Alexandria University
Faculty of Engineering
Electrical Engineering Department

ECE 336: Semiconductor Devices
Lab 3: Bipolar Junction Transistor

Objectives

The purpose of this exercise is to analyze the properties of the bipolar junction transistor, understand the effect of each of the model parameters discussed in the exercise.
By the end of this exercise you should be able to:

1. The effect of Is on the turn on voltage of the BJT
2. The effect of BF on the performance of the transistor as an amplifier.
3. The effect of the VA on the BJT performance as an amplifier.
4. The effect of the parasitic capacitance on the amplifier circuit

Requirements and Deliverables

In this exercise you are required to use the BJT to obtain its characteristic curves, and use it on an amplifier circuit, explain the results based on the initial conclusions.

You should deliver a technical report containing the following sections:

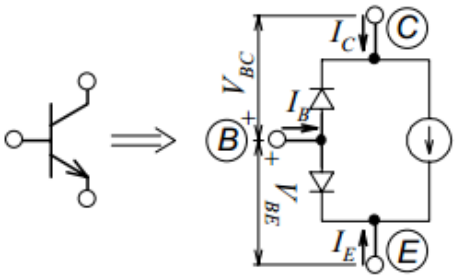
- A brief survey on the difference between the Ebers Moll model and the Gummel-poon model .
- Procedures: A description and snapshots of the lab procedures taken from your PC,
- Results: Numerical and graphical simulation results as requested
- Comments: Your conclusion about the results and your answers for the assignment questions.

BJT Device Model

EBERS-MOLL PARAMETERS				
Symbol	**Usual SPICE Keyword**	**Parameter Name**	**Typical Value**	**Unit**
I_{S0}	IS	Saturation current	10^{-16}	A
β_F	BF	Normal c.e. current gain	150	-
β_R	BR	Inverse c.e. current gain	5	-
V_A	VA	Normal Early voltage	> 50	V
V_B	VB	Inverse Early voltage		V

EBERS-MOLL MODEL

NPN BJT

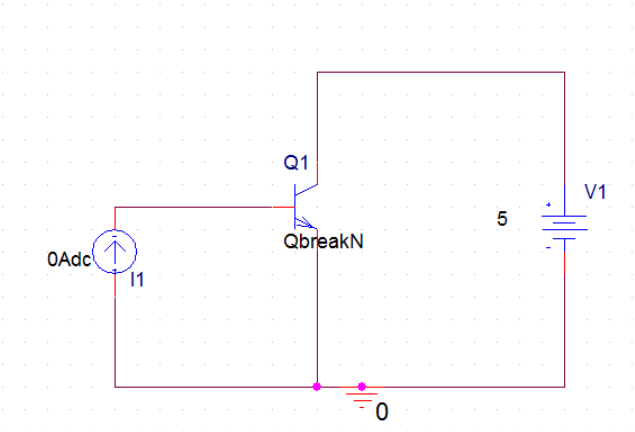


$$I_S = \mathrm{IS}\left(1 - \frac{V_{BC}}{\mathrm{VA}} - \frac{V_{BE}}{\mathrm{VB}}\right)$$

$$\begin{aligned}
I_C &= I_S\ (e^{V_{BE}/V_t} - 1) - \left(1 + \tfrac{1}{\mathrm{BR}}\right) I_S\ (e^{V_{BC}/V_t} - 1) \\
I_E &= -\left(1 + \tfrac{1}{\mathrm{BF}}\right) I_S\ (e^{V_{BE}/V_t} - 1) + I_S\ (e^{V_{BC}/V_t} - 1) \\
I_B &= \tfrac{1}{\mathrm{BF}} I_S\ (e^{V_{BE}/V_t} - 1) + \tfrac{1}{\mathrm{BR}} I_S\ (e^{V_{BC}/V_t} - 1)
\end{aligned}$$

Procedures:

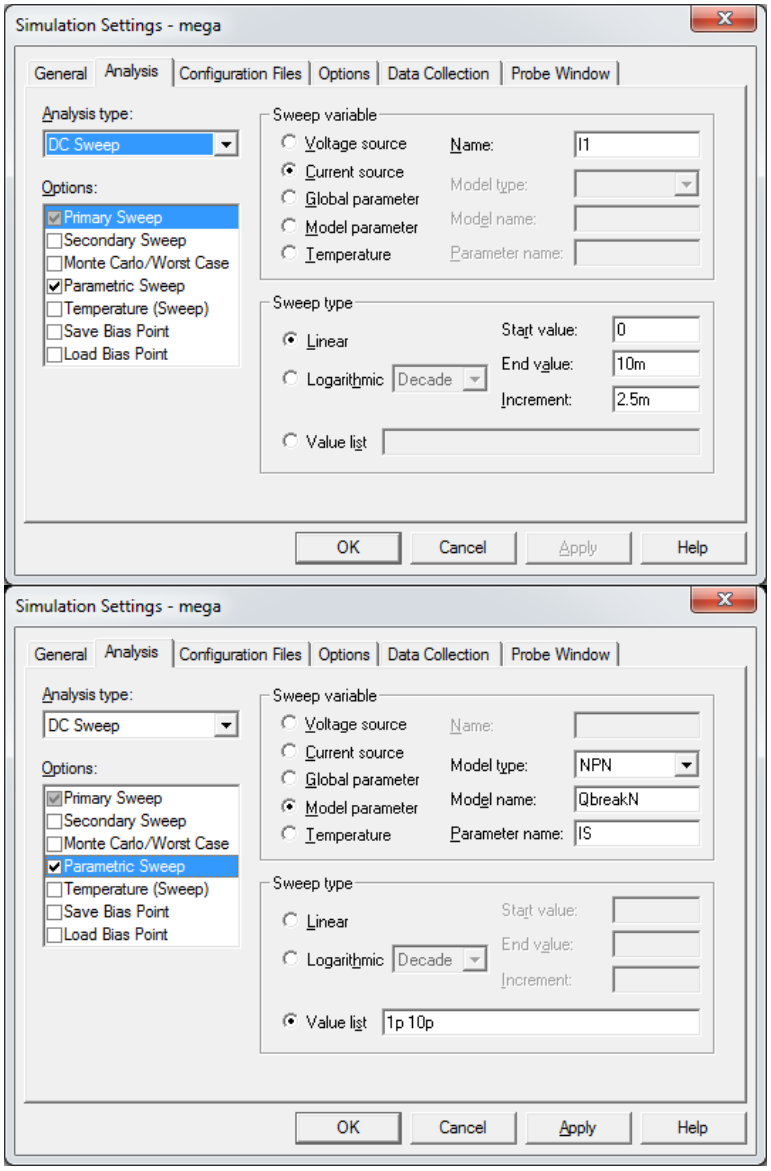
1- Connect the circuit as shown in the figure below, using QBREAKN device from the BREAKOUT library.



2- Place a current probe on the collector of the BJT.

3- Create a simulation profile using DC sweep + parametric analysis with the following settings, we are doing this to change the Is parameter for of

the BJT.



4- Is there a change between the two curves, why ? What does the slope of the curve represent ?

5- Cancel the parametric sweep.

6- Edit pspice model with Is = 1p.

7- Run DC sweep, on the plot, choose Plot >> Axis settings >> X axis >> choose V(I1: -).

8- Record the turn on voltage , What does the slope of the curve represent ?

9- Repeat the previous steps for Is = 10p , record the turn on voltage, explain the change.

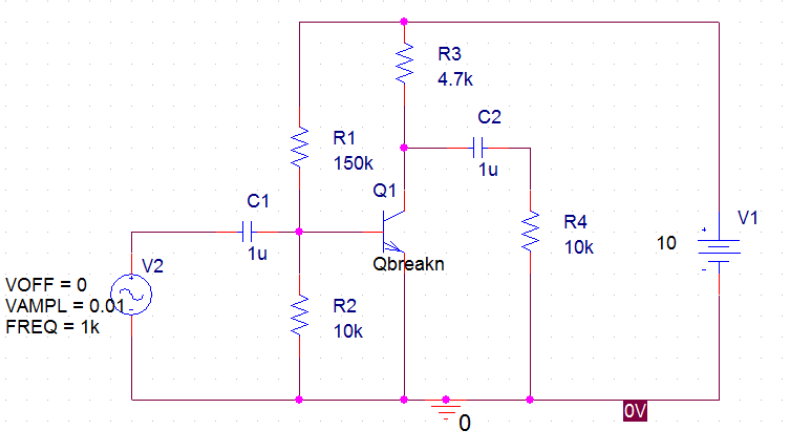
10- Repeat steps 3 and 4 but with the parameter BF= 100 and 200. Comment on the results.

11- Repeat the steps 5 till 9 with BF = 100 and BF = 200, comment.

12- Using the same circuit, make the primary sweep on the voltage source and the parametric on the current source with BF = 100.

13- Repeat the step for BF = 200, comment on the results.

14- Connect the circuit as shown in the following figure:



15- For Is = 1pA and BF = 100, run transient simulation (you have to figure out the setup yourself) and plot the output, then change BF to 200 and explain the reason for the change in the results.

16- Replace the sine source with an AC source.

17- Run AC sweep from 10Hz to 10GHz + parametric sweep with VA = 1000V and VA = 20V.

18- An empty plot should appear, to plot the gain, choose **add trace** , then write the expression V(R4:2)/V(C1:1) (It can change according to the schematic).

19- Explain the change in the gain due to the change in VA, also explain the change in the gain with the frequence.

20- Repeat the previous steps with the following new parameters (without the parametric sweep):
CJE = 3pF , VJE = 0.85V , MJE = 0.45, CJC= 3pF , VJC = 0.7V , MJC = 0.35), explain the results.