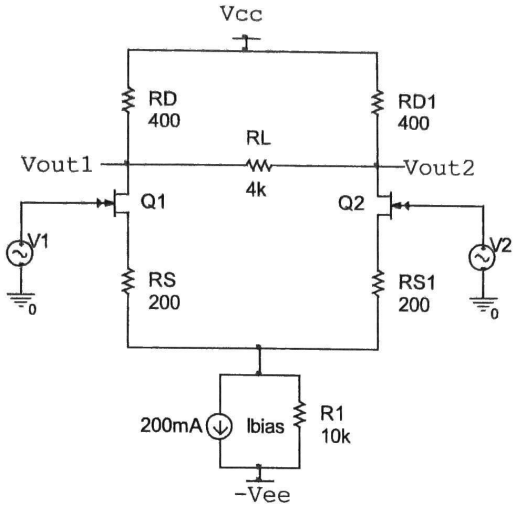
ECSE-2050 **Introduction to Electronics** **Summer 2020** **Name** Soaif Ahmed

Homework 19

In all BJT problems, you may assume that $V_{CEsat} \sim 0.2V$, $V_{BE} \sim 0.7V$ and $r_o \rightarrow \infty$ when the transistor is in the forward active region. Also, the thermal voltage is Vth = 26mV.

Problem 1) Differential Amplifier

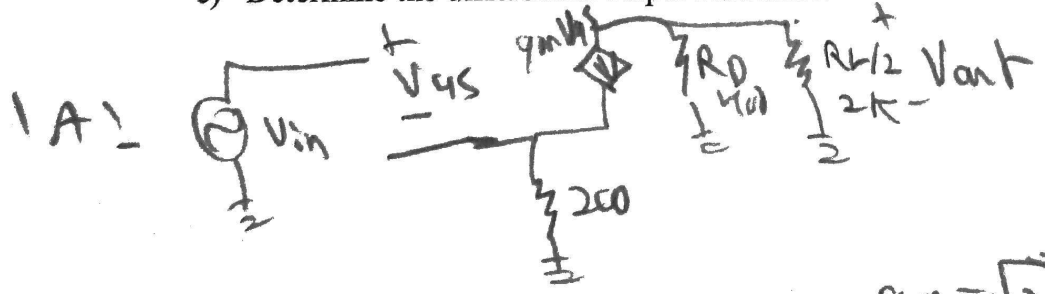


In the above circuit, $K_n = 0.1A/V^2$,
(Same differential circuit as problem 3 in HW18)

a) Using superposition and the symmetric characteristics for differential inputs (V1=-V2), draw the small signal half circuit.
b) Determine the half circuit differential mode gain, A_{DMHC}.

c) Determine the input impedance 'seen by' common mode inputs, R_{inCM}.
d) Determine the input impedance 'seen by' differential inputs, R_{inDM}.
(The above are kind of 'trick' questions).

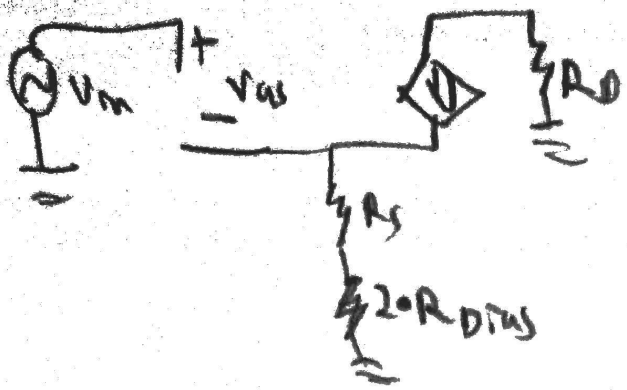
e) Determine the differential output resistance.



$$A_{DMHC} = \frac{-g_m V_{gs}(R_D \| 2K)}{V_{gs} + g_m V_{gs} \cdot 200} \quad g_m = \sqrt{2K_n I_D} = .141$$

$$= \frac{-47}{29.2} = \underline{1.610}$$

C:



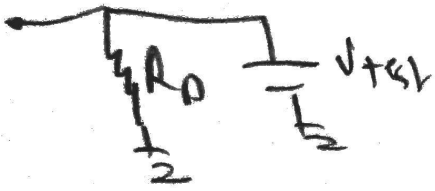
$R_{in\,CM}$ = open circuit

$= \infty$

D: referencing the differential circuit: $R_{in\,DM}$ = open circuit

$= \infty$

E:

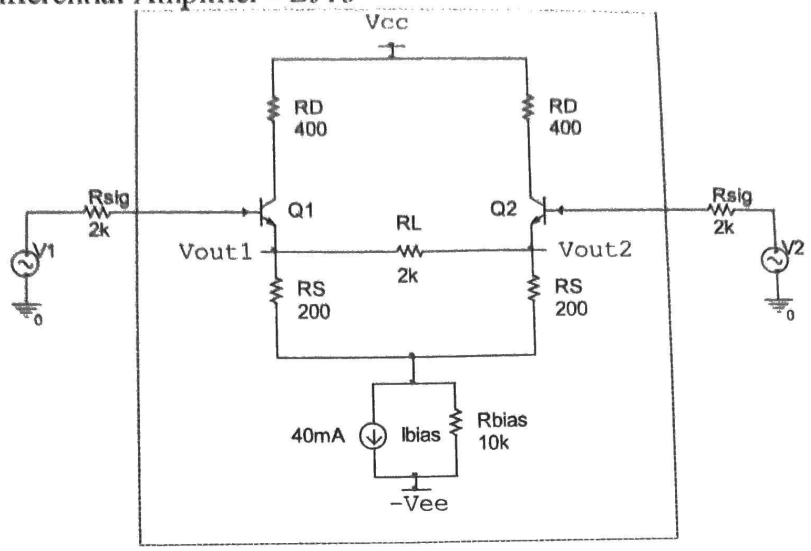


$R_{out\,DM\,HC} = 400$

$\Downarrow$

$R_{out\,DM} = 800$

Problem 2) Differential Amplifier - BJTs



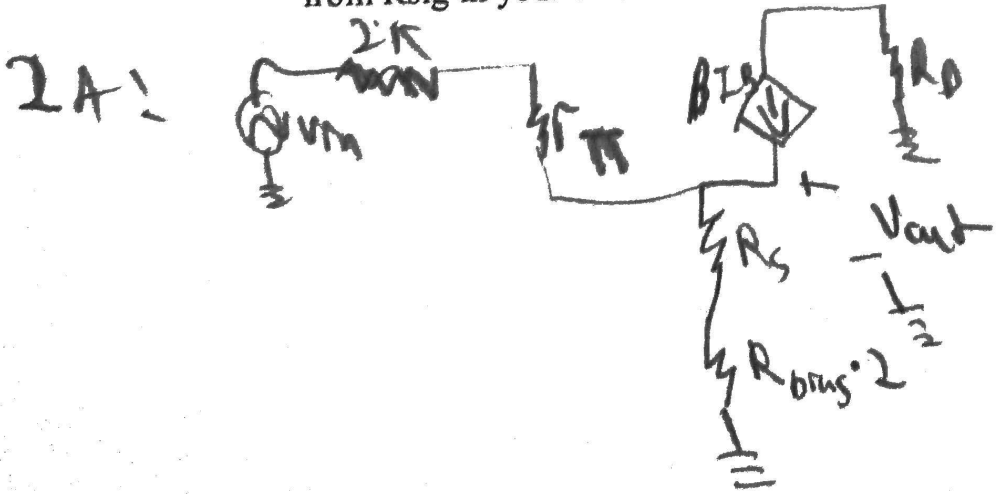
In the above circuit, $\beta = 100$,

a) Using superposition and the symmetric characteristics for common mode inputs (V1=V2), draw the small signal half circuit.
b) Using superposition and the symmetric characteristics for differential inputs (V1=-V2), draw the small signal half circuit.

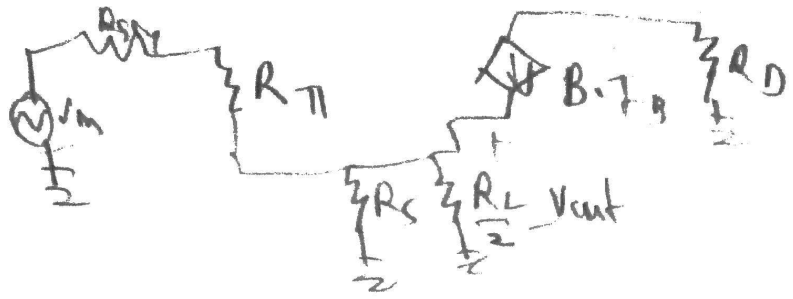
c) For the indicated dashed box, determine the input impedance 'seen by' common mode inputs, R_{inCM}.
d) For the indicated dashed box, determine the input impedance 'seen by' differential inputs, R_{inDM}.
(The above are kind of 'trick' questions).

e) Determine the differential output resistance.

f) Determine the half circuit common mode gain, A_{CMHC}. Include the contribution from Rsig in your calculation.
g) Determine the half circuit differential mode gain, A_{DMHC}. Include the contribution from Rsig in your calculation.



B:



C: $R_{in\,CM+C} = R_\pi + (R_S + 2 \cdot R_{bias})(B+1)$

$= 2.04 \cdot 10^6$

$\Downarrow$

$R_{in\,CM} = \underline{1.02 \times 10^6}$

D: $R_{in\,DM+C} = r_\pi + (B+1)(R_S \| \frac{R_L}{2}) = 16964.63$

$\Downarrow$

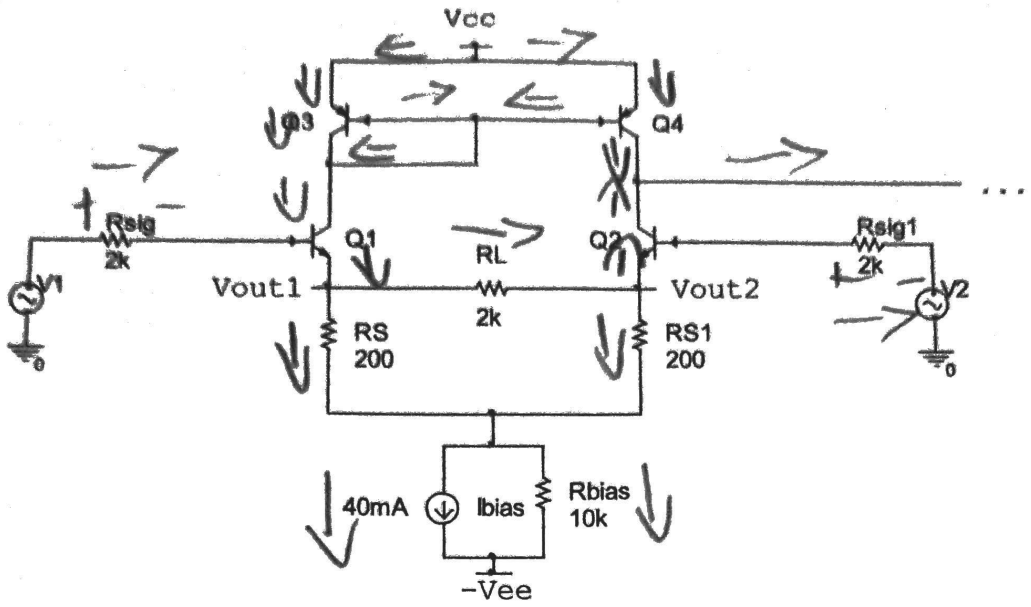
$R_{in\,DM} = \underline{33929.26}$

E: $R_{out} = R_S \| R_\pi = 130.45$

F: $A_{CM+C} = \frac{(B+1)(R_S + 2R_{bias})}{R_{sig} + R_{in\,CM+C}} = .999$

G: $A_{DM+C} = \frac{(B+1)(R_S \| R_L/2)}{R_{sig} + R_\pi + (B+1)(R_S \| R_L/2)} = .888$

Problem 3) Current mirror loads



In the above circuit, $\beta = 100$,

1) **Assuming V1 is a small positive voltage and V2 is an equal and opposite small negative voltage, draw the polarity/direction of the small signal current for each resistor and transistor** (base, emitter and collector).