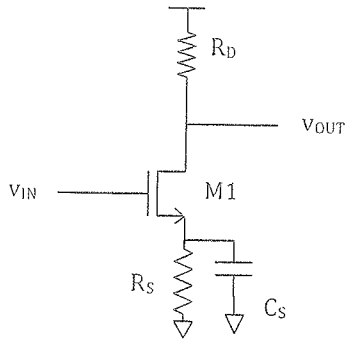
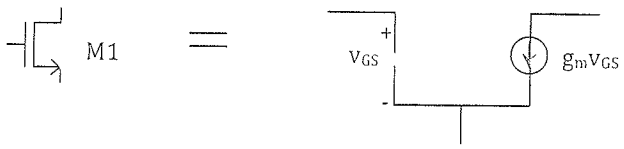
1. [25 points] For the circuit shown below, calculate voltage gains (v_{out}/v_{in}) at f = 0Hz and f = ∞ Hz.



Assume M1 can be modeled as an ideal transconductor as shown below.



g_m = 20 mA/V
R_D = 1 kΩ
R_S = 500 Ω
C_S = 1 pF

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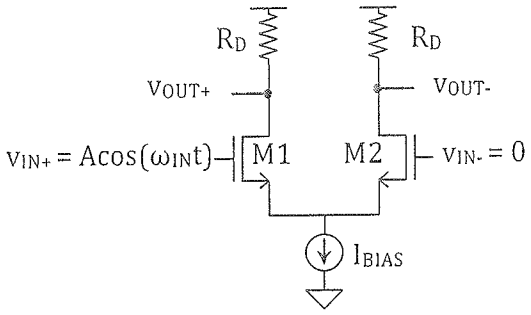
2. [25 points] For the circuit shown below, calculate v_{OUT+} and v_{OUT-}. Assume M1 and M2 are biased in saturation region. Assume I_{BIAS} is an ideal current source. Ignore channel length modulation and body effect. Assume $\omega_{in} << \omega_{pole}$, where ω_{pole} is the main pole of the differential amplifier.



$g_{m1} = g_{m2} = 10mA/V$
$R_D = 600\ \Omega$

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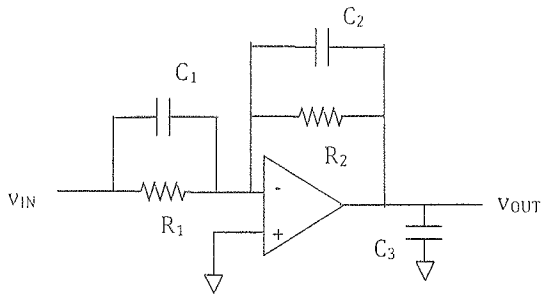
3. [25 points]For the circuit shown below, calculate H(s) = v_{OUT}/v_{IN}. Assume the op-amp is ideal. From the H(s), calculate 3-dB bandwidth.



$C_1 = 0.5C_2$
$R_1 = 2R_2$

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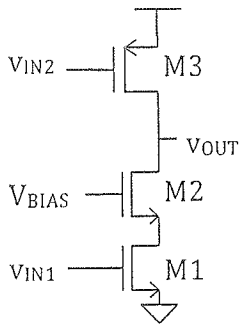
4. [25 points] For the circuit shown below, calculate v_{OUT} as a function of v_{IN1} and v_{IN2} at low frequencies (ignore all parasitic capacitances).

   Assume:
   - M1, M2, and M3 are biased in saturation
   - $g_{m1} = g_{m2} = g_{m3} = g_m$
   - $r_{O1} = r_{O2} = r_{O3} = r_O$



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