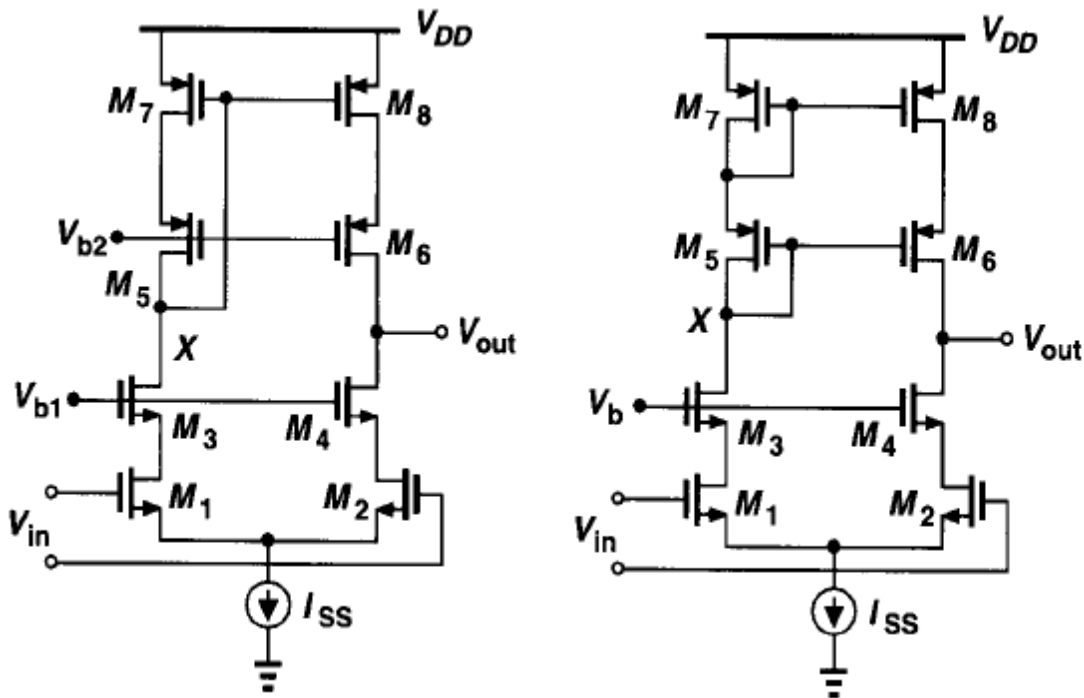


## Problem Set: Operational Amplifiers

### Problem (1)



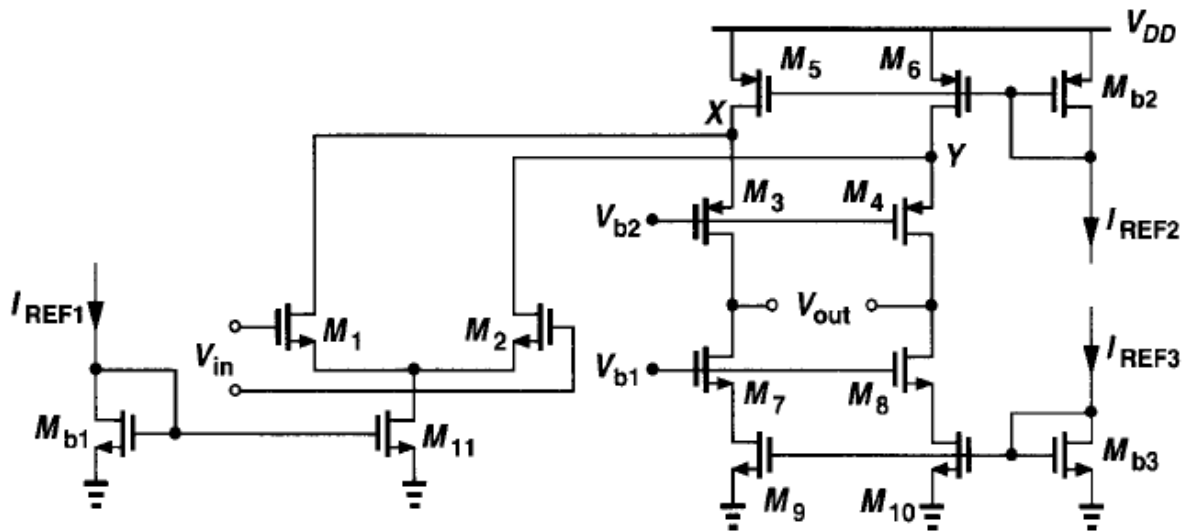
Compare between the two operational amplifier circuits in terms of:

- 1- DC-gain
- 2- GBW (assume a load capacitance  $C_L$ )
- 3- Slew rate
- 4- Maximum available output swing.
- 5- Input common-mode range (assume  $V_b = V_{b1} = V_{TH} + 4V_{eff}$ )

### Problem (2)

Study the stability of the self-regulated current source in the previous sheet of current mirrors (problem #3) considering only the capacitors shown in the figure.

### Problem (3)

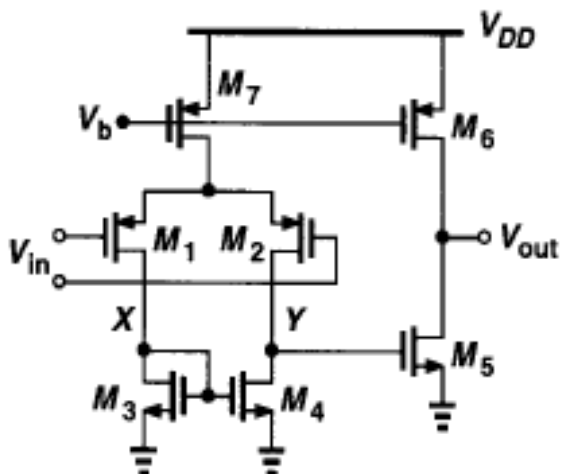


For the shown operational amplifier:

- 1- What is the type of this op-amp?
- 2- Find the relation between  $I_{REF1}$ ,  $I_{REF2}$  and  $I_{REF3}$ .
- 3- Find an expression for the poles in this op-amp in terms of the circuit parameters (Consider  $C_{gs}$  only).
- 4- Assume output load capacitance  $C_L$  at  $V_{out}$ , find an expression of the Gain-Bandwidth product (GBW) in terms of the circuit parameters. Find an expression for the Slew rate (SR).
- 5- Find the maximum output range as a function of  $V_{b1}$  and  $V_{b2}$ .
- 6- Find the values of  $V_{b1}$  and  $V_{b2}$  for maximum output swing. Find an expression for the maximum output swing in this case.

#### Problem (4)

For the two-stage op-amp shown:  $V_{DD}=2.5V$ ,  $\mu_n C_{ox}=100\mu A/V$ ,  $\mu_p C_{ox}=50\mu A/V$ ,  $\lambda_n=\lambda_p=0.01V^{-1}$ , and  $V_{thn}=|V_{thp}|=0.6V$ . For a total power consumption of 6mW, find the maximum GBW for  $C_L=1pF$  such that the non-dominant pole is double GBW. Calculate the DC-gain and the maximum output swing. What is the optimum value for  $V_{eff5}$ ? Assume: Compensation capacitor =  $C_L / 2$ , and  $V_{eff5}=V_{eff6}$  and  $V_{eff1}=V_{eff3}$ . If the amplifier is placed in a unity feedback configuration, calculate the closed loop gain and BW. What is the fractional gain error (FGE) and settling time?



#### Problem (5)

For the following op-amp circuit:

- 1- Find the DC gain.
- 2- Find the locations and expressions of the poles.
- 3- Is there a zero in the transfer function? Find its location.

