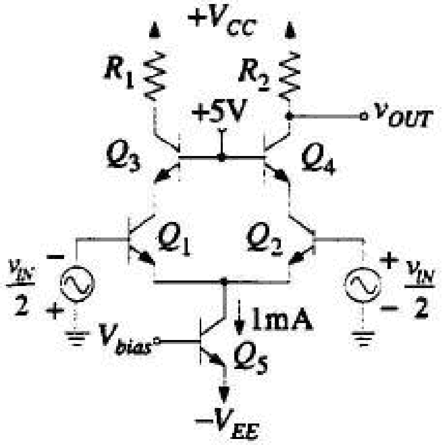
QUESTION (1)

In the following circuits, assume that $\beta = 100$, $V_{BE} = 0.7V$, $V_{CE(sat)} = 0.4V$ and $V_A = 100V$ for all transistors.



Given:

$R_1 = R_2 = 10k\Omega$

$V_{CC} = V_{EE} = 10V$

V_{bias} is adjusted such that $I_{C5} = 1mA$

$V_T = 25mV$

a) Estimate the differential gain v_{OUT}/v_{IN} in (V/V). (4 points)

b) Find the differential input resistance R_{id}. (2 points)

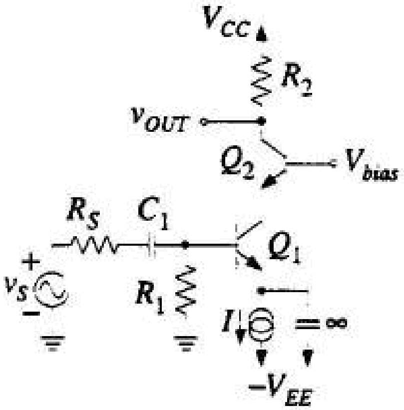
c) Find the common mode input resistance R_{icm}. (4 points)

d) Find the common mode input range. (4 points)

e) Estimate the common mode rejection ratio, CMRR. Express your result in dB. (6 points)

QUESTION (2)

In the following circuit, assume that $\beta = 100$, $V_{BE} = 0.7V$, $V_{CE(sat)} = 0.4V$, $V_A = 100V$, $C_\mu = 2pF$ for all transistors. Neglect r_x and r_O.



Given:

$R_1 = 100k\Omega$

$R_2 = 5k\Omega$

$R_S = 600\Omega$

$C_1 = 1\mu F$

$I = 1mA$

$V_{CC} = V_{EE} = 10V$

$V_{bias} = 5V$

$V_T = 25mV$

a) Estimate the mid-band gain v_{OUT}/v_S in (V/V). (4 points)

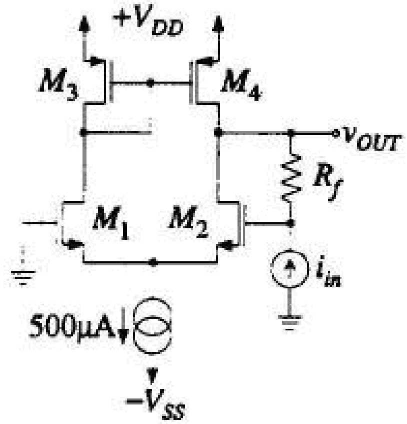
b) Find the lower 3dB frequency f_L in (Hz) (4 points)

c) Find the upper 3dB frequency f_H in (Hz) (6 points)

d) Find the 2nd high frequency dominant pole in (Hz) (6 points)

QUESTION (3)

The following CMOS trans-resistance amplifier have a feebdback resistor R_f. Assume that all n-MOSFETs have $k'_n = \mu_n C_{ox} = 50\mu A/V^2$, $V_{tn} = 1V$, and $\lambda_n = V_{An}^{-1} = 0.02V^{-1}$. All p-MOSFETs have $k'_p = \mu_p C_{ox} = 25\mu A/V^2$, $V_{tp} = -1V$, and $\lambda_p = V_{Ap}^{-1} = 0.02V^{-1}$.



Given:

M_1 and M_2 has $(W/L)_{1,2} = 120\mu m/3\mu m$

M_3 and M_4 has $(W/L)_{3,4} = 60\mu m/3\mu m$

$R_f = 100k\Omega$,

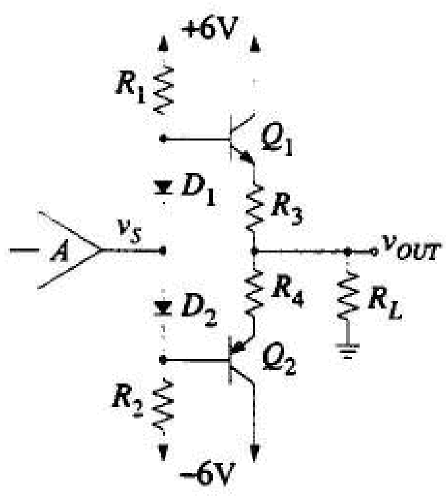
a) Find the closed loop trans-resistance gain v_{OUT}/i_{in} in (V/A) (12 points)

b) Find the input resistance, R_{if} seen by the input current source i_{in}. (4 points)

c) Find the output resistance, R_{of} at the output terminal. (4 points)

QUESTION (4)

The following class AB amplifier stage is biased such that the dc output voltage is 0V if the input voltage, v_S is zero. The forward voltage drop of the diodes D_1 and D_2 are 0.7V and the $|V_{BE}|$ for the complementary power transistors Q_1 and Q_2 are 0.6V (independent of current level). The input voltage, v_S is supplied by an ideal voltage amplifier.



Given:

$\beta = 50$ for Q_1 and Q_2

$|V_{CE(sat)}| = 0.3V$ for Q_1 and Q_2

$R_1 = R_2 = 560\Omega$

$R_3 = R_4 = 10\Omega$

$R_L = 8\Omega$,

a) Estimate the standby power, $P_{standby}$ with $v_S = 0V$ (not including the amplifier A) (6 points)

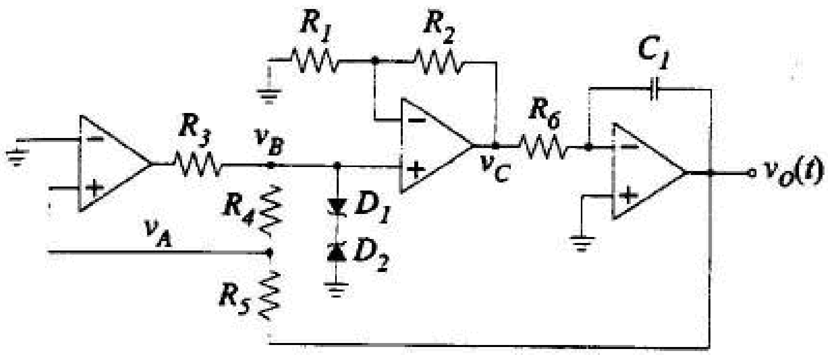
b) Find the maximum peak to peak output voltage swing, $V_{O(p\text{-}p)}$ (4 points)

c) Find the maximum rms output power, $P_{out(max)}$ that can be delivered to R_L (4 points)

d) Find the efficiency, η of this output stage when delivering maximum output power (6 points)

QUESTION (5)

In the following circuit, assume that all op amps are ideal, the zener diodes have a forward voltage drop of 0.7V and V_Z of 6.8V and $r_Z = 0\Omega$. $V_Z = 6.8$V. Assume that the circuit has reached steady state operation.



Given:

$R_1 = R_4 = R_6 = 10\text{k}\Omega$

$R_2 = 6\text{k}\Omega$

$R_3 = 1\text{k}\Omega$,

$R_5 = 20\text{k}\Omega$,

$C_1 = 0.1\mu\text{F}$

a) Find the peak to peak voltage swing at v_B. (4 points)

b) Find the peak to peak voltage swing at $v_o(t)$ (6 points)

c) Find the oscillation frequency of $v_o(t)$ in (Hz) (6 points)

d) Sketch the waveforms of v_B and $v_o(t)$ on a set of common voltage-time axes (4 points)