

## **SIMULATION HOMEWORK 4: BIPOLAR JUNCTION TRANSISTOR (BJT) CHARACTERISTICS**

### **Objectives**

The objective of this experiment is to obtain DC characteristics of BJT transistor and to learn the operation of bipolar transistors practically.

### **Components Required:**

DC Voltage Source

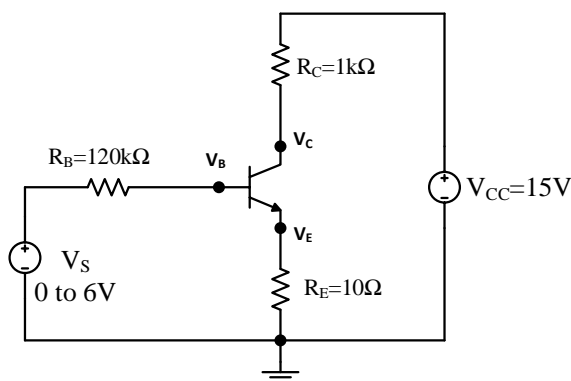
**Transistor:** Q2N3904 transistor

**Resistors:** 120k $\Omega$ , 1k $\Omega$ , 10 $\Omega$

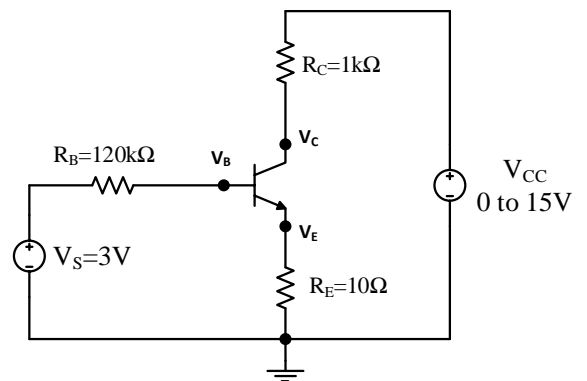
### **Preliminary Work:**

1. Find and examine the datasheet of the 2N3904 transistor on the Internet.
2. Research how to extract and use the transistor's transfer and output characteristics. Give brief information about this.
3. Identify the operating regions of a BJT transistor. How are the operating regions determined? Explain.
4. What are the signs (positive or negative) of  $I_E$ ,  $I_C$ ,  $I_B$ ,  $V_{CB}$  and  $V_{EB}$  for a PNP transistor operating in the active area?
5. What are the signs (positive or negative) of  $I_E$ ,  $I_C$ ,  $I_B$ ,  $V_{CB}$  and  $V_{EB}$  for an NPN transistor operating in the active area?
6. An NPN - BJT is used as a switch. Write the necessary conditions for BJT to be operated in saturation or in cut-off.
7. Setup the circuit given in Figure 1 in OrCAD. Use Q2N3904 transistor model. Plot input characteristic of the transistor ( $V_{BE}$ – $I_B$ ). You can select the analysis type as 'DC Sweep' and options as 'Primary Sweep'. Sweep input voltage ( $V_{BB}$ ) from 0 to 6V in steps of 0.1V. Specify critical points on the plot and comment about your simulation result.
8. Setup the circuit given in Figure 2 in OrCAD. Use Q2N3904 transistor model. Plot output characteristic of the transistor ( $V_{CE}$ – $I_C$ ). You can select the analysis type as 'DC Sweep' and options just as 'Primary Sweep'. Sweep input voltage ( $V_{CC}$ ) from 0 to 15V in steps of 1V. Specify critical points on the plot and comment about your simulation result.

9. Setup the circuit given in Figure 2 in OrCAD. Use Q2N3904 transistor model. Plot output characteristic of the transistor ( $V_{CE}$ – $I_C$ ). You can select the analysis type as ‘DC Sweep’ and options as ‘Primary Sweep’ with ‘Secondary Sweep’. Primary Sweep input voltage ( $V_{CC}$ ) from 0 to 15V in steps of 1V. Secondary Sweep input voltage ( $V_{BB}$ ) from 0 to 3V in steps of 1V. What is the relationship between  $I_C$  and  $I_B$  according to result? What is the relationship between  $V_{CE}$  and  $I_C$  according to result? Specify critical points on the plot and comment about your simulation result.



**Figure 1**



**Figure 2**

**Note:**

You must add BIPOLAR.OLB library from the ‘Add Library’ menu to find the transistor.

You can use the steps (Plot -> Axis Settings -> Axis Variable) to select x-axes in the graph and use the steps (Trace-> Add Trace) to select y-axes variable.

