ECE 2200L
Introduction to Microelectronics Circuits Laboratory

Experiment 5
Bipolar Junction Transistor Current-Voltage Characteristics

Report

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October 14, 2020

Objective

To study the current-voltage relationships of the bipolar junction transistors through laboratory experimentation.

Result

The following is the experimental data obtained from 1N2222 BJT.

Table 1: I_B and V_{BE} values at circuit without $500\,\Omega$ resistor at collector

V_{BE}	I_B
0 mV	0 µA
639 mV	10 µA
658 mV	20 µA
668 mV	30 µA
676 mV	40 µA
682 mV	50 µA
686 mV	60 µA
689 mV	70 µA
692 mV	80 µA
695 mV	90 µA
698 mV	100 µA

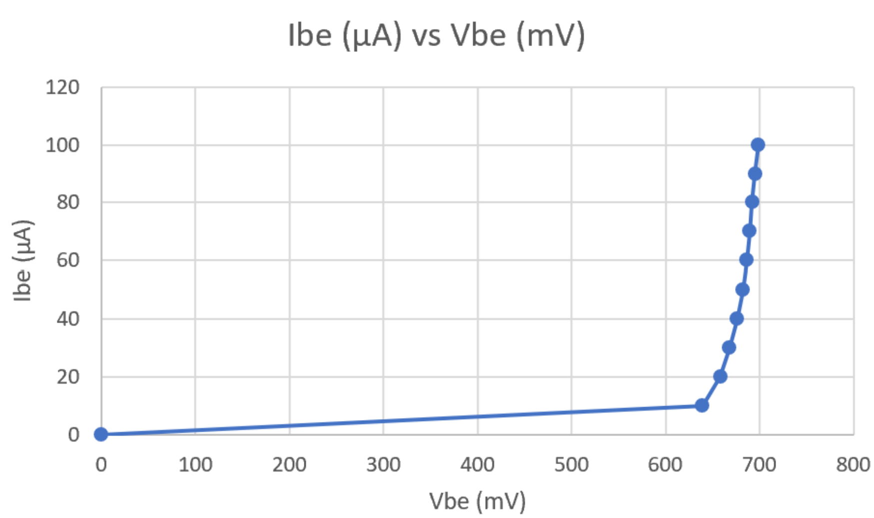

Figure 1: I_B vs V_{BE} chart of 1N2222 at circuit without $500\,\Omega$ resistor at collector

Table 2: I_C and V_{CE} values at circuit with $500\,\Omega$ resistor at collector

	$I_B = 20\,\mu A$		$I_B = 40\,\mu A$		$I_B = 60\,\mu A$	
V_{CE}	V_{CC}	I_C	V_{CC}	I_C	V_{CC}	I_C
1 V	2.28 V	0.002 296 A	3.64 V	0.004 736 A	4.97 V	0.007 122 A
3 V	4.31 V	0.002 350 A	5.72 V	0.004 880 A	7.05 V	0.007 266 A
5 V	6.31 V	0.002 350 A	7.83 V	0.005 077 A	9.28 V	0.007 679 A
7 V	8.36 V	0.002 440 A	9.93 V	0.005 257 A	11.43 V	0.007 948 A
9 V	10.37 V	0.002 458 A	11.99 V	0.005 364 A	13.67 V	0.008 378 A
11 V	12.4 V	0.002 512 A	13.98 V	0.005 346 A	15.95 V	0.008 881 A

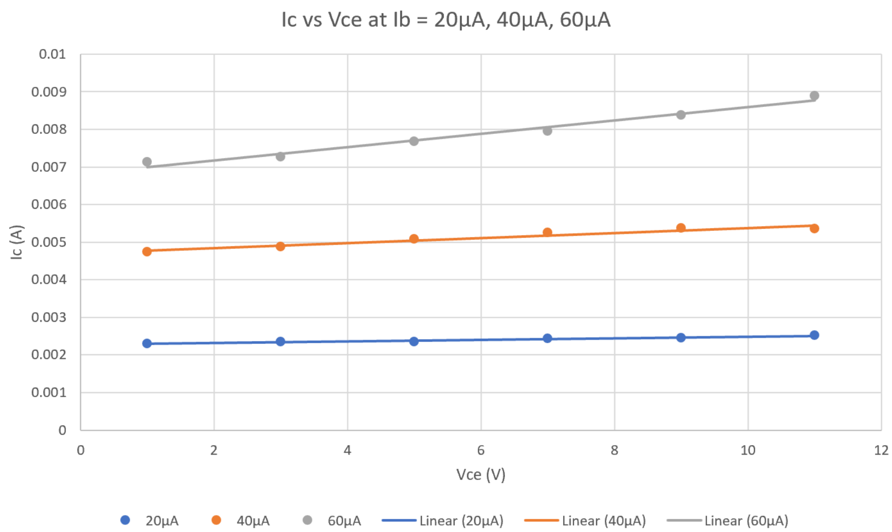

Figure 2: I_C vs V_{CE} chart of 1N2222 at circuit with $500\,\Omega$ resistor at collector

DC β at operating point of $V_{CE} = 5\,V$ and $I_B = 40\,\mu A$ can then be derived.

$$\beta_{DC} = \frac{I_C(V_{CE} = 5\,V, I_B = 40\,\mu A)}{I_B = 40\,\mu A} = \frac{0.005\,077\,A}{0.000\,040\,A} = 126.925 \tag{1}$$

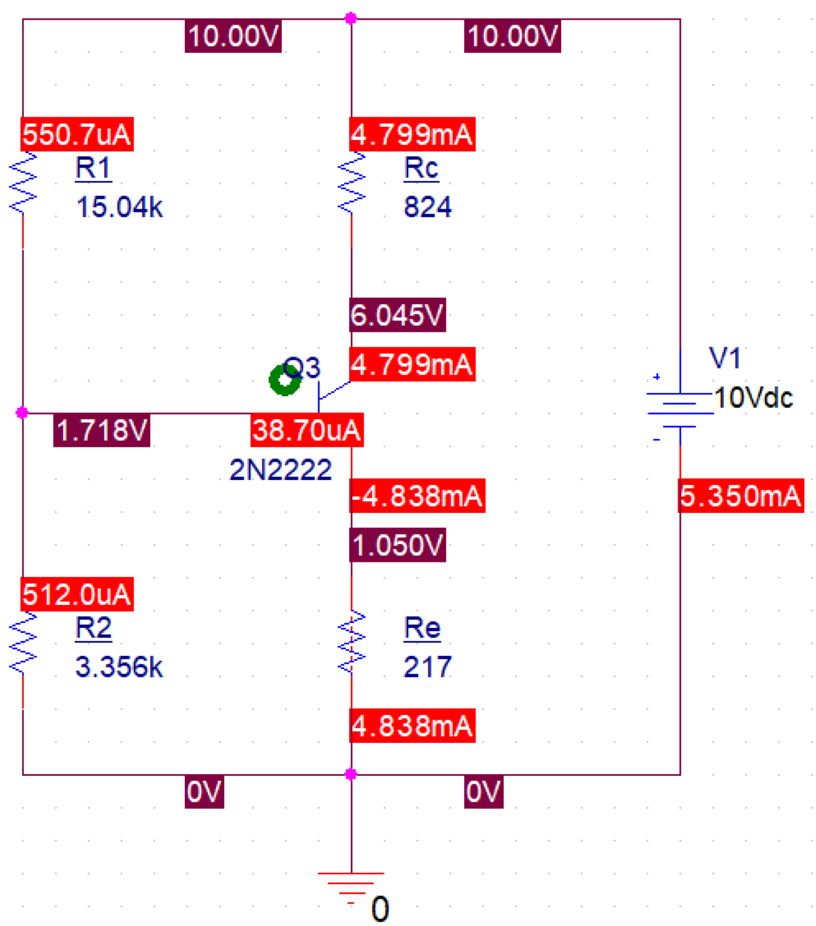

Figure 3: PSpice simulation with bias display of the circuit

R_1	=	$15.04\,\mathrm{k\Omega}$
R_2	=	$3.356\,\mathrm{k\Omega}$
R_E	=	$217\,\mathrm{k\Omega}$
R_C	=	$824\,\mathrm{k\Omega}$
V_{CC}	=	$10.00\,\mathrm{V}$
V_C	=	$5.98\,\mathrm{V}$
V_E	=	$1.067\,\mathrm{V}$
V_B	=	$1.719\,\mathrm{V}$

Table 3: Values from circuit

R_1	=	$15.04\,\mathrm{k\Omega}$
R_2	=	$3.356\,\mathrm{k\Omega}$
R_E	=	$217\,\mathrm{k\Omega}$
R_C	=	$824\,\mathrm{k\Omega}$
V_{CC}	=	$10.00\,\mathrm{V}$
V_C	=	$6.045\,\mathrm{V}$
V_E	=	$1.050\,\mathrm{V}$
V_B	=	$1.718\,\mathrm{V}$

Table 4: Values from simulation

Assuming I_B, I_C enter and I_E exit the BJT, for this circuit,

$$I_C = \frac{V_{CC} - V_C}{R_C}$$

$$I_B = I_E - I_C = \frac{V_E}{R_E} - \frac{V_{CC} - V_C}{R_C}$$

$$V_{CE} = V_C - V_E$$

$$\beta = \frac{I_C}{I_B}$$

We can then calculate β and the BJT bias point I_B, I_C and V_{CE} from table 3 and table 4.

I_C	=	4.88 mA
I_B	=	38.4 µA
V_{CE}	=	4.913 V
β	=	127.1

Table 5: Derived from circuit

I_C	=	4.799 mA
I_B	=	38.70 µA
V_{CE}	=	4.995 V
β	=	124

Table 6: Derived from simulation

Conclusion

From equation 1 we found that $beta = 126.925$, which is close to the value from table 5. The experimental value at table 3 and table 5 are also similar to the values obtain from PSpice simulation listed in table 4 and table 6.