Pre-Lab 7:

Characterization and DC Biasing of the BJT

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ECEN 325 Section 514

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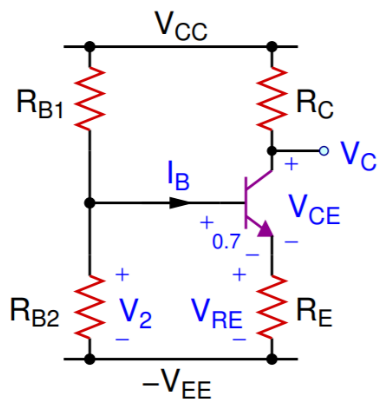
Calculations

(1)

NPN Resistive DC Biasing Circuit



NPN

I_C	$1mA$
V_C	$3.5V$
V_{CE}	$\geq 1V$
V_{RE}	$\geq 1V$
V_{CC}	$5V$
V_{EE}	0
β	100
V_T	$25mV$
I_{supply}	$\leq 2mA$

$R_C = 1.5k\Omega$

$V_{RE} = 2.222V$

$V_2 = 2.922V$

$R_E = 2.2k\Omega$

$R_{B1} = 1.95k\Omega$

$R_{B2} = 2.7k\Omega$

$$R_C = \frac{V_{CC} - V_C}{I_C} = \frac{5 - 3.5}{1m} = 1.5k\Omega$$

$$I_E \approx I_C = 1mA$$

$$V_{RE} + V_{CE} = 3.5V \quad (\text{Assume } V_{CE} = 1.278V)$$

$$V_{RE} = 2.222V$$

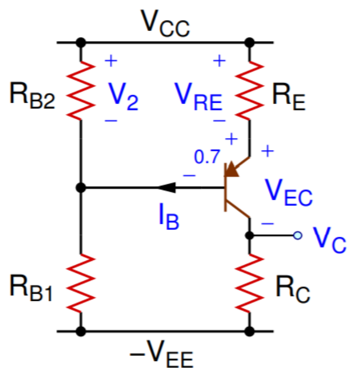
$$R_E = \frac{V_{RE}}{I_E} = \frac{2.222V}{1m} = 2.2k\Omega$$

$$V_2 - V_{RE} = 0.7V \Rightarrow V_2 = 2.922V$$

$$5 \cdot \frac{R_{B2}}{R_{B1} + R_{B2}} = 2.922 \Rightarrow \frac{R_{B2}}{R_{B1} + R_{B2}} = \frac{2.922}{5}$$

$$R_{B2} = 2.7k\Omega \quad R_{B1} = 1.95k\Omega = 3.3k \| 4.7k$$

PNP Resistive DC Biasing Circuit



PNP

I_C	$1mA$
V_C	$1.5V$
V_{EC}	$\geq 1V$
V_{RE}	$\geq 1V$
V_{CC}	$5V$
V_{EE}	0
β	100
V_T	$25mV$
I_{supply}	$\leq 2mA$

$R_C = 1.5k\Omega$

$V_{RE} = 2.2V$

$V_2 = 2.9V$

$R_E = 2.2k\Omega$

$R_{B1} = 1.8k\Omega$

$R_{B2} = 2.47k\Omega$

$$R_C = \frac{V_C}{I_C} = \frac{1.5}{1m} = 1.5k\Omega$$

$$I_E \approx I_C = 1mA$$

$$V_{RE} = 5 - 1.3 - 1.5 = 2.2V \quad (\text{Assume } V_{EC} = 1.3V)$$

$$5 - V_2 = 2.1V \quad \Rightarrow V_2 = 2.9V$$

$$R_E = \frac{2.2}{1m} = 2.2k\Omega$$

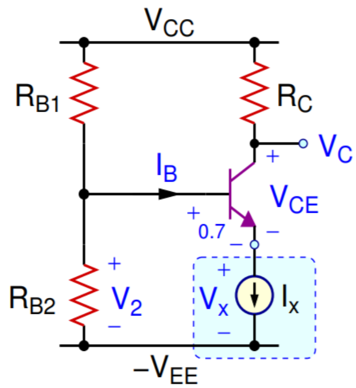
$$5 \cdot \frac{R_{B1}}{R_{B2} + R_{B1}} = 2.1$$

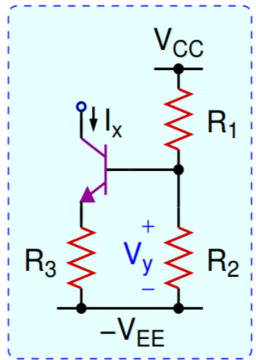
$$\Rightarrow R_{B1} = 1.8k\Omega, \quad R_{B2} = 2.47k\Omega$$

$$= 2k + 470\,\Omega$$

(2)

NPN DC Biasing Circuit





NPN

I_C	$2mA$
V_C	$3.5V$
V_{CE}	$\geq 1V$
V_x	$\geq 1.5V$
V_{CC}	$5V$
V_{EE}	0
β	100
V_T	$25mV$
I_{supply}	$\leq 5mA$

$R_C = 0.75k\Omega \quad R_1 = 1K \quad R_2 = 1.5K \quad R_3 = 1.2K$

$R_{B1} = 1.8K \quad R_{B2} = 3.3K$

$$R_C = \frac{5-3.5}{2m} = 0.75k\Omega$$

$$I_E \approx I_C = 2mA = I_X \approx I_{R3}$$

$$2mA \cdot R_3 + 0.7 = V_y = 5 \cdot \frac{R_2}{R_2+R_1} \quad (\text{Assume } V_y = 3V)$$

$$R_3 = 1.2k\Omega \quad R_1 = 1k\Omega \quad R_2 = 1.5k\Omega$$

$$V_X + V_{CE} = V_C = 3.5V \quad (\text{Assume } V_{CE} = 1V)$$

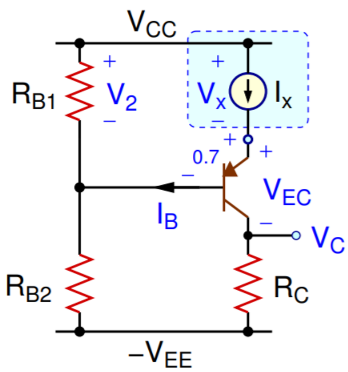
$$V_X = 2.5V$$

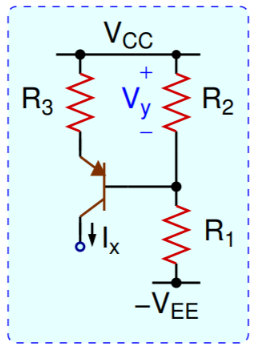
$$V_2 = V_X + 0.7V = 3.2V$$

$$3.2V = 5 \cdot \frac{R_{B2}}{R_{B2} + R_{B1}}$$

$$R_{B1} = 1.8k\Omega \quad R_{B2} = 3.3k\Omega$$

PNP DC Biasing Circuit





PNP

I_C	$2mA$
V_C	$1.5V$
V_{EC}	$\geq 1V$
V_x	$\geq 1.5V$
V_{CC}	$5V$
V_{EE}	0
β	100
V_T	$25mV$
I_{supply}	$\leq 5mA$

$R_C = 0.75k\Omega \quad R_1 = 1.5K \quad R_2 = 1k \quad R_3 = 650$

$R_{B1} = 3.2k \quad R_{B2} = 1.8K$

$$R_C = \frac{1.5}{2m} = 0.75K$$

$$I_E \approx I_C = 2mA = I_x$$

$$5 \cdot \frac{R_1}{R_1+R_2} = 3V \quad (\text{Assume } V_y = 2V)$$

$$\Rightarrow R_1 = 1.5k \quad R_2 = 1k$$

$$R_3 = \frac{5-(3+0.7)}{2m} = 650\Omega$$

$$5 = V_x + V_{EC} + V_C \Rightarrow V_x = 2.5V \quad (\text{Assume } V_{EC} = 1V)$$

$$5 - V_2 = 1.8V$$

$$5 \cdot \frac{R_{B2}}{R_{B1}+R_{B2}} = 1.8V$$

$$R_{B2} = 1.8K \quad R_{B1} = 3.2K$$

Simulations

(1)

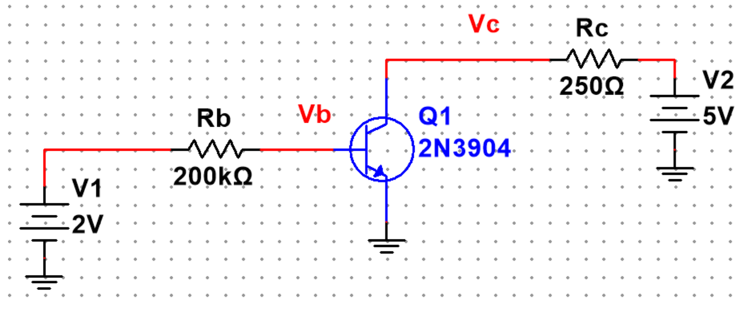


Figure 1: Schematic of NPN BJT characterization circuit for Fig. 2 ▲

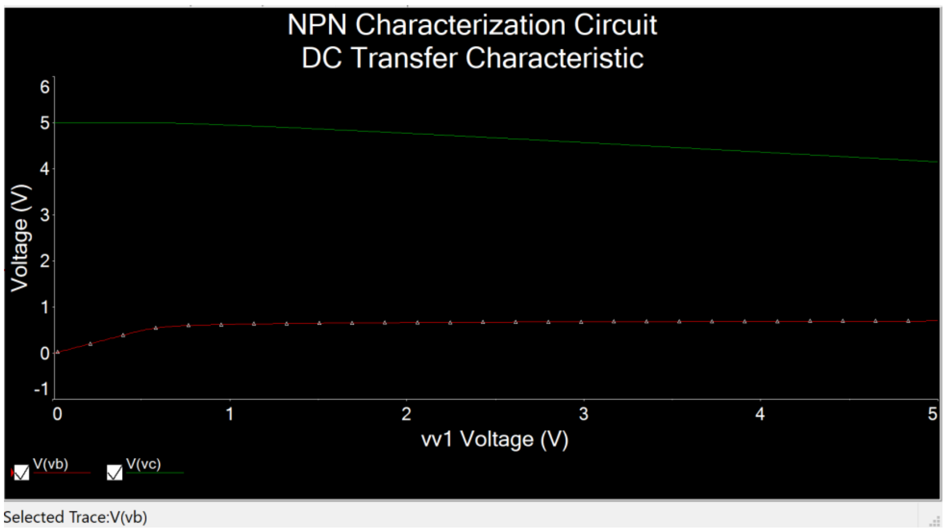


Figure 2: Simulation plot of NPN BJT characterization circuit using DC sweep of V1 from 0 to 5V, while V2 = 5V ▲

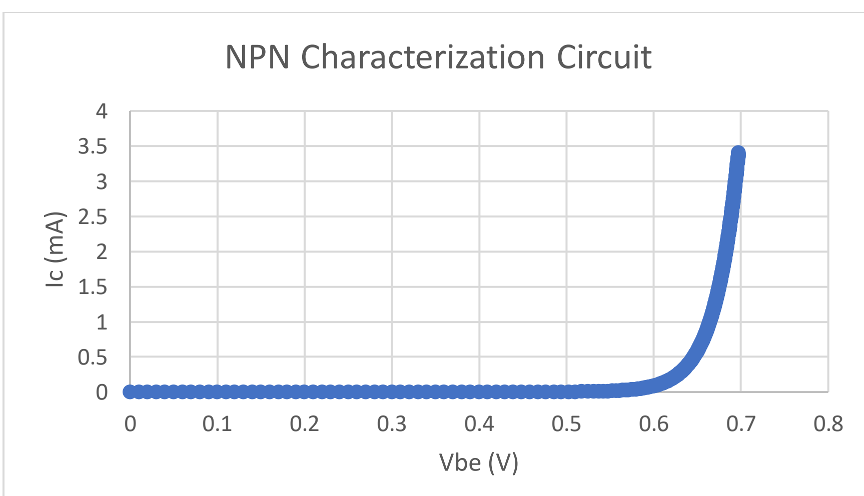


Figure 3: Excel plot for collector current (IC) of an NPN BJT as a function of Vbe ▲

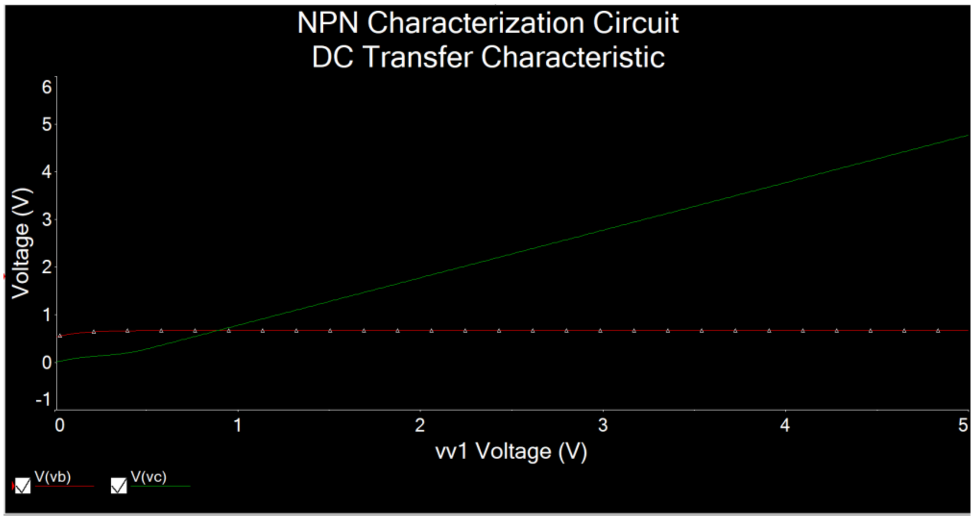


Figure 4: Simulation plot of NPN BJT characterization circuit using DC sweep of V2 from 0 to 5V, while V1 = 2V ▲

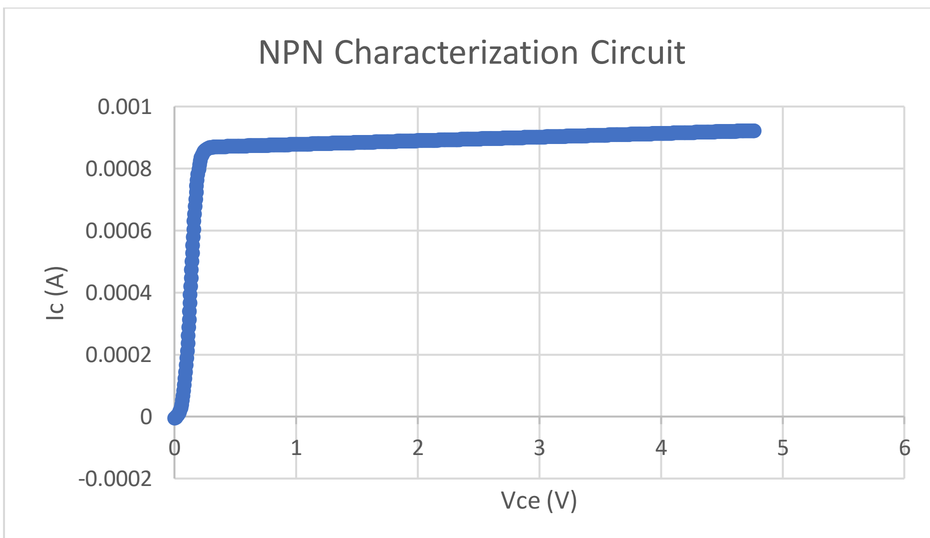


Figure 5: Excel plot for collector current (IC) of an NPN BJT as a function of Vce ▲

(2)

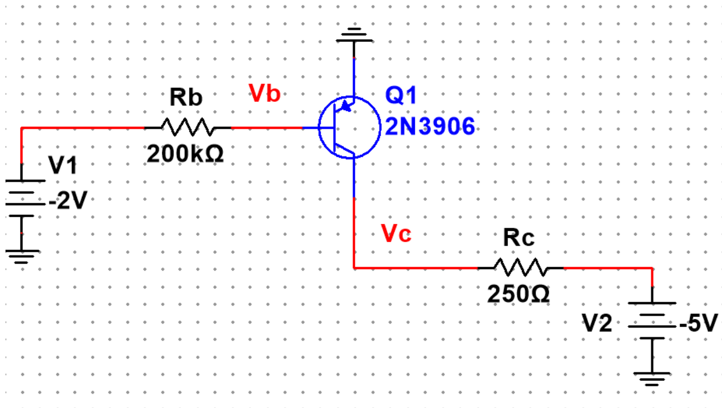


Figure 6: Schematic of NPN BJT characterization circuit for Fig. 4 ▲

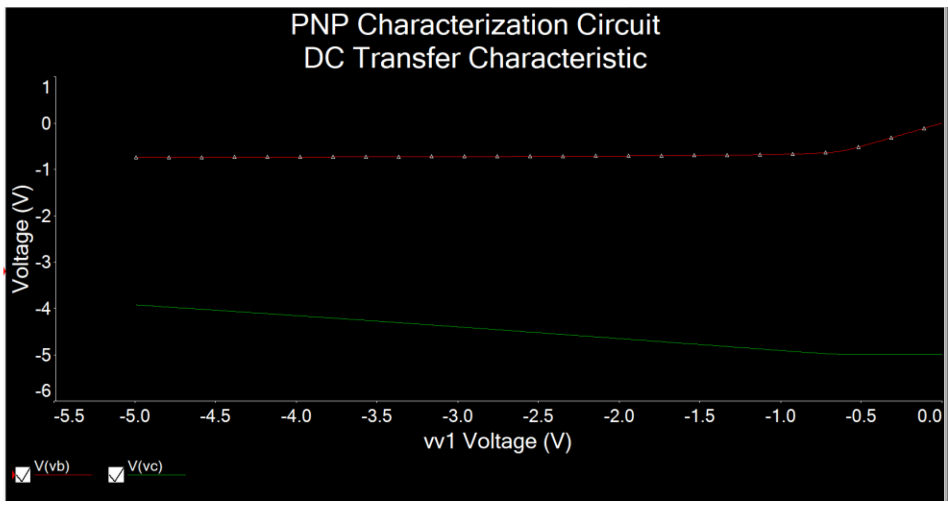


Figure 7: Simulation plot of PNP BJT characterization circuit using DC sweep of V1 from -5 to 0V, while V2 = -5V ▲

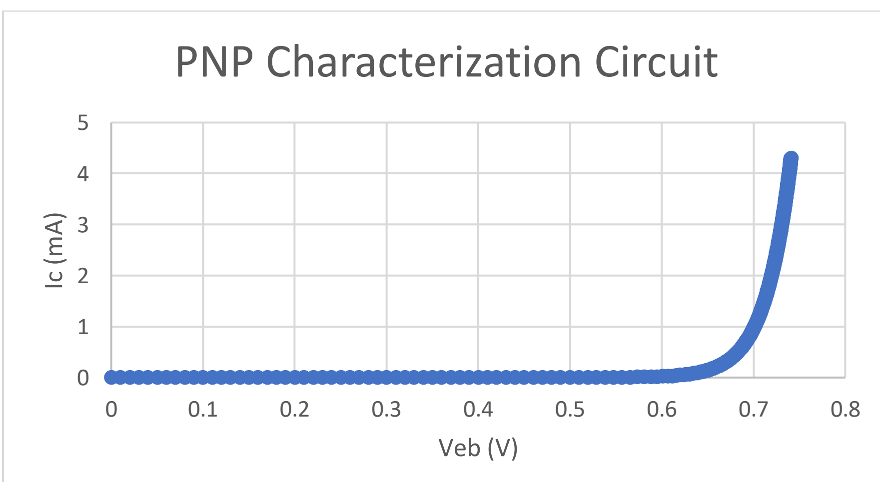


Figure 8: Excel plot for collector current (IC) of an PNP BJT as a function of Veb ▲

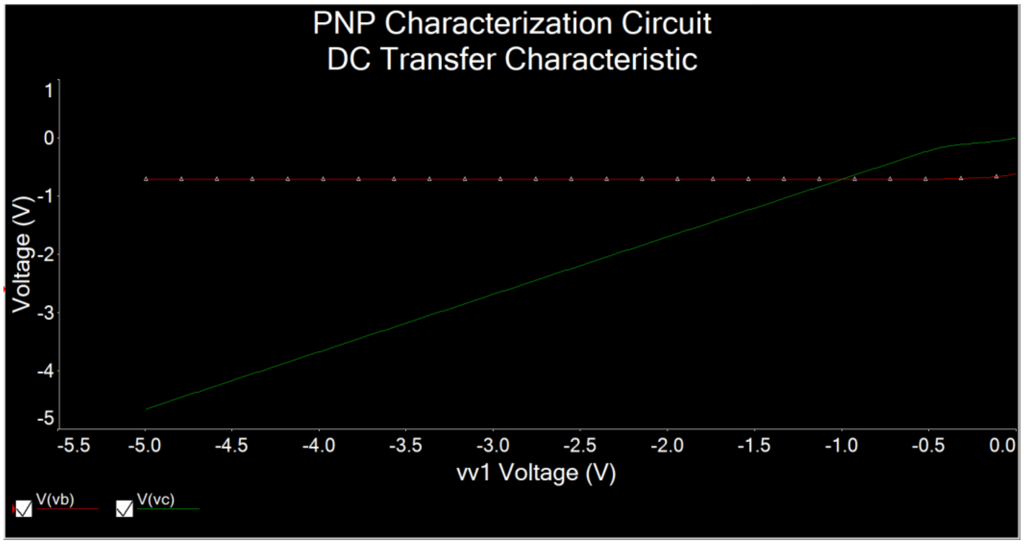


Figure 9: Simulation plot of PNP BJT characterization circuit using DC sweep of V2 from -5 to 0V, while V1 = -2V ▲

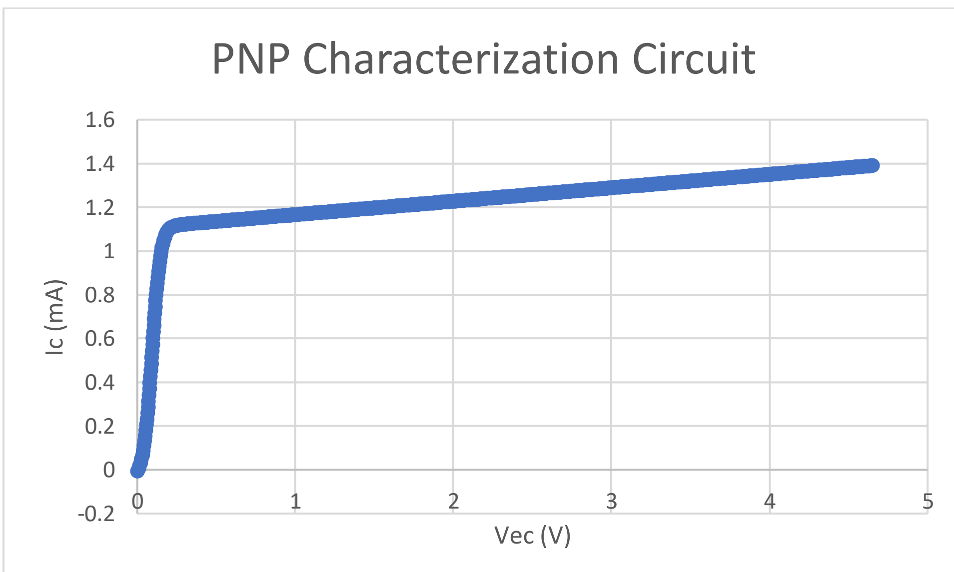


Figure 10: Excel plot for collector current (IC) of an PNP BJT as a function of Vec ▲

(3)

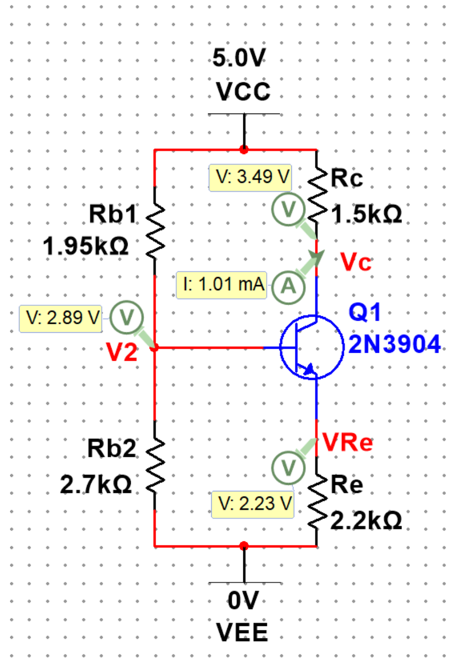


Figure 11: Schematic and interactive simulation for I_C, V_C, V_{RE}, and V_2 for NPN Resistive DC biasing circuit in Fig. 6(a) ▲

$I_C = 1.01$ mA, $V_C = 3.49$ V, $V_{RE} = 2.23$ V, $V_2 = 2.89$ V

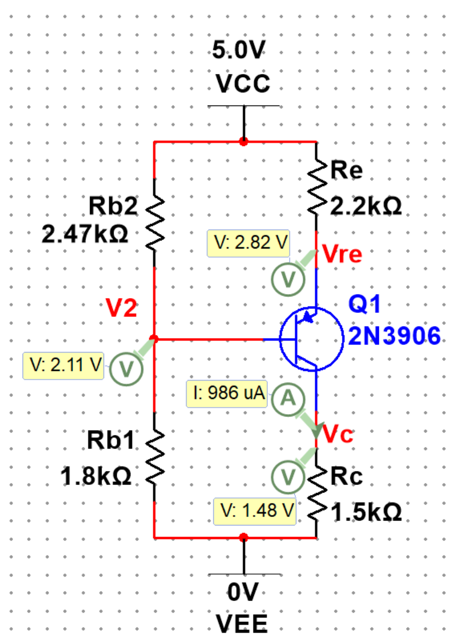


Figure 12: Schematic and interactive simulation for I_C, V_C, V_{RE}, and V_2 for PNP Resistive DC biasing circuit in Fig. 6(b) ▲

$I_C = 0.986$ mA, $V_C = 1.48$ V, $V_{RE} = 2.82$ V, $V_2 = 2.11$ V

(4)

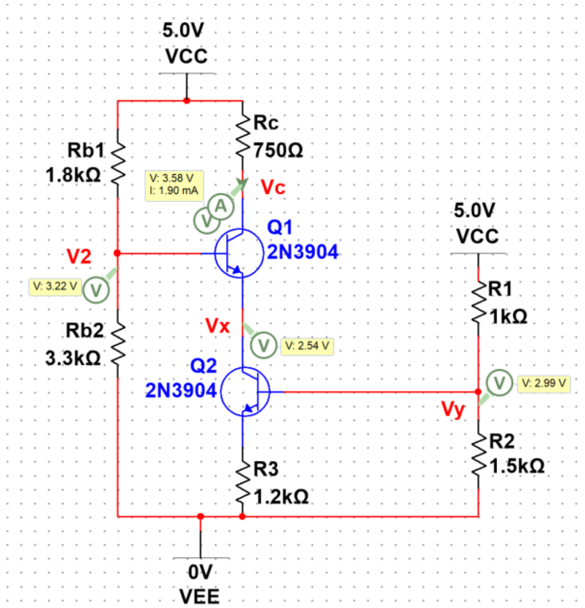


Figure 13: Schematic and interactive simulation for I_C, V_C, V_2, $V_{x,}$ and V_y for NPN DC biasing circuit using current source in Fig. 7(a) and Fig. 7(b) ▲

$I_C = 1.90$ mA, $V_C = 3.58$ V, $V_2 = 3.22$ V, $V_x = 2.54$ V, $V_y = 2.99$ V

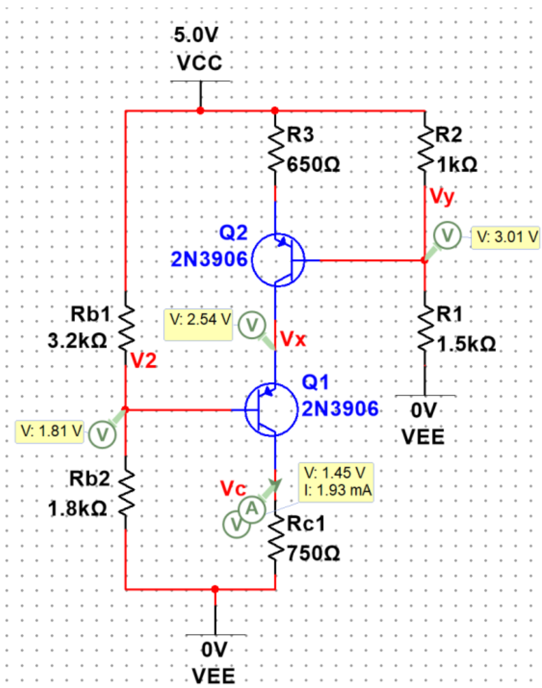


Figure 14: Schematic and interactive simulation for I_C, V_C, V_2, $V_{x,}$ and V_y for NPN DC biasing circuit using current source in Fig. 8(a) and Fig. 8(b) ▲

$I_C = 1.93$ mA, $V_C = 1.45$ V, $V_2 = 3.19$ V, $V_x = 2.54$ V, $V_y = 1.99$ V