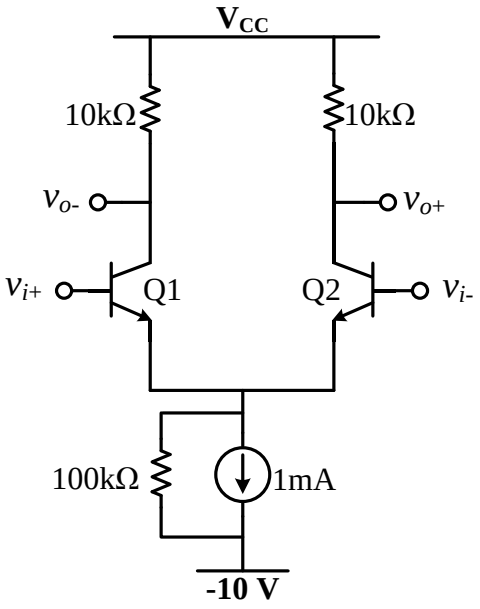
In the Name of God, the Compassionate, the Merciful.

Electronics 2, Assignment #6, Differential amplifiers.

Shahrood University of Technology

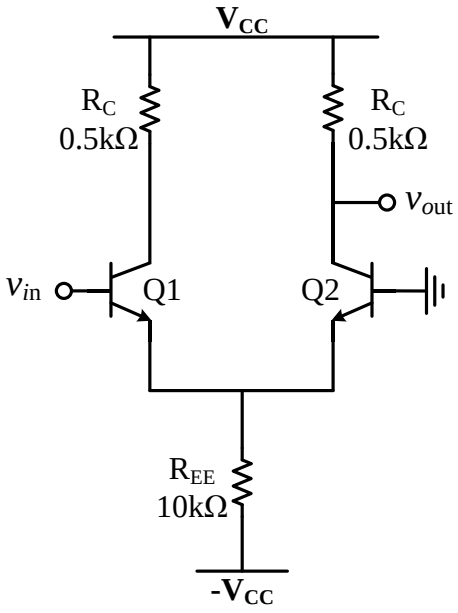
1- Determine v_{o-}, v_{o+}, and $v_{od} = (v_{o+} - v_{o-})$ for the following circuit.



$$\begin{cases} V_A = \infty \\ V_T = 25mV \\ \beta = 100 \\ V_{i+} = +0.5 \times V_{id} \\ V_{i-} = -0.5 \times V_{id} \\ V_{id} = 10\sin 10t \quad mV \end{cases}$$

2- Calculate the voltage gain ($A_v = \frac{v_{out}}{v_{in}}$) of the circuit shown below using the following methods:

a) Direct analysis.
b) Half-circuit analysis (break the input voltage to a differential term and a common-mode one, compute the differential and common-mode output voltages and add the results together).

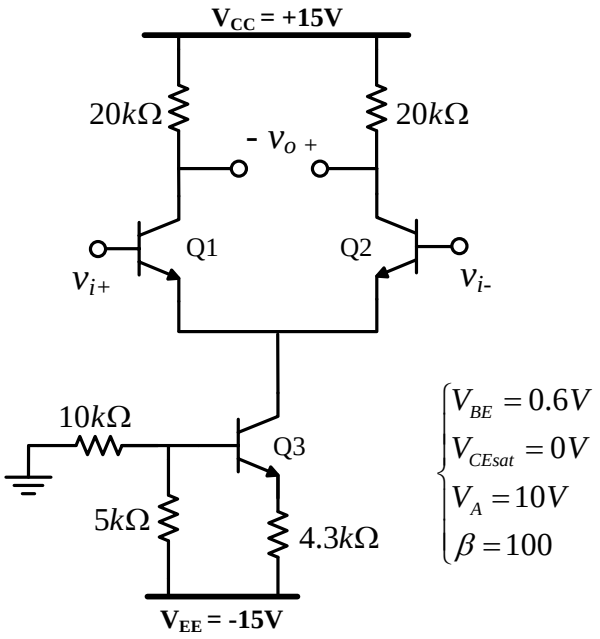


$$\begin{cases} I_{C1} = I_{C2} = 1mA \\ \beta = 100 \\ V_A = \infty \\ V_T = 25mV \end{cases}$$

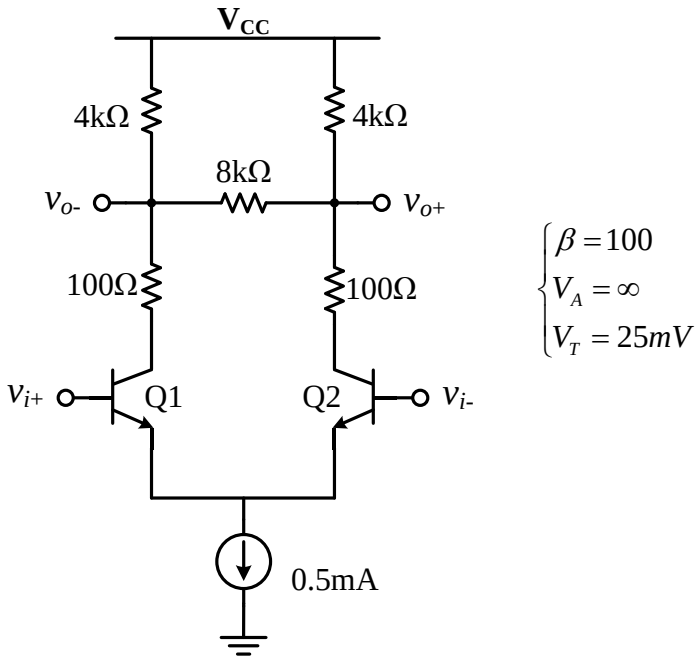
3- In the circuit shown below, the transistors are the same. Neglect β effect in DC analysis.

a) Calculate the input DC common-mode voltage range and the output swing.

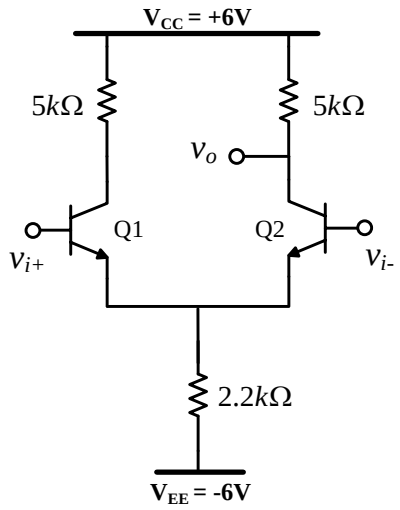
b) Determine CMRR.



4- In the following circuit, Q_1 and Q_2 are the same and are biased in the active region. Calculate the differential voltage gain ($A_d = \frac{v_{od}}{v_{id}} = \frac{v_{o+} - v_{o-}}{v_{i+} - v_{i-}}$).

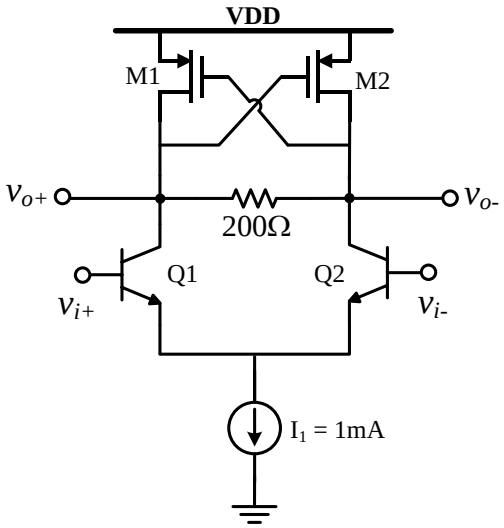


5- In the following differential amplifier circuit, determine the input DC common-mode range.



$$\begin{cases} V_{BE} = 0.6V \\ V_{CE,sat} = 0.2V \end{cases}$$

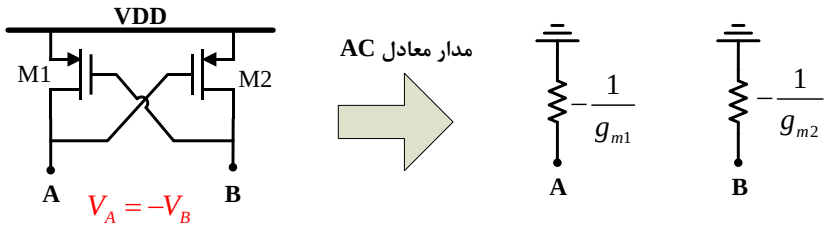
6- Calculate the single-ended voltage gain $\{ v_{o+} / (v_{i+} - v_{i-}) \}$ as well as the fully-differential voltage gain $\{ (v_{o+} - v_{o-}) / (v_{i+} - v_{i-}) \}$ for the following circuit.



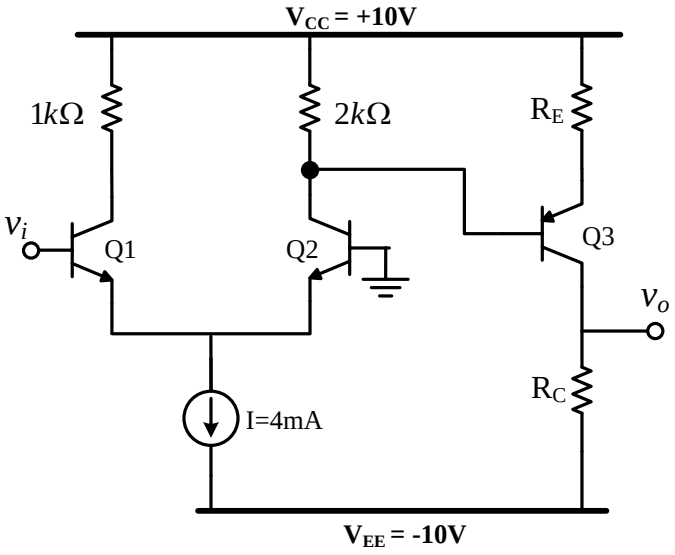
$$Q_{1,2}: \begin{cases} \beta = 100 \\ V_T = 25mV \\ |V_A| = 10V \end{cases}$$

$$M_{1,2}: \begin{cases} g_m = 10\dfrac{mA}{V} \\ |\lambda| = 0V^{-1} \end{cases}$$

(Hint: the following configuration is called the "cross-coupled" configuration. The equivalent Thevenin circuit seen from the terminals "A" or "B", can be modeled as a negative resistance which is equal to $-1/g_m$. To prove this issue, note that in a symmetric differential amplifier, all of the voltages in one side are equal to the negative of the corresponding voltages in the other side when the input voltage is differential (Prove that).)



7- In the following circuit, the DC output voltage is equal to zero. Calculate the voltage gain.



$$\begin{cases} V_i(DC) = 0V \\ V_O(DC) = 0V \\ |V_{BE}| = 0.6V \\ V_T = 25mV \\ V_A = \infty \\ \beta \gg 1 \\ R_E \gg \dfrac{1}{g_m} \end{cases}$$

Good Luck- M.R. Ashraf