Electrical and Computer Engineering Department

Written by:

Group K

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ECE 2200L:

Experiment Number 6

Bipolar Junction Transistor Biasing Circuits and Bias Point Stability
Represented to

Professor Mostafa Yazdy

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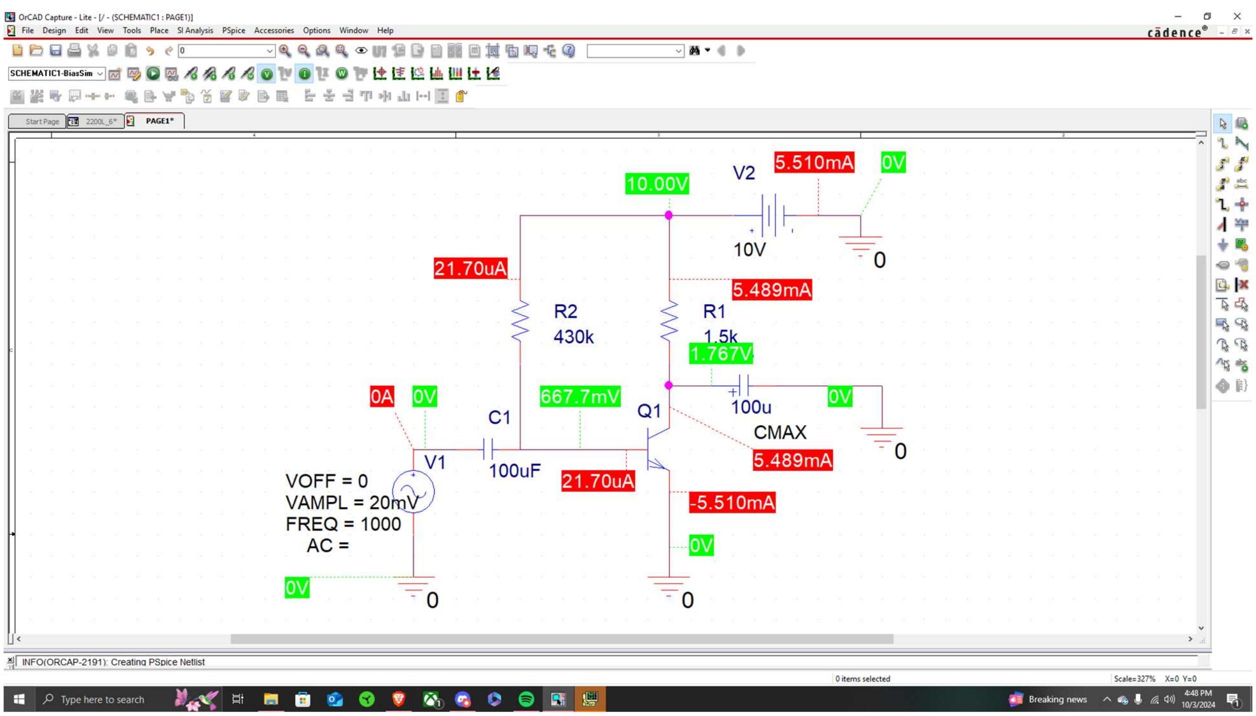
Background Information:

PNP transistor, also known as a Bipolar Junction Transistor (BJT), is a semiconductor device used in various applications. One of its primary functions is to amplify AC signals. To ensure stable operation, a BJT must be properly biased to maintain consistent values regardless of β.

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.

Pre-Lab:



A)

$$I_B = \frac{V_{cc} - V_{be}}{R_B} = \frac{10 - V_{be}}{R_B} \quad \text{Assume } V_{be} = 0.7$$

$$I_C = \beta \cdot I_B = \frac{V_{cc} - 10}{R_C}$$

$$I_C = \beta \cdot I_B = \frac{V_{cc} - 10}{R_C}$$

$$I_B = \frac{10 - 0.7}{430 \times 10^3} \approx 22\,\mu A$$

$$I_C = \beta \cdot I_B = 3.244\,mA$$

$$10 - I_C R_C - V_{CE} = 0 \quad \Rightarrow \quad V_{CE} = 10 - (3.244 \times 10^{-3})(1.5 \times 10^3)$$

$$V_{CE} = 5.1337\,V \approx 5.13\,V$$

$$I_B = \frac{10 - 0.7}{430 \times 10^3} = 22\,\mu A$$

$$I_C = \beta \cdot I_B = 4.326\,mA$$

$$V_{CE} = 10 - (4.326 \times 10^{-3})(1.5 \times 10^3) = 3.512\,V \approx 3.5\,V$$

B)

$$\text{Percentage Change} \rightarrow \frac{\text{New Value} - \text{Old Value}}{\text{Old Value}} \times 100$$

$$I_C \rightarrow \frac{4.33\,mA - 3.24\,mA}{3.24\,mA} \times 100 \approx 33.64\%$$

$$V_{CE} \rightarrow \frac{5.14 - 3.5}{5.14} \times 100 = 31.91\%$$

c)

$$V_{eq} = 10 \cdot \frac{3.3k}{15k + 3.3k} = 1.80328\,V$$

$$R_{eq} = \frac{15k \cdot 3.3k}{15k + 3.3k} = 2.70492\,k\Omega$$

$$\text{Assume } V_{BE} = 0.7$$

$$\text{KVL:} \quad 1.8 - 2.7kI_B - V_{BE} - 200I_E = 0$$

$$I_E = I_B + I_C \quad \Rightarrow \quad I_E = I_B(1+\beta)$$

$$1.8 - 2.7kI_B - 0.7 - 200I_B(1+\beta) = 0$$

$$I_B = \frac{1.10328}{32.9k} = 33.529\,\mu A \approx 33.5\,\mu A$$

$$I_C = \beta I_B = 5.029\,mA \approx 5.03\,mA$$

$$I_E = I_B + I_C = 5.063\,mA$$

$$\text{KVL:} \quad 10 - 820I_C = V_{CE} - 200I_E = 0$$

$$V_{CE} = 10 - 820(5.03\,mA) - 200(5.063\,mA) = 4.8633\,V \approx 4.86\,V$$

$$I_B = 25.7\,\mu A$$

$$I_E = I_B + I_C = 5.169\,mA$$

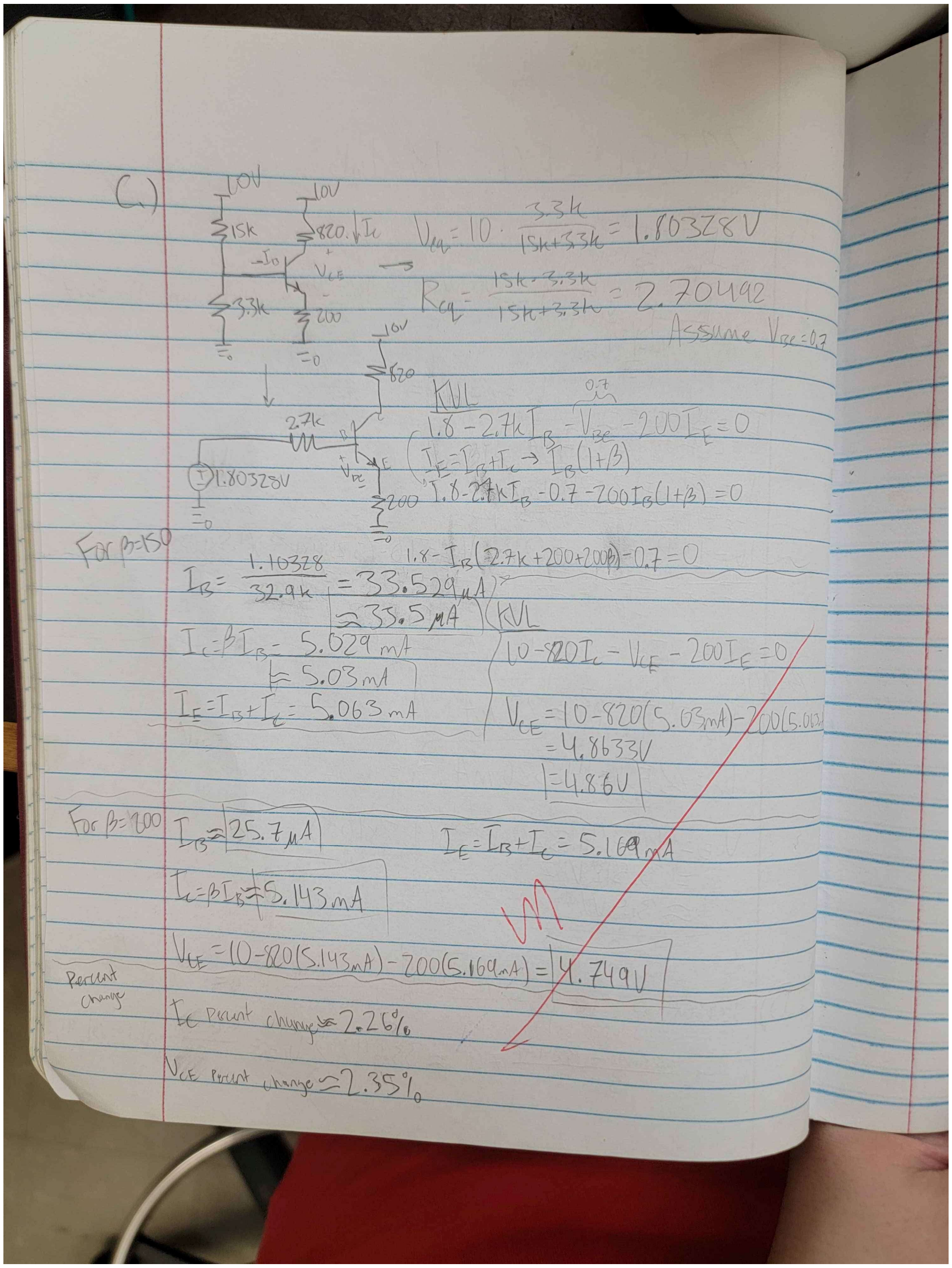
$$I_C = \beta I_B = 5.143\,mA$$

$$V_{CE} = 10 - 820(5.143\,mA) - 200(5.169\,mA) = 4.749\,V$$

$$I_C \text{ percent change} \approx 2.26\%$$

$$V_{CE} \text{ percent change} \approx 2.35\%$$

Proof of verified work:



(c.)

$V_{eq} = 10 \cdot \frac{3.3k}{15k+3.3k} = 1.80328V$

$R_{eq} = \frac{15k \cdot 3.3k}{15k+3.3k} = 2.70492$

Assume $V_{BE} = 0.7$

KVL

$1.8 - 2.7k I_B - \underbrace{V_{BE}}_{0.7} - 200 I_E = 0$

$(I_E = I_B + I_C \rightarrow I_B(1+\beta)$

$1.8 - 2.7k I_B - 0.7 - 200 I_B(1+\beta) = 0$

$1.8 - I_B(2.7k + 200 + 200\beta) - 0.7 = 0$

For $\beta = 150$

$I_B = \frac{1.10328}{32.9k} = 33.529 \mu A$

$\boxed{\approx 33.5 \mu A}$

$I_C = \beta I_B = 5.029 mA$

$\boxed{\approx 5.03 mA}$

$I_E = I_B + I_C = 5.063 mA$

KVL

$10 - 820 I_C - V_{CE} - 200 I_E = 0$

$V_{CE} = 10 - 820(5.03mA) - 200(5.063...$

$= 4.8633V$

$\boxed{= 4.86V}$

For $\beta = 200$ $I_B \approx \boxed{25.7 \mu A}$ $I_E = I_B + I_C = 5.169 mA$

$I_C = \beta I_B \approx \boxed{5.143 mA}$

$V_{CE} = 10 - 820(5.143mA) - 200(5.169mA) = \boxed{4.749V}$

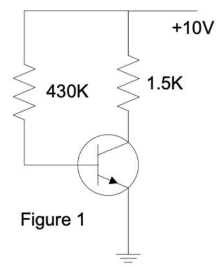
Percent change

I_C Percent change $\approx 2.26\%$

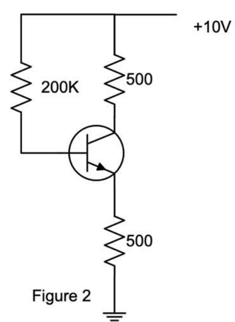
V_{CE} Percent change $\approx 2.35\%$

Lab Report:

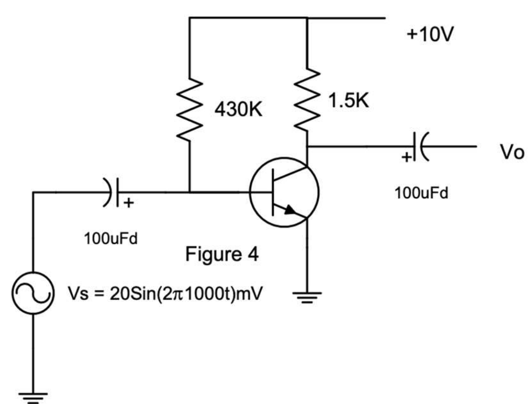
1. ***Figure 1:***



2. ***Figure 2:***



3. ***Figure 3:***



Data tables:

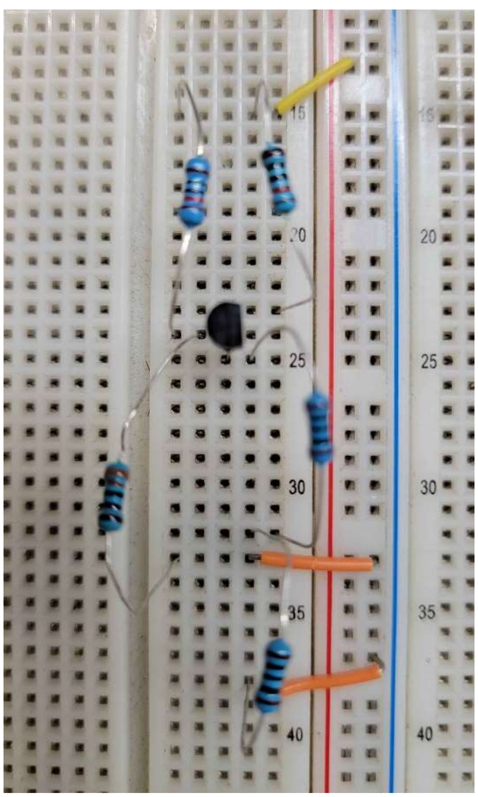
Q1=3904
Q2=2222

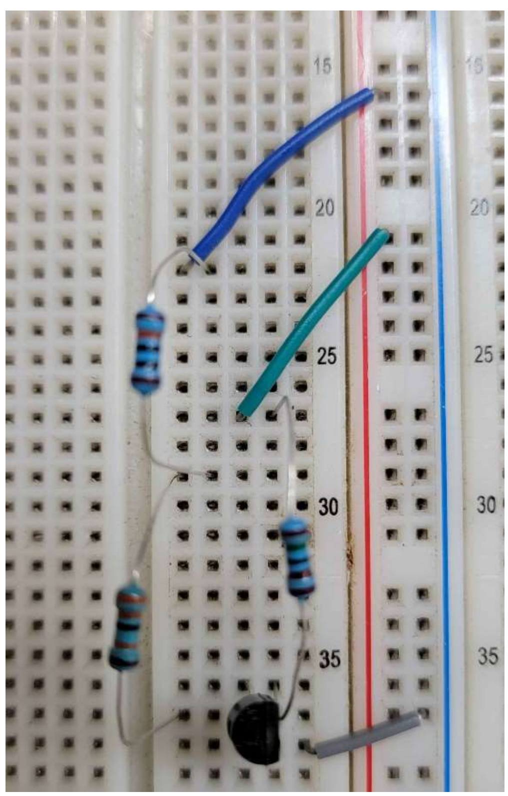
Figure1	Vb	Vc		Ic(mA)	Ib(mA)	Beta
Q1	0.72	4.74E+00		3.51E+00	0.021581	1.62E+02
Q2	0.67	1.88E+00		5.41E+00	0.021698	2.49E+02

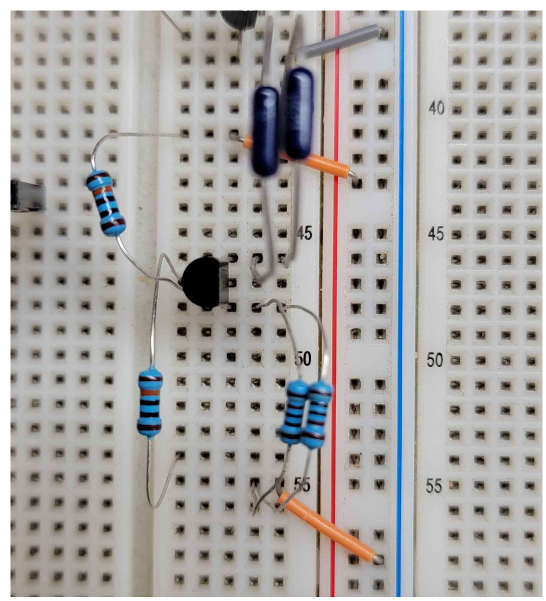
Figure2	Vb	Vc	Ve	Ic(mA)	Ib(uA)	Beta
Q1	3.44	7.25	2.75	5.5	50.94	1.08E-01
Q2	4.28	6.35	3.64	7.3	43.62	1.67E-01

Figure3	Vb	Vc	Ve	Ic(mA)	Ib(uA)	Beta
Q1	1.74	5.80E+00	1.04	5.12E+00	32.63	1.57E-01
Q2	1.76	5.48	1.115	5.51E+00	28.3	1.95E-01

Constructed circuits:







Conclusion:

In this Experiment, we build the three circuits physically in the lab. Each circuit had different number of resistors to see which one will give us the most stability regardless of the value of β. In the last figure, we created an AC Amplifier using a BJT and 4 resistors, and 2 coupling capacitors. We also plotted $V_{in}\ and\ V_{out}\ vs\ time$, as well as $V_s\ and\ V_{in}\ vs\ time$ on the oscilloscope to calculate the gain.

Post Lab:

1. For the circuits in Figures 1, 2 and 3, calculate and tabulate Ic, Ib and Beta for two different BJT's. → Done in the lab report chart
2. Compare the measurements for Vbe, Vce, Ic and Ib (in Figure 3) to the simulation results from prelab of experiment 5 (the same circuit).

After Implementing the above figure on the breadboard, we got:

$V_{BE} = 0.7V$

$V_E = 1.08V$

$V_c = 5.5\ V$

$$I_{15K} \approx 10I_B = \frac{V_{CC} - V_B}{15k\Omega} = \frac{10 - 1.7}{15k} = 5.53\ \times 10^{-4}\ A = 0.55\ mA$$

- $I_B = 55.3\ \mu A$
- $I_c = \frac{V_{CC} - V_C}{820\Omega} = \frac{10-\ \ .5}{820} = 5.49\ mA$
- $I_E = \frac{1.08V}{200\Omega} = \ 5.4mA$
- $I_C \approx I_E$