Pre-Lab 7: Characterization and DC Biasing of the BJT

ECEN 325 - 511

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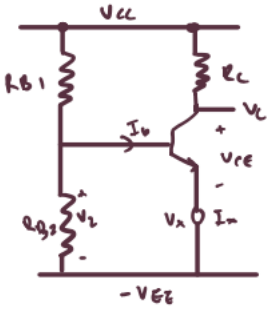
Due Date: October 26, 2021

Calculations

1) NPN



$V_{cc} = 5V$

$V_c = 3.5V$

$I_c = 1mA$

$V_C = I_C R_C - V_{CC}$

$R_C = \frac{V_{cc} - V_c}{I_c} = \frac{5 - 3.5}{1mA} = \underline{1.5k\Omega}$

$R_E = \frac{V_{RE}}{I_E} \rightarrow I_E = (1+\beta) I_B = (1+\beta)\left(\frac{I_C}{\beta}\right)$

$I_E = (101)\frac{1mA}{100} = \underline{1.01mA}$

$I_B = I_E - I_C = \underline{0.01mA}$

$V_{RC} = R_C(I_C) = 1.5k(1m) = 1.5V$

$V_c = V_{RE} + V_{RC} = \underline{3.5V}$

$V_{RC} = \underline{1.5V} \rightarrow V_{RE} = \underline{2V}$

$R_E = \frac{V_{RE}}{I_E} = \frac{2V}{1.01mA}$ $\quad R_E = \underline{1.98k\Omega} \approx 2k\Omega$

$I_{supply} = 2mA = I + I_C \quad I = 1mA$

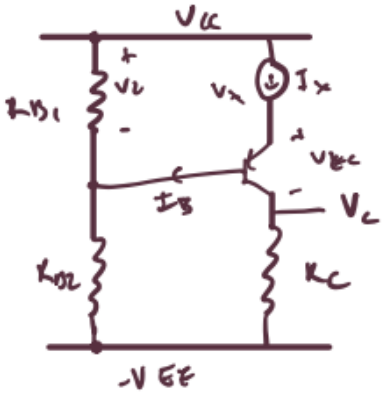
$V_{B1} + V_{B2} = V_{CC} \rightarrow V_{B2} = 0.7 + V_{RE} = 2.7V$

$V_{B1} = 5 - 2.7 = 2.3V$

$V_{B1} = I R_{B1} = 2.3 = 1mA(R_{B1}) \rightarrow \underline{R_{B1} = 2.3k\Omega}$

$V_{B2} = (I - I_B) R_{B2} = (2.7)(.99mA) = \underline{R_{B2} = 2.7k\Omega}$

1) PNP



$V_{EE} = 0V$

$V_C = 1.5V$

$I_C = 1mA$

$R_C = \frac{V_C - V_{EE}}{I_C} = \frac{1.5V}{1mA} = 1.5k\Omega$

$I_B = I_C/\beta = \frac{1mA}{100} = 0.01mA$

$I_E = I_B + I_C = \underline{1.01mA}$

$V_{RE} = V_{CC} - V_{RC} - V_C = 5 - 1.5 - 1.5 = 2V$

$R_E = \frac{V_{RE}}{I_E} = \frac{2V}{1.01mA} = 1.98k\Omega = 2k\Omega$

$V_{R1} + V_{R2} = V_{CC} \rightarrow V_{R2} = .7 + 2 = 2.7V$

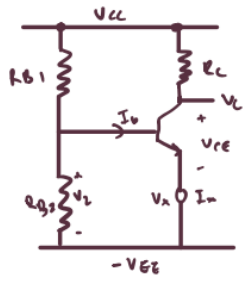
$V_{R1} = 2.3V$

$I_{supply} = I + I_B = 2mA \qquad I = 2mA - 1.01mA = 0.99mA$

$R_{B2} = \frac{V_{R2}}{I} = \frac{2.7V}{.99mA} = \underline{2.72k\Omega}$

$R_{B1} = \frac{V_{R1}}{I + I_B} = \frac{2.3}{1mA} = \underline{2.3k\Omega}$

2) NPN



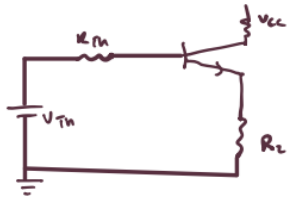
$I_C = 2mA$

$V_C = 3.5V$

$V_{CE} \geq 1V$

$V_X \geq 1.5V$, $V_{CC} = 5$, $V_{EE} = 0$

$\beta = 100$, $V_T = 25mV$, $I_{supply} \leq 5mA$



$V_{Th} = V_{CC}\left(\frac{R_2}{R_{B1}+R_{B2}}\right)$ $\quad R_{Th} = \frac{R_{B1}R_{B2}}{R_{B1}+R_{B2}}$

$V_{CC} = I_C R_C + V_C \Rightarrow R_C = \frac{V_{CC}-V_C}{I_{CC}} = \frac{5-3.5}{2\times10^{-3}} = 0.75k\Omega$

$= 750\Omega$

$V_{Th} = V_{BE} + I_B R_{Th} + V_{CE} = .7 + 20\times10^{-6}(R_{Th}) + 1.5 = 2.2V$

$V_L \geq 1.5V$

$I_B = I_E/I_{100} = 2/100 = 20\mu A$

$I_C \approx I_E = 2mA$

$V_{th} = V_{CE}\left(R_2/R_{B1}+R_{B2}\right)$

$2.2 = 5\left(R_2/R_1+R_2\right)$

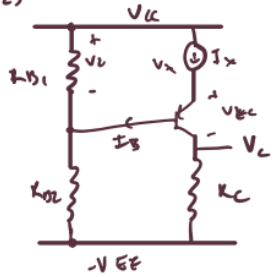
$2.2(R_1+R_2) = 5R_2$

$R_1 = 1.27R_2$

$R_{B2} = 1k\Omega$ $\quad R_{B1} = 1.27k\Omega$

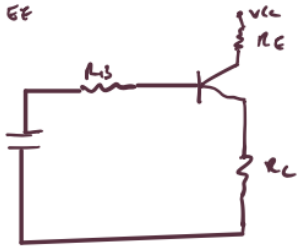
$R_1 = R_2 = R_3 = 500\Omega$

2) PNP



$I_L = 2mA$
$V_L = 1.5V$
$V_{EC} \geq 1V$
$V_{2E} \geq 1V$
$V_{CC} = 5V$
$V_{EE} = 0V$

$\beta = 100$
$V_T = 25mV$



$V_2 = V_{CC} - V_{EC} - V_L = 5 - 1.5 - 1 = 2.5V$

$V_2 = 2.5V$

$I_E = I_C = 2mA$

$R_E = \frac{V_2}{I_E} = \frac{2.5}{2\times10^{-3}}$ $\quad R_E = 1.25k\Omega$

$R_C = \frac{V_C}{I_C} = \frac{1.5}{2\times10^{-3}}$ $\quad R_C = 0.75k\Omega$

$V_2 = V_2 + 0.7 \rightarrow 2.5 + 0.7$ $\quad V_2 = 3.2V$

$V_2 = \left(\frac{R_1}{R_1 + R_2}\right) V_{CC} \rightarrow 3.2 = \left(\frac{R_1}{R_1 + R_2}\right) 5$

$R_1 = 1.77 R_2$

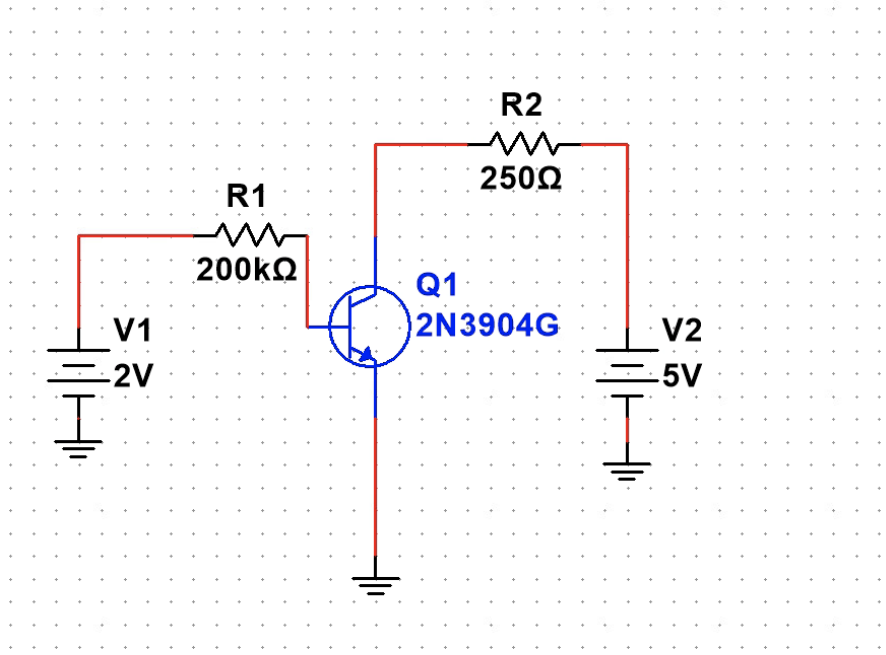
$R_2 = 1k\Omega$

$R_1 = 1.77k\Omega$

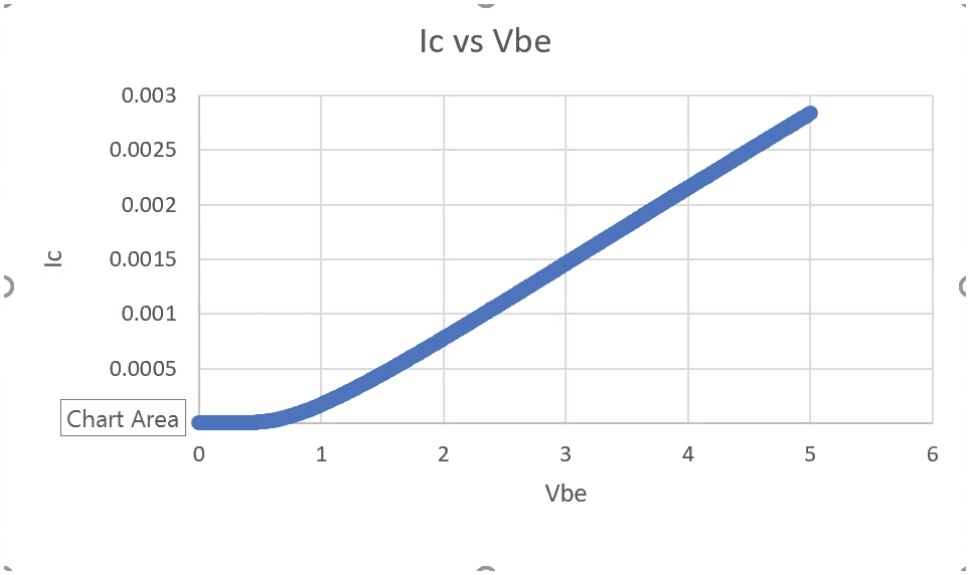
$R_1 = R_2 = R_3 = 500\Omega$

Simulations (on Multisim)

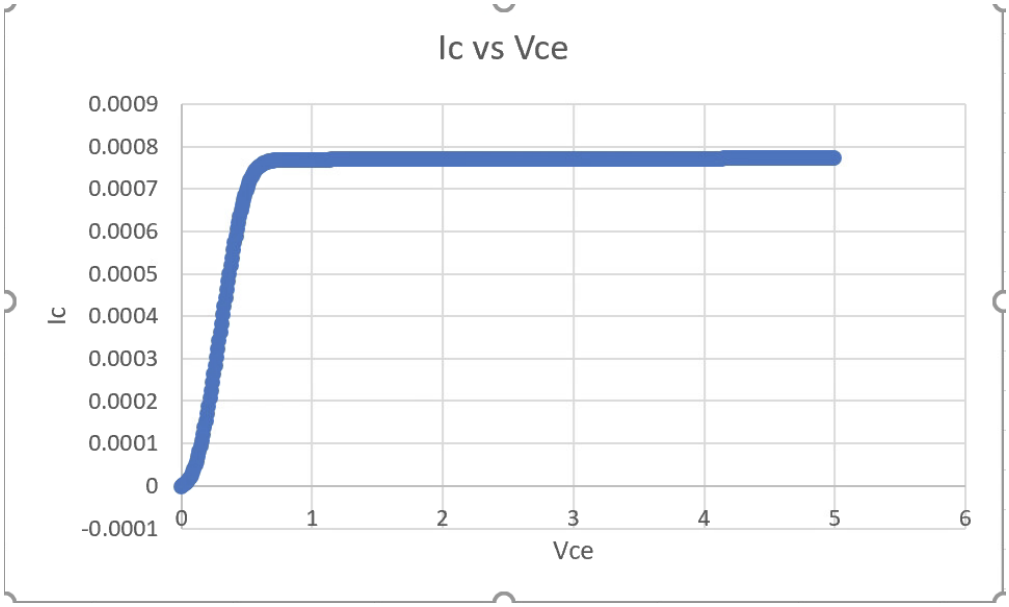
Schematic NPN



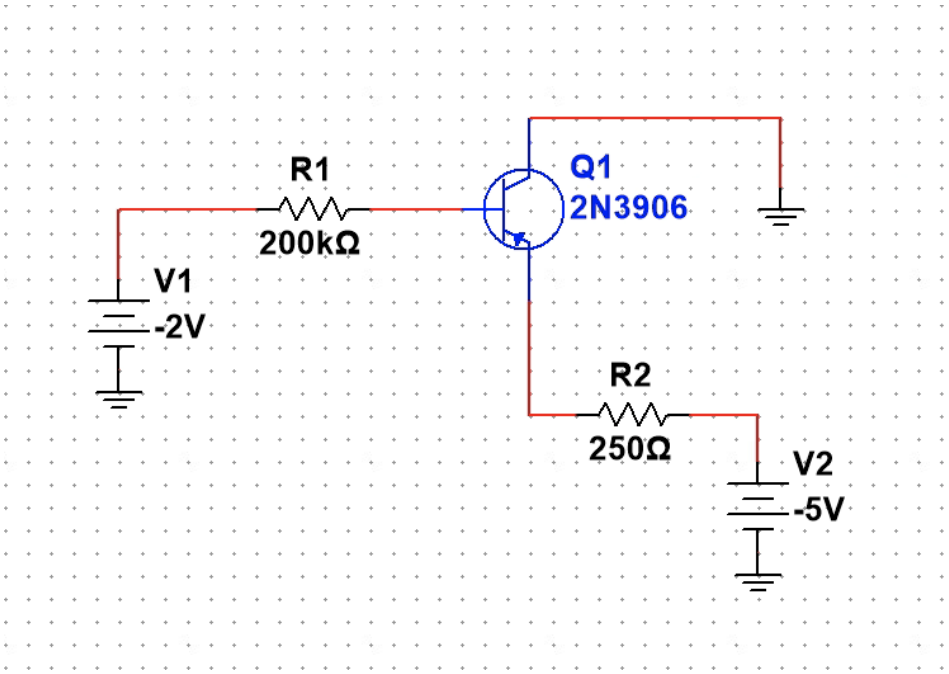
I_c vs V_{BE}



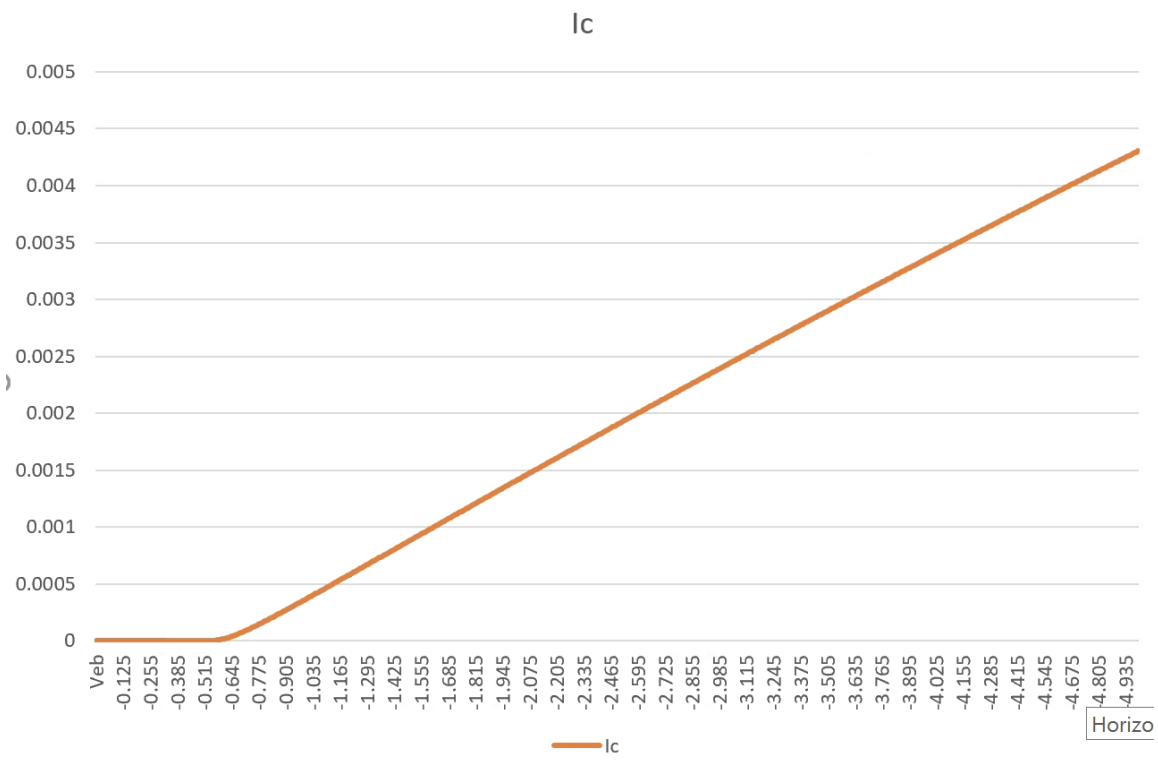
I_c vs V_{CE}



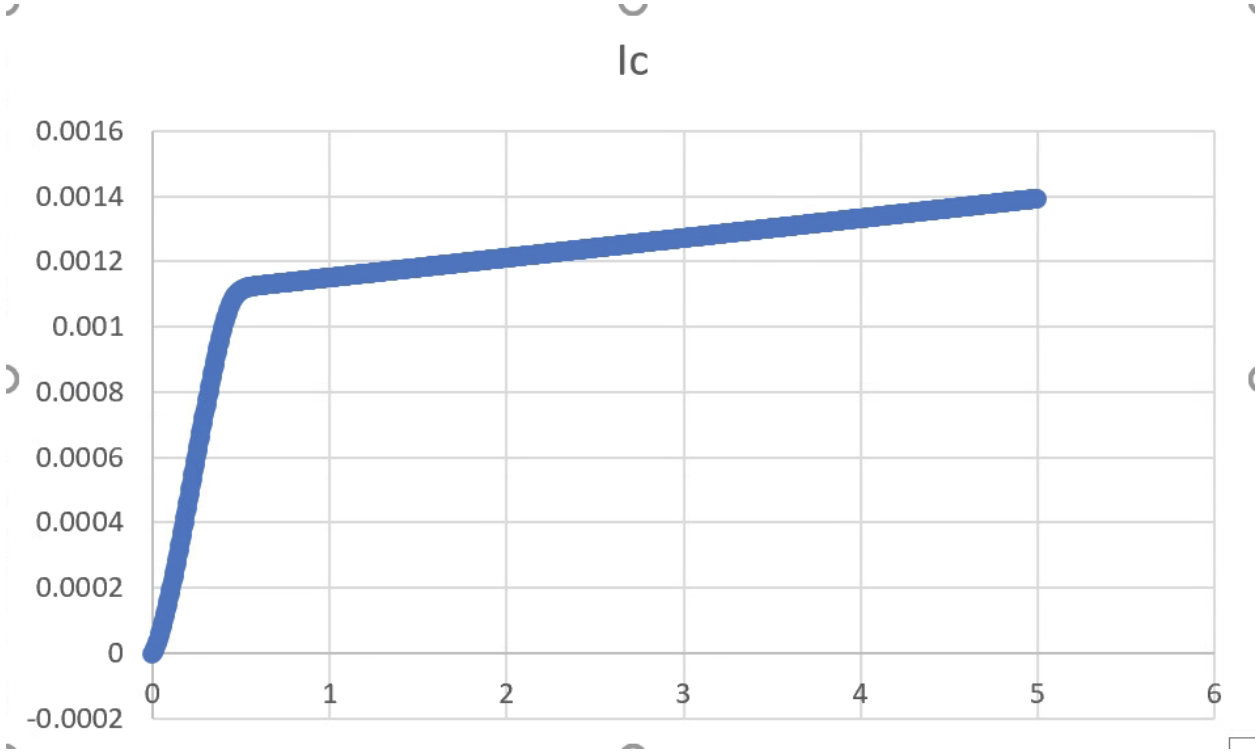
Schematic PNP



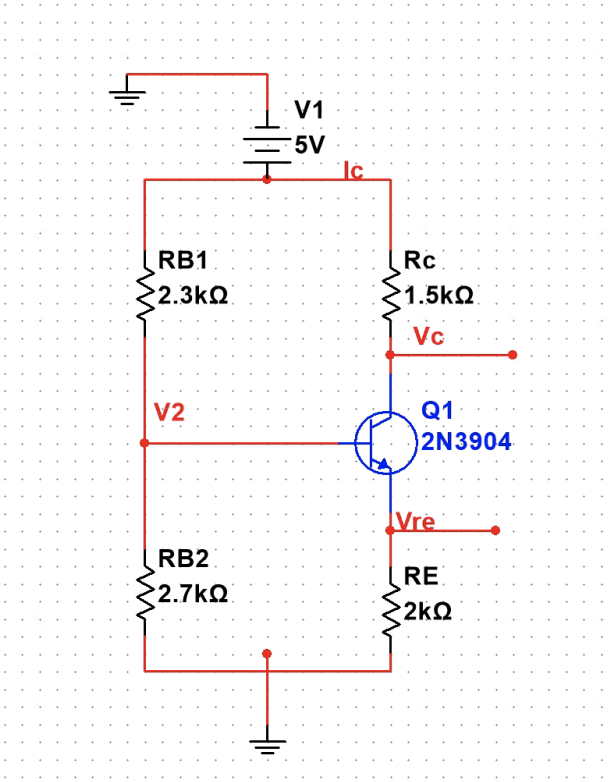
I_c vs V_{EB}



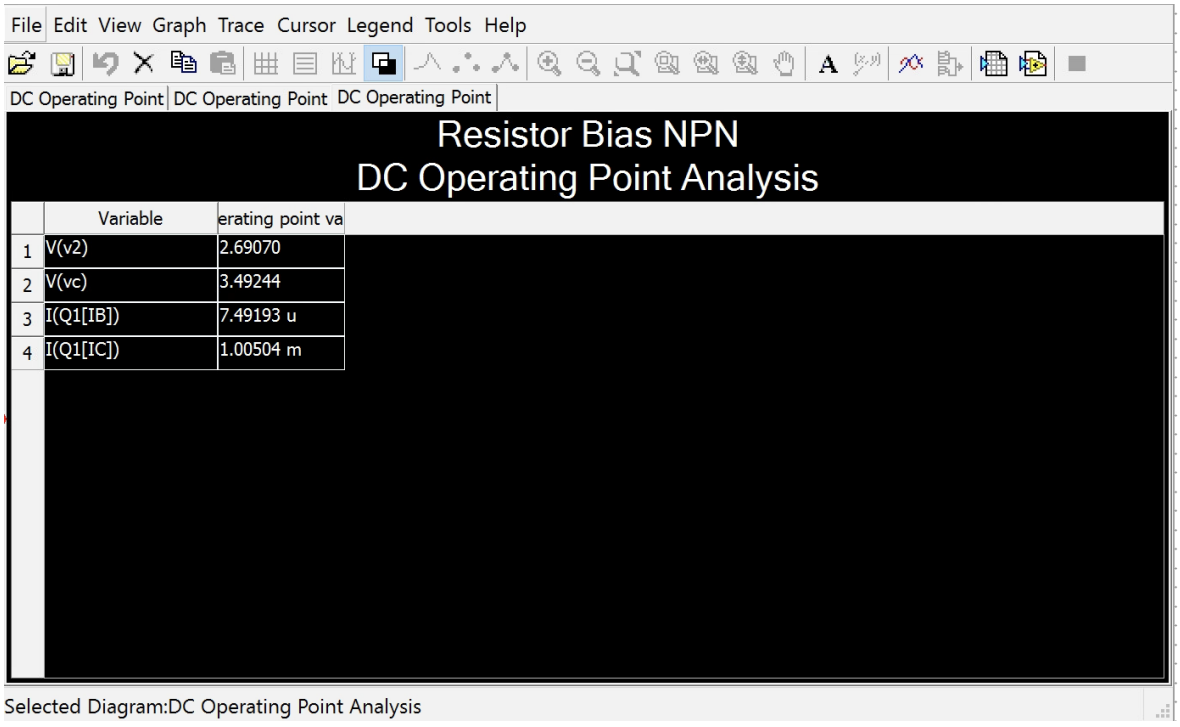
I_c vs V_{EC}



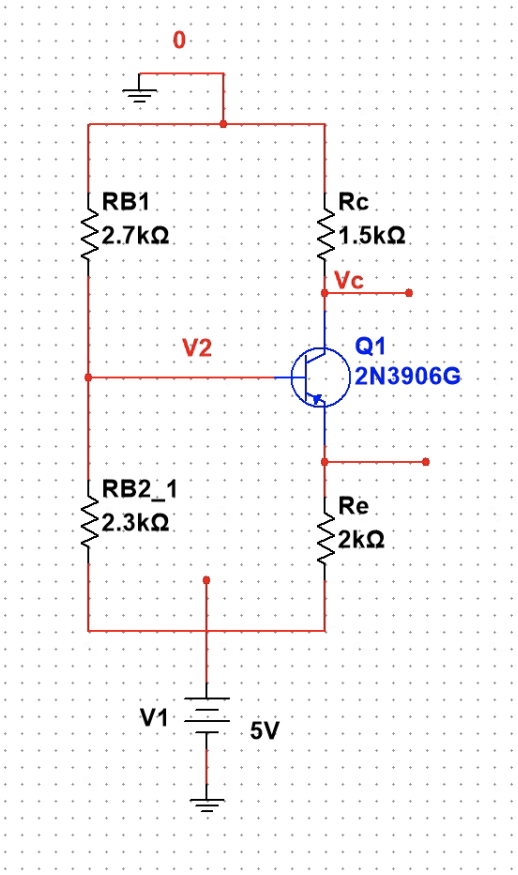
Schematic 6a



DC operating point or interactive simulation for 6a



Schematic 6b



DC operating point or interactive simulation for 6b

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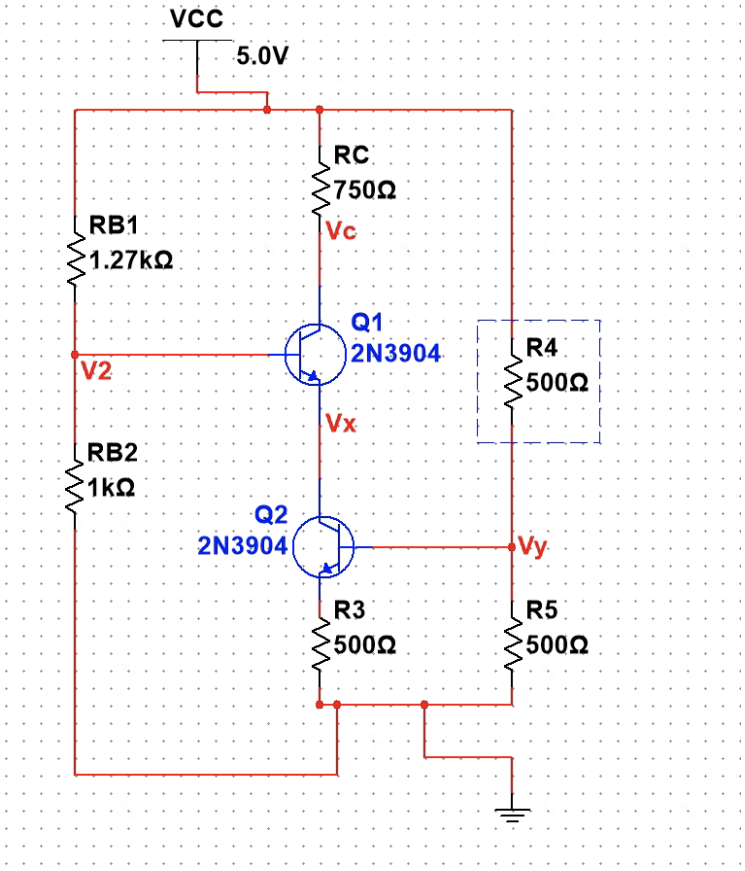
DC Operating Point | DC Operating Point

Resistor Bias PNP
DC Operating Point Analysis

	Variable	erating point va
1	V(v2)	2.70833
2	V(vc)	1.22001
3	V(ve)	3.35990
4	I(Q1[IB])	6.71014 u
5	I(Q1[IC])	813.34229 u

Selected Diagram:DC Operating Point Analysis

Schematic 7a



DC operating point or interactive simulation for 7a

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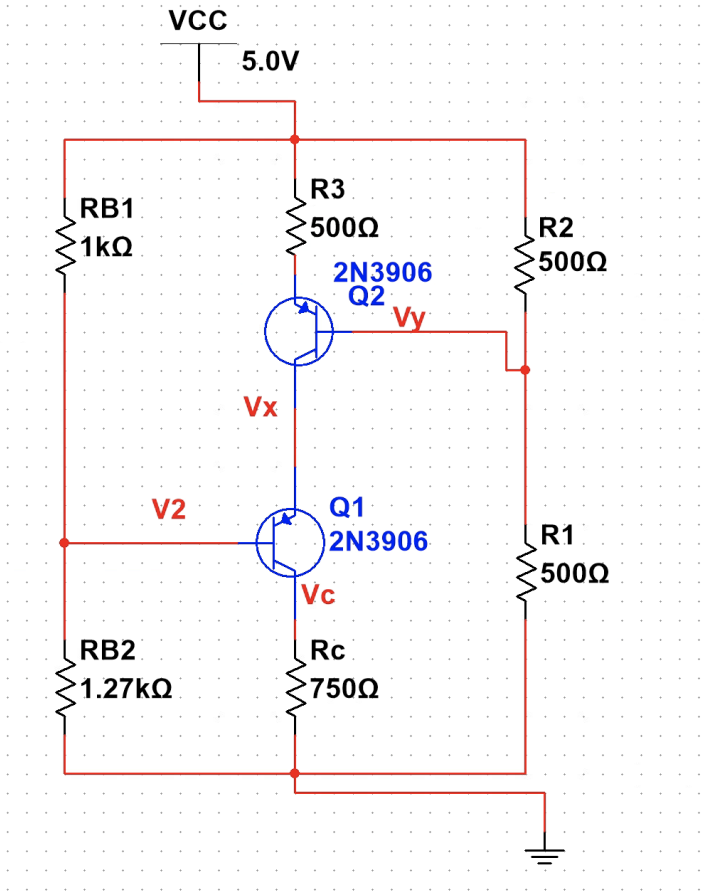
DC Operating Point | DC Operating Point | DC Operating Point

Current Source Bias NPN
DC Operating Point Analysis

	Variable	erating point va
1	V(v2)	2.19604
2	V(vc)	3.72471
3	V(vx)	1.51676
4	V(vy)	2.18993
5	I(Q1[IB])	11.79822 u
6	I(Q1[IC])	1.70039 m

Selected Diagram:DC Operating Point Analysis

Schematic 8a



DC operating point or interactive simulation for 8a