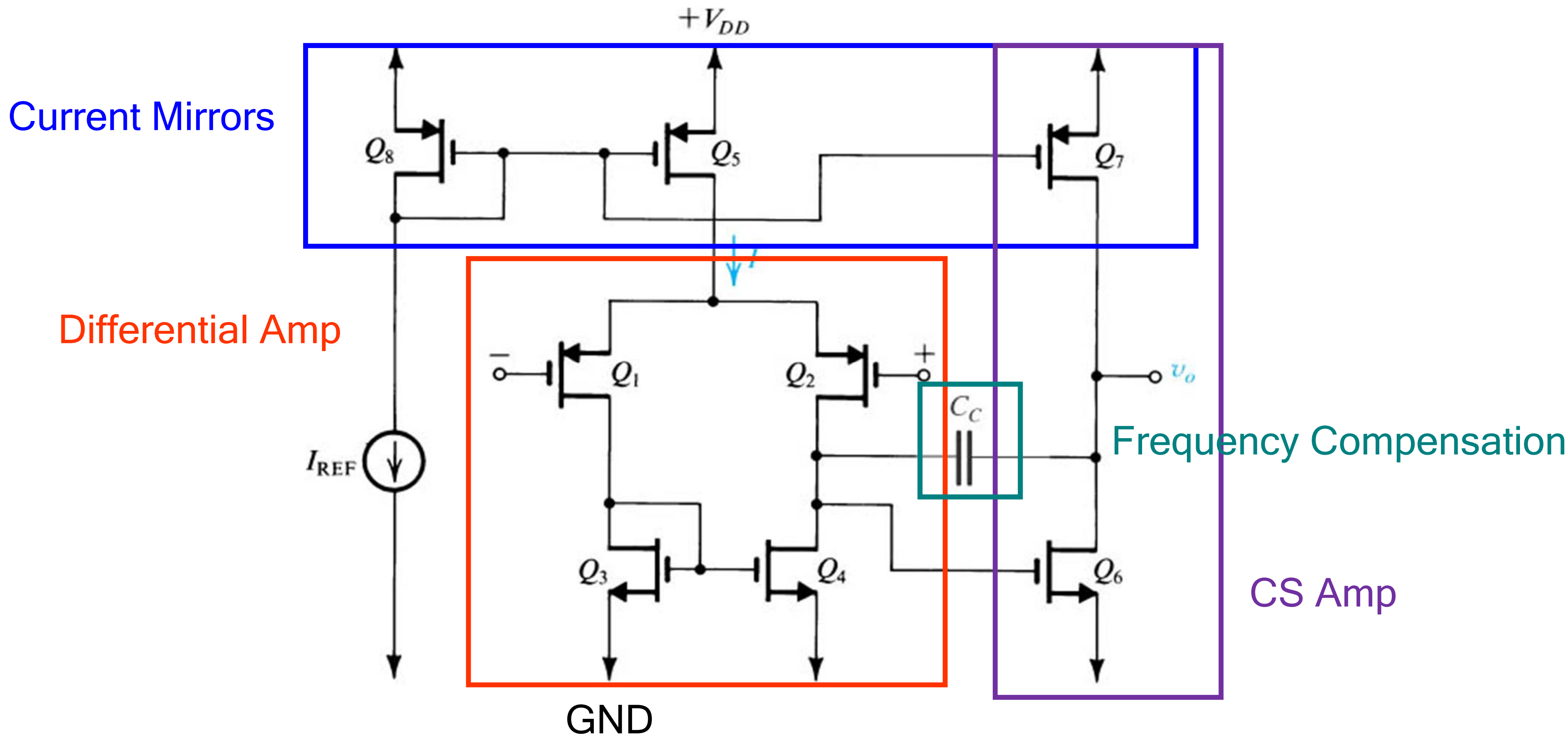
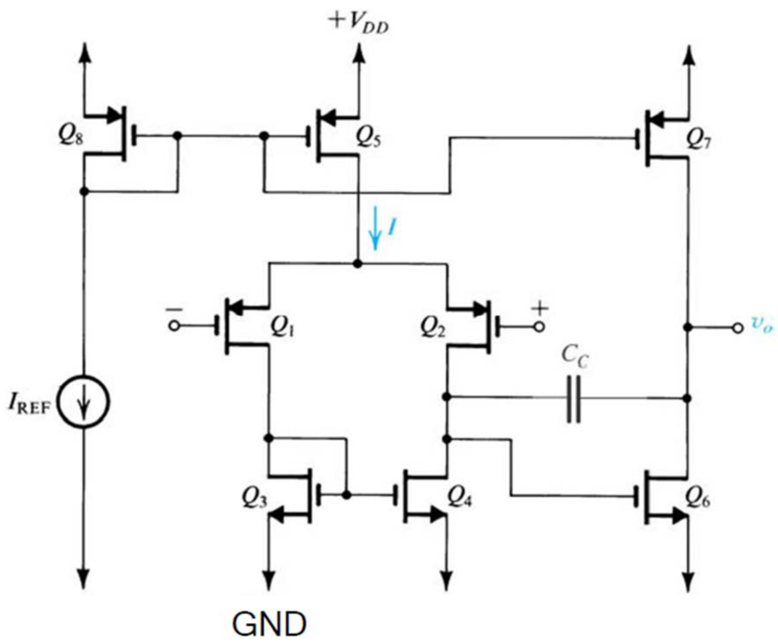
Lect. 17: Two-Stage Amplifier

Qualitative analysis of two-stage transconductance amplifier



Input Common-Mode Range



For $V_{CM,min}$, Q_1, Q_2 should be in saturation

$$V_{SD1} > V_{SG1} - |V_{TH,p}|$$

$$V_{S1} - V_{D1} > V_{S1} - V_{CM} - |V_{TH,p}|$$

$$V_{CM} > V_{D1} - |V_{TH,p}|$$

$$V_{CM,min} = V_{GS3} - |V_{TH,p}|$$

For $V_{CM,max}$, Q_5 should be in saturation

$$V_{SD5} > V_{SG5} - |V_{TH,p}|$$

$$V_{S5} - V_{D5} > V_{S5} - V_{G5} - |V_{TH,p}|$$

$$V_{D5} < V_{G5} + |V_{TH,p}| = V_{DD} - V_{SG5} + |V_{TH,p}|$$

$$V_{CM} + V_{SG1} < V_{DD} - V_{SG5} + |V_{TH,p}|$$

$$V_{CM,max} = V_{DD} - V_{SG5} - V_{SG1} + |V_{TH,p}|$$

Large I ➔ Large V_{SG5}, V_{SG1}, V_{GS3}

➔ Small input CM range

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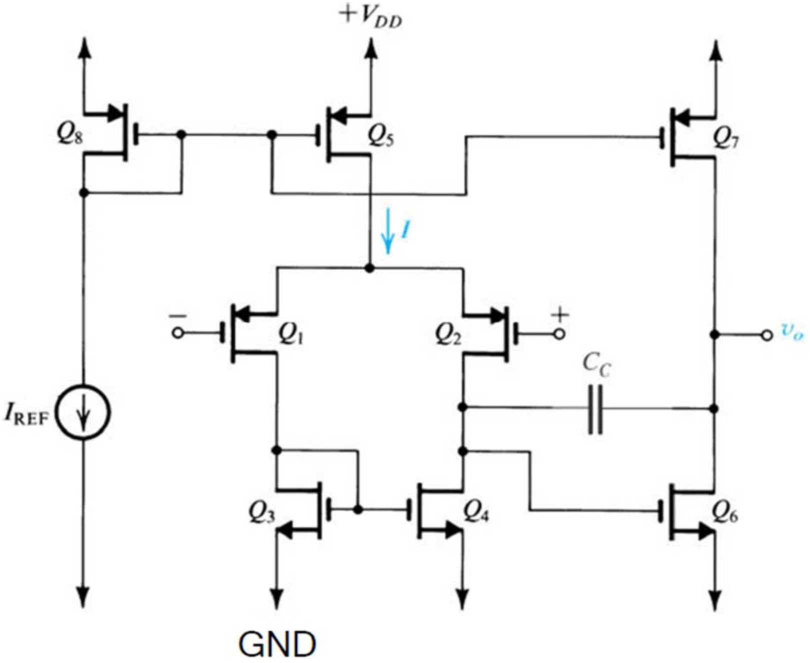
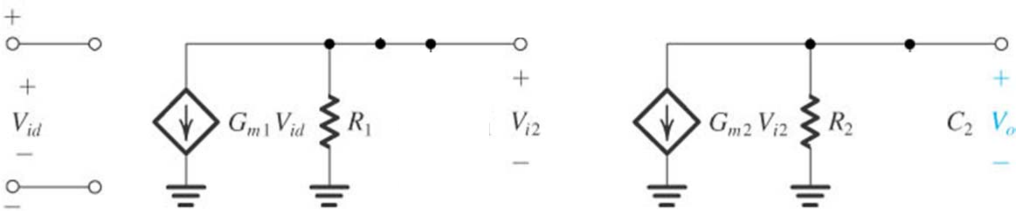


Equivalent Circuit



Voltage Gain (DC)

Two CS amps in cascade

G_{m1}=

R_1=

A_{v1} =

G_{m2}=

R_2 =

A_{v2} =

A_v=

R_{in}:

R_{out}:

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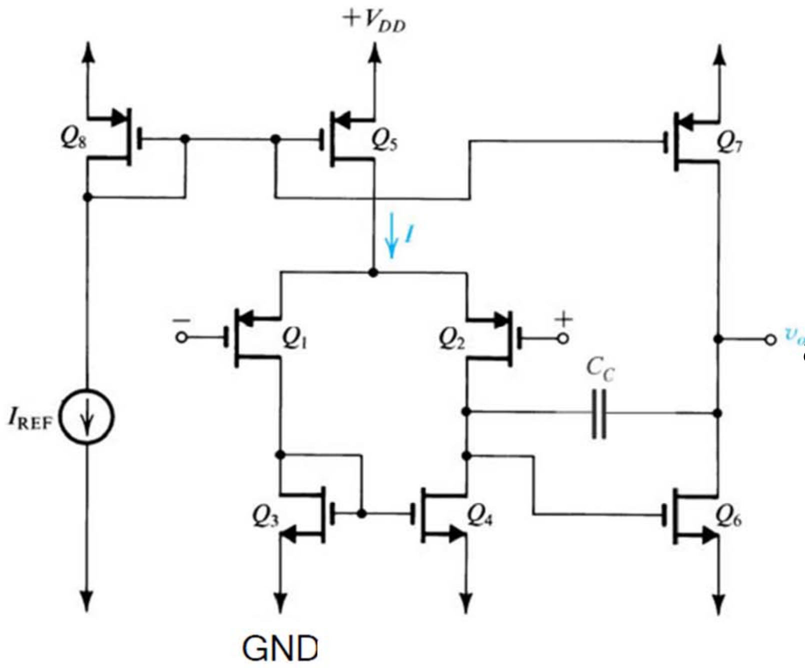
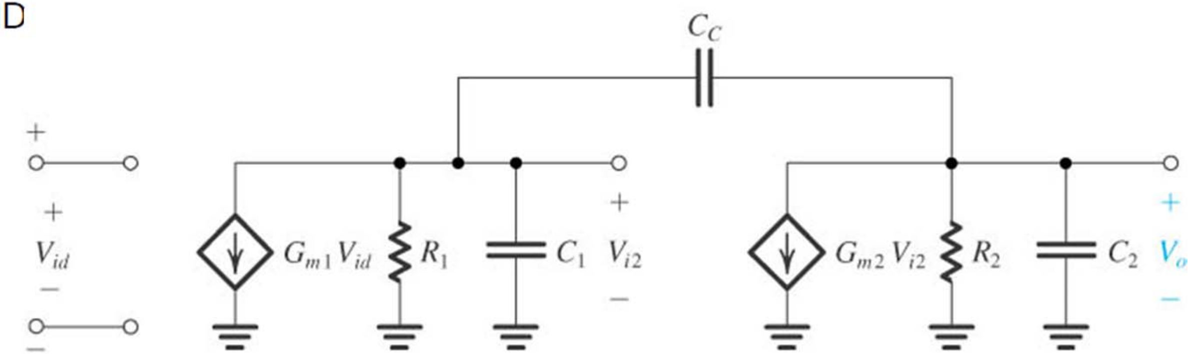


Frequency Response

For simplicity, assume all the capacitive elements are lumped together as C_1 and C_2.



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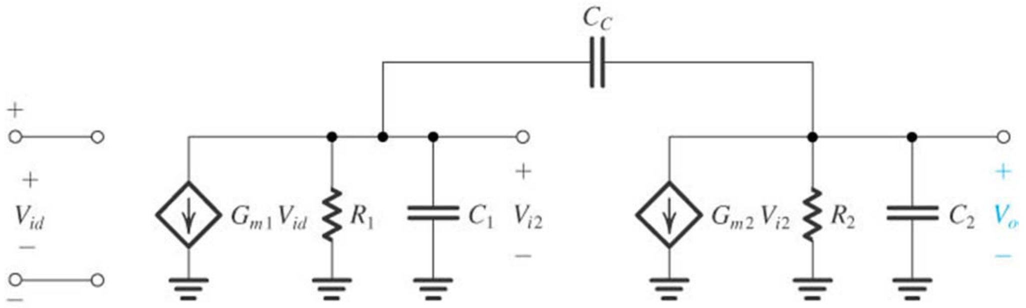
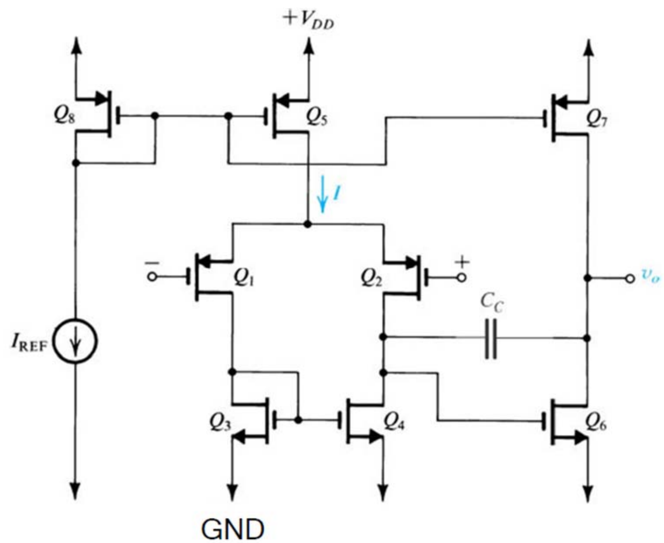


$$\frac{V_o(s)}{V_{id}(s)} = ?$$

$$\omega_{P,in} \sim \frac{1}{R_1\left[C_1 + (1+G_{m2}R_2)C_C\right]} \sim \frac{1}{R_1 G_{m2} R_2 C_C}$$

$$\omega_{P2} \sim \frac{1}{R_2\left[\left(1+\frac{1}{G_{m2}R_2}\right)C_C + C_2\right]} \sim \frac{1}{R_2\left(C_C + C_2\right)}$$



Reduce C_C for bandwidth enhancement

Why do we need C_C?

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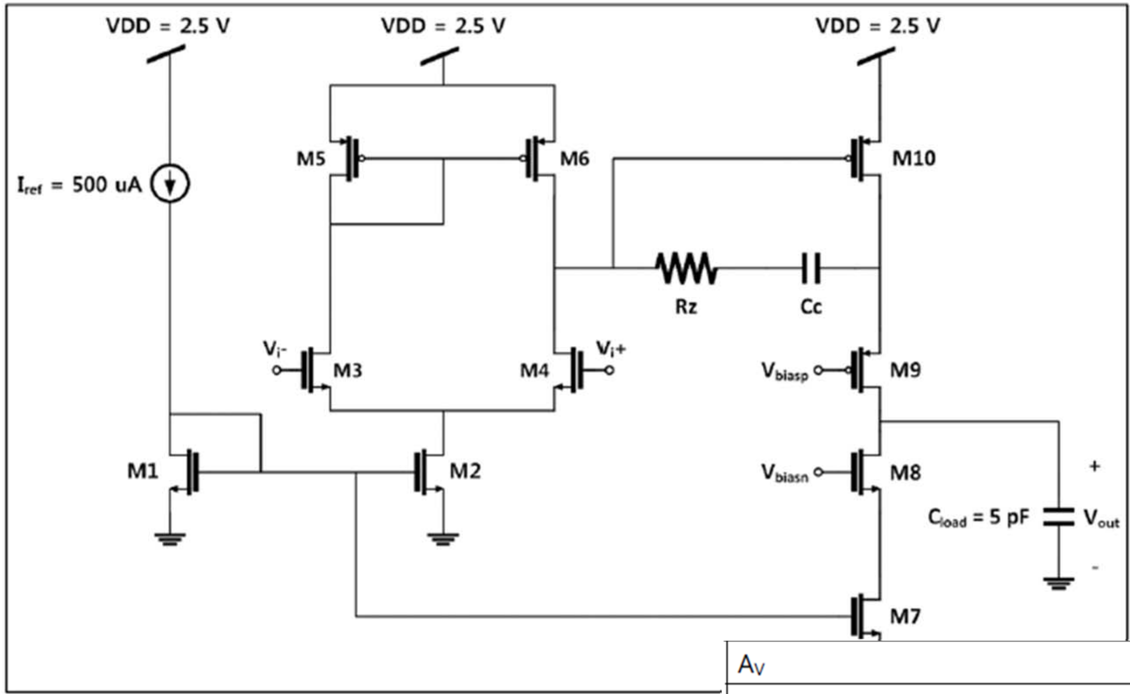
Design Project #1 (Due May 4. Details available in tera.yonsei.ac.kr)

Two-stage OTA (Operational Transconductance Amplifier)



A_V	> 76 dB
Bandwidth	> 25 kHz
Phase Margin	> 75 °
CMRR	> 75 dB
Input Common Mode Range	> 1.8 V
Power Consumption	< 2.5 mW

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