American International University- Bangladesh
Department of Electrical and Electronic Engineering
EEE2104: Electronic Devices Laboratory

A. Title: Study of BJT Biasing Circuit

B. Abstract:

The operating point (Q) of BJT is very important for amplifiers, since a wrong 'Q' point selection increases amplifier distortion. It is imperative to have a stable 'Q' point, meaning that the operating point should not be sensitive to variation to temperature or BJT β, which can vary widely. In this experiment, four different circuits will be analyzed for two different β to check the stability of biasing points.
The analysis of the BJT circuits is a systematic process. Initially, the operating point of a transistor circuit is determined then the small signal BJT model parameters are calculated. Finally, the dc sources are eliminated, the BJT is replaced with an equivalent circuit model and the resulting circuit is analyzed to determine the voltage amplification (A_V), current amplification (A_i), Input impedance (Z_i), Output Impedance (Zo), and the phase relation between the input voltage (Vi) and the output voltage (Vo).
The experiment is a very good practical realization of bipolar junction transistor (BJT) biasing circuit.A BJT biasing circuit will be designed and simulated to find DC operation point using a circuit simulation tool. Then a fixed-biasing and a self-biasing BJT circuits will be implemented on the trainer board to find DC operation point for two different β of the transistor.

C. Introduction:

The main objectives of this experiment are to-

1. Establish the proper operating point
2. Study the stability of the operating point with respect to changing β in different biasing circuits

D. Theory and Methodology:

The dc analysis is done to determine the mode of operation of the BJT and todetermine the voltages at all nodes and currents in all branches. The operatingpoint of a transistor circuit can be determined by mathematical or graphical (usingtransistor characteristic curves) means. Here we will describe only the mathematicalsolution.

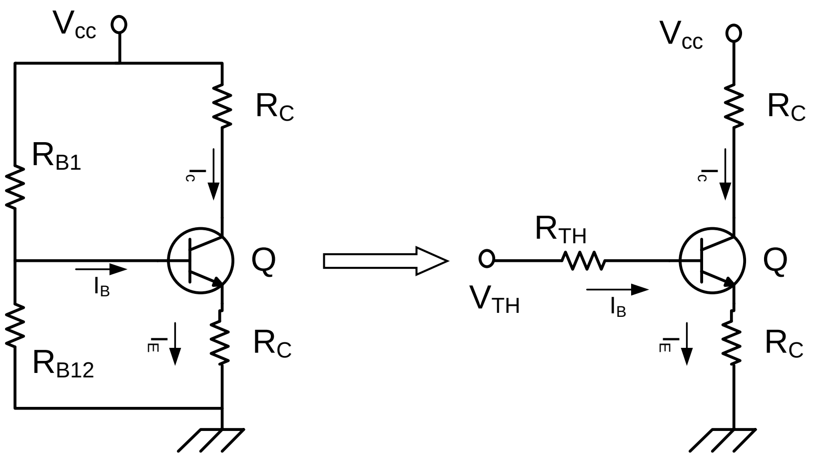


Fig 1: Biasing Circuit

We will use the most commonly applied biasing circuit to operate the BJT as an amplifier. A single power supply is used and the voltage divider networkconsisting of R_{B1} and R_{B2} is used to adjust the base voltage. Using the Theveninequivalent, the voltage divider network isreplaced by V_{th} and R_{th} where,

$$V_{th} = \frac{R_{B2}}{R_{B1}+R_{B2}} V_{CC} \qquad \text{and} \qquad R_{th} = \frac{R_{B1}R_{B2}}{R_{B1}+R_{B2}}$$

The dc analysis of the circuit is simple by applying two KVL's at the input and theoutput loop.

$$V_{th} = I_B R_{th} + R_{BE} + I_E R_E = I_B(R_{th} + (\beta + 1)R_E) + V_{BE}$$
$$V_{CC} = I_C R_C + V_{CE} + I_E R_E = I_C\left(R_C + \frac{R_{B2}}{\alpha}\right) + V_{CE}$$
$$I_B = \frac{V_B - V_{BE}}{R_B + (1+\beta)R_E}$$
$$I_{CQ} = \beta I_B$$
$$I_{EQ} = (1+\beta)I_B$$
$$V_{CEQ} = V_{CC} - I_C R_C - I_E R_E$$

If the BJT is in the active mode the following typical values can be observed:

$$V_{BE} \approx 0.7\ V \text{and } I_C \approx \beta I_B$$

R_C is used to adjust the collector voltage. Finally, R_E is used to stabilize the dcbiasing point (operating point). Using the above equations, the stability of biasing points for different transistor of β can be calculated.

Note: It is a good idea to set the bias for a single stage amplifier to half thesupply voltage, as this allows maximum output voltage swing in both directions ofan output waveform. For maximum symmetrical swing, it is clear from the figuresthat V_{CE} should be $V_{CE}= V_{CC}/2$.

E. Pre-Lab Homework:

Implement the biasing circuits using Multisim. Fill up the table which is given in the experimental procedure section using the simulation tool.

F. Apparatus:

1)	Trainer Board	:		[1pc]
2)	Transistor	:	C828(NPN)	[1pc]
			BD135(NPN)	[1pc]
3)	Resistors	:	R=22KΩ	[1pc]
			R_C= 470Ω	[1pc]
			R_{B1} = 10KΩ	[1pc]
			R_E = 560Ω	[1pc]
			R_B=500K(Potentiometer)	
4)	DC Power Supply (V_{CC} = +15V DC)			
5)	Multimeter			
6)	Power Supply Cable	:		[1pc]

G. Precautions:

Transistors are sensitive to be damaged by electrical overloads, heat, humidity, andradiation. Damage of this nature often occurs by applying the incorrect polarityvoltage to the collector circuit or excessive voltage to the input circuit. One of themost frequent causes of damage to a transistor is the electrostatic discharge fromthe human body when the device is handled. The applied voltage, current should not exceed the maximum rating of the given transistor.

H. Experimental Procedure:

1. Measure the value of R_c by using multimeter and record.
2. Measure the value of β for each transistor by using multimeter.
3. Construct the fixed bias circuit with transistors as shown in fig. 1(a).
4. Set V_{CC} = 15 V and adjust 500K potentiometer until V_{CE} is approximately equal to $V_{CC}/2$.

5. Measure V_{CE}, V_{BE} and V_{RC} then calculate I_C from V_{RC} and R_C. I_B also calculates from I_c.
6. Now replace the first transistor by second one (Different β) and repeat the step 5.
7. Construct the emitter bias circuit shown in fig. 1 (b) and repeat step 4, 5, 6.
8. Construct the voltage divider circuit shown in fig. 1(c) and repeat step 4, 5, 6.

I. Circuit Diagrams:

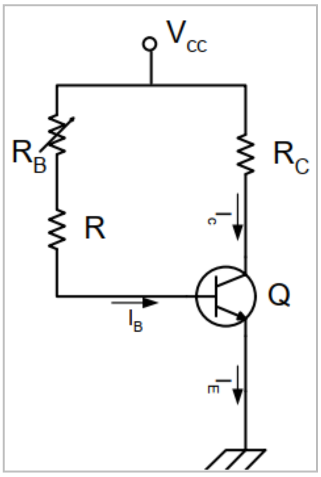


Figure 1(a)

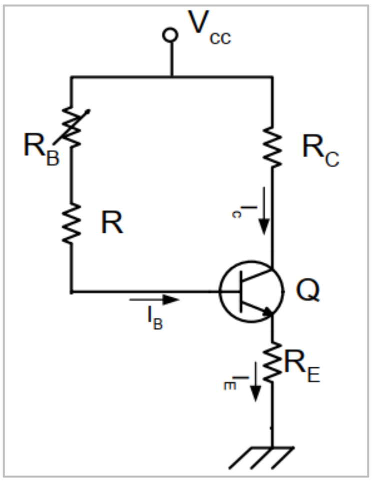


Figure 1(b)

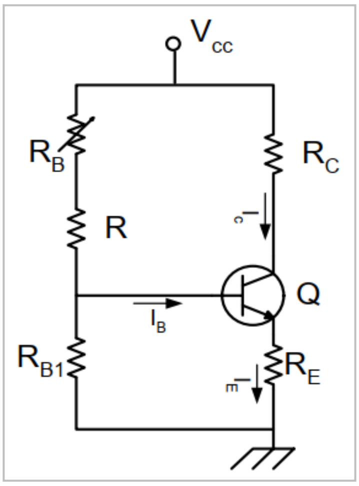
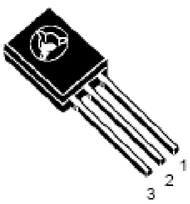


Figure 1(c)



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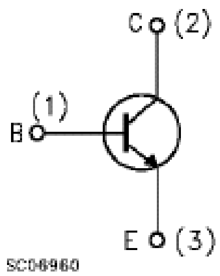
INTERNAL SCHEMATIC DIAGRAM



J. Data Table:

	β	**V_{CE}**	**V_{BE}**	**V_{RC}**	**I_C**	**I_B**
Figure 1(a)						
% of change						
Figure 1(b)						
% of change						
Figure 1(c)						
% of change						

K. Simulation and Measurement:

Compare the simulation results with your experimental data/ wave shapes and comment on the differences (if any).

L. Questions for report writing:

1. Why biasing is necessary?
2. Compare the circuits of Fig. 1(a) and 1(b) with respect to stability against variation in β.
3. Compare the circuits of Fig. 2(a) and 2(b) with respect to stability against variation in β.
4. Compare the stability of fixed bias circuits with that of self-bias circuits.
5. What do you mean by stability and Q-point?

M. Discussion:

Interpret the data/findings and determine the extent to which the experiment was successful in complying with the goal that was initially set.

N. Conclusion:

Discuss what you have learned about biasing circuits from this lab.

O. Reference(s):

[1] American International University–Bangladesh (AIUB) Electronic Devices Lab Manual.
[2] A.S. Sedra, K.C. Smith, Microelectronic Circuits, Oxford University Press (1998)
[3] J. Keown, ORCAD PSpice and Circuit Analysis, Prentice Hall Press (2001)
[4] P. Horowitz, W. Hill, The Art of Electronics, Cambridge University Press (1989).