Başkent University
Department of Electrical and Electronics Engineering
EEM 214 Electronics I
Experiment 8

BJT BIASING

Aim:

The aim of this experiment is to examine the different methods of setting the D.C. operating point of a transistor which is usually referred to as the Q-point or quiescent operation point and determine the most effective configuration for providing bias ensuring good stability with respect to changes in the Beta (β) and understand how the change of β in a transistor circuit can change the Q-point of the circuit.

Theory:

In order to use a transistor in an amplifying circuit it has to be biased so the purpose of transistor biasing is to set the DC operating levels of transistor currents and voltages (i.e., I_B, I_C & I_E and V_B, V_C & V_E). For linear applications, the bias circuit is designed to ensure that the transistor remains in the active state over the range of input and output signals required. There are several methods which can be used bias a transistor.

An important issue in transistor biasing is bias stability. Typically the β of a transistor may vary significantly from transistor to transistor, plus it may vary with temperature for the same transistor. So the Q point has to be stabilized against β variations.

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Preliminary Work:

1) Review Section 5.12 from the textbook.

2) Explain why biasing is needed in transistor amplifier circuits.

3) **a.** For the circuit in Fig.1 obtain the equations for base current I_B, collector current I_C, collector emitter voltage V_{CE}.
b. For the β=200 calculate the values of the specified resistor R_B for the circuit in Fig.1 to give I_C = 6mA.
c. Using the calculated value of R_B, calculate the I_C for β=100 and β=300 .

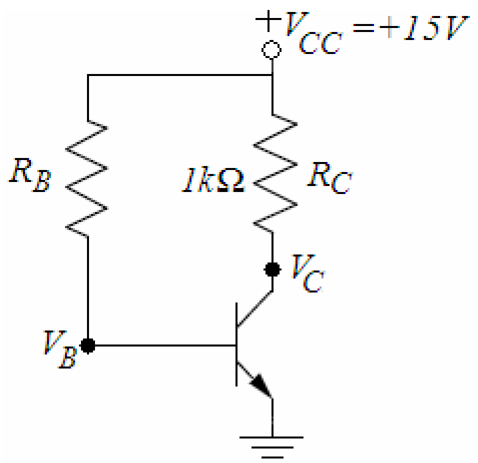

Figure_1

4) **a.** For the circuit in Fig.2 obtain the equations for base current I_B, collector current I_C, collector emitter voltage V_{CE}.
b. For the β=200 calculate the values of the specified resistor R_B for the circuit in Fig.2 to give I_C = 6 mA.
c. Using the calculated value of R_B, calculate the I_C for β=100 and β=300 .

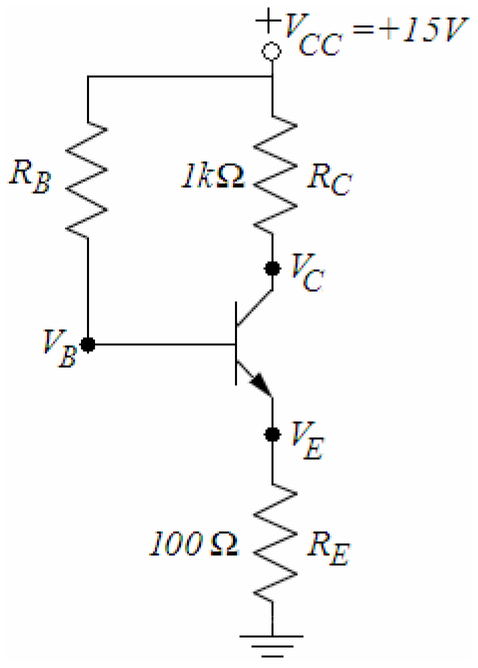

Figure_2

5) **a.** For the circuit in Fig.3 obtain the equations for base current I_B, collector current I_C, collector emitter voltage V_{CE}.

b. For the β=200 calculate the values of the specified resistor R_F for the circuit in Fig.3 to give $I_C = 6$ mA.

c. Using the calculated value of R_F, calculate the I_C for β=100 and β=300 .

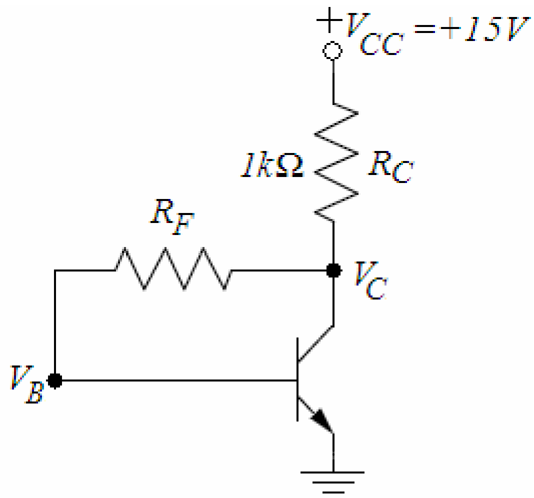

Figure_3

6) **a.** For the circuit in Fig.4 obtain the equations for base current I_B, collector current I_C, collector emitter voltage V_{CE}.

b. For the β=200 calculate the values of the specified resistor R_2 for the circuit in Fig.4 to give $I_C = 6$ mA.

c. Using the calculated value of R_2, calculate the I_C for β=100 and β=300.

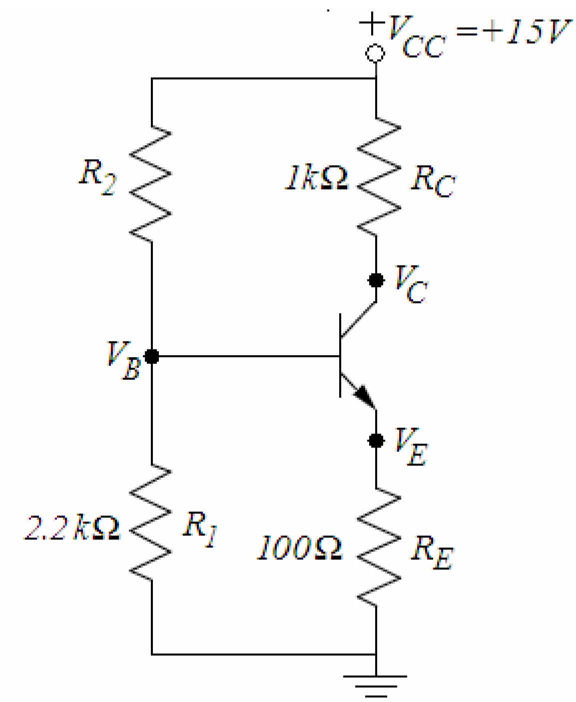

Figure_4

7) **a.** Calculate the range of variation of I_{CQ} for each circuit. Express this range as a percent of the value of I_{CQ} for the medium β transistor.

$$\% range = 100 * \frac{(I_{CQhigh} - I_{CQlow})}{I_{CQmedium}}$$

b. Rate the bias circuits in order from most stable (smallest variation in I_{CQ}) to the least stable.

8) Read the experimental work.

Experimental Work:

1) Measure and record the actual value of each of the resistor used in the circuit.

$1k\Omega=$ $100\Omega=$ $2.2k\Omega=$ $47k\Omega=$

2) Build circuit in Fig.1 with R_B = 470kΩ and use it to calculate the beta of each of the three transistors. This is done by first measuring the following **node** voltages: V_{CC}, V_C, and V_B. Then using the equations that you obtain at preliminary work Part1a, calculate I_C, I_B, and finally $\beta = I_C/I_B$. The three transistors should have widely different values of β, one below 100, one greater than 300, and one somewhere near the middle of the range. Record which transistor has the medium value of beta. This one will be used for designing the four bias circuits to be used in the rest of the experiment. The Pin Diagram of the BC238B is in Fig.5a, the Pin Diagram of 2N3904 and 2N3903 are in Fig.5b.

	V_{CC}	$V_{C\ measured}$	$V_{B\ measured}$	$\beta_{\ calculated}$
2N3903	15 V			
2N3904	15 V			
BC238B	15 V			

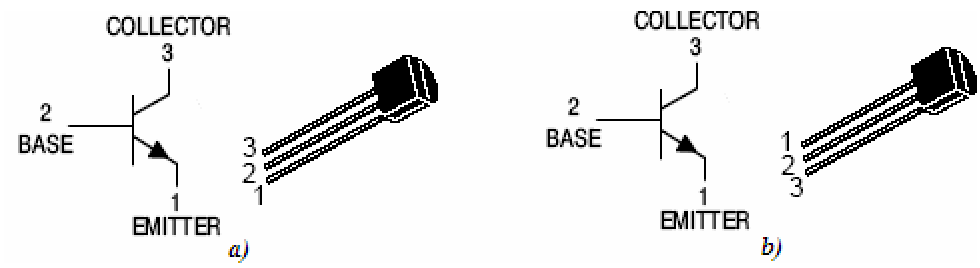

figure_5

3) Using the medium value of β found in Part2 calculate the values of the specified resistor for each of the four circuits shown below to give I_C = 6mA. First calculate the required value of $I_B=I_C/\beta$=6mA/β. Then calculate the required resistors to supply this base current in each of the four circuits as follows(assume V_{BE}=0.65):

a. In circuit Fig.1. $R_B = (V_{CC} - V_{BE})/I_B$.

b. In circuit Fig.2. $R_B = (V_{CC} - V_{BE} - I_C R_E)/I_B$, using I_C = 6mA.

c. In circuit Fig.3. $R_F = (V_{CE} - V_{BE})/I_B$. Note: in this circuit $V_{CE} = V_C$ since $V_E = 0$ and $V_C = V_{CC} - I_C R_C$, using I_C = 6mA.

d. In circuit Fig.4. $R_2 = (V_{CC} - V_{BE} - I_C R_E)/(I_{R1} + I_B)$ where $I_{R1} = V_B/R_1 = (V_{BE} + I_C R_E)/R_1$, and again using I_C = 6mA.

4) Do followings for each circuit;

a. Use your calculated(calculated in Part3) resistor and build the circuit with the **medium beta transistor**.

b. Measure and record V_C in the circuit. Calculate I_{CQ} by dividing $V_{RC} = V_{CC} - V_C$ by the measured value of R_C, if necessary adjust your bias resistor value until V_C is in the range 9V ± 0.5V. What value of I_{CQ} will this give?

c. Then turn off the power to the circuit and replace the transistor with the low beta transistor. Measure and record the V_C in the circuit and calculate I_{CQ} by dividing $V_{RC} = V_{CC} - V_C$ by the measured value of R_C. Repeat with the high beta transistor.

		$V_{C\ measured}$	$I_{CQ\ calculated}$
Circuit in Fig.1	**Low β**		
	Medium β		
	High β		
Circuit in Fig.2	**Low β**		
	Medium β		
	High β		
Circuit in Fig.3	**Low β**		
	Medium β		
	High β		
Circuit in Fig.4	**Low β**		
	Medium β		
	High β		

5) **a.** Calculate the range of variation of I_{CQ} for each circuit by the same method in preliminary work.

b. Rate the bias circuits in order from most stable (smallest variation in I_{CQ}) to the least stable. Discuss qualitatively (in words) and quantitatively (with range of variation), how the Q point varies with β using a biasing scheme.

c. Is there any difference between theoretical and experimental order? Why?

6) What effect does adding an emitter resistor to the small-signal bias circuit have on the bias stability? What should be the value of emitter resistor to make collector current less dependent on β.

Lab Instruments:	**Components:**	
Breadboard Multimeter DC Power Supply	1 500k Pot 1 1kΩ 1 100Ω 1 2.2kΩ	1 2N3903 1 2N3904 1 BC238B

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Experiment Results

	V_{CC}	$V_{C\ measured}$	$V_{B\ measured}$	β $_{calculated}$
2N3903	15 V			
2N3904	15 V			
BC238B	15 V			

		$V_{C\ measured}$	$I_{CQ\ calculated}$
Circuit in Fig.1	Low β		
	Medium β		
	High β		
Circuit in Fig.2	Low β		
	Medium β		
	High β		
Circuit in Fig.3	Low β		
	Medium β		
	High β		
Circuit in Fig.4	Low β		
	Medium β		
	High β		

Student Name :

Number :

Signature…………………………………