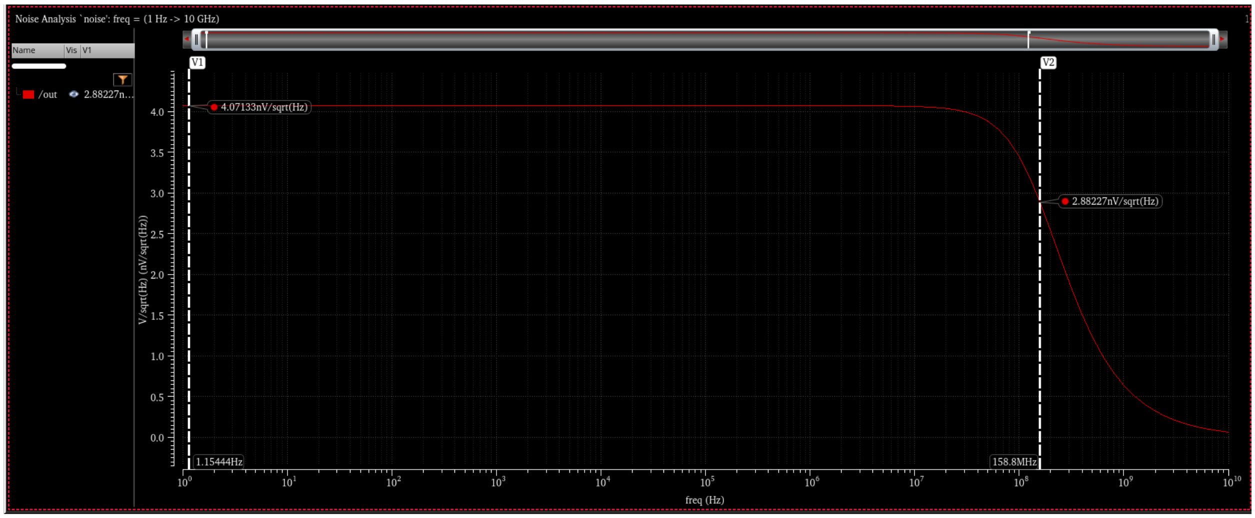
PART1

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



2 Calculate RMS output noise using RMS noise function in the calculator.

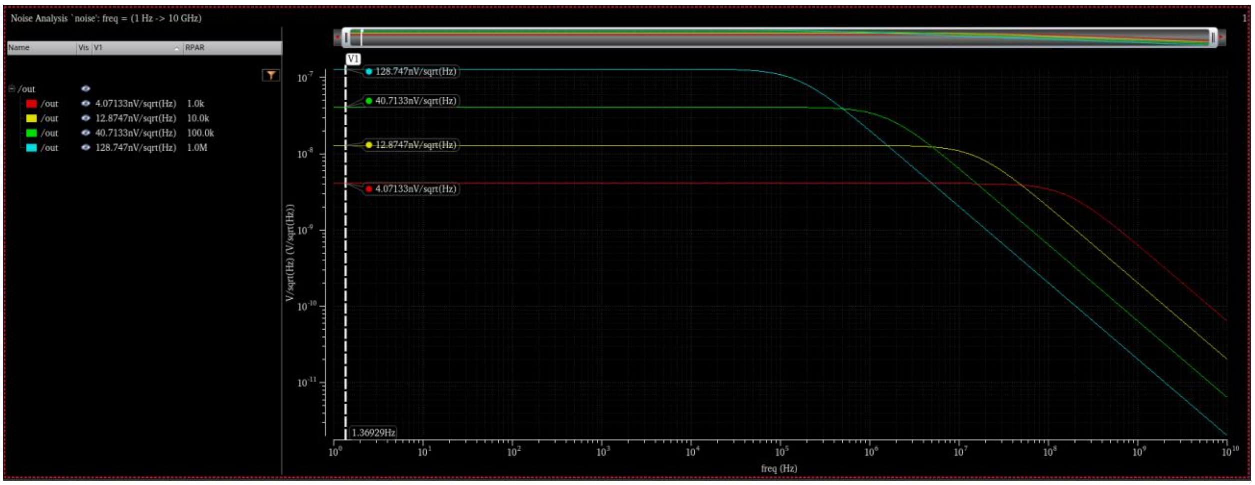
Expression	Value
rmsNoise(1 10G)	64.32E-6

3 Compare the simulation results (noise density, bandwidth, and RMS) with hand analysis.

	SIM	ANALYTICAL
noise density	4.07 n	$\sqrt{4KTR} = \sqrt{4 * 4.14 * 10^{-21} * 10^{3}} =$ 4.07 =
bandwidth	158.8 M	$\frac{1}{2\pi RC} = 159.15M$
rms	64.32u	$\sqrt{\frac{KT}{C}} = 64.34u$

4 RUN PARAMETRIC SWEEP FOR RPAR = 1K, 10K, 100K, 1000K.

5 PLOT OUTPUT NOISE OVERLAID ON THE SAME PLOT. USING LOG-SCALE FOR Y-AXIS. COMMENT ON THE RESULTS



AS R increased the noise density increased, but in the same time the bandwidth decreased.

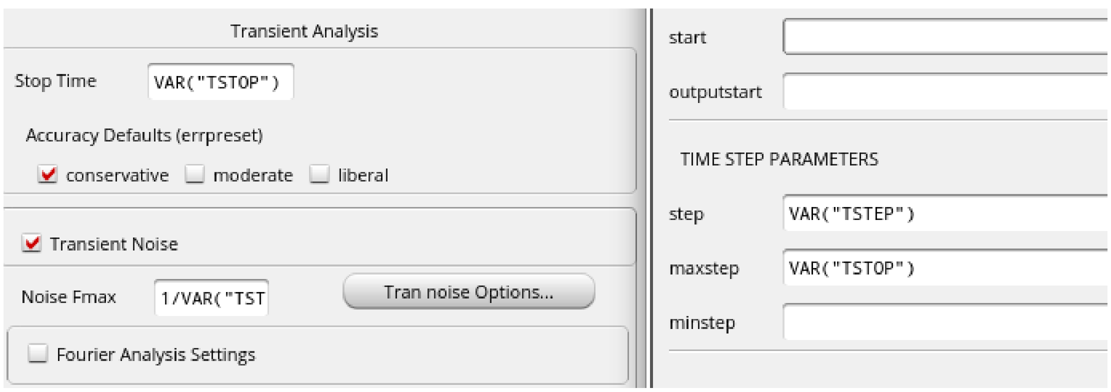
6 CALCULATE THE RMS NOISE USING THE CALCULATOR. COMMENT ON THE RESULTS.

Point	Test	Output	Nominal	Spec	Weight	Pass/Fail
Filter	Filter	Filter	Filter	Filter	Filter	Filter
Parameters: RPAR=1K						
1	LAB9_part1_1	rmsNoise(1 1e+...	64.32u			
Parameters: RPAR=10K						
2	LAB9_part1_1	rmsNoise(1 1e+...	64.62u			
Parameters: RPAR=100K						
3	LAB9_part1_1	rmsNoise(1 1e+...	64.65u			
Parameters: RPAR=1M						
4	LAB9_part1_1	rmsNoise(1 1e+...	64.66u			

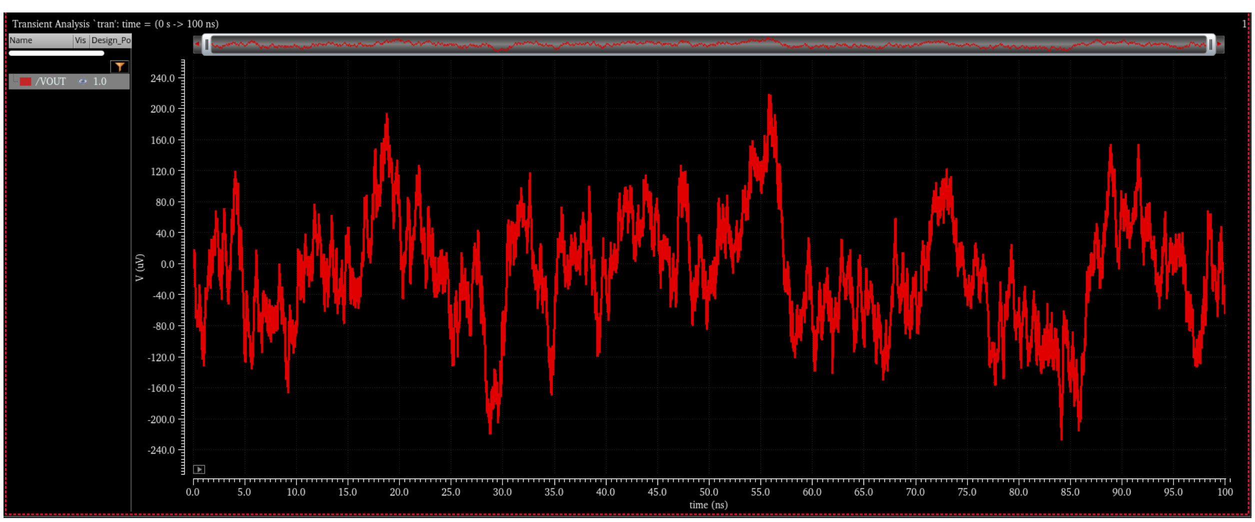
As expected the rms value is approximately constant, when we increase the resistance the noise density increases, but in the same time the bandwidth decreases, so rms value kept the same independent of resistance value

PART2

1 Setup transient noise analysis as shown below. Fmax is set to 1/TSTEP and Fmin is set to 1/TSTOP. You can think of these as the start and end frequencies used in generating the noise samples (i.e., equivalent to the start and end frequencies used in integrating the PSD). Only one transient noise simulation run will be performed.



2 Report the noise output waveform. Annotate the min and max values.



LAB9_part1_1	ymax(v("/VOUT"...	218u
LAB9_part1_1	ymin(v("/VOUT" ...	-226.7u

3 USE THE RMS FUNCTION IN THE CALCULATOR TO CALCULATE THE RMS NOISE. COMPARE IT TO THE VALUE CALCULATED IN PART 1.

LAB9_part1_1	rms(mag(v("/VO...	73.04u			

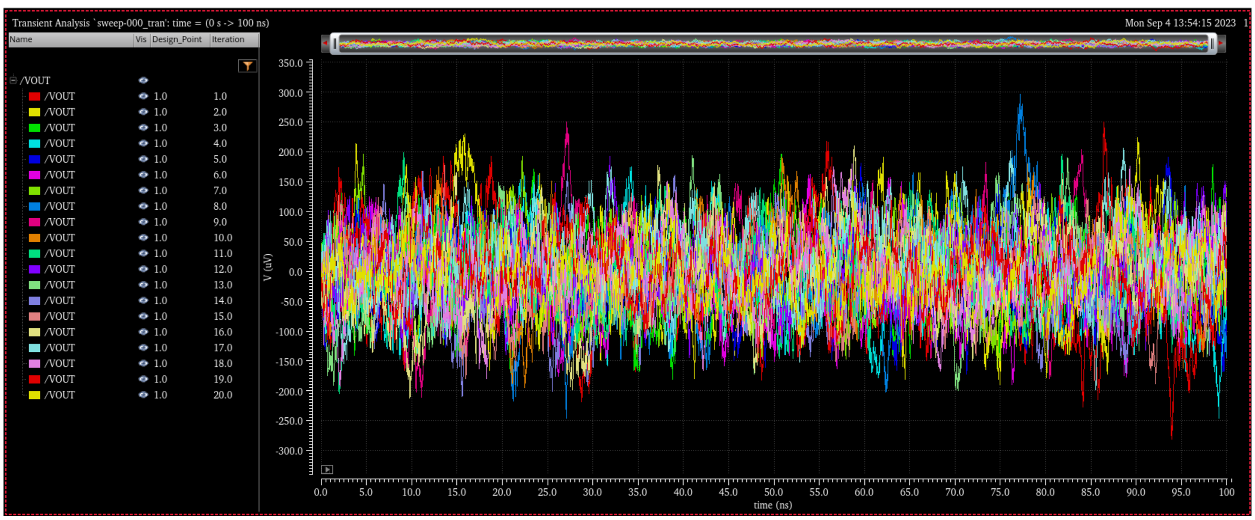
Part2	Part1
73.04u	64.32u

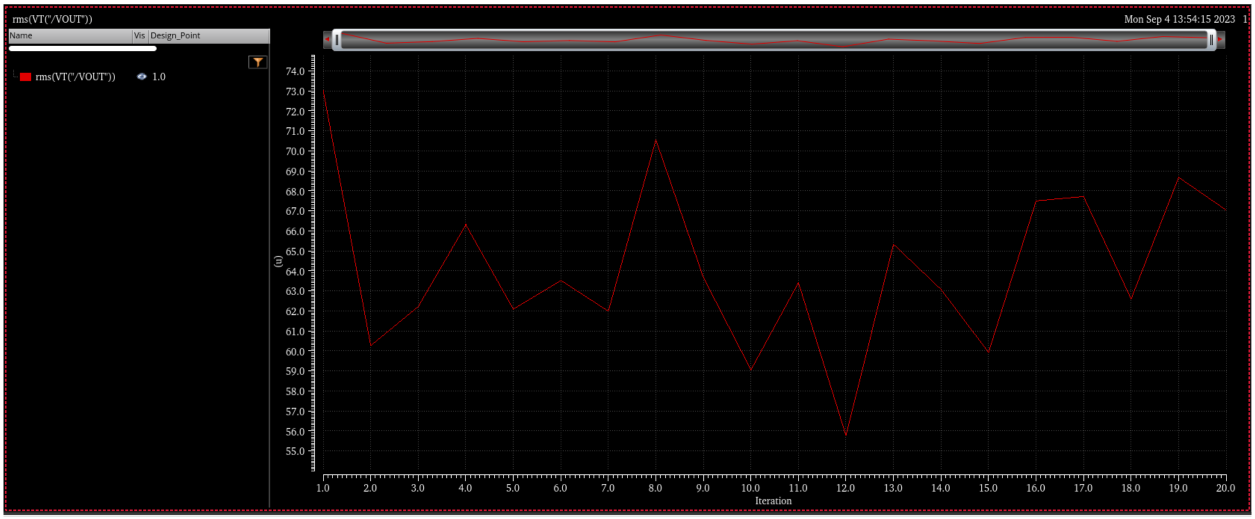
4 REPEAT THE SIMULATION WITH TSTEP = TAU/10. DOES THE CALCULATED RMS NOISE INCREASE OR DECREASE? WHY?

LAB9_part1_1	rms(mag(v("/VOUT" ?result "tran")))	68.92u			

Decreased, as when we increased the step we decreased fmax so we decreased the noise range.

5 BACK TO TSTEP = TAU/100. CHANGE THE TRANSIENT NOISE OPTIONS AS SHOWN BELOW. NOW IT WILL RUN 20 RUNS OF TRANSIENT NOISE ITERATIONS, REPORT THE RMS NOISE VS ITERATION.





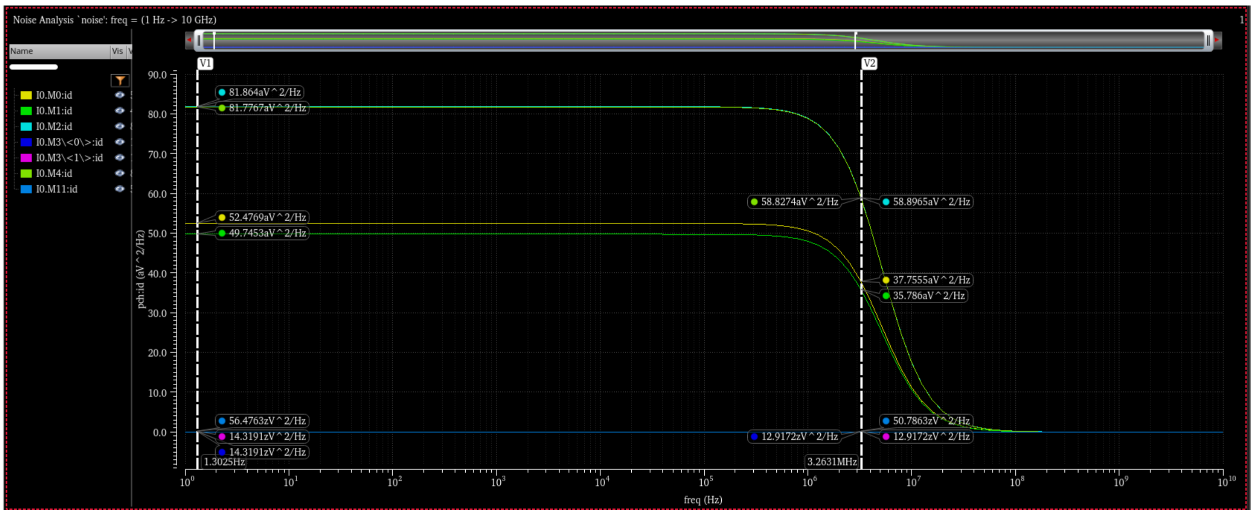
6 USE THE CALCULATOR TO CALCULATE THE AVERAGE RMS NOISE. COMPARE THE CALCULATED VALUE WITH THE RMS NOISE PREVIOUSLY OBTAINED IN PART 1 AND PART 2

LAB9_part1_1	average(rms(VT(...	63.89u

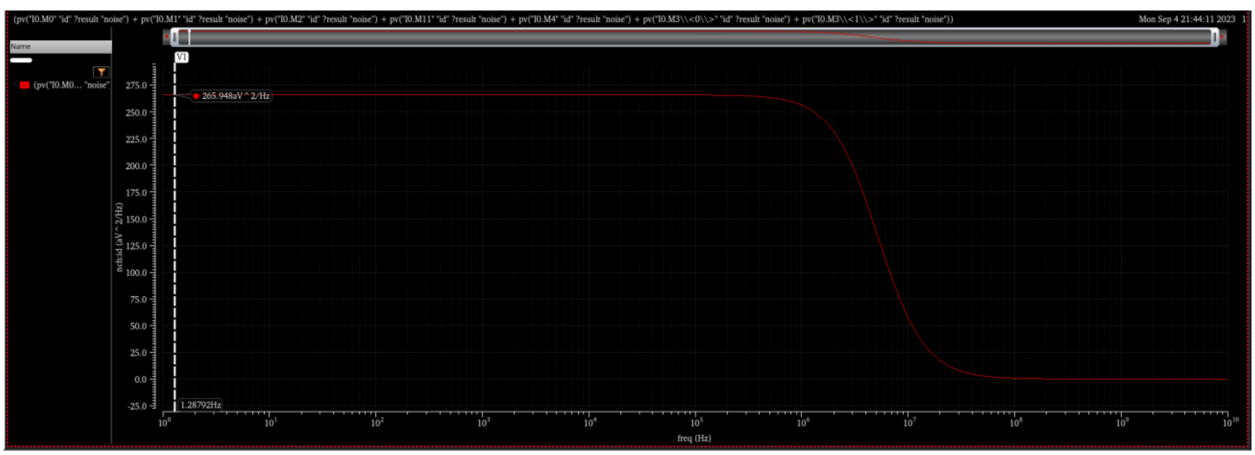
PART2	PART1
63.89u	64.32u

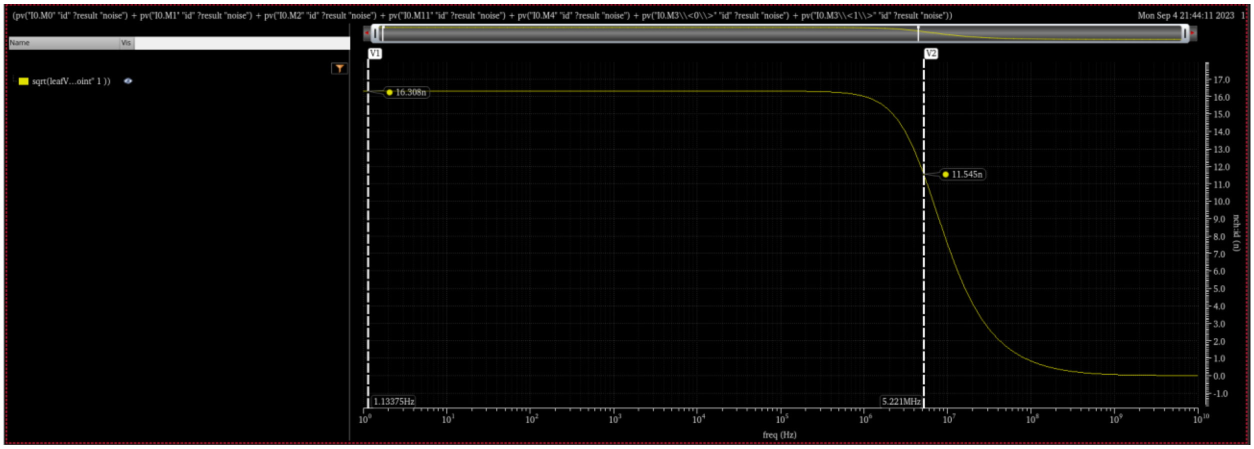
PART3

1 REPORT OUTPUT THERMAL NOISE VS FREQUENCY. ANNOTATE NOISE DENSITY AND BANDWIDTH IN THE PLOT. COMPARE THE SIMULATION RESULTS WITH HAND ANALYSIS.



TOTAL THERMAL:

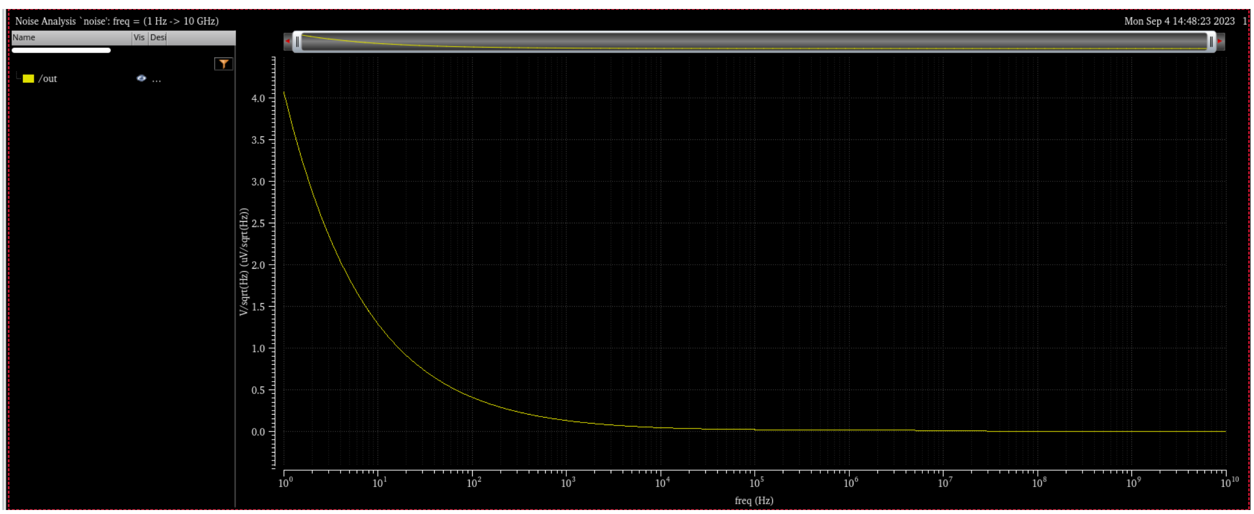


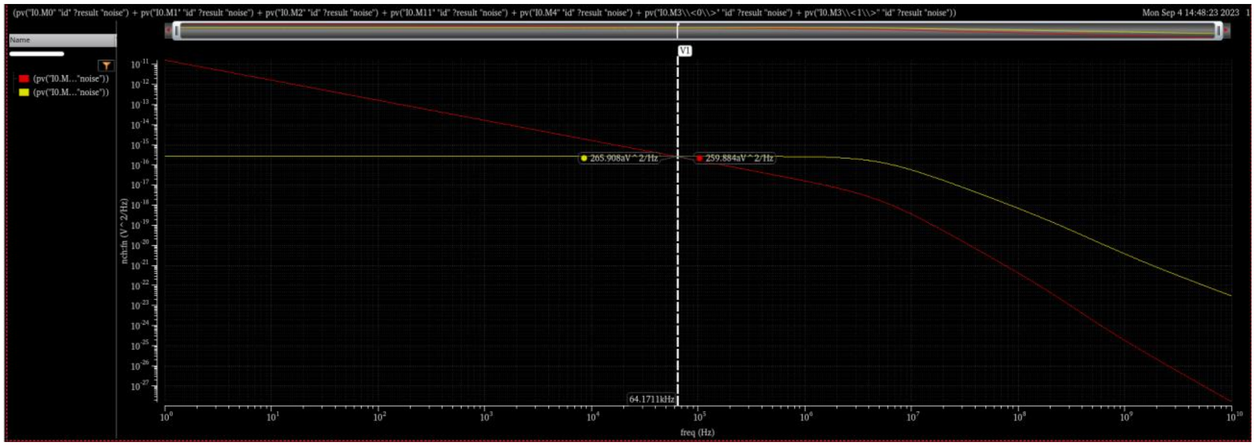



```
sqrt(integ(pv("I0.M0" "id" ?result "noise")+pv("I0.M1" "id" ?result "noise")+pv("I0.M2" "id" ?result "noise")+pv("I0.M11" "id" ?result "noise")+pv("I0.M4" "id" ?result "noise")+pv("I0.M3\\<0\\>" "id" ?result "noise")+pv("I0.M3\\<1\\>" "id" ?result "noise") 1 10G " " ))
```

LAB9_part3_1	sqrt(integ((pv("I0.M0" "id" ?result "noise") + pv("I0.M1" "i...	46.74u

2 Report total output noise (thermal + flicker) vs frequency. Estimate the Flicker noise corner.





The flicker noise corner = 64.17 kHZ

3 CALCULATE RMS OUTPUT NOISE (CALCULATE THE RMS NOISE DUE TO THERMAL NOISE ONLY USING NOISE SUMMARY).

Thermal:

LAB9_part3_1	sqrt(integ((pv("I0.M0" "id" ?result "noise") + pv("I0.M1" "i...	46.74u

Total:

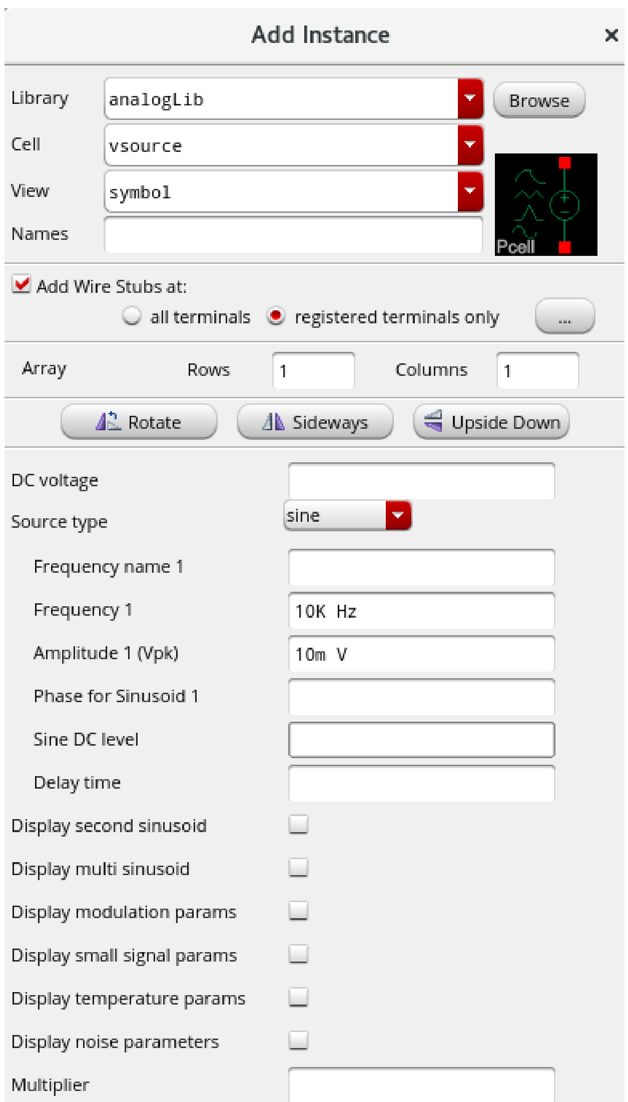
LAB9_part3_1	rmsNoise(1 1e+10)	49.44u

4 COMPARE THE SIMULATION RESULTS (NOISE DENSITY, BANDWIDTH, AND RMS) WITH HAND ANALYSIS.

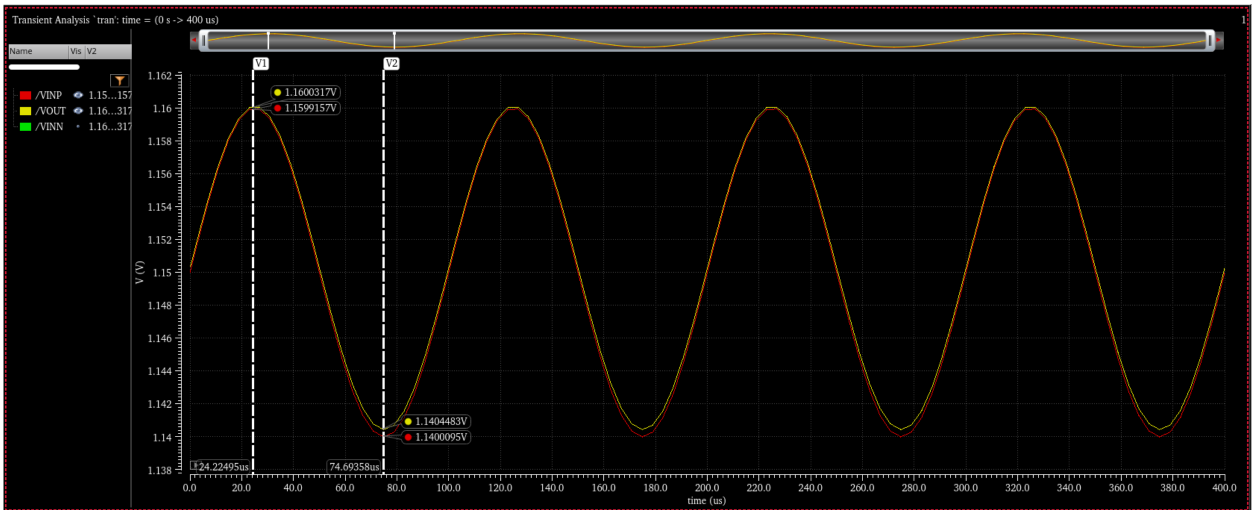
	SIM	ANALYTICAL
noise density	266 atto VN=16.308 n	$V^2 = \frac{8KT\gamma}{gm_{i/p}}(1 + \frac{gm_{mirror}}{gm_{i/p}}) = \frac{8 * 4.14 * 10^{-21} * 0.8}{160.3u}(1 + \frac{160.3u}{96u}) = 264.3atto$ SO V=16.25 n
bandwidth	5.2 MHZ	Buffer BW=UGF(from lab7)=$\frac{gm}{2\pi C_L} = 5.1MHZ$
Rms	46.74 u	$\sqrt{5.1M * 264.3atto * (\pi/2)}$ =46u

PART4

1 SET THE INPUT SIGNAL AS A SIN WAVE WITH AMPLITUDE = 10MV AND FIN = 10KHZ FREQUENCY SUPERIMPOSED ON A CM LEVEL EQUAL TO THE MIDDLE VALUE OF THE CMIR.

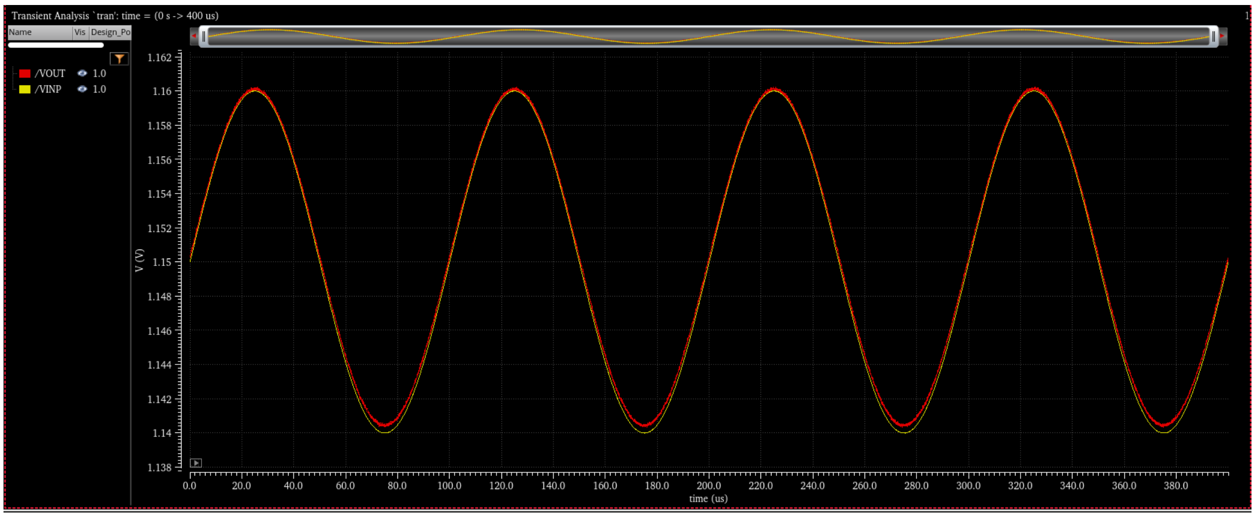


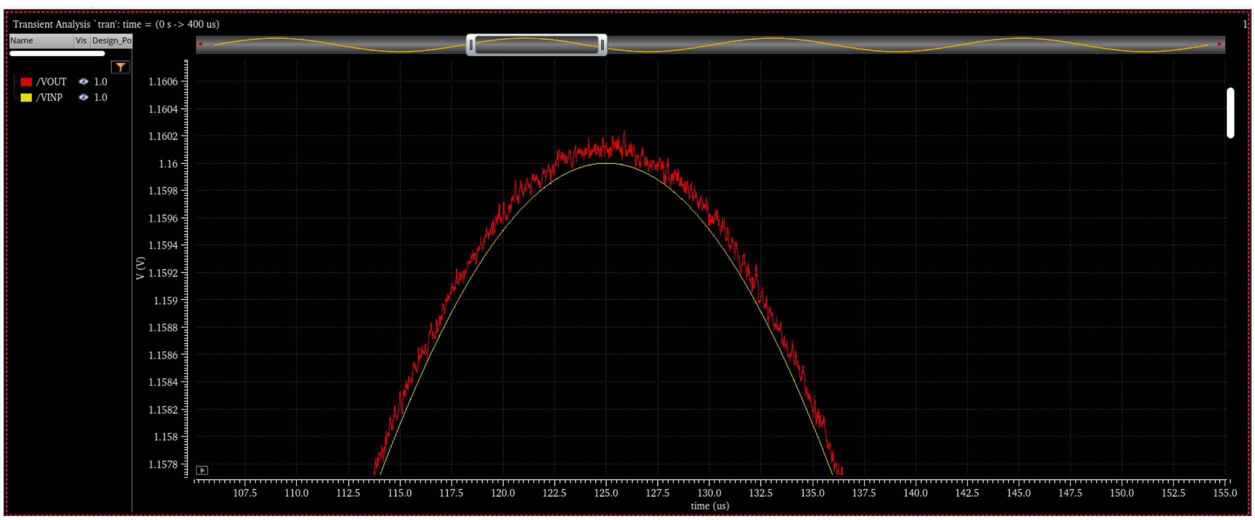
2 RUN TRANSIENT ANALYSIS WITH MAX TIME STEP = 0.02/FIN (50 POINTS FOR CYCLE) AND STOP TIME = 4/FIN (SIMULATE 4 CYCLES), PLOT INPUT AND OUTPUT OVERLAID AND MAKE SURE THEY MATCH WELL (VERIFY THAT THE CIRCUIT BEHAVES AS A BUFFER).



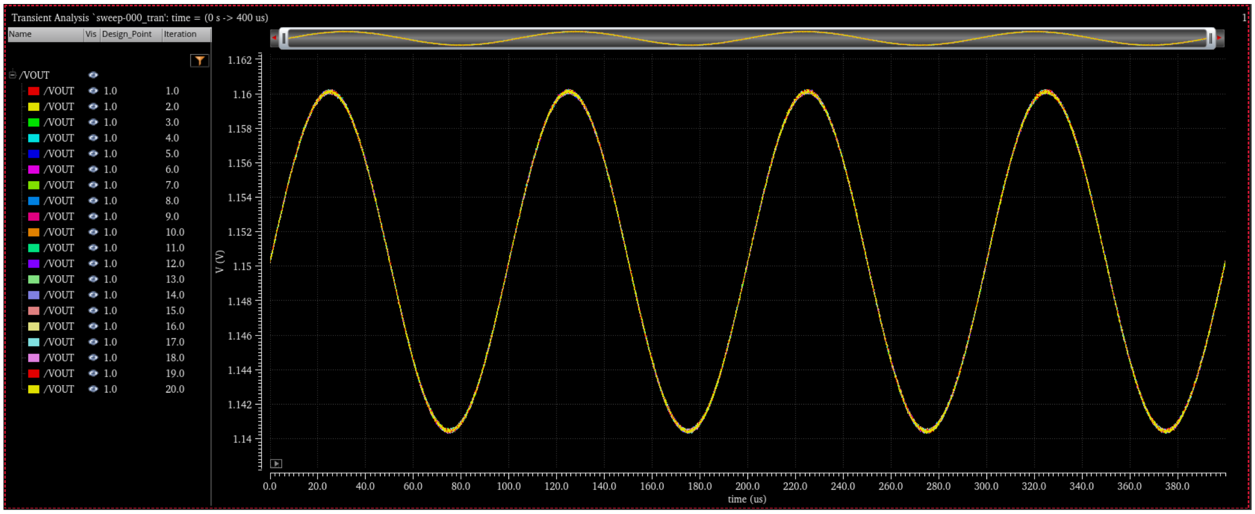
VOUT=VIN just very little error

3 NOW WE WILL RUN TRANSIENT NOISE ANALYSIS SIMILAR TO PART 2. USE A SINGLE NOISE SIMULATION RUN. SET TRANSIENT NOISE UPPER FREQUENCY AT 10 TIMES THE OTA GBW, REPORT THE "NOISY" OUTPUT WAVEFORM (ZOOM-IN TO HIGHLIGHT THE NOISE). NOTICE THAT OUTPUT SIGNAL AND NOISE ARE SUPERIMPOSED.

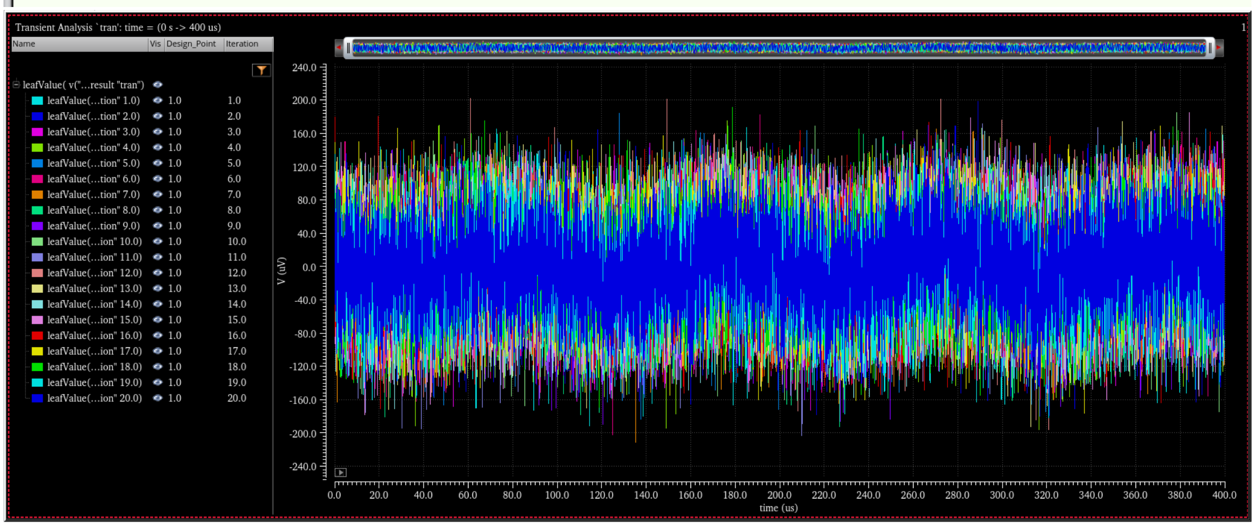




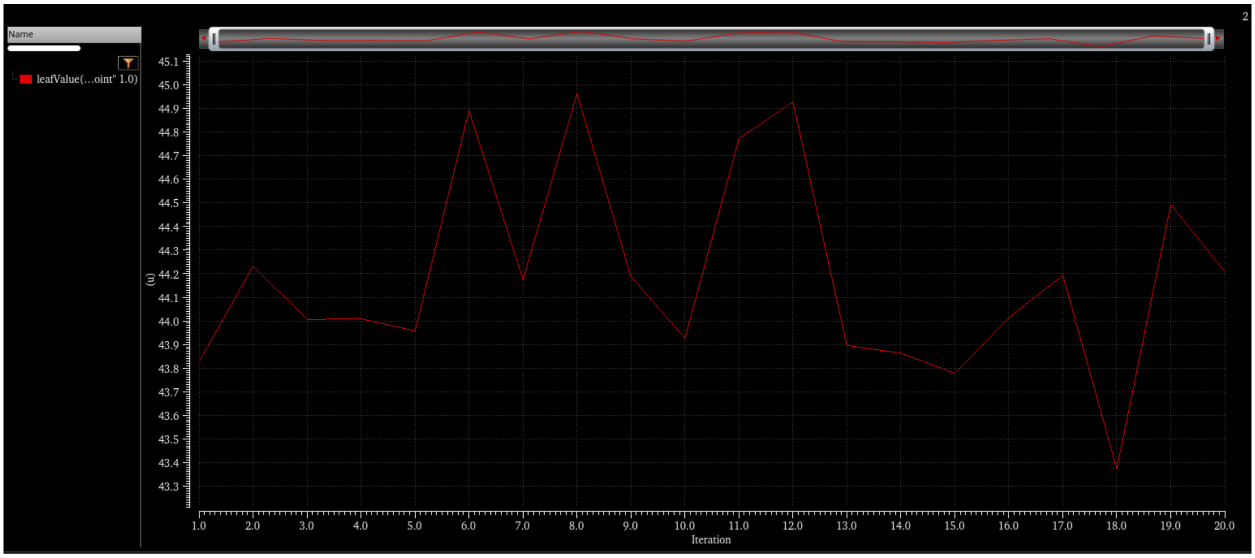
4 CHANGE THE TRANSIENT NOISE OPTIONS TO RUN 20 SIMULATION RUNS. NOW SPECTRE WILL RUN 20 RUNS OF TRANSIENT NOISE.




```
leafValue( v("/VOUT" ?result "tran" ?resultsDir "/home/user01/simulation/LAB9/part3/maestro/results/maestro/Interactive.37/psf/LAB9_part3_1/psf") "Design_Point" 1 )-v("/VOUT" ?result "tran")
```



5 REPORT THE RMS NOISE VS ITERATION.



6 USE THE CALCULATOR TO CALCULATE THE AVERAGE RMS NOISE. COMPARE THE CALCULATED VALUE WITH THE RMS NOISE PREVIOUSLY OBTAINED IN PART 3.

Expression	Value
average(leafVal...	44.19E-6

PART4	PART3
44.19 u	THERMAL :46.74u TOTAL: 49.44u