25 Spring ECEN 607: Advanced Analog Circuit Tech Design Post-lab Report

Lab3: Op Amp Design - I

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Section:601

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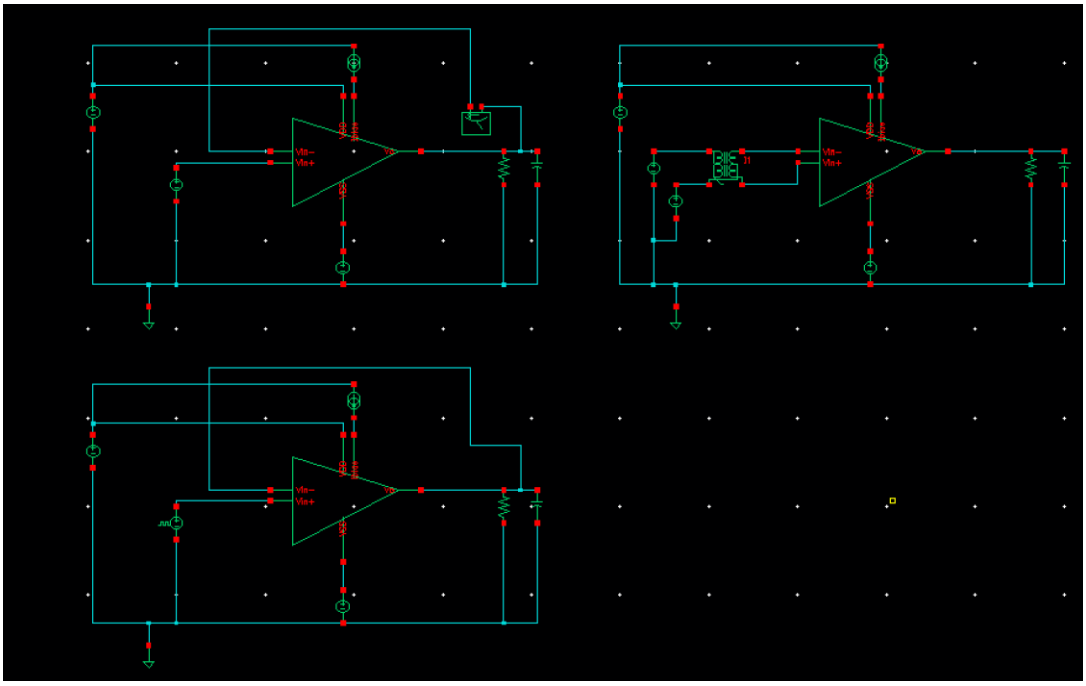
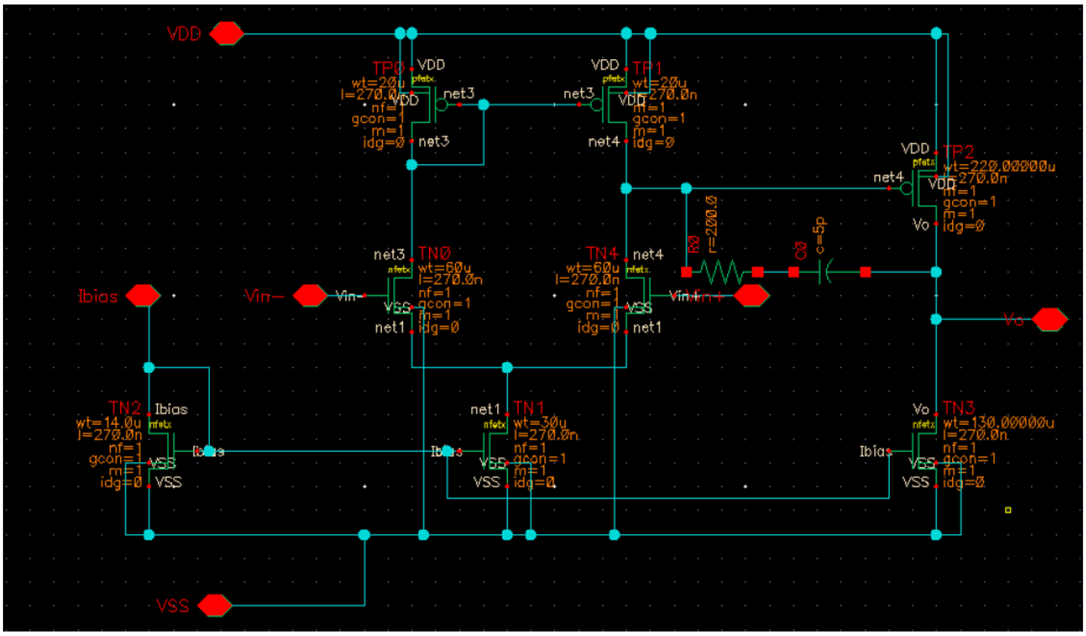
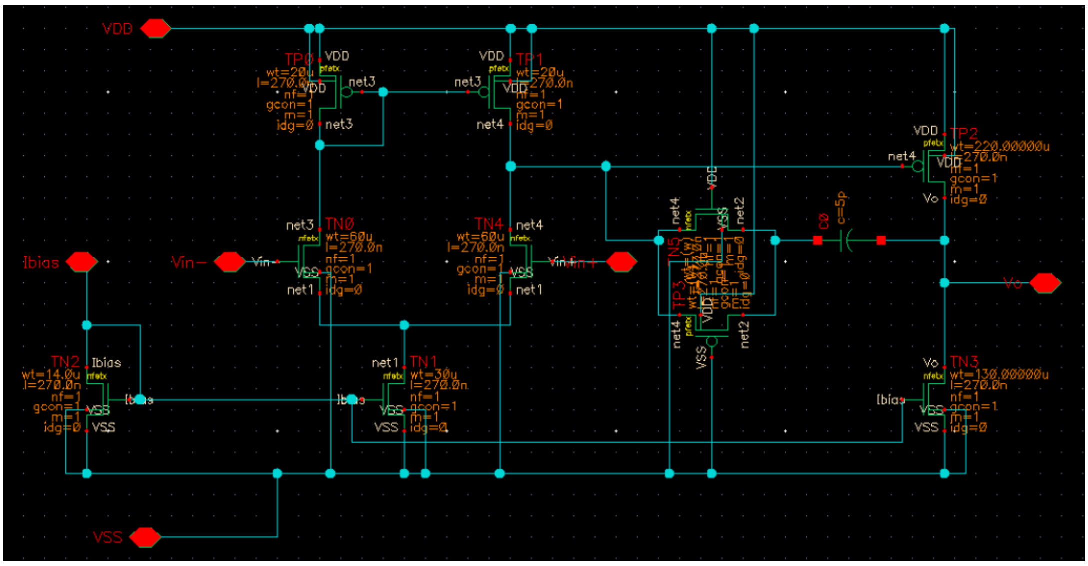
Table 2-1: Design specifications

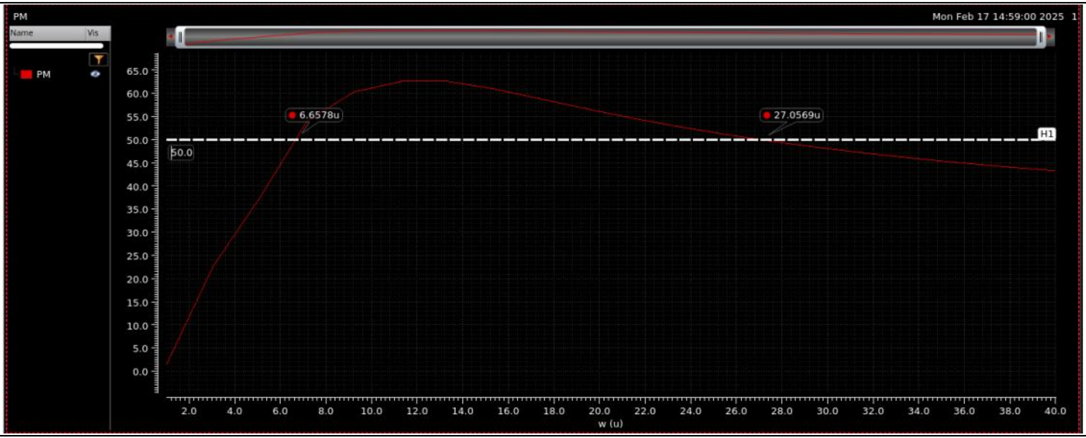
V_{DD}-V_{SS}	1.8V
A_{v0}	> 40 dB
GBW	> 2 MHz
PM	> 45°
Output Swing	> 1 V
C_L	20 pF
R_L	20kΩ
Integrated input referred noise (10 Hz – 2 MHz)	< 30 µVrms





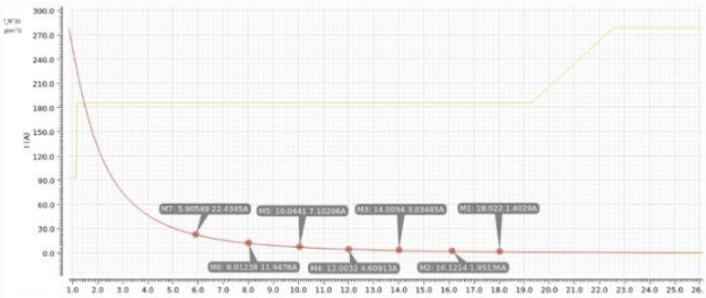


W= 27u for two triode mode transistor

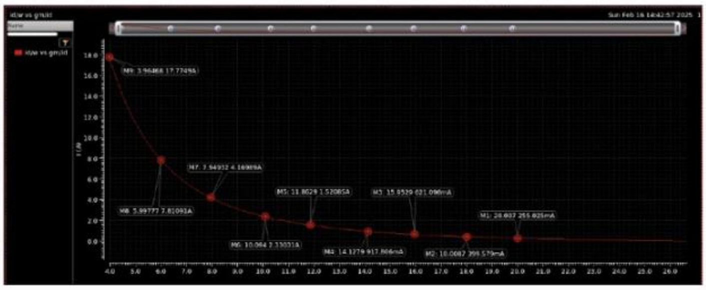


1. Simulate the circuit from the prelab and adjust the transistor sizes accordingly.

Nmos



pmos



make gm2 bigger for lower noise

$\frac{I_{D2}}{W2\ (60u)} = y(16) = 1.95$ $\quad gm_2 = 1.87m \quad I_{D2} = 117uA$ $\quad W\ tail\ (\frac{gm}{I_D} = 10) = 32.95 \quad I_{tail} = 234uA$

$\frac{I_D\ (100u)}{W} = y(10) = 7.1 \quad W\ I_{bias} = 14.08 \quad (\frac{32.95}{14.08} = \frac{234uA}{100uA})$

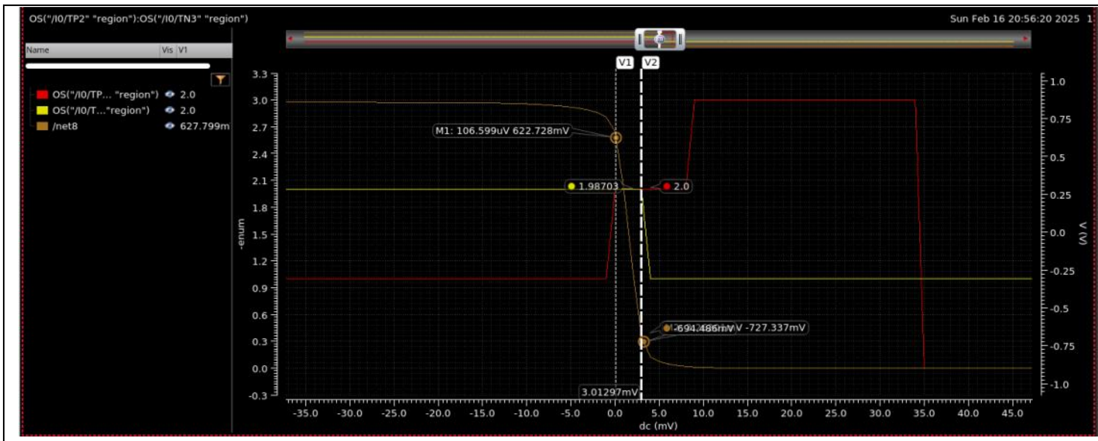
$GBW = \frac{1.87}{2\pi \times C_c} = 59M\ Hz$

If $f_{p2} = GBW$ (PM 45) $\quad \frac{gm8}{2\pi C_L} = GBW \quad gm8 = 7.4m$

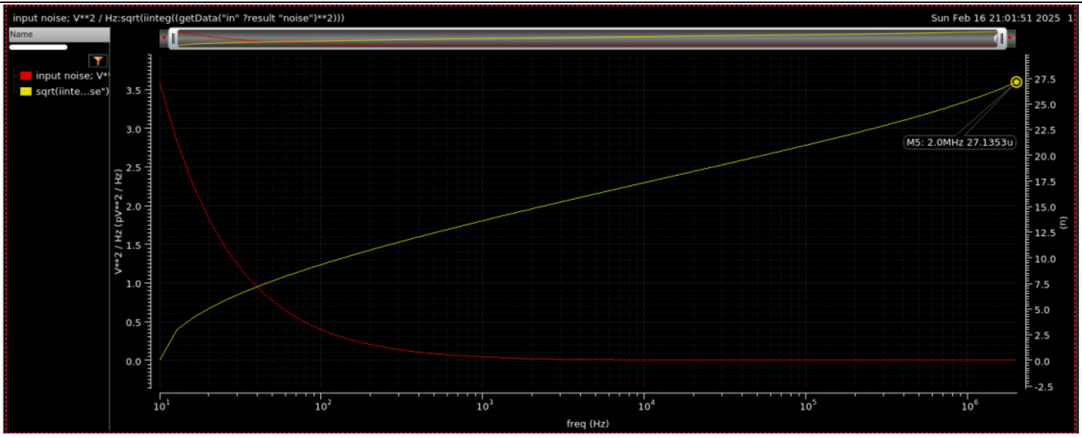
set $\frac{gm8}{I_{D}8} = 8 \quad I_D 8 = 926uA \quad W8 = \frac{I_{D}8}{y(8)} = 222u$

$I_D7 = 926uA \quad \frac{I_D7}{W7} = 10 \quad W7 = 130u \quad (\frac{130u}{14u} = \frac{926u}{100u})$

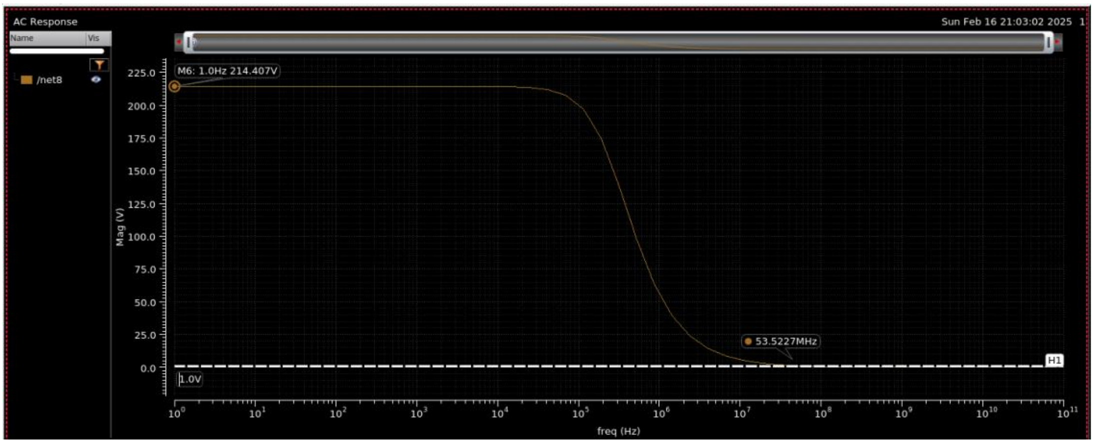
Vcm range



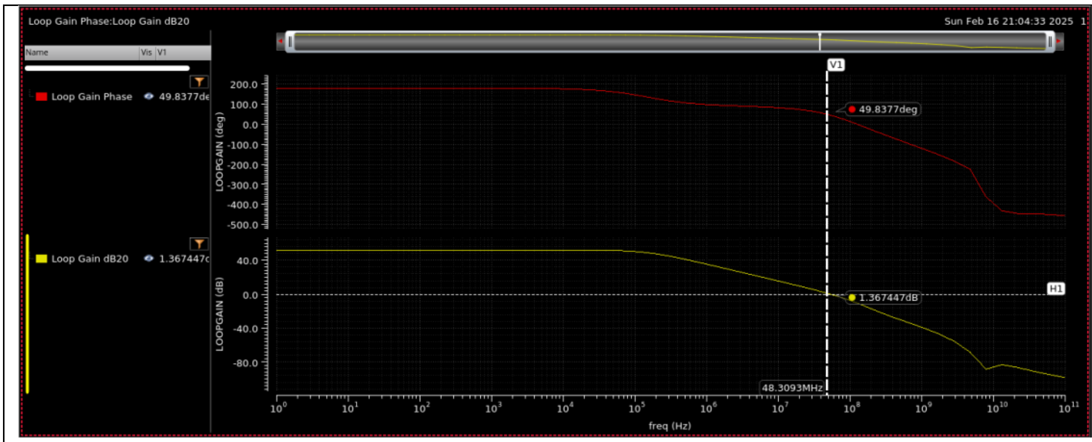
Output swing: 0.6 ~ -0.7= 1.3v



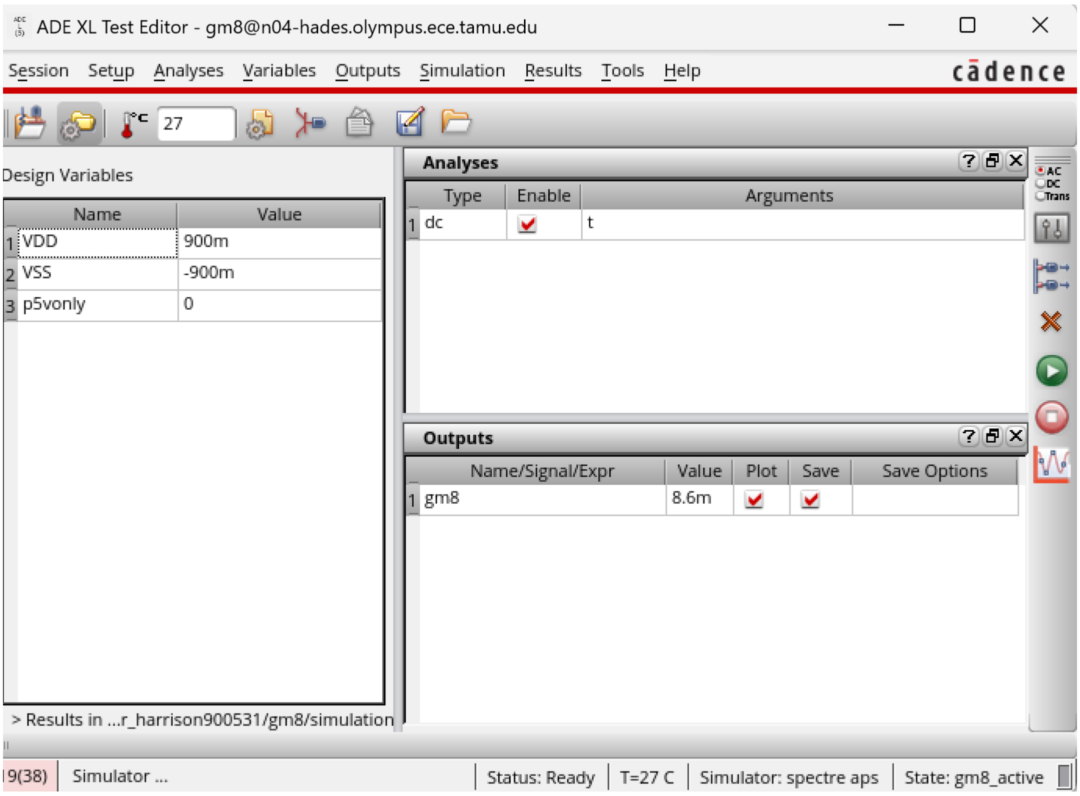
Input ref noise



GBW & Av0



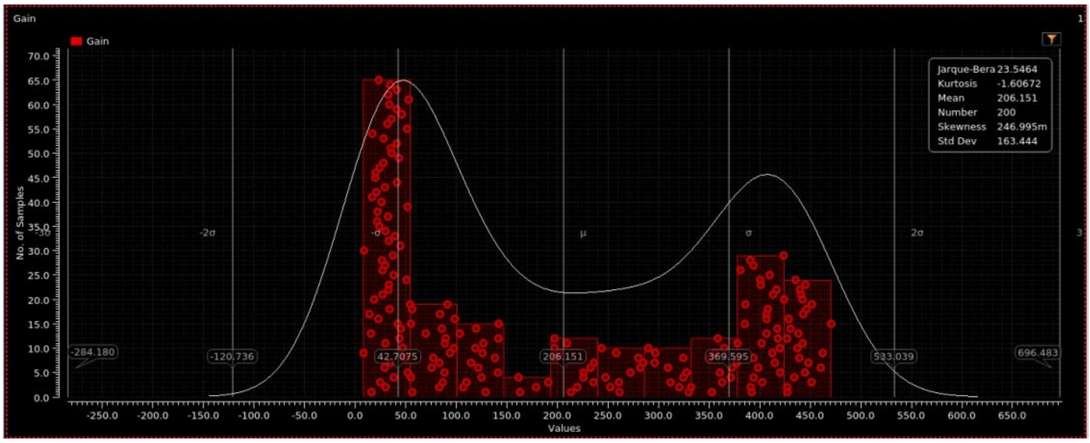
PM

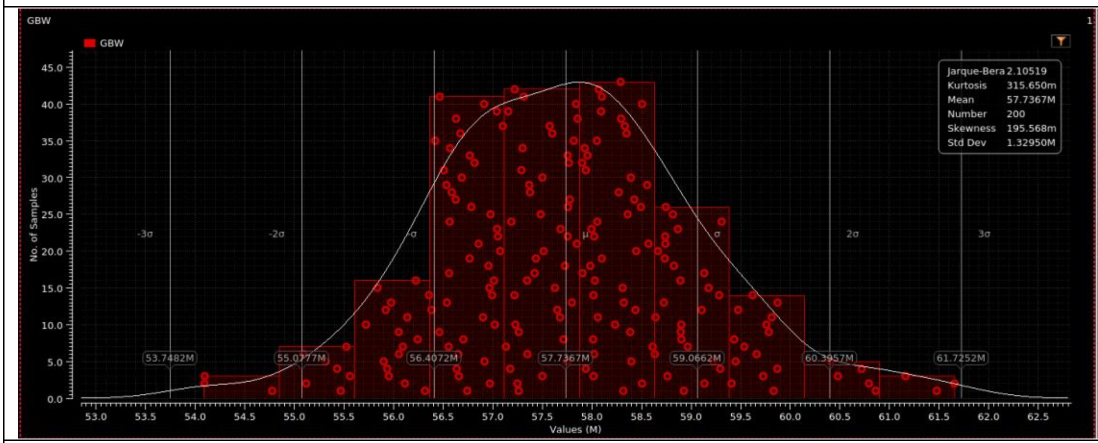


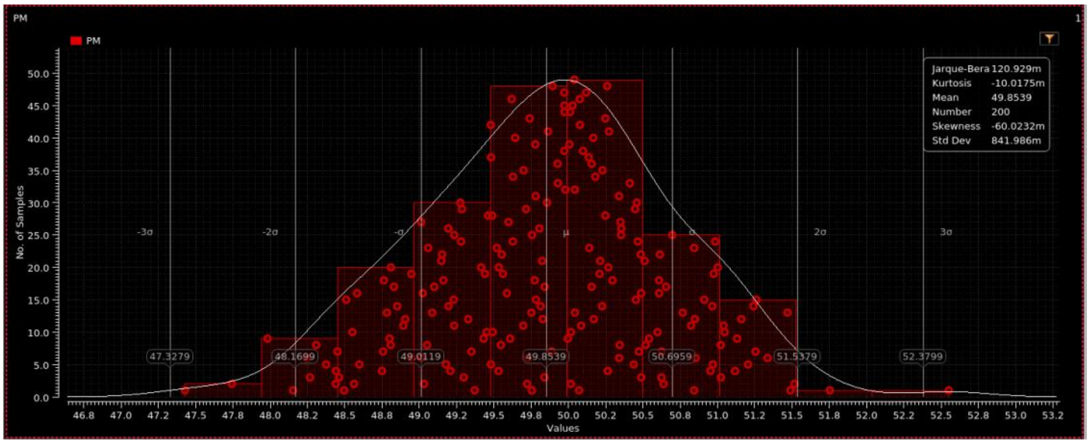
Gm8

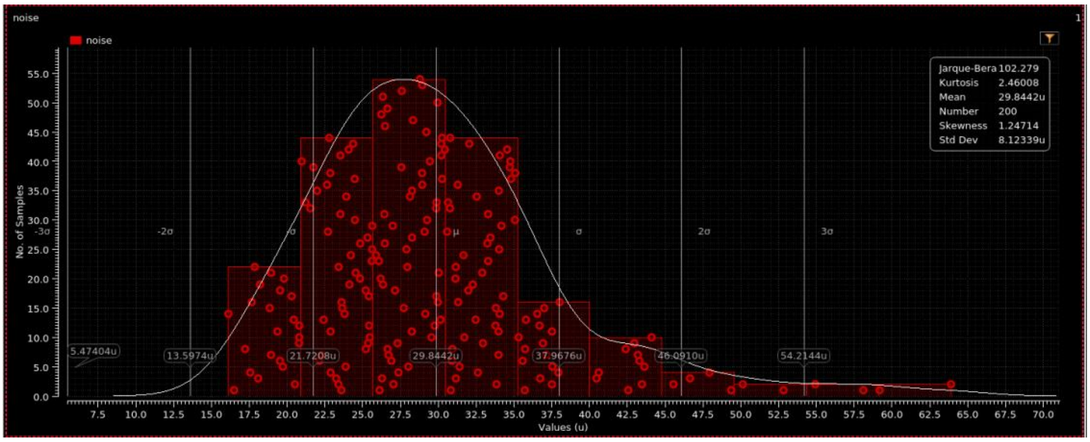
Test	Output	Nominal	Spec	Weight	Pass/Fail
AC	/net8				
AC	Gain	214.4			
AC	net8				
stability	GBW	61.95M			
stability	PM	45.49			
stability	/I0/TP2				
noise	noise	27.14u			
gm8	gm8	8.6m			
gm8	/I0/TP2				

2. Run MC simulation and adjust your design to target a 3-sigma yield for DC Gain, GBW, Phase Margin and input referred noise until all specifications are met. Provide necessary screen shots such that you clearly show the specs are met. (including histogram plots).



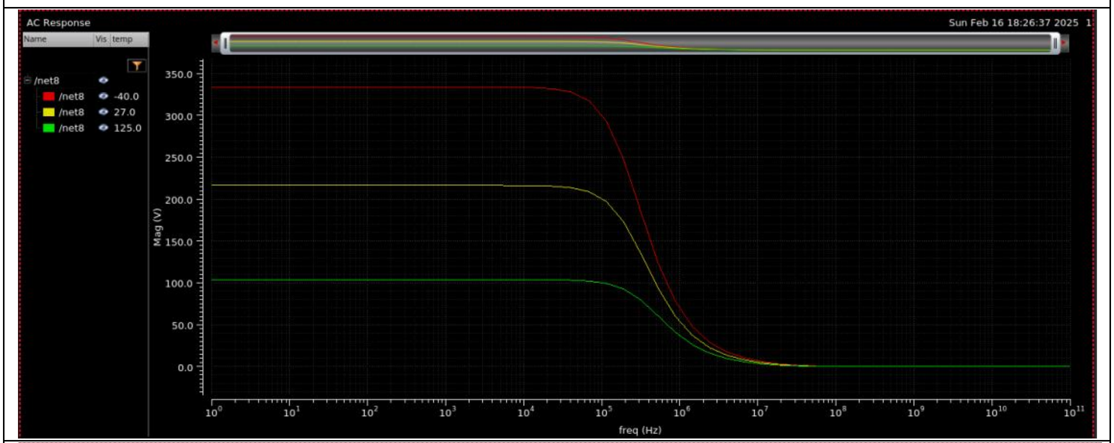


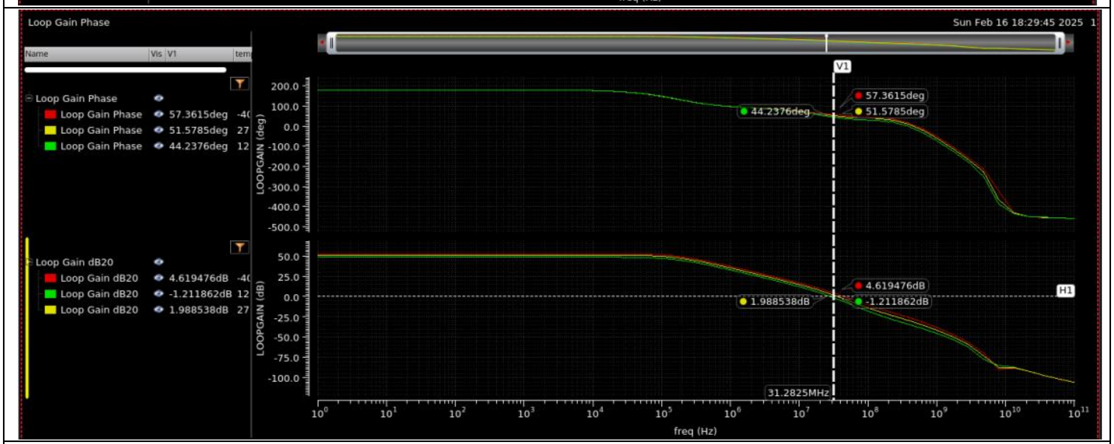




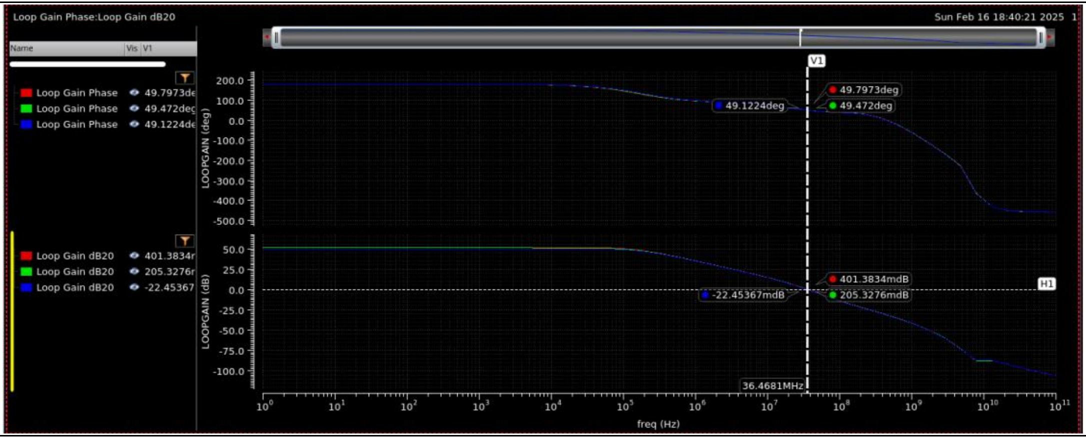
3. Simulate the supply voltage variations (+5, -5%) and temperature (-40, 125C) for DC Gain, GBW, Phase Margin. You do not have to adjust the design if specs are not met.

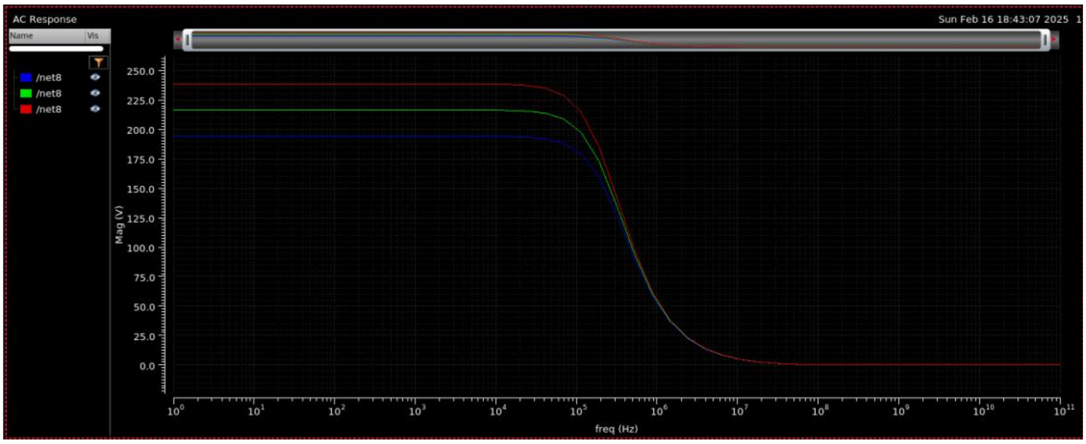
Temp



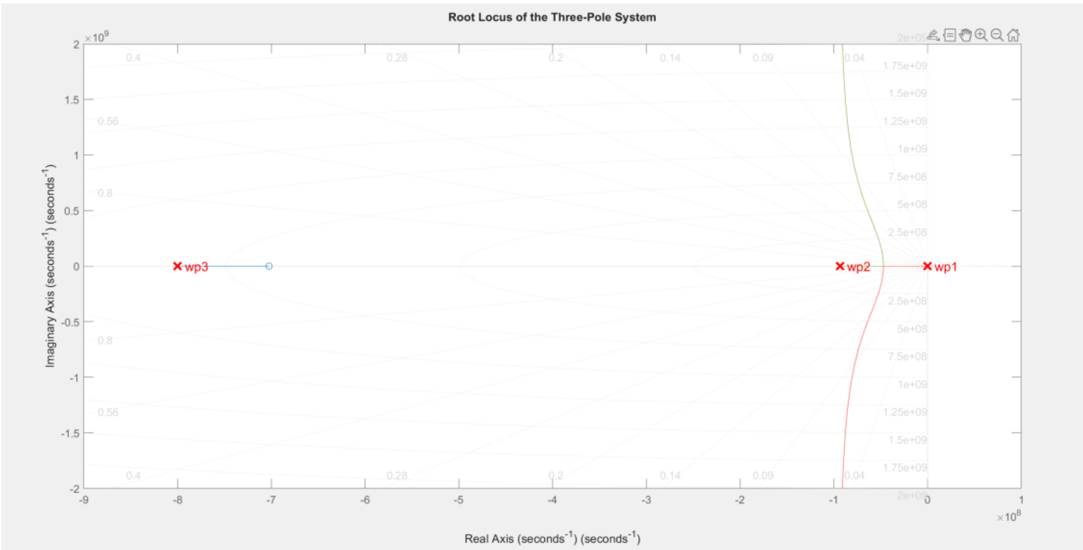


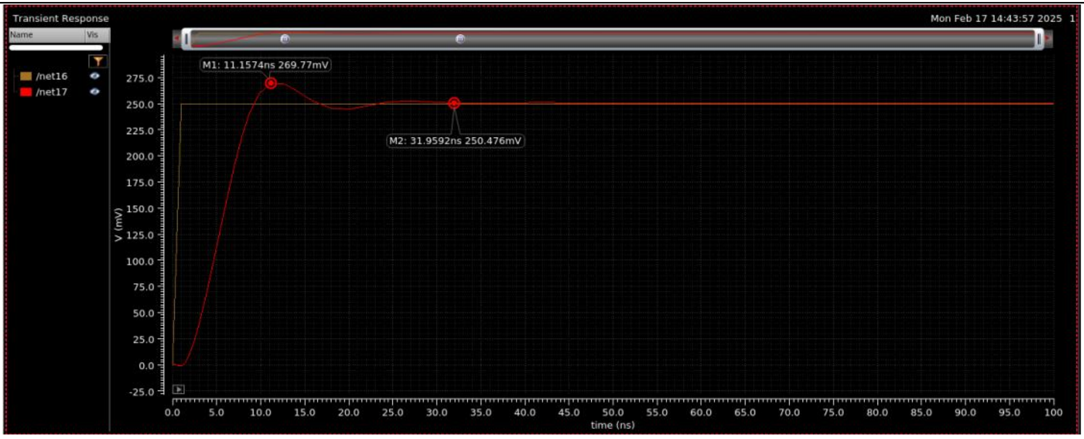
Power (blue for -5% Red for +5% Green for 1.8 Vpp)





4. Plot the root-locus of the transfer function from pre-lab (Over design the RHZ, 2*gm8/Cc). Use MATLAB function rlocus. Comment on the result with 250mV step response on unity-gain buffer configuration (beta=1).





PM around 50 with a little ringing but stable faster

- **Conclusion**

  Miller compensation is essential for stabilizing OPAs but introduces an undesirable **Right-Half Plane (RHP) zero**, which degrades phase margin and stability. To counteract this, **zero canceling** techniques introduce a **Left-Half Plane (LHP) zero** via a series resistor, effectively mitigating the RHP zero's impact. Proper **Miller RC compensation** shapes the **root locus**, optimizing pole placement, loop stability, and transient response. By carefully designing **zero placement**, designers can enhance **bandwidth, phase margin, and gain performance**, ensuring a well-behaved amplifier with minimal overshoot and ringing.

- **Appendix**

Current Folder

Name

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ECEN607 prelab3 Yu_Hao Chen.pdf
prelab.docx
untitled.m

Details

Editor - C:\Users\harri\OneDrive\[illegible]\TAMU\ECEN 607 Advanced Analog circuit\lab3\untitled.m

read_sparam.m | channel_data.m | xfr_fn_to_imp.m | untitled.m

```
clc; clear; close all;

gm2 = 1.87e-3;
gm8 = 8e-3;
R1 = 65e3;
R2 = 20e3;
Cc = 5e-12;
CL = 20e-12;
R = 2/gm8; % move to LHP zero

% === calculate poles and zero ===
wp1 = -1 / (gm2 * R1 * R2 * Cc); % Wp1
wp2 = -gm2 / CL;                 % Wp2
wp3 = -1 / (R * Cc);             % Wp3
wz  = 1 / (Cc * ((1/gm2)-R));    % RHZ WZ

% === H(S) ===
s = tf('s');
H_corrected = (s + wz) / ((s - wp1) * (s - wp2) * (s - wp3)); % H(s)

% === Root Locus ===
figure;
rlocus(H_corrected); hold on;
title('Root Locus of the Three-Pole System');
xlabel('Real Axis (seconds^{-1})');
ylabel('Imaginary Axis (seconds^{-1})');
```

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ECEN607 prelab3 Yu_Hao Chen.pdf
prelab.docx
untitled.m

```
title('Root Locus of the Three-Pole System');
xlabel('Real Axis (seconds^{-1})');
ylabel('Imaginary Axis (seconds^{-1})');
grid on;

% === mark poles and zero ===
plot(real([wp1, wp2, wp3]), imag([wp1, wp2, wp3]), 'rx', 'MarkerSize', 10, 'LineWidth', 2);
plot(real(wz), imag(wz), 'go', 'MarkerSize', 10, 'LineWidth', 2);

% === marker ===
text(real(wp1), imag(wp1), '  wp1', 'FontSize', 12, 'Color', 'r');
text(real(wp2), imag(wp2), '  wp2', 'FontSize', 12, 'Color', 'r');
text(real(wp3), imag(wp3), '  wp3', 'FontSize', 12, 'Color', 'r');
text(real(wz), imag(wz), '  wz', 'FontSize', 12, 'Color', 'g');

hold off;
```