Lab#4 – The Differential Amplifier

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The goal of this exercise is to analyze the differential amplifier circuit.

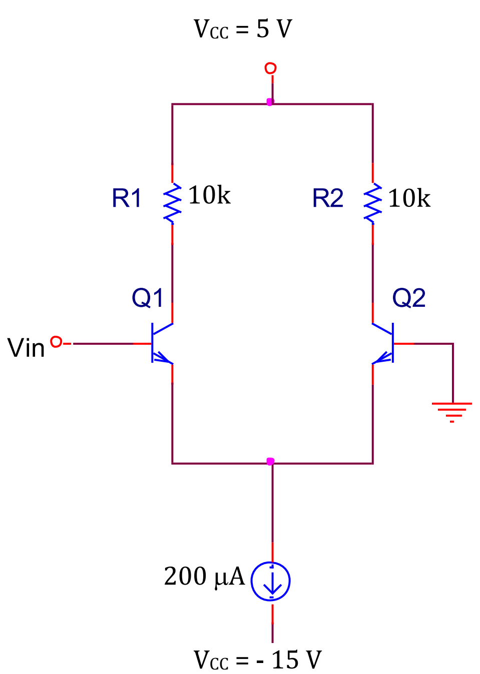


Figure 1(a)

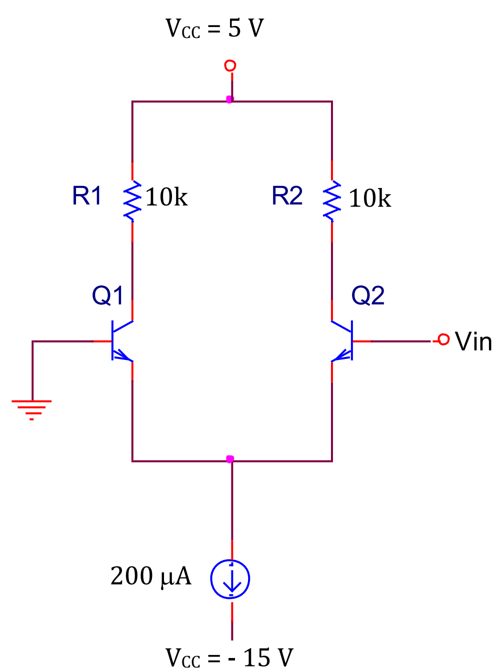
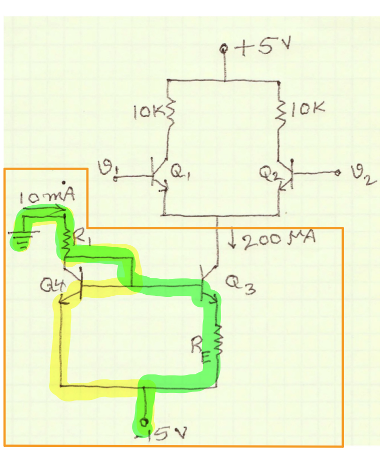


Figure 1(b)



$$I_o R_E = V_T \ln\left(\frac{I_{REF}}{I_o}\right)$$ 10 mA

$$R_E = \frac{V_T \ln\left(\frac{I_{REF}}{I_o}\right)}{I_o}$$

$$R_E = \frac{25\times10^{-3} \ln\left(\frac{10\,mA}{200\,\mu A}\right)}{200\,\mu A}$$

$$\boxed{R_E = 489\,\Omega}$$

widlar current source

$$0-(10mA\cdot R_1)-0.7-(-15)=0$$

$$10mA\cdot R_1 = 14.3$$

$$\boxed{R_1 = \frac{14.3}{10mA} = 1430\,\Omega}$$

$0-(10mA\cdot R_1)-0.7-(200\mu A\, R_E)-(-15)=0$

$200\mu A\cdot R_E = 0$

$R_E = ??$

$0-R_1\times10+0.7-R_E\times0.2=-15$

$\cancel{15.7}\ 1.4 = \cancel{R_1\times10}\ 14.3 - R_E\times0.2$

$\rightarrow R_E = \frac{0.2}{1.4} = \frac{1}{7}$

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Part-1: Basic Operation of a Differential Pair

a) Implement the circuit shown in figure 1(a). Implement the current source as shown in figure 4. Apply a dc voltage at the base of Q1. Measure currents and voltages as required in table-1. R1 and R2 must be measured by a meter (**NOT** the colour code value).

Table-1

	Measurement for **Q1**				Measurement for **Q2**				
V_{in} (V)	R_1 (Ω) (Actual)	V_{R1} (V)	$I_{C1} = V_{R1}/R_1$ (mA)	Status On/Off	R_2 (Ω) (Actual)	V_{R2} (V)	$I_{C2} = V_{R1}/R_1$ (mA)	Status On/Off	V_E (V)
0 (B1 grounded)									
0.1									
2.0									
- 2.0									

b) Implement the circuit shown in figure 1(b). Apply a dc voltage at the base of Q2. Measure currents and voltages as required in table-2. R1 and R2 must be measured by a meter (**NOT** the colour code value).

Table-2

	Measurement for **Q1**				Measurement for **Q2**				
V_{in} (V)	R_1 (Ω) (Actual)	V_{R1} (V)	$I_{C1} = V_{R1}/R_1$ (mA)	Status On/Off	R_2 (Ω) (Actual)	V_{R2} (V)	$I_{C2} = V_{R1}/R_1$ (mA)	Status On/Off	V_E (V)
0 (B2 grounded)									
0.1									
2.0									
-2.0									

Part-2: Common Mode Voltage

a) Implement the circuit shown in figure 2. Apply a common-mode (dc) voltage as shown in the circuit. Measure currents and voltages as required in table-3 and table-4. R1 and R2 must be measured by a meter (**NOT** the colour code value). Record the correct polarity of V_{CB}. Determine the biasing of the CB junction.

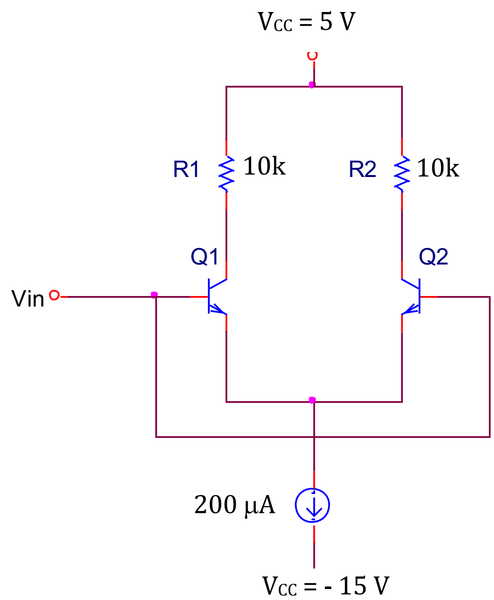

Figure 2

Table-3

V_{iCM} (V)	V_{C1} (V)	V_{C2} (V)	$V_0 = V_{C1} - V_{C2}$ (V)	$I_{C1} = V_{R1}/R_1$ (mA)	$I_{C2} = V_{R2}/R_2$ (mA)	V_{CB1} (V)	V_{CB2} (V)
0							
1							
3							
4							
5							
6							

Table-4

V_{iCM} (V)	V_{C1} (V)	V_{C2} (V)	$V_0 = V_{C1} - V_{C2}$ (V)	$I_{C1} = V_{R1}/R_1$ (mA)	$I_{C2} = V_{R2}/R_2$ (mA)	V_{CB1} (V)	V_{CB2} (V)
-2							
-4							
-6							
-8							
-12							
-14							
-15							

Determine the theoretical limits of the common-mode input voltage of this circuit.

Part-3: Differential Input Resistance

a) Implement the circuit shown in figure 3. Apply a differential input voltage of 150 mV (peak), as shown in the circuit. Measure the differential input resistance, and compare it with the calculated value of R_{id}.

b) Calculated R_{id}:

$Rid = 2(\beta + 1)\,(r_e + Re)$

Here, $r_e = (V_T)/(I_E)$

$Re = 100\ \Omega$

Assume $\beta = 165$ (for 3904)

Calculation (using formula)**:**

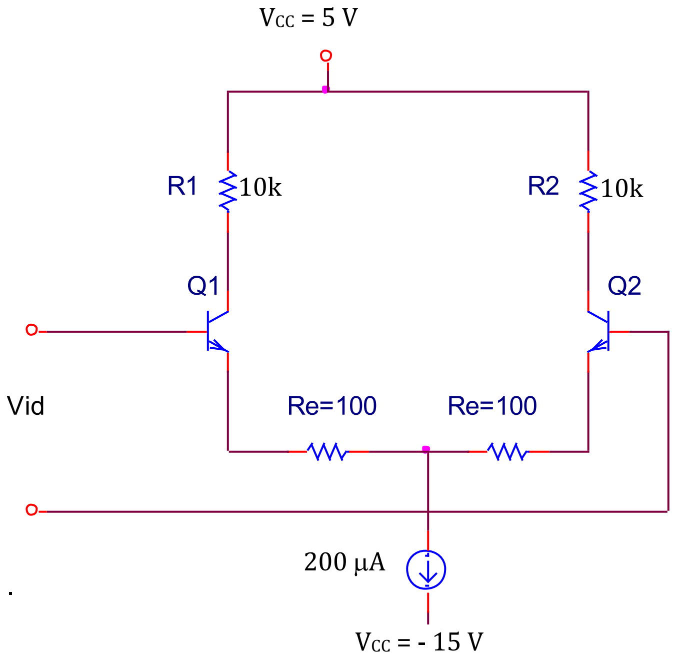

Figure 3

c) **Determination of R_{id}:**

$Rid = v_{id}/i_{in}$

Apply a signal voltage of v_{id} = 20 mV and v_{id} = 400 mV. Here, i_{in} can be measured by measuring the **AC voltage drop** across Re and dividing the voltage by Re (**Not** the colour code value).

<u>The experimentally measured value of R_{id}:</u>

For v_{id} = 20 mV

v_{id} = 400 mV

Implement the following circuit and repeat Table 1. Identify the differences.

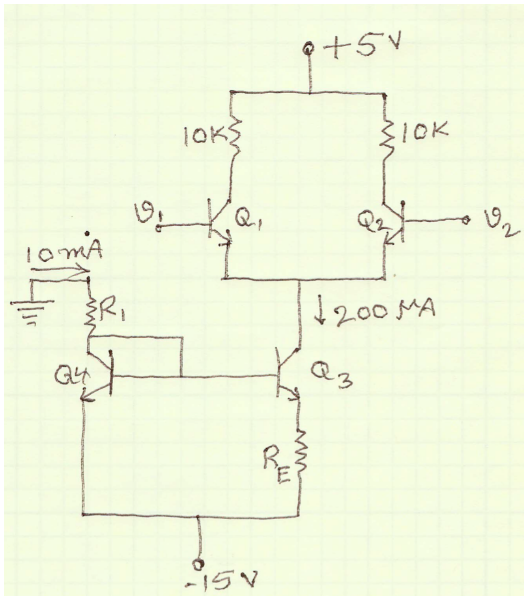

Figure 4