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

Lab3: Op Amp Design - I

Name: Yu-Hao Chen

UIN:435009528

Section:601

Professor: Jose Silva-Martinez

TA: Yoon, Sung J

a) Design the circuit shown in Fig 1 to obtain the specifications given (Table 1). Identify the dominant noise sources and find the expression for the input referred thermal noise density. Show the hand-calculations for the input referred thermal noise density and report the estimated value. Obtain the profile of the flicker noise from simulations and identify the corner frequency between thermal and flicker noise density.

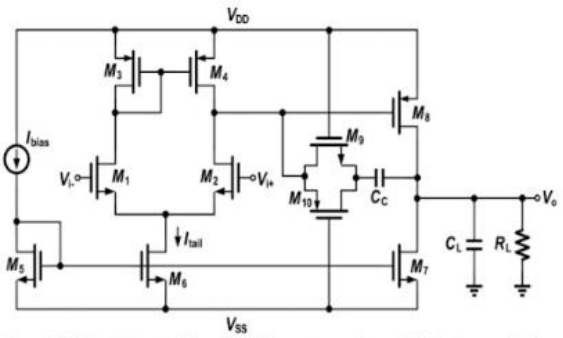
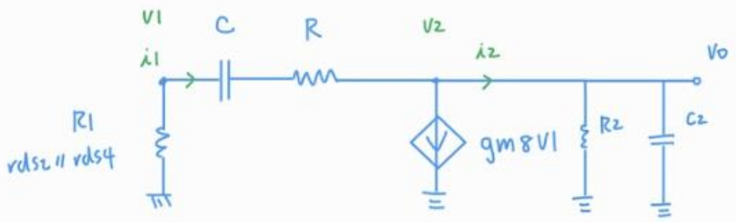


Figure 2-1: Two-stage amplifier with Miller compensation and RHP zero cancellation

Table 2-1: Design specifications

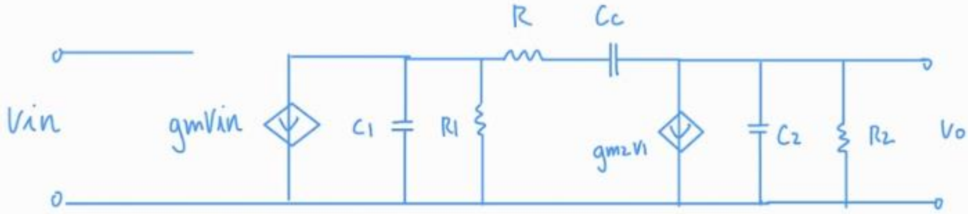
~~V_{DD}-V_{SS}~~	1.8V
~~A_{v0}~~	> 40 dB
GBW	> 2 MHz
PM	> 45°
Output Swing	> 1 V
~~C_L~~	20 pF
~~R_L~~	20kΩ
Integrated input referred noise (10 Hz – 2 MHz)	< 30 μVrms



$WZ:\quad i_2 = 0 \quad V_o = 0 \qquad i_1 = gm_8\ V_1$

$$\frac{V_1}{\frac{1}{sC} + R} = gm_8 V_1 \qquad s = \frac{1}{C\left(\frac{1}{gm_8} - R\right)} \qquad \left(1 - sC\left(\frac{1}{gm_8} - R\right)\right)$$

$$WZ = sC_c\left(\frac{1}{gm_8} - R\right) \qquad \text{if } R = \frac{1}{gm_8} \quad \text{no zero}$$



$$Wp_1 = \frac{-1}{(1 + gm_8 R_2) R_1 C_c} \approx \frac{-1}{gm_8 R_1 R_2 C_c}$$

$$Wp_2 = \frac{-gm_8}{C_L} \qquad Wp_3 = \frac{-1}{R C_c}$$

$$GBW = \frac{g_{m2}}{2\pi \times C_c} \qquad g_{m2} \geq 2\pi \times C_c \times 2M$$

$$PM = 90^\circ - \tan^{-1}\left(\frac{GBW}{w_{p2}}\right) \pm \tan^{-1}\left(\frac{GBW}{w_z}\right)$$

$$GBW : \quad g_{m2} \geq 2\pi \times 5pF \times 2M = 62.8\ \mu A/V.$$

$$\text{If} \quad \frac{g_{m2}}{I_{D2}} = 16 \qquad I_{D2} = 3.92\ \mu A \qquad I_{tail} = 7.85\ \mu A$$

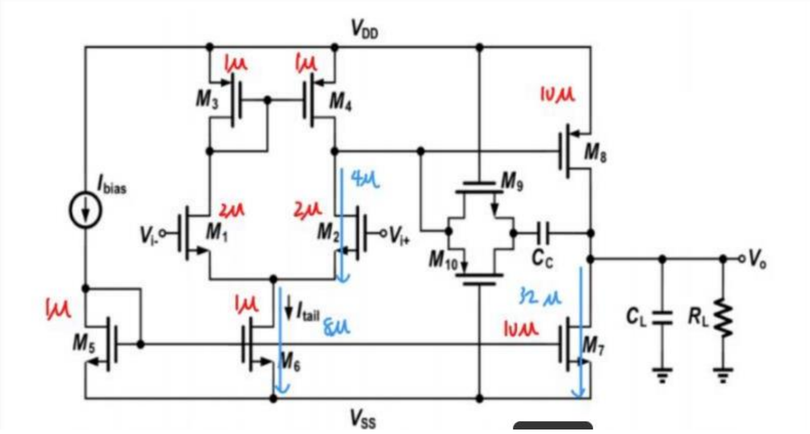
$$\text{If} \quad w_{p2} \geq 2GBW \qquad w_{p2}\ min = 2GBW$$

$$g_{m8\,(min)} = 2\pi\, w_{p2}\, C_L = 2\pi \times 2 \times 2M \times 20p = 502\ \mu A/V$$

$$\frac{g_{m8}}{I_{D8}} = 16 \qquad I_{D8} = 31.37\ \mu A$$

$$\frac{g_{m2}}{I_{D2}} = 16 \quad \text{current density} = 1.95 = \frac{I_{D2}}{W} \qquad W_2 = 2.01\mu$$

$$M6 \quad \frac{g_{m6}}{I_{D6}} = 10\ , \quad \frac{I_{D6}}{W_6} = 7.1 \qquad W_6 = 1.1\mu$$



noise :

$\overline{V_{n2}^2}$ (2nd stage)

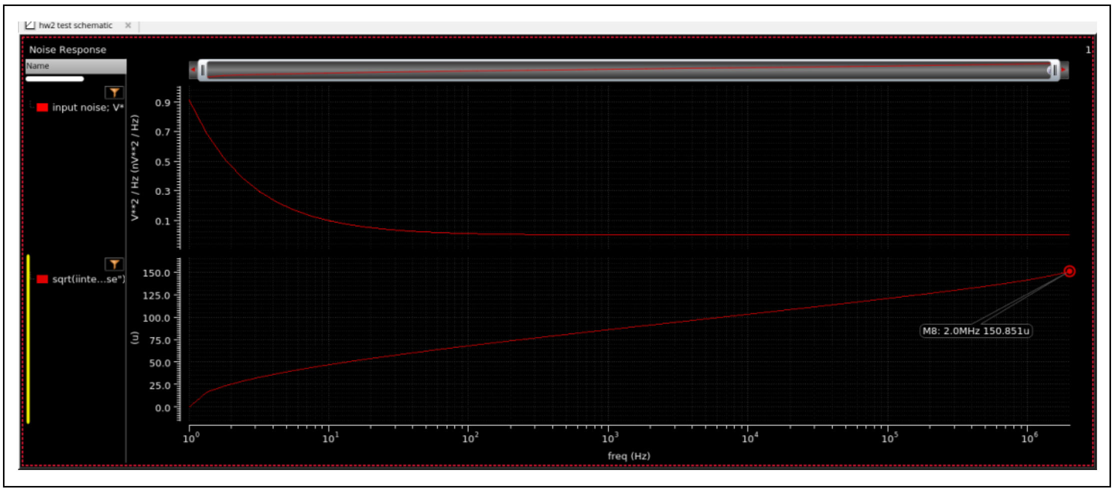
$$2 \times 4kT \frac{2}{3} (g_{m8}+g_{m7})(r_{ds8} \parallel r_{ds7}) \times \frac{1}{A_{V2}^2}$$

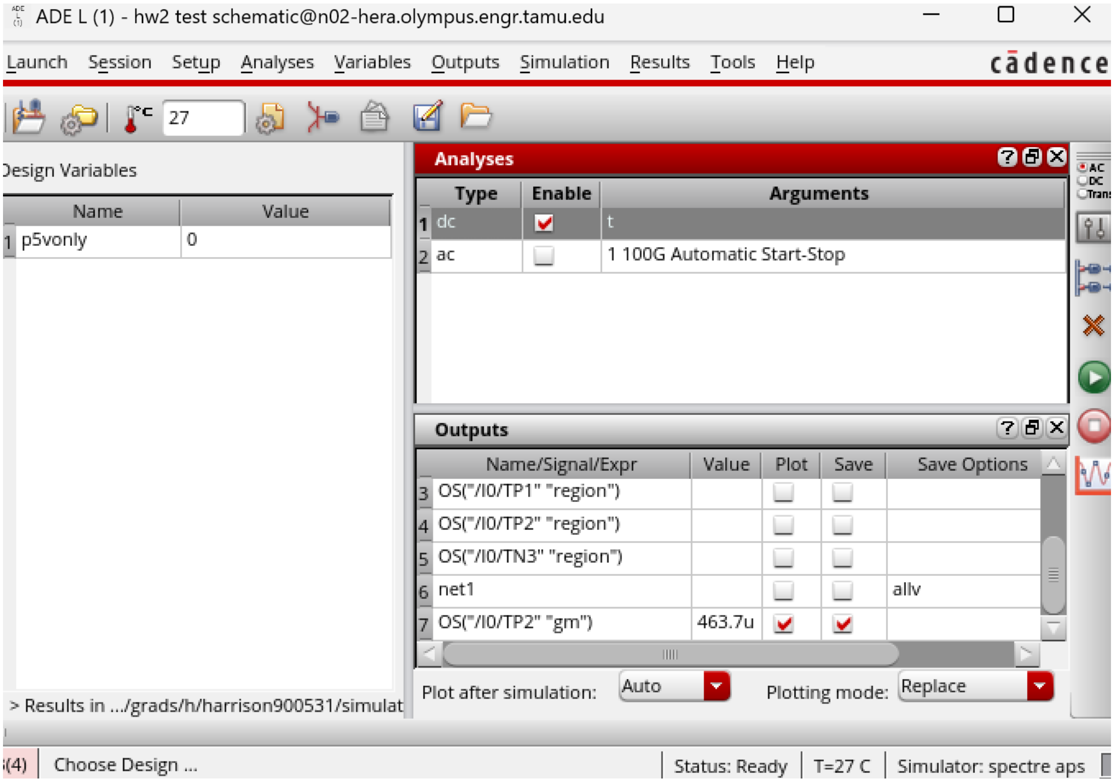
$$= \frac{16kT}{3} \frac{g_{m8}+g_{m7}}{g_{m1}^2 \, g_{m8}^2 \, (r_{o1} \parallel r_{o3})^2}$$

$\overline{V_{n1}^2}$ (1st stage)

$$2 \times 4kT \frac{2}{3} \frac{g_{m1}+g_{m3}}{g_{m1}^2}$$

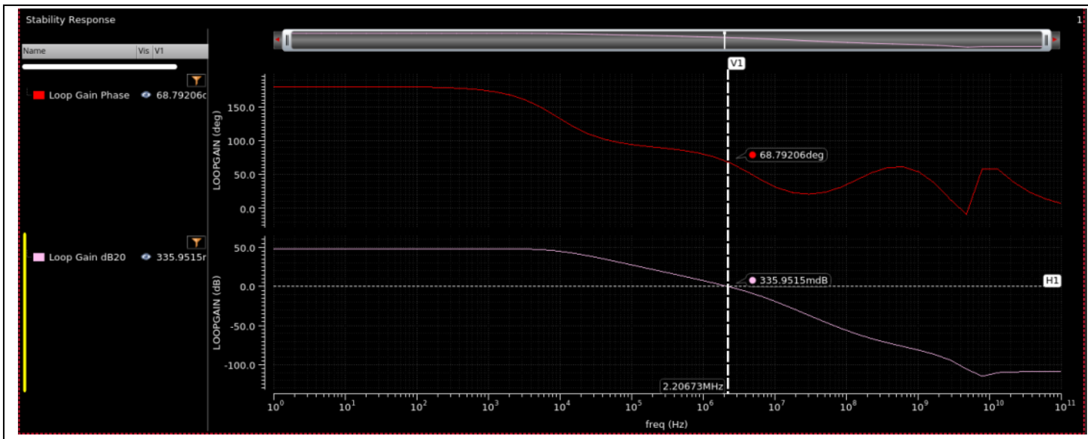
$$\overline{V_{n\,total}^2} : \frac{16kT}{3} \frac{1}{g_{m1}^2} \left[g_{m1} + g_{m2} + \frac{g_{m8}+g_{m7}}{g_m^{8} (r_{o1} \parallel r_{o2})^2} \right]$$





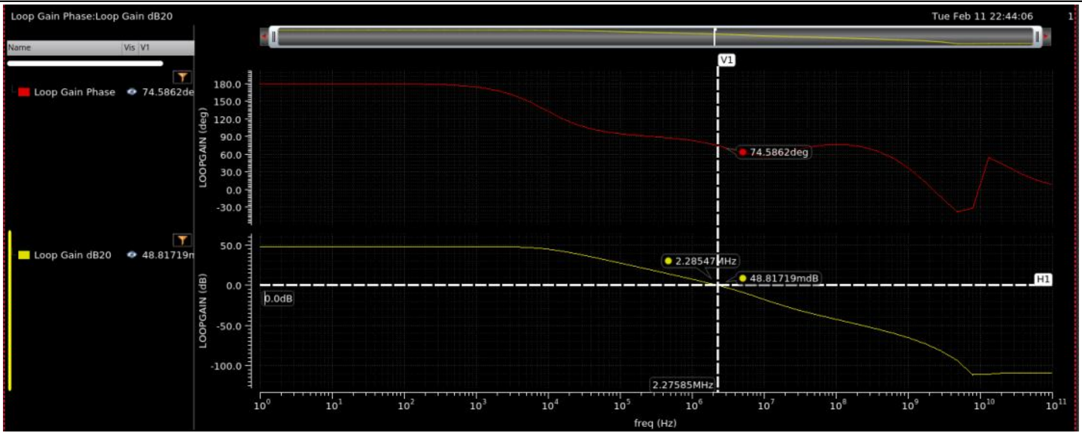
1/gm8= 2.156k

b) Estimate the compensating resistor to cancel the RHP zero and be sure you guarantee phase margin of 450 or better. One can become greedy and decide to move the zero and cancel the first non-dominant pole. Compare the magnitude and phase response of the circuit and report phase and gain margin values. Include screen shots in your report.



R=1/gm8 cancel zero

c) Over design the RHZ by moving the zero to the left-hand side of the S-plane around the value of 2*gm8/Cc. Repeat the simulations in b) and compare the results. Conclusions?



R=2/gm8 LHP zero

Rz

4k Ω Moves zero to LHP, improves phase margin slightly

2k Ω Cancel the zero