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

Lab4: Op Amp Design - I


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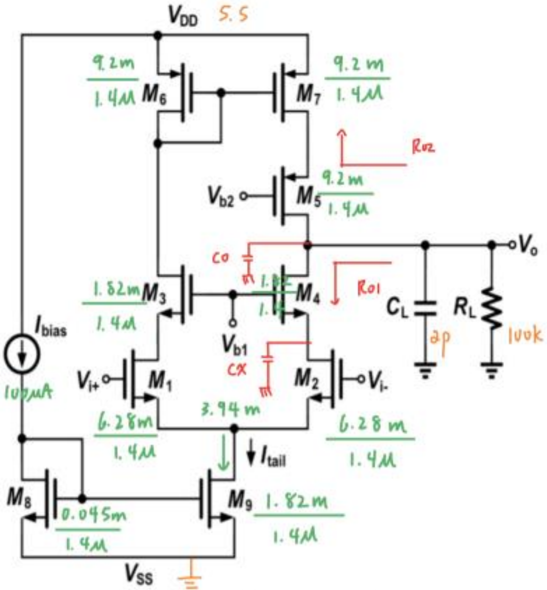
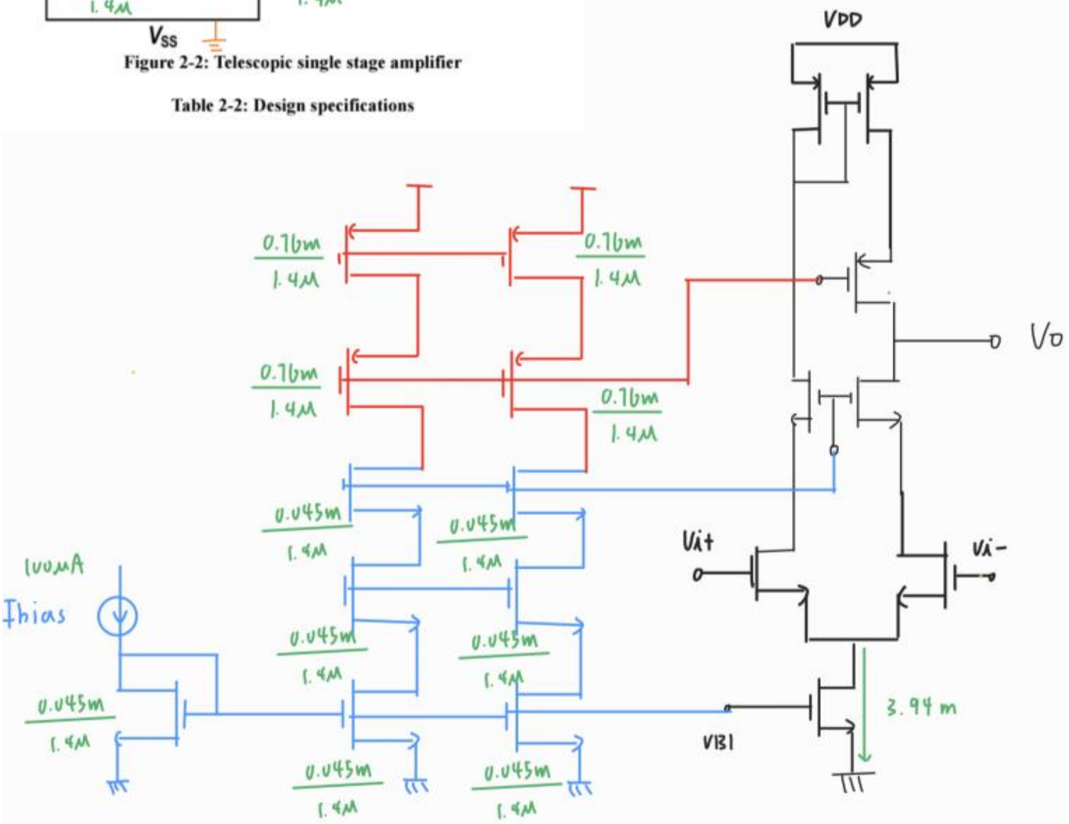



**Figure 2-2: Telescopic single stage amplifier**

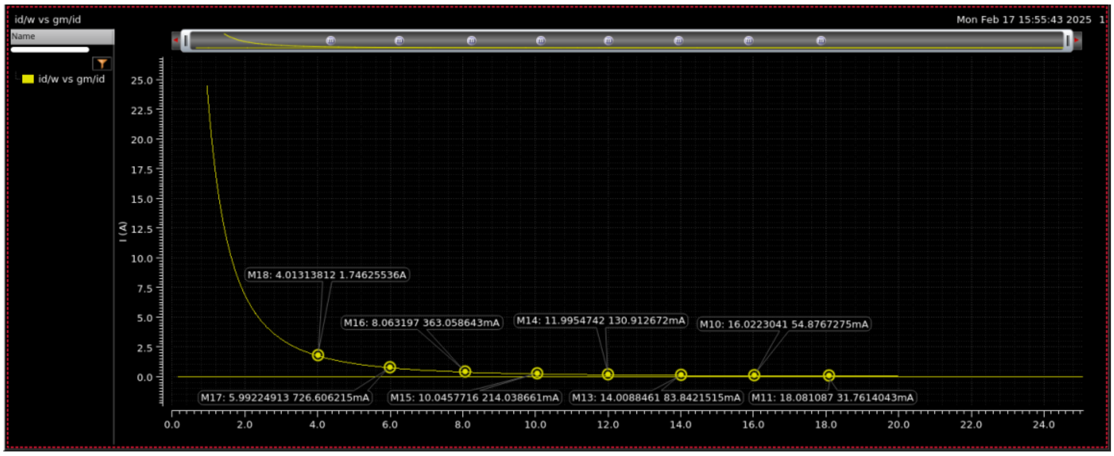
3163

| | |
|---|---|
| ~~$V_{DD}$-$V_{SS}$~~ | ~~5.5 V~~ |
| $A_{v0}$ ✓ | > 70 dB |
| GBW ✓ | > 2 MHz |
| PM ✓ | > 45° |
| Output Swing @ gain>40dB ✓ | > 0.8 V |
| ~~$C_L$~~ | ~~2 pF~~ |
| ~~$R_L$~~ | ~~100kΩ~~ |
| Power Dissipated | < 300 µW |
| Input referred noise (10 Hz – 2 MHz) ✓ | <30 µVrms |

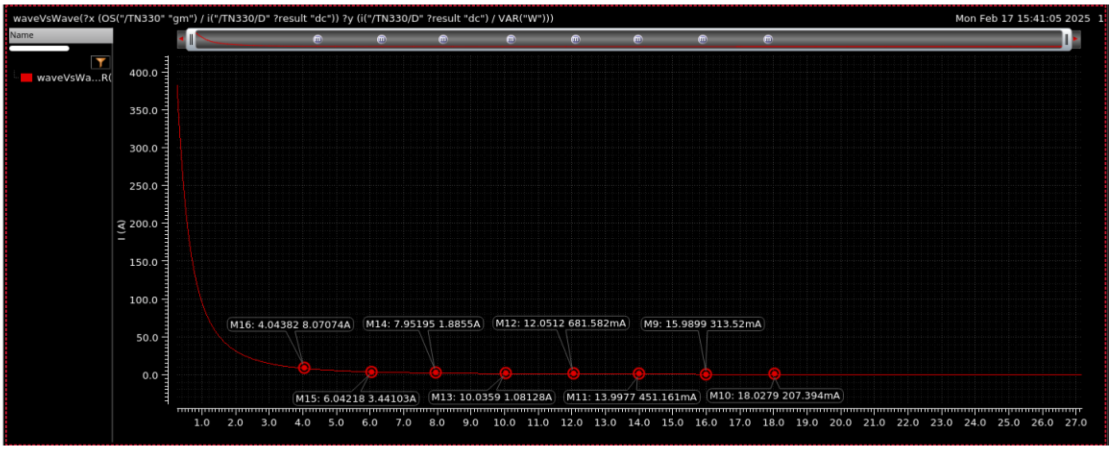
**Table 2-2: Design specifications**




$$\text{Power} = I_{total} \times 5.5 \le 300\mu\ W \qquad I_{total} \le 5.45\ \mu A$$




L=1.4u pmos Gm/ID




L= 1.4u nmos Gm/ID

$$GBW = \frac{gm_2}{2\pi\ CL} \geq 2M \qquad gm_2 \geq 25.12\ \mu$$

$$wp_1 = \frac{-1}{CL\ (100k\ //\ ro_1\ //\ ro_2)} \qquad \begin{matrix} ro_2 \approx gm_5\ rds_5\ rds_7 \\ ro_1 \approx gm_4\ rds_4\ rds_2 \end{matrix} \qquad \approx \frac{-1}{2p \times 100k} = 5M$$

$$wp_2 = \frac{-1}{CX\ (\frac{1}{gm_4}\ //\ rds_4\ //\ rds_2)} \quad \Big| \quad \text{highf}\ \ CL\ \&\ Co \approx \perp \qquad \approx \frac{-1}{100f \times \frac{1}{gm_4}} = \frac{gm_4}{100f}$$

$$Avo = -gm_2 \frac{gm_4 + \frac{1}{rds_4}}{gm_4 + \frac{1}{rds_2} + \frac{1}{rds_4}} \times (ro_1\ //\ ro_2\ //\ RL)$$

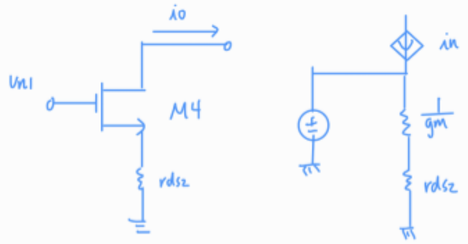
$$\approx -gm_2 \times 100k = 3163 \qquad \left.\begin{matrix} gm_2\ (min) = 31.63\ m \\ I_{D2}\ (min) = 1.97\ m \end{matrix}\right\} \frac{gm}{ID} = 16$$

$$L_2 = 1.4\mu \qquad W_2 = 6.28\ m$$

output swing :

$$max: \quad VDD - \sqrt{\frac{2ID}{Kn\ (\frac{W}{L})_7}} - \sqrt{\frac{2ID}{Kn\ (\frac{W}{L})_5}}$$

$$min: \quad Vss + \sqrt{\frac{2ID}{Kn\ (\frac{W}{L})_4}} + \sqrt{\frac{2ID}{Kn\ (\frac{W}{L})_2}} + \sqrt{\frac{2ID}{Kn\ (\frac{W}{L})_9}}$$




M5 noise

$$i_{o5}^2 = \frac{V_{n2}^2}{\left(\frac{1}{g_{m5}} + r_{ds7}\right)}$$

$$= \frac{4kT}{g_{m5}} \times \frac{1}{\left(\frac{1}{g_{m5}} + r_{ds7}\right)}$$

M4 noise

$$i_{n4}^2 = \frac{V_{n1}^2}{\left(\frac{1}{g_{m4}} + r_{ds2}\right)^2}$$

$$i_{n4}^2 = \frac{4kT}{g_{m4}} \times \frac{1}{\left(\frac{1}{g_{m4}} + r_{ds2}\right)^2}$$

M7 noise

$$i_{o7}^2 = 4kT\, g_{m7}$$

$$i_{o\,total}^2 \,(M2\,M4) = 4kT\, g_{m2} + \frac{4kT}{g_{m4}} \times \frac{1}{\left(\frac{1}{g_{m4}} + r_{ds2}\right)^2}$$

$$= 4kT\left(g_{m2} + \frac{1}{g_{m4}\left(\frac{1}{g_{m4}} + r_{ds2}\right)^2}\right)$$

$$\approx 4kT\, g_{m2}$$

$$i_o^2\, total\, (M7M5) \approx 4kT\, g_{m7}$$

$$V_{in\,noise}^2 = \frac{i_{o\,total}^2}{G_m^2} = \frac{4kT\,(g_{m7} + g_{m2})}{g_m^2}$$

$$V_{in\,ref} = \frac{K}{f W L C_{ox}} + \frac{4kT\,(g_{m7} + g_{m2})}{g_m^2}$$