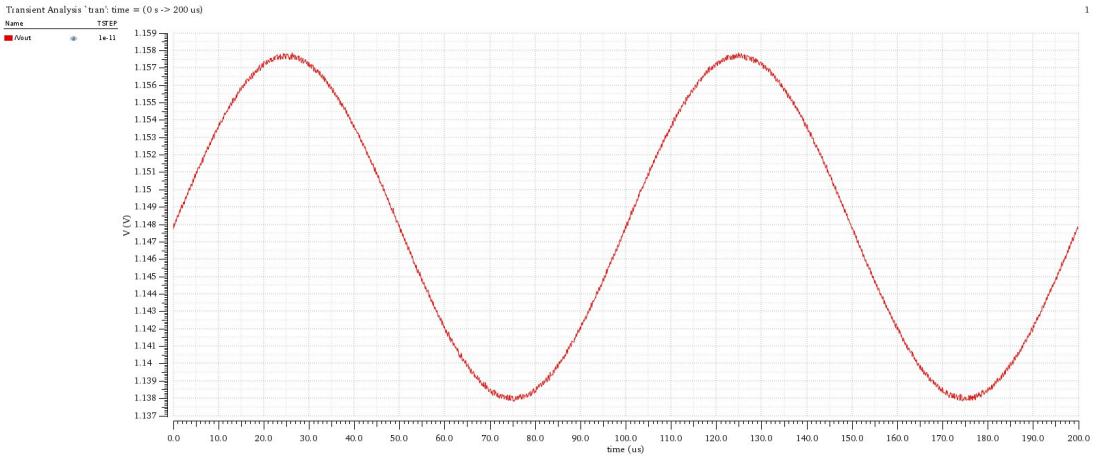
PART 4: 5T OTA Transient Noise Analysis

1) Plot input and output overlaid and make sure they match well (verify that the circuit behaves as a buffer).



Transient analysis for OTA vin and vout overlaid

2) Report the “noisy” output waveform. Notice that output signal and noise are superimposed.



Noisy vout from transient analysis