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

Lab2: Two-Stage Amplifier Design with 3σ Driven Statistical Corner Extraction

Name: Yu-Hao Chen

UIN:435009528

Section:601

Professor: Jose Silva-Martinez

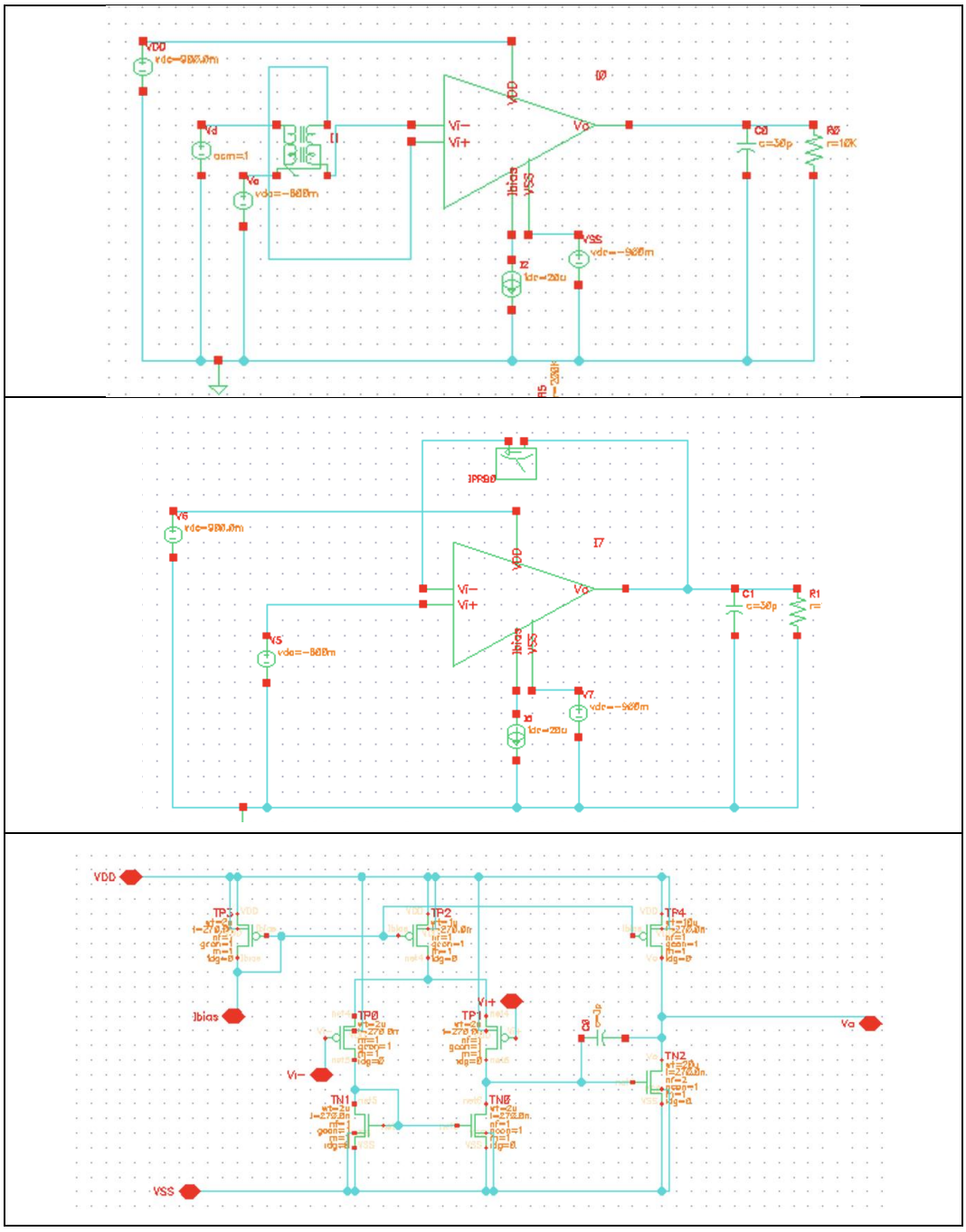
TA: Yoon, Sung J

Objectives:

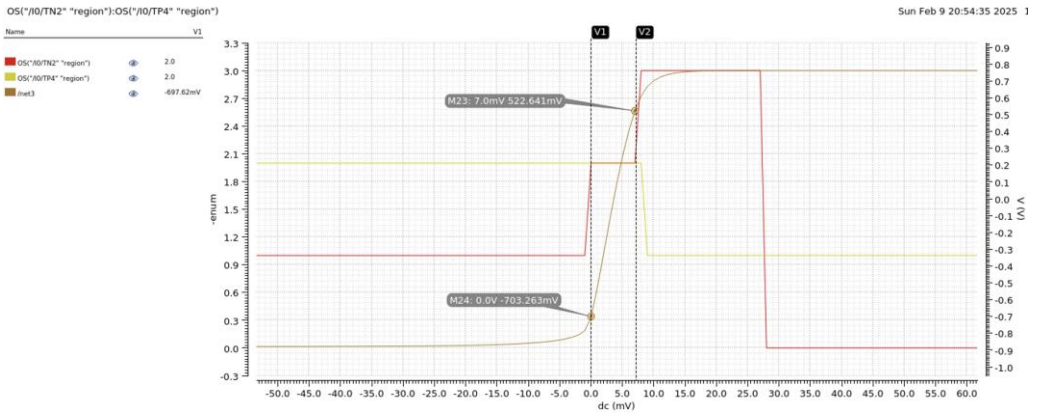
1. Design and simulate a two-stage Miller-compensated amplifier.
2. Observe the effect of voltage and temperature variations.
3. Verify the design with Monte-Carlo simulation.

Design & results:

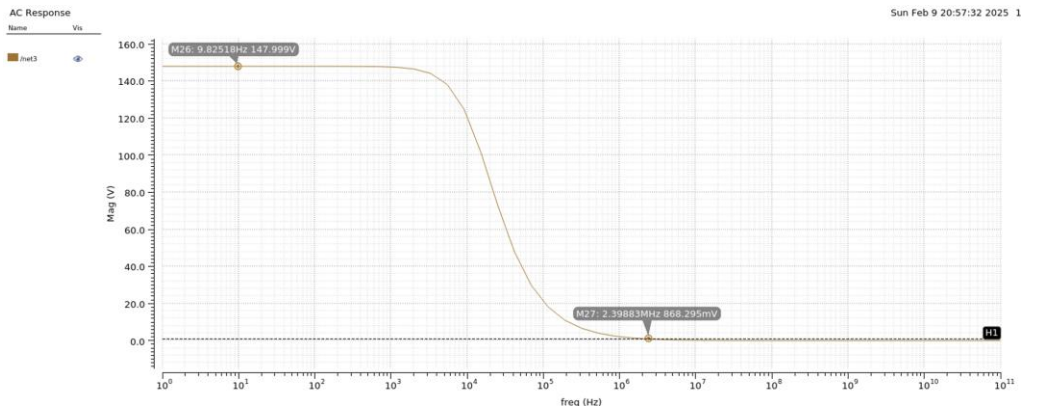
1. Simulate the design from the prelab and adjust the transistor sizes accordingly until all specifications are met. Notice that most relevant transistors are M1=M2 and M8. Check the slides discussed lecture 01/30/2024.



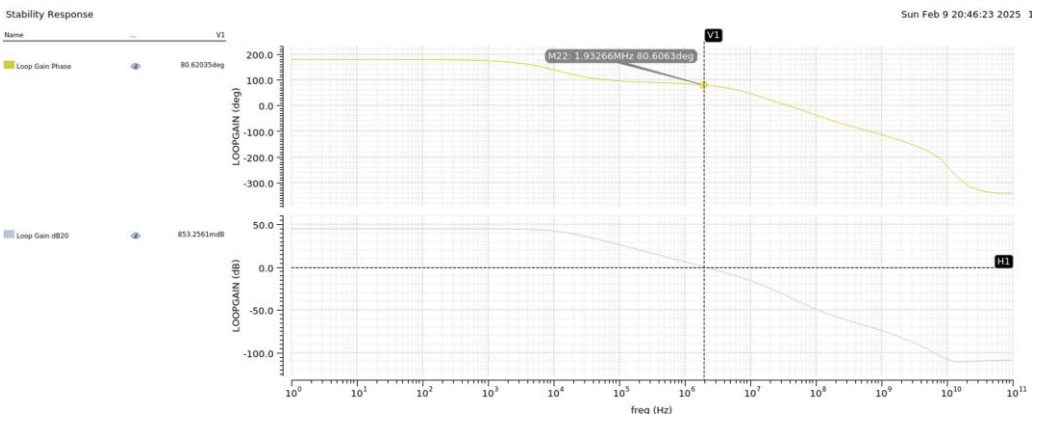
- Vcm range the dc operation point (-0.9~-0.54)



- Output swing (under Vcm=-600m) 0.52-(-0.7)= 1.2
- Show the small range for Vd-linear because of the high gain and open loop

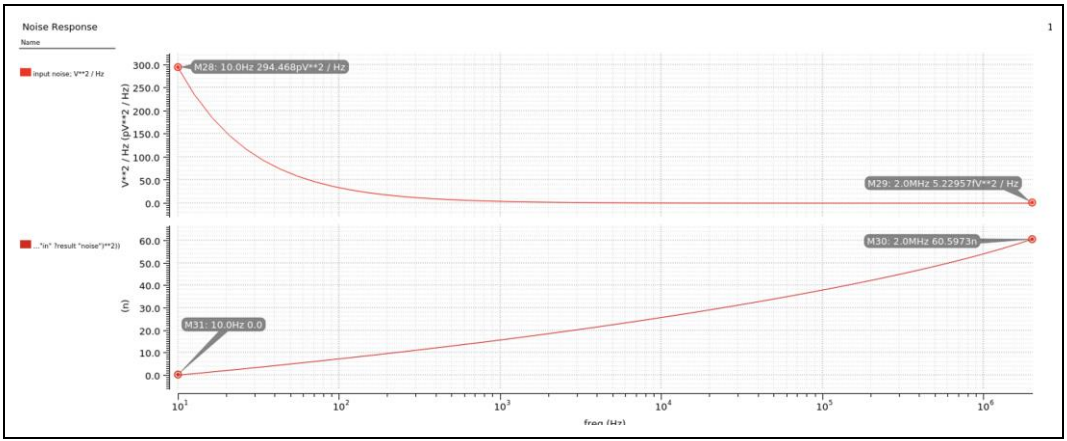


- Gain= 43dB, GBW=2.3M



- PM= Gain=1's phase= 180-80.6 degree

2. Plot and report (from simulations) the input referred noise density (what this does mean?) and find RMS voltage noise integrated in the band (10 Hz – 2 MHz).



- In analog circuit design (such as op-amps and ADCs), the **input-referred noise density** represents all noise sources **referred back to the input**, making it easier to evaluate their impact on the signal.
- Input-Referred Noise Density= Total Output Noise Density / Gain ^{2}
- **Top Curve (pV²/Hz) → Input-Referred Noise Density**

  At **low frequencies (~10 Hz)**, noise is higher, which is mainly due to **1/f (Flicker) noise**.

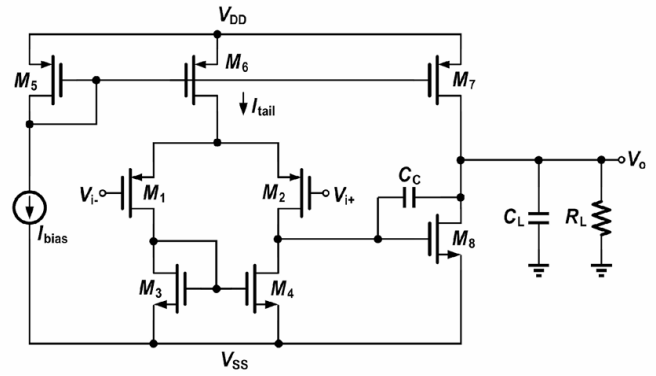
  At **high frequencies (~2 MHz)**, the noise density stabilizes, dominated by **thermal noise**.
- **Bottom Curve (nV) → Integrated RMS Noise**

  This curve represents the cumulative noise across the 10 Hz to 2 MHz band.

  As frequency increases, total integrated noise accumulates, leading to a higher noise voltage.

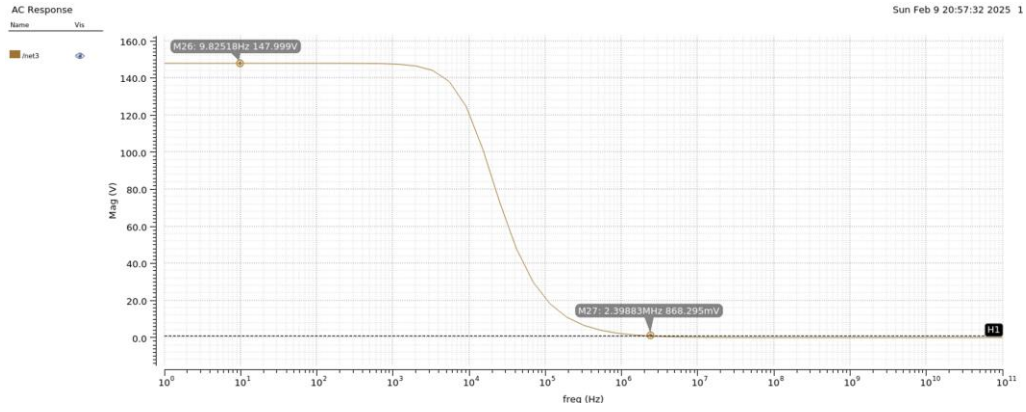
3. In addition, provide comparison tables of hand-calculated vs. final transistor sizes, and required specs (Table 1-1) vs. simulated specs. Comment on your results.

Due to the miscalculation of PM and didn't consider about the Vcm range, I redesign the circuit into following size

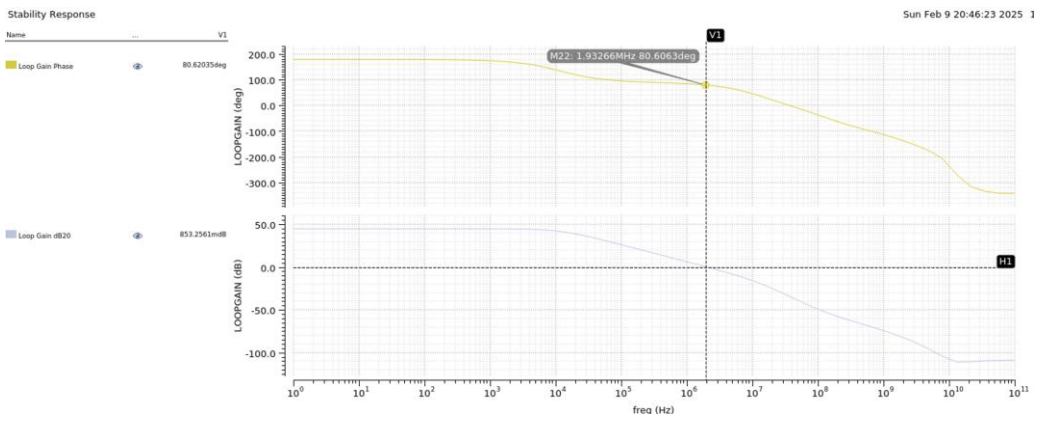


	Pre	Post		Pre	Post
Ibais	20u	20u	Av	196	146
Cc	16p	3p	GBW	2.48M	2.3M
M1	10u/0.18u	2u/0.27u	PM	60.18(mis)	80
M2	10u/0.18u	2u/0.27u	Swing	1.56	1.2
M3	5u/0.18u	2u/0.27u			
M4	5u/0.18u	2u/0.27u			
M5	5u/0.18u	2u/0.27u			
M6	5u/0.18u	1u/0.27u			
M7	10u/0.18u	10u/0.27u			
M8	10u/0.18u	20u/0.27u			

4. Plot the magnitude and phase response of your amplifier. Measure the phase margin and unity gain frequency from simulations.

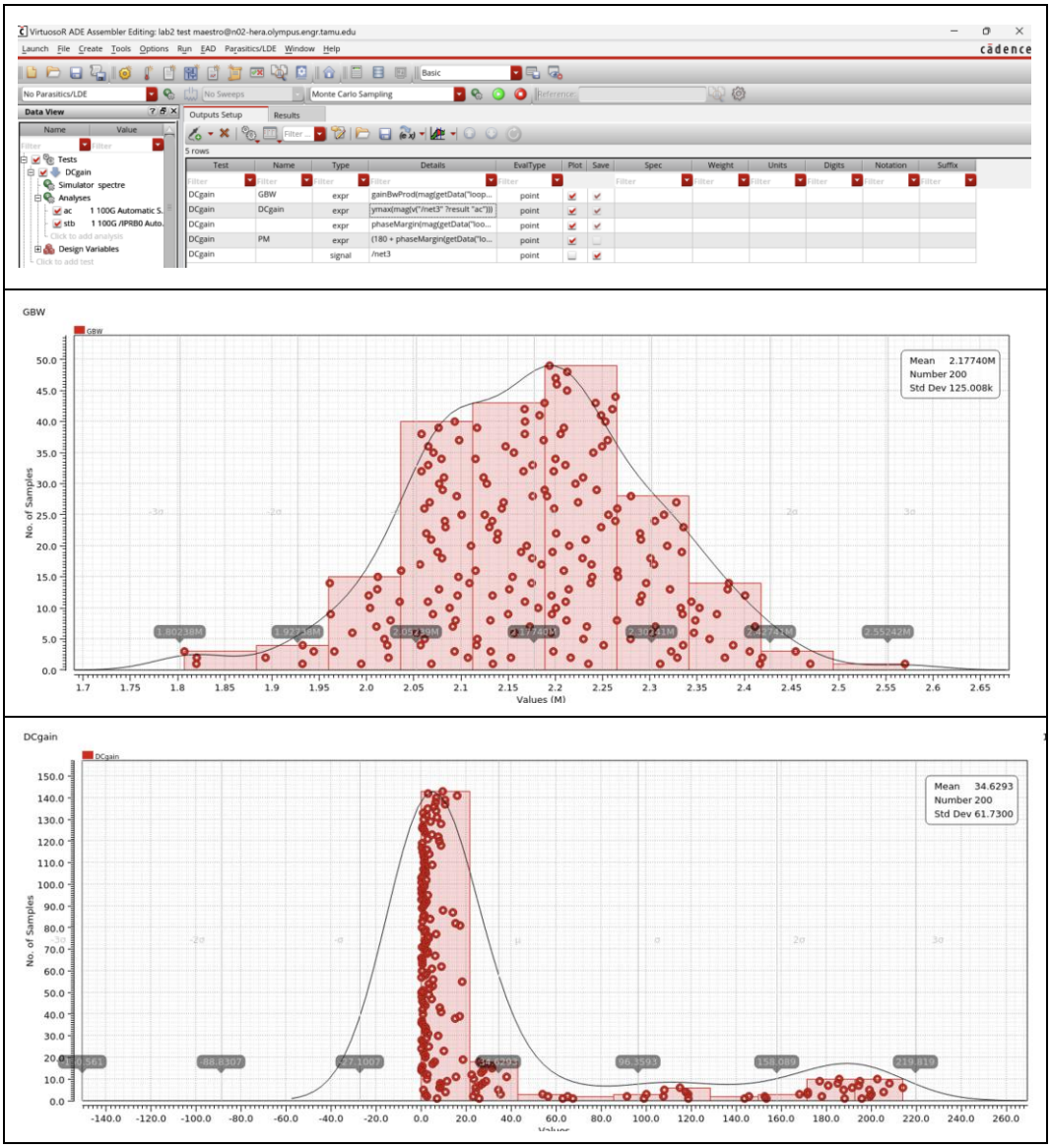


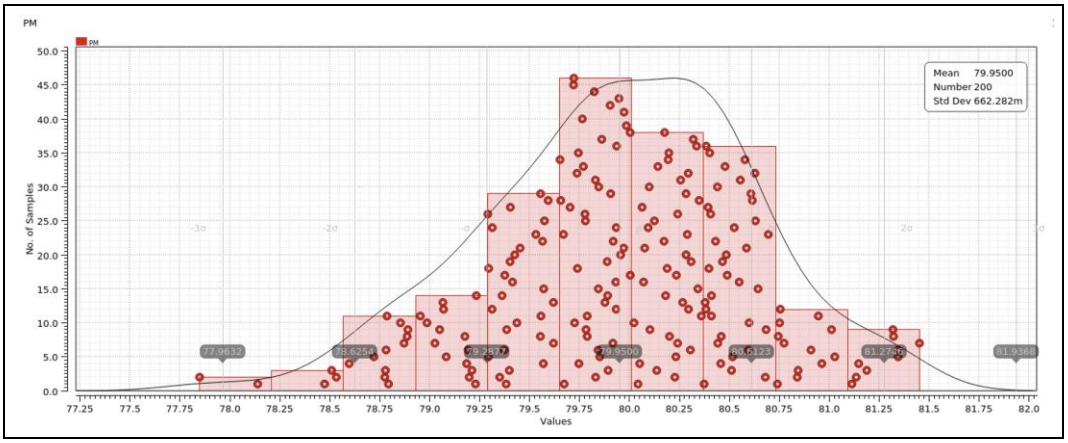
- Gain= 43dB, GBW=2.3M



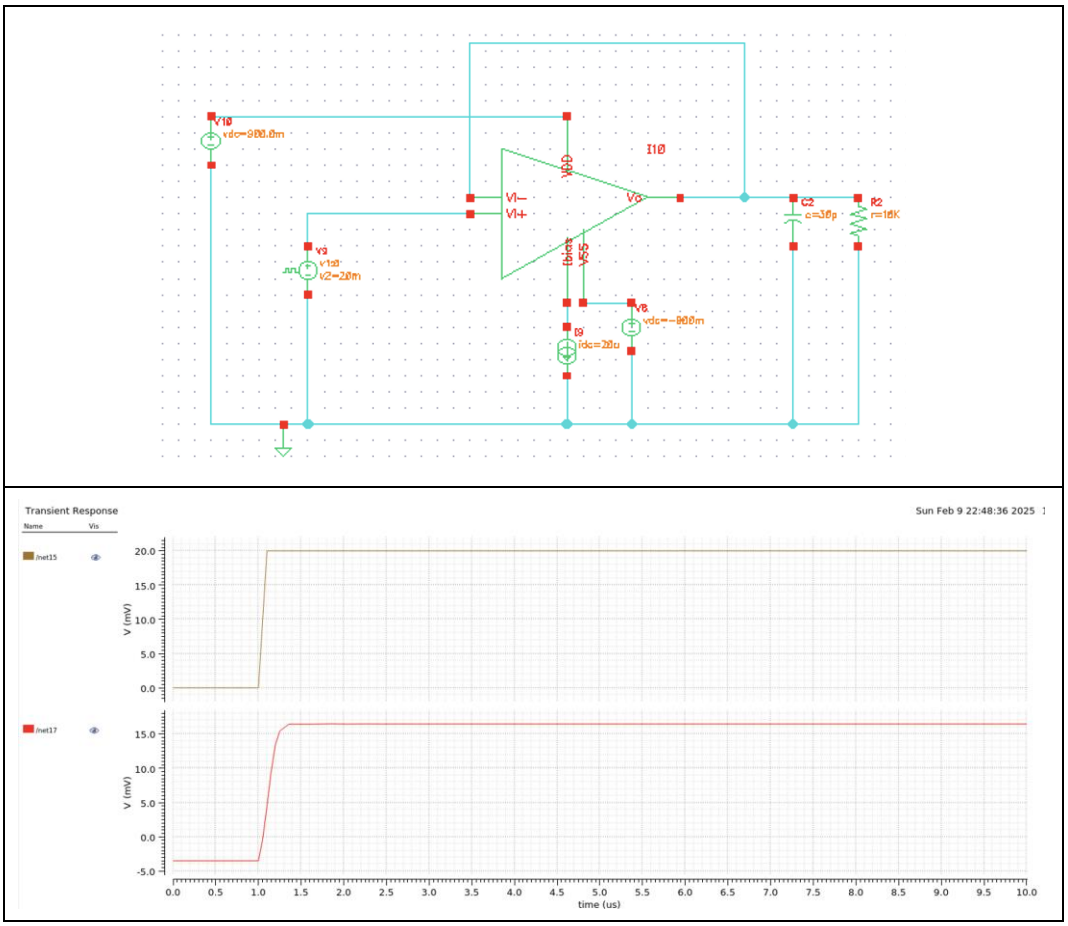
- PM= Gain=1's phase= 180-80.6 degree

5. Simulate statistical simulation, Monte-Carlo, for GBW, Phase Margin and DC gain at least 200 points. Plot the histograms.





6. Close the loop to implement a unity gain buffer (b factor =1) and measure the step response for an input step of 20mV. Report the results.



7. Close the loop with two resistors of 100kΩ and/or larger to implement a 6dB gain inverting amplifier. Report the 250mV step response. Any ringing? Explain your results.

$$H(s) = \underbrace{\left(\frac{R_{in}+R_F}{R_{in}}\right)}_{\text{linear}} \left(\frac{1}{1+\frac{1}{A_V\left(\frac{R_{in}}{R_{in}+R_F}\right)}}\right) \cong \left(\frac{R_{in}+R_F}{R_{in}}\right)\left(1-\frac{1}{A_V\left(\frac{R_{in}}{R_{in}+R_F}\right)}\right)$$

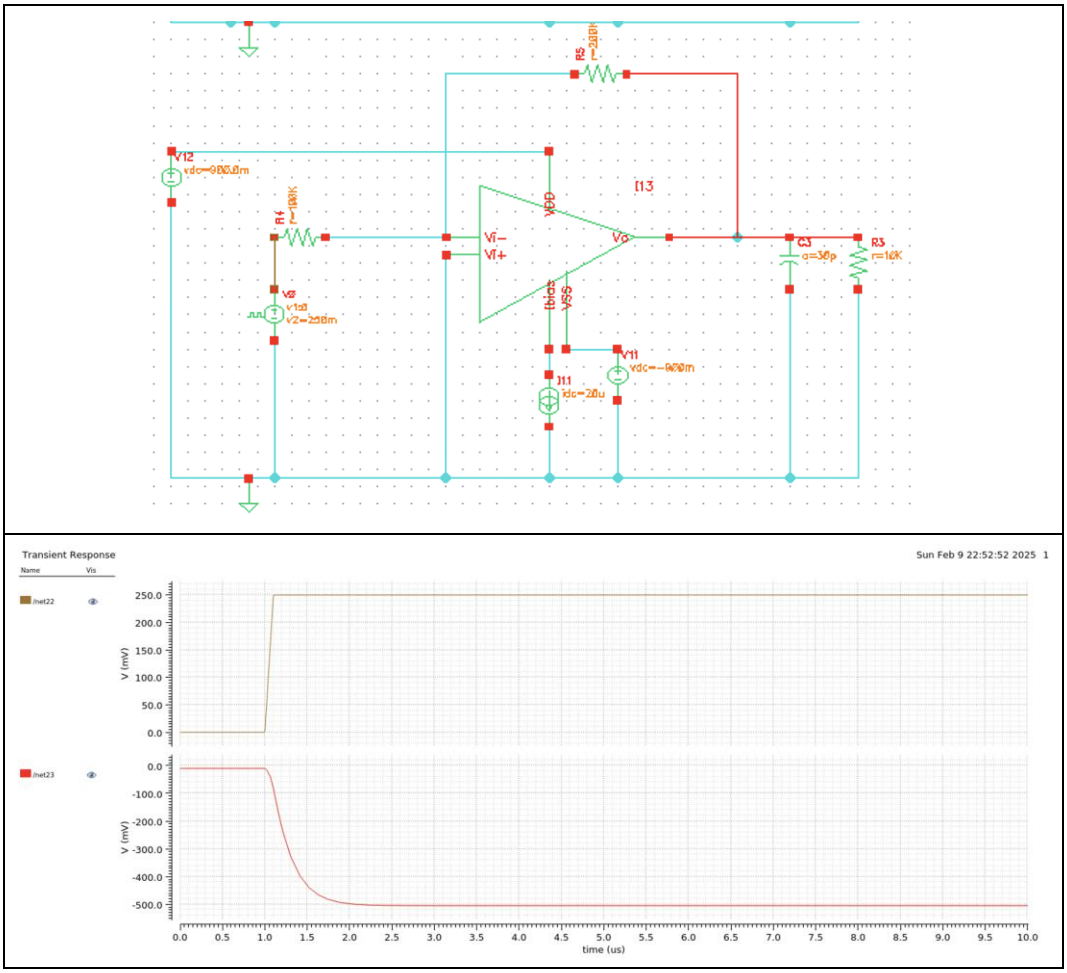
non-linear $\quad \frac{1}{1+\frac{1}{\infty}} \approx 1$

In case of **large *loop gain*** $A_V\left(\frac{R_{in}}{R_{in}+R_F}\right) \gg 1$, the system can safely be approximated by the first factor, then we called this term as the ideal system transfer function

$$H_{ideal}(s) = \left(\frac{1}{\beta}\right) = \left(\frac{R_{in}+R_F}{R_{in}}\right) = 1 + \frac{R_F}{R_{in}}$$

$L = A\beta$ (VLSI Ch5)

when $A \to \infty$ $L = \frac{1}{\beta}$



- **PM > 60°** → Smooth response, minimal overshoot or ringing.
- **PM 30° ~ 60°** → Some overshoot and slight ringing.
- **PM < 30°** → Significant overshoot, potential sustained oscillation