ECE 2200L
Introduction to Microelectronics Circuits Laboratory

Experiment 6
Bipolar Junction Transistor Biasing Circuits and Bias Point Stability

Report

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Objective

To study and experiment on three types of DC biasing circuits for BJTs, and compare the stability of the bias point in these circuits.

Prelab

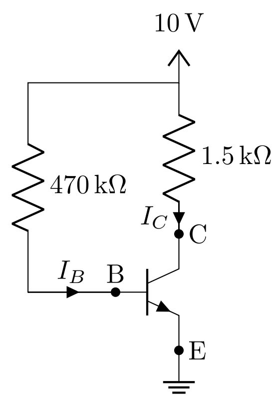

Figure 1: Circuit 1

Assuming $V_{BE} = 0.7\,\mathrm{V}$

$$I_B = \frac{10 - 0.7}{470000} = 19.8\,\mu\mathrm{A} \tag{1}$$

$$I_C = \beta I_B = \beta 19.8\,\mu\mathrm{A} \tag{2}$$

$$V_{CE} = 10 - 1500\beta I_B = 10 - 1500\beta\left(19.8 \times 10^{-6}\right)\,\mathrm{V} \tag{3}$$

Table 1: Quiescent point parameter of circuit 1 for transistor with different β

	Q_1	Q_2	% difference
β	100	124	24%
I_B	19.8 µA	19.8 µA	0%
I_C	1.98 mA	2.46 mA	24%
V_{CE}	7.03 V	6.32 V	−10%

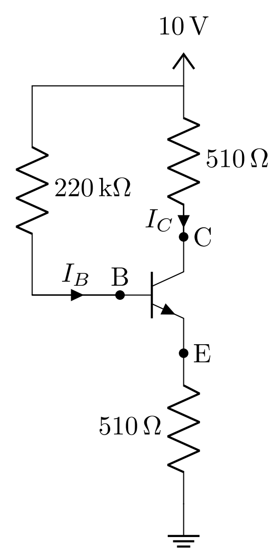

Figure 2: Circuit 2

Assuming $V_{BE} = 0.7\,\mathrm{V}$

$$I_E = (1+\beta)I_B \tag{4}$$

$$10\,\mathrm{V} = 220000 I_B + 0.7 + 510(1+\beta)I_B \tag{5}$$

$$I_B = \frac{9.3}{220510 + 510\beta} \tag{6}$$

$$I_C = \beta I_B = \frac{9.3\beta}{220510 + 510\beta} \tag{7}$$

$$V_{CE} = \left(10 - \frac{(510)(9.3)\beta}{220510 + 510\beta}\right) - \frac{510(1+\beta)9.3}{220510 + 510\beta} \tag{8}$$

Table 2: Quiescent point parameters of circuit 2 for transistors with different β

	Q_1	Q_2	% difference
β	100	124	24%
I_B	34.3 µA	32.8 µA	−4%
I_C	3.43 mA	4.06 mA	18%
V_{CE}	6.49 V	5.84 V	−10%

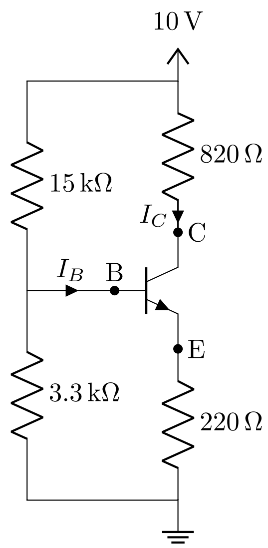

Figure 3: Circuit 3

Assuming $V_{BE} = 0.7\,\mathrm{V}$

$$I_B = \frac{10 - V_B}{15000} - \frac{V_B}{3300} = \frac{20190 - 18300V_E}{49500000} \tag{9}$$

$$I_E = (1+\beta)I_B = \frac{(1+\beta)(20190 - 18300V_E)}{49500000} = \frac{V_E}{220} \tag{10}$$

$$V_E = \frac{44418000(1+\beta)}{53526000 + 4026000\beta} \tag{11}$$

$$I_B = \frac{20190 - 18300\frac{44418000(1+\beta)}{53526000+4026000\beta}}{49500000} \tag{12}$$

$$I_C = \beta I_B \tag{13}$$

$$V_{CE} = V_C - V_E = (10 - 820I_C) - V_E \tag{14}$$

Table 3: Quiescent point parameters of circuit 3 for transistors with different β

	Q_1	Q_2	% difference
β	100	124	24%
I_B	44.3 µA	36.5 µA	−17%
I_C	4.42 mA	4.53 mA	2%
V_{CE}	5.39 V	5.28 V	−2%

Result

Circuit 1

The following is the experimental data obtained from circuit 1.

Table 4: V_B, V_C and V_E of circuit 1 for transistor with different β

	Q_1	Q_2	% difference
β	100	124	24%
V_B	0.642 V	0.644 V	0%
V_C	5.984 V	5.552 V	−7%
V_E	0 V	0 V	0%

I_B, I_C and V_{BE} can be derived from the below equations,

$$I_B = \frac{10 - V_B}{470000} \tag{15}$$

$$I_C = \beta I_B \tag{16}$$

$$V_{CE} = V_C - V_E \tag{17}$$

Table 5: Quiescent point parameter of circuit 1 for transistor with different β

	Q_1	Q_2	% difference
β	100	124	24%
I_B	19.9 µA	19.9 µA	0%
I_C	1.99 mA	2.47 mA	24%
V_{CE}	5.984 V	5.552 V	−7%

Circuit 2

The following is the experimental data obtained from circuit 2.

Table 6: V_B, V_C and V_E of circuit 1 for transistor with different β

	Q_1	Q_2	% difference
β	100	124	24%
V_B	2.91 V	3.086 V	0%
V_C	7.74 V	7.56 V	−7%
V_E	2.296 V	2.467 V	0%

I_B, I_C and V_{BE} can be derived from the below equations,

$$I_B = \frac{10 - V_B}{220000} \tag{18}$$

$$I_C = \beta I_B \tag{19}$$

$$V_{CE} = V_C - V_E \tag{20}$$

Table 7: Quiescent point parameter of circuit 2 for transistor with different β

	Q_1	Q_2	% difference
β	100	124	24%
I_B	32.2 µA	31.4 µA	0%
I_C	3.22 mA	3.89 mA	20%
V_{CE}	5.444 V	5.093 V	−6%

Circuit 3

The following is the experimental data obtained from circuit 3.

Table 8: V_B, V_C and V_E of circuit 3 for transistor with different β

	Q_1	Q_2	% difference
β	100	124	24%
V_B	1.731 V	1.738 V	0%
V_C	6.031 V	6.008 V	0%
V_E	1.08 V	1.083 V	0%

I_B, I_C and V_{BE} can be derived from the below equations,

$$I_B = \frac{I_C}{\beta} \tag{21}$$

$$I_C = \frac{10 - V_C}{820} \tag{22}$$

$$V_{CE} = V_C - V_E \tag{23}$$

Table 9: Quiescent point parameter of circuit 3 for transistor with different β

	Q_1	Q_2	% difference
β	100	124	24%
I_B	48.4 µA	39.3 µA	−18%
I_C	4.84 mA	4.87 mA	1%
V_{CE}	4.951 V	4.925 V	−1%

Circuit 4

Figure 4: Oscilloscope output for circuit 4

Gain $= \frac{1.61\,\mathrm{V}}{18.1\,\mathrm{mV}} = 89$

Conclusion

As demonstrated in this document above, circuit 3 setup is considerably stable across transistors with different β value compare to circuit 1 and circuit 2