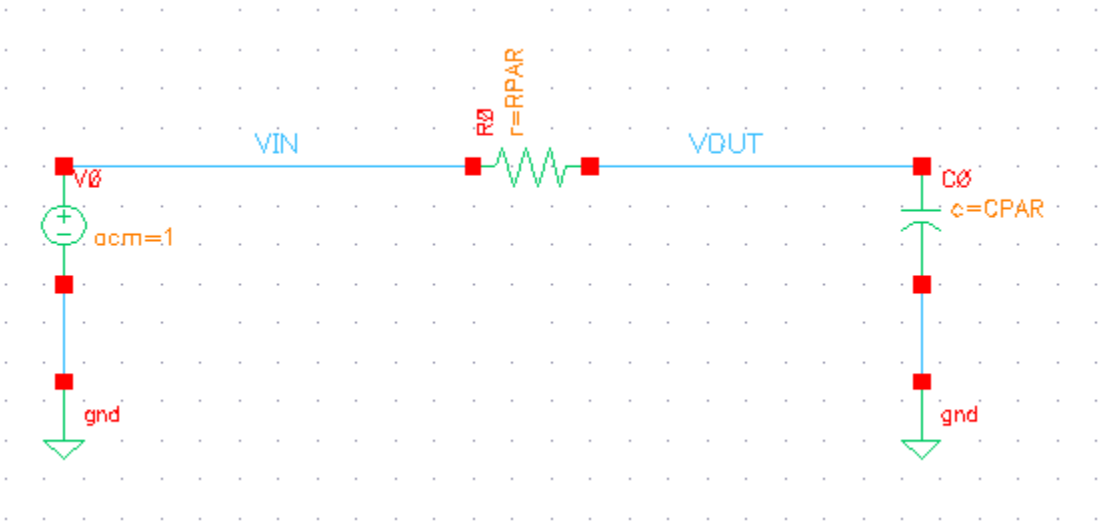
ITI
LAB10
Noise Simulation

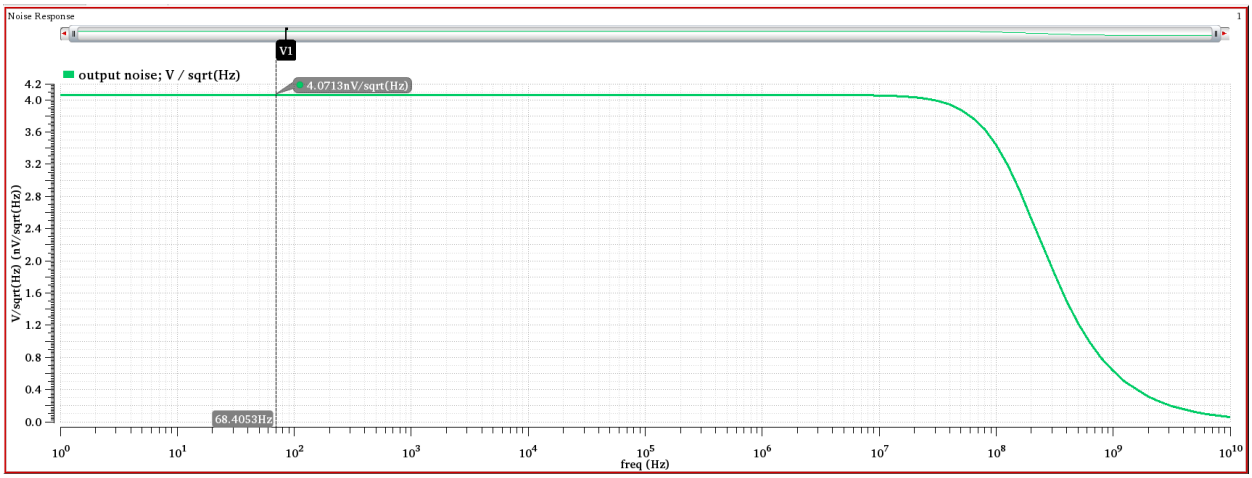
Contents

PART 1: LPF AC Noise Analysis

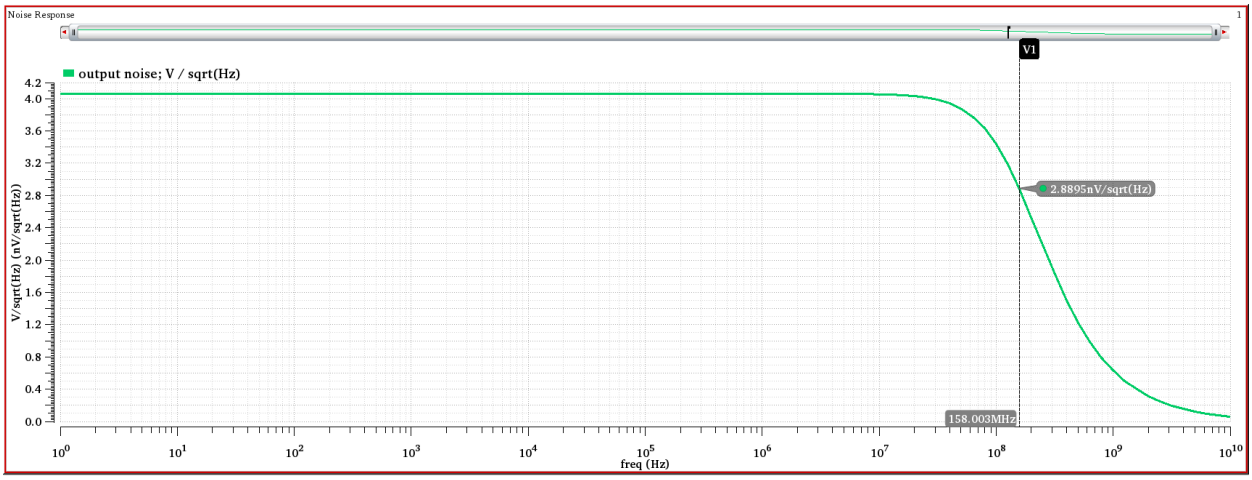
Schematic



Output noise vs frequency with the noise density annotated



Output noise vs frequency with the bandwidth annotated



rms output noise

```
/R0        rn        4.07133e-09           100.00
/R0        fn        0                     0.00

Spot Noise Summary (in V/sqrt(Hz)) at 1K Hz Sorted By Noise Contributors
Total Summarized Noise = 4.07133e-09
Total Input Referred Noise = 4.07133e-09
The above noise summary info is for noise data with  RPAR = 1000.0


Device     Param     Noise Contribution     % Of Total
/R0        rn        6.43237e-05           100.00
/R0        fn        0                     0.00

Integrated Noise Summary (in V) Sorted By Noise Contributors
Total Summarized Noise = 6.43237e-05
Total Input Referred Noise = 0.000407133
The above noise summary info is for noise data with  RPAR = 1000.0
```

Hand analysis

- Noise density

$$Noise\ density = \sqrt{4KTR}$$

$$Noise\ density = 4nV/Hz^{\frac{1}{2}}$$

- Bandwidth

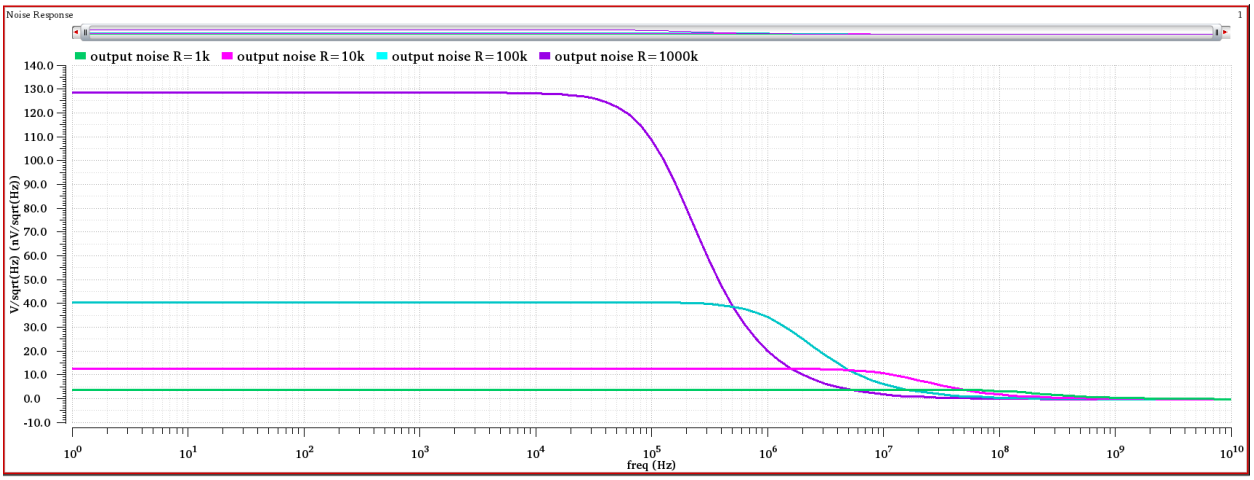
$$Bandwidth = \frac{1}{2\pi RC}$$

$$Bandwidth = 159.154MHz$$

- $RMS = \sqrt{\frac{KT}{C}}$

  $RMS = 64.35\mu V$

Parametric sweep



Point	Test	Output	Nominal	Spec	Weight	Pass/Fail
Parameters: RPAR=1k						
1	ITI:LAB10:1	VOUT				
1	ITI:LAB10:1	Bandwidth	158.8M			
1	ITI:LAB10:1	noise	64.32u			
Parameters: RPAR=10k						
2	ITI:LAB10:1	VOUT				
2	ITI:LAB10:1	Bandwidth	15.88M			
2	ITI:LAB10:1	noise	64.62u			
Parameters: RPAR=100k						
3	ITI:LAB10:1	VOUT				
3	ITI:LAB10:1	Bandwidth	1.588M			
3	ITI:LAB10:1	noise	64.65u			
Parameters: RPAR=1M						
4	ITI:LAB10:1	VOUT				
4	ITI:LAB10:1	Bandwidth	158.8k			
4	ITI:LAB10:1	noise	64.66u			

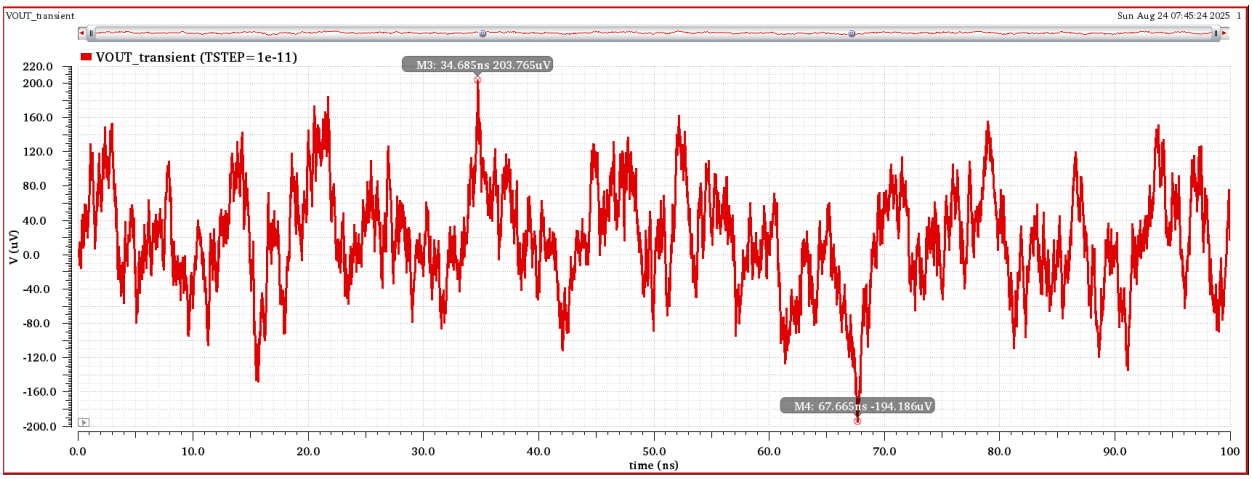
Comment:

When sweeping the resistor value R, the total integrated output noise remains nearly constant. This is because two opposing effects cancel each other

Thermal noise=$4KTR$, $Bandwidth = \frac{1}{2\pi RC}$

And the $noise = Thermal\ noise \times Bandwidth$

PART 2: LPF Transient Noise Analysis



Test	Output	Nominal	Spec	Weight	Pass/Fail
ITI:LAB10:1	rms(VT("/VOUT"))	60.88u			

Comment:

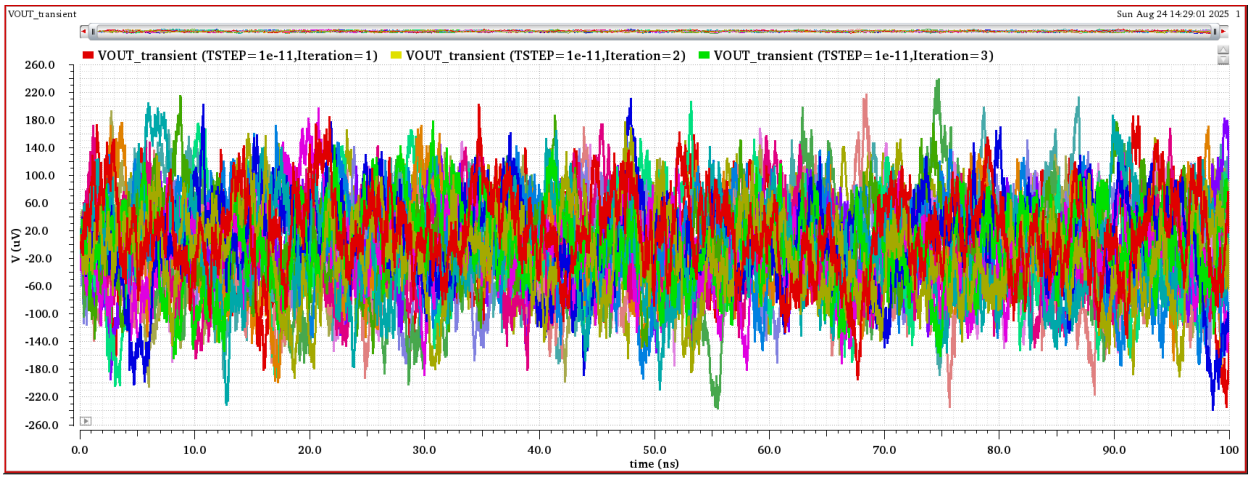
The value of the output noise is smaller than the obtained value from part1

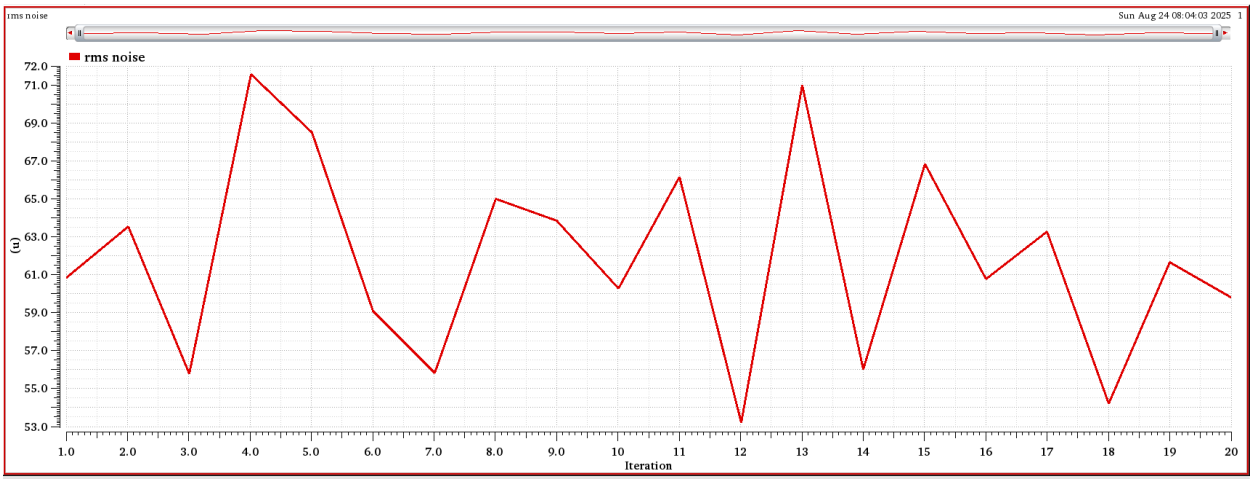
Test	Output	Nominal	Spec	Weight	Pass/Fail
ITI:LAB10:1	VOUT_transient				
ITI:LAB10:1	rms(VT("/VOUT"))	61.59u			

Comment:

Since T_{step} changed from $\frac{TAU}{100}$ to $\frac{TAU}{10}$ the time increased so the frequency decreases and the $rms \propto \sqrt{f}$

So the value of the of the rms should decrease

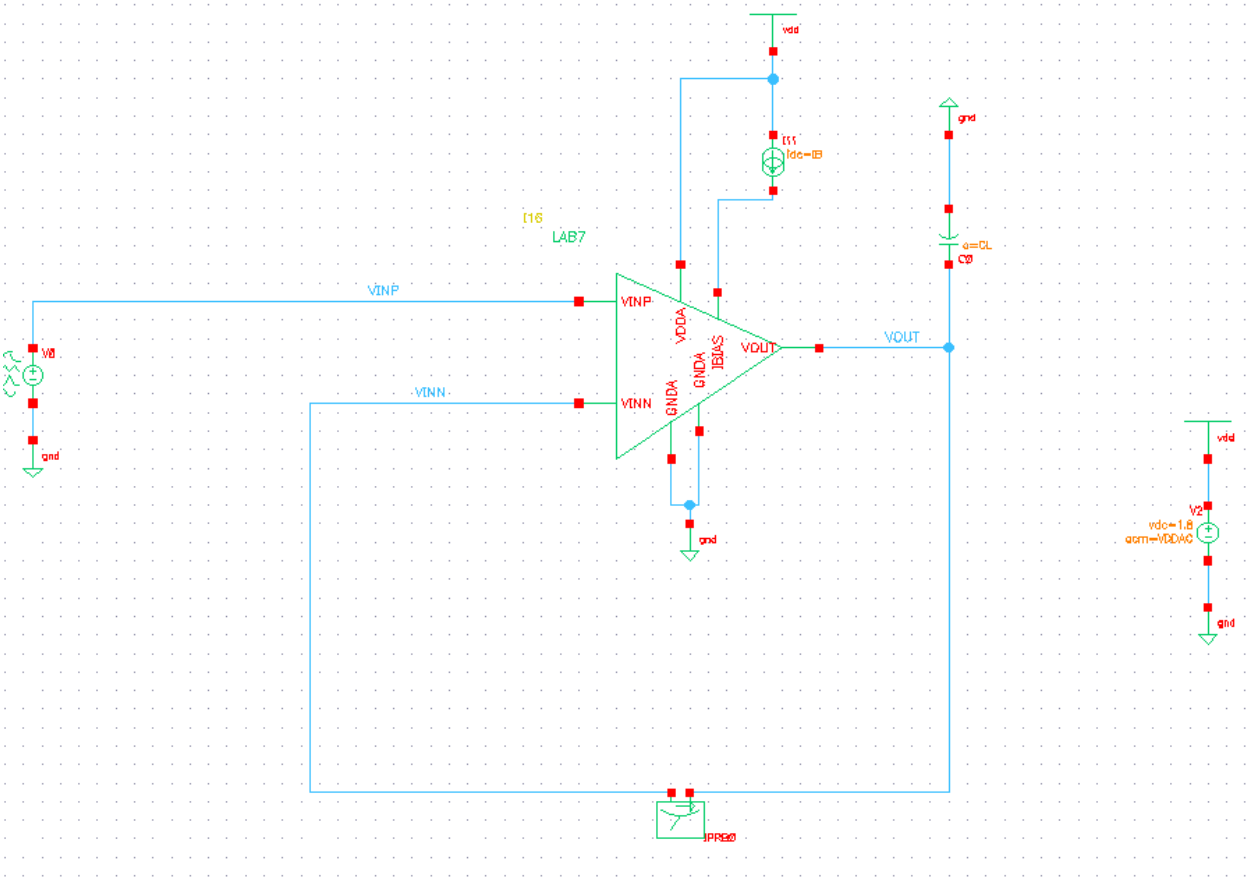




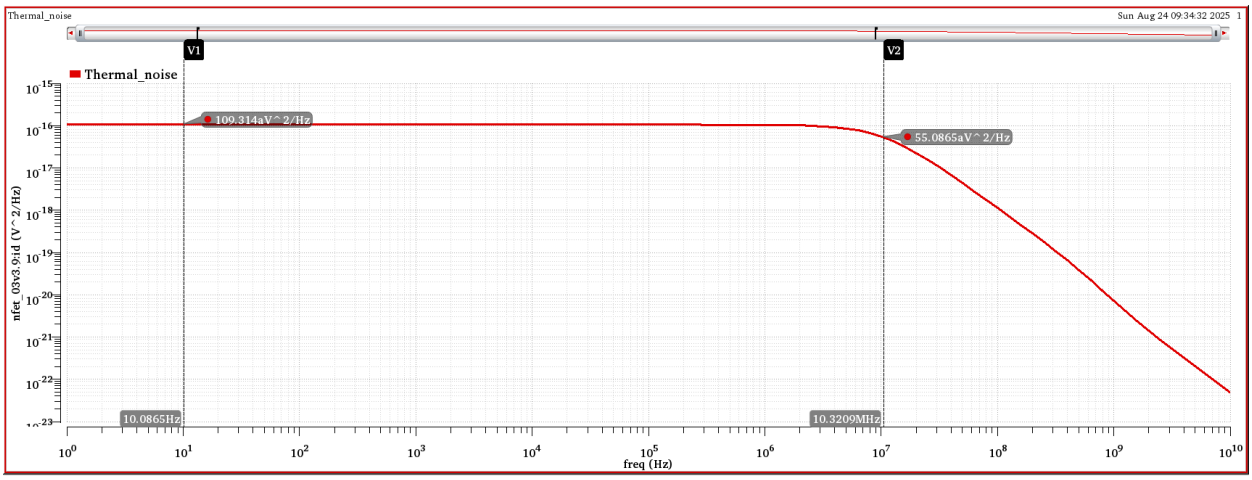
Test	Output	Nominal	Spec	Weight	Pass/Fail
ITI:LAB10:1	VOUT_transient				
ITI:LAB10:1	rms noise				
ITI:LAB10:1	average rms noise.	61.97u			

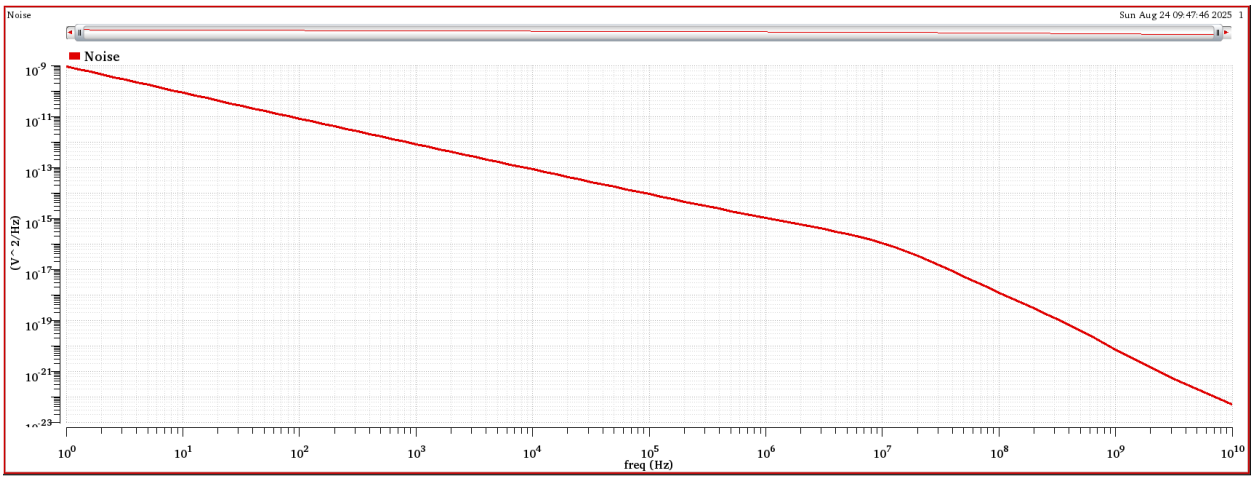
Current value	Part2 value	Part1 value
$61.97u$	$61.59u$	$64.32u$

PART 3: 5T OTA AC Noise Analysis

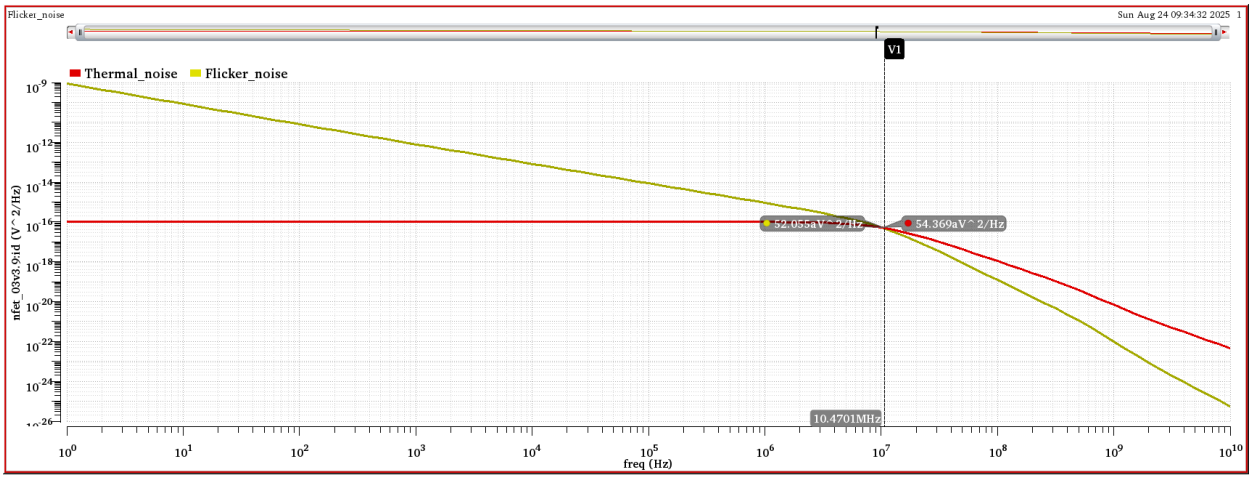


Thermal noise





Corner frequency



Rms noise (due to the thermal noise only)

ITI:LAB10_OTA_part:1	rms noise	42.25u			

Hand analysis

- BW

$$BW = GBW$$

$$GBW = \frac{g_{m_n}}{2\pi C_L}$$

And from LAB7

$g_{m_n} = 0.0003283\Omega^{-1}$

$g_{m_p} = 0.0001964\Omega^{-1}$

$C_L = 5pF$

$BW = 10.45MHz$

- RMS

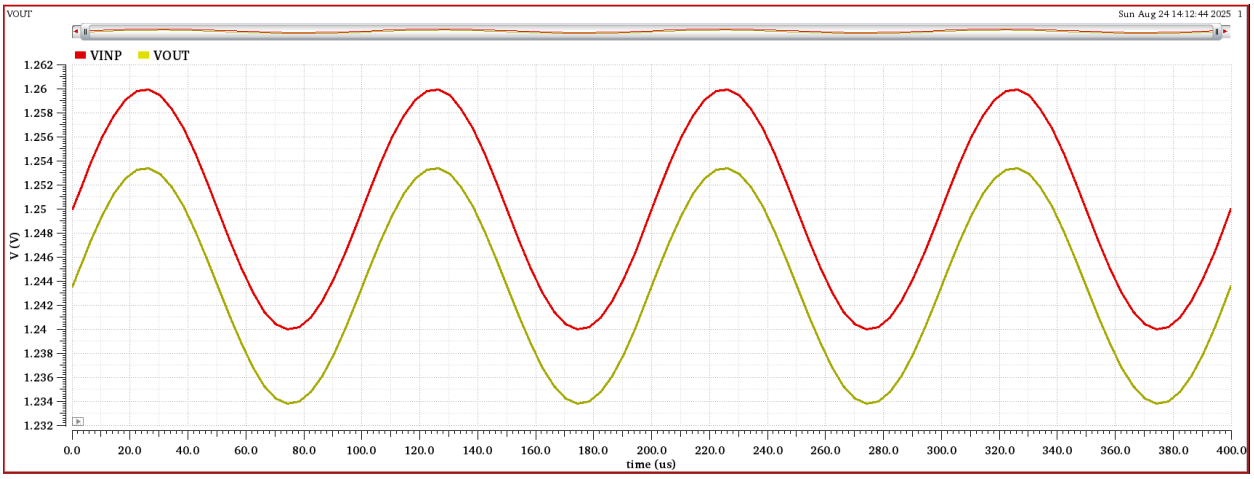
$$V_{noise}{}^2 = \frac{8KT\Upsilon}{g_{m_n}}(1 + \frac{g_{m_p}}{g_{m_n}})$$

$V_{noise}{}^2 = 108.517\ aV^2/Hz$

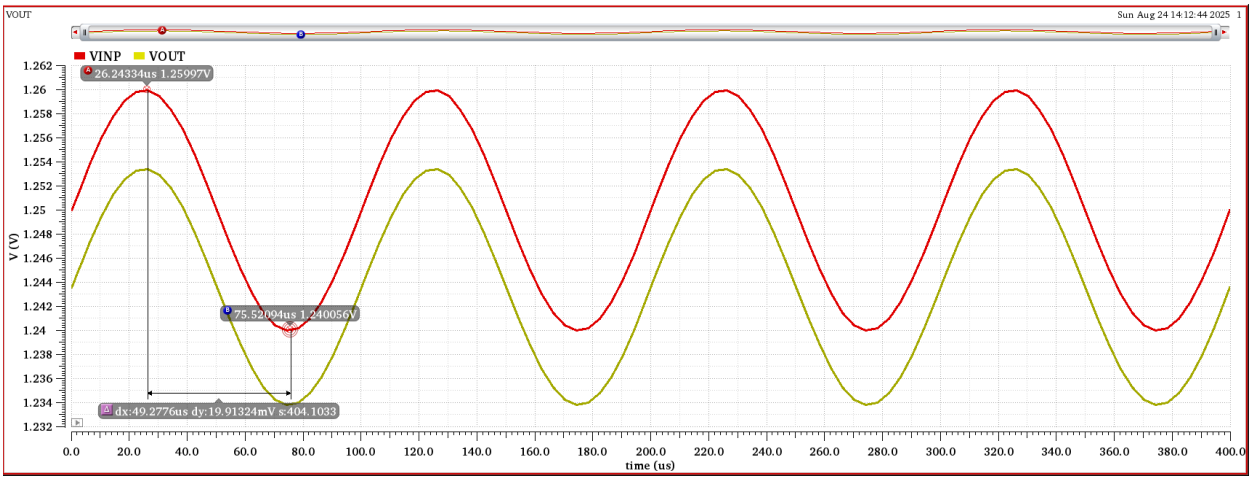
$$RMS = \sqrt{V_{noise}{}^2 \times BW\ \times \frac{\pi}{2}}$$

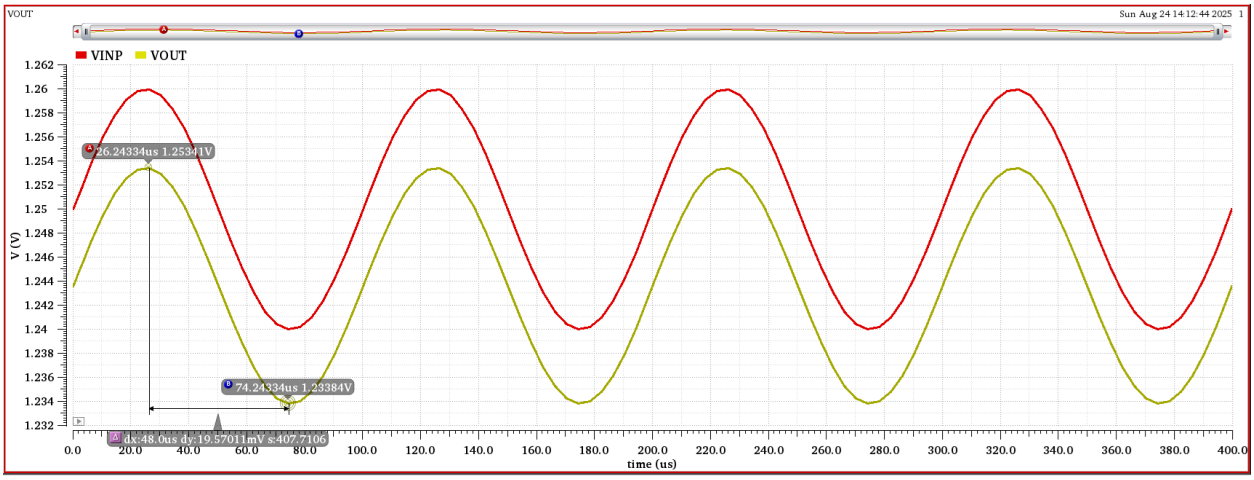
$$RMS = 41.28\mu V$$

PART 4: 5T OTA Transient Noise Analysis

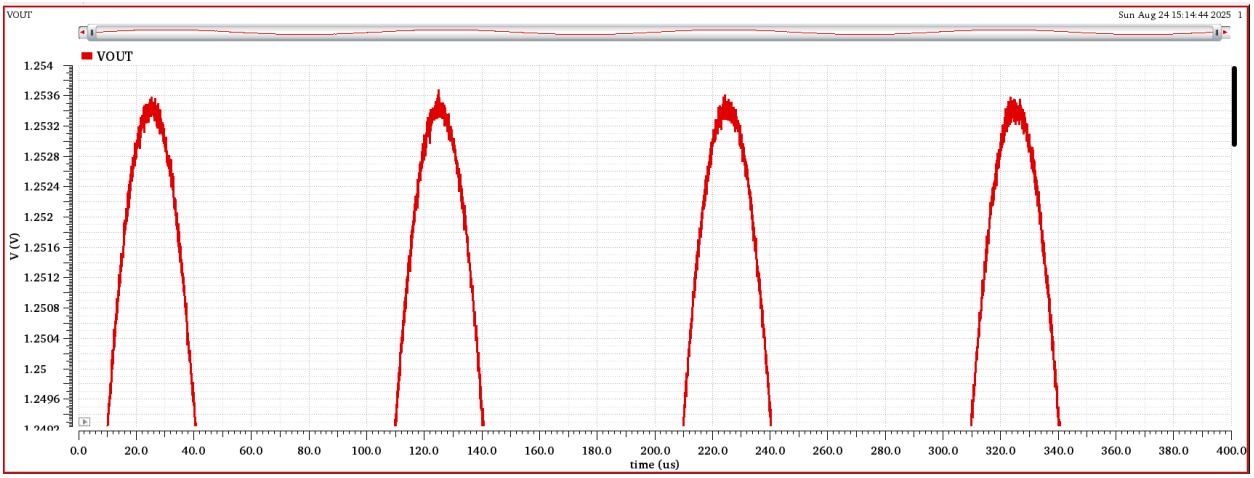


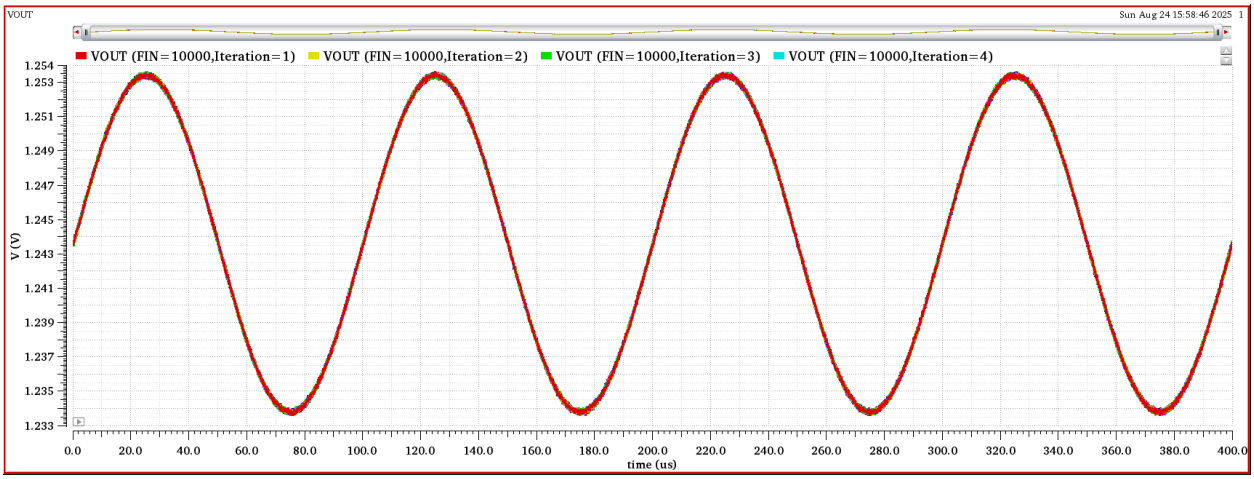
Verifying if the circuit behave as a buffer

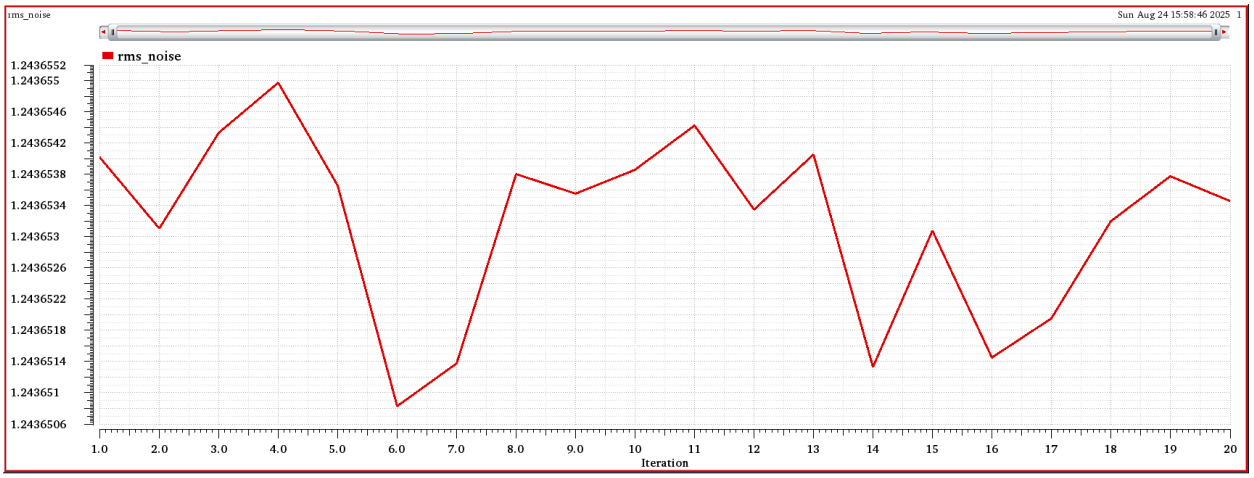


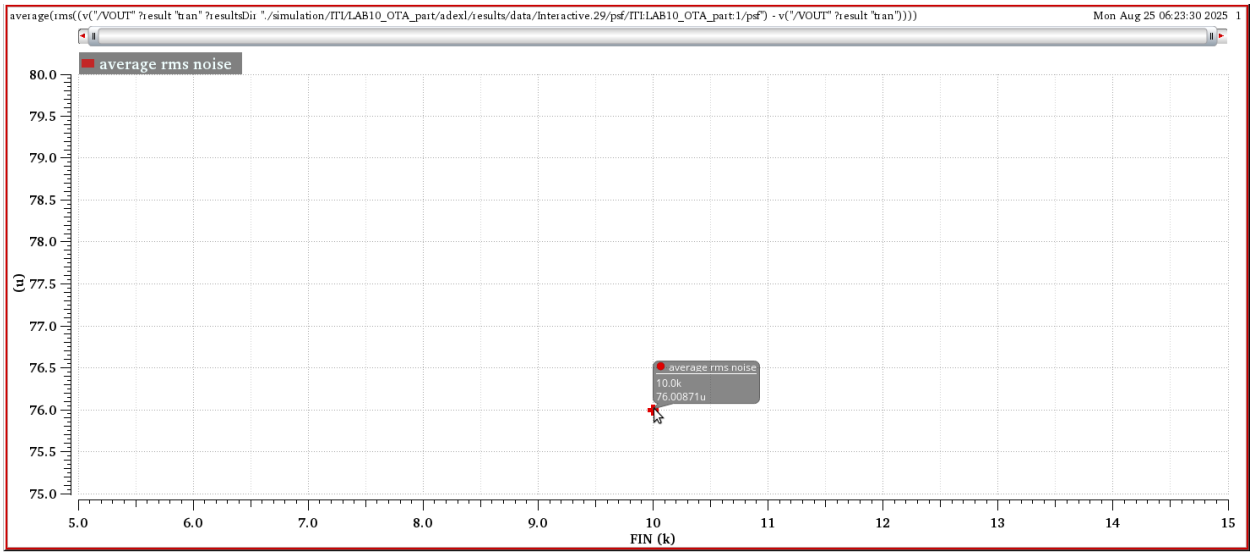


Since both signals have the same peak to peak value, then this circuit behave as a buffer


VOUT
Sun Aug 24 15:14:44 2025
VOUT
V (V)
time (us)


VOUT
Sun Aug 24 15:58:46 2025
VOUT (FIN=10000,Iteration=1)
VOUT (FIN=10000,Iteration=2)
VOUT (FIN=10000,Iteration=3)
VOUT (FIN=10000,Iteration=4)
V (V)
time (us)


rms_noise
Sun Aug 24 15:58:46 2025
rms_noise
Iteration



average RMS from part3	*average RMS noise from part4*
42.25*u*	76*u*