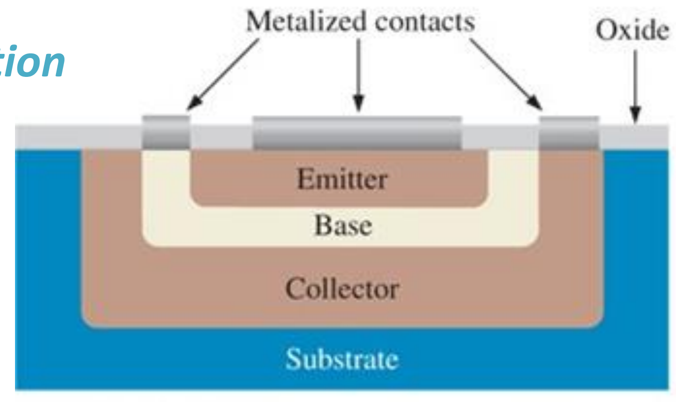
Last Lecture → BJTs - Chapter 6

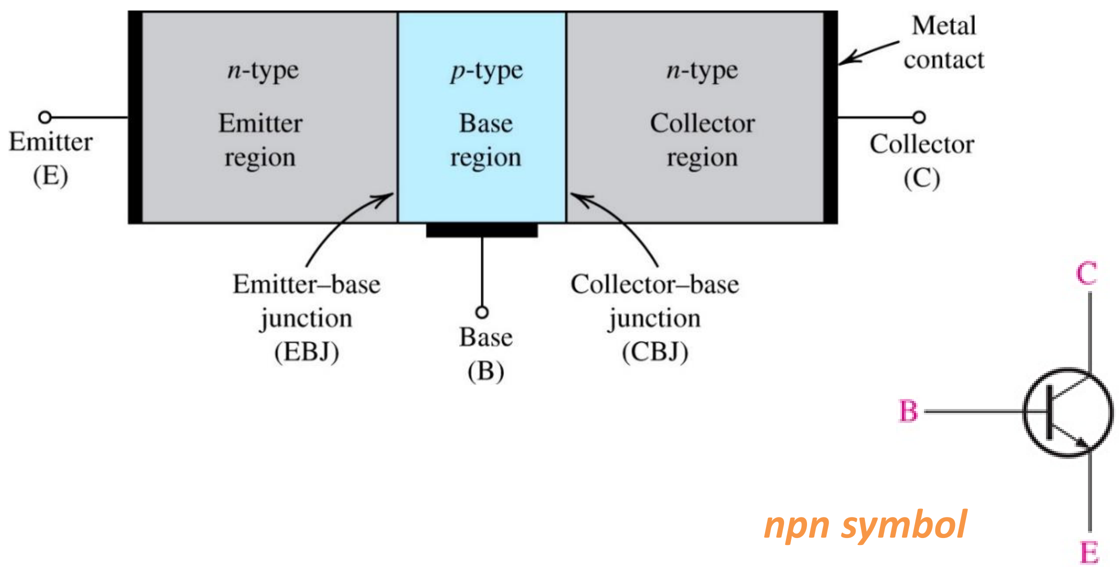
cross-section



- Two external voltage sources are required for biasing
- Three operation modes:

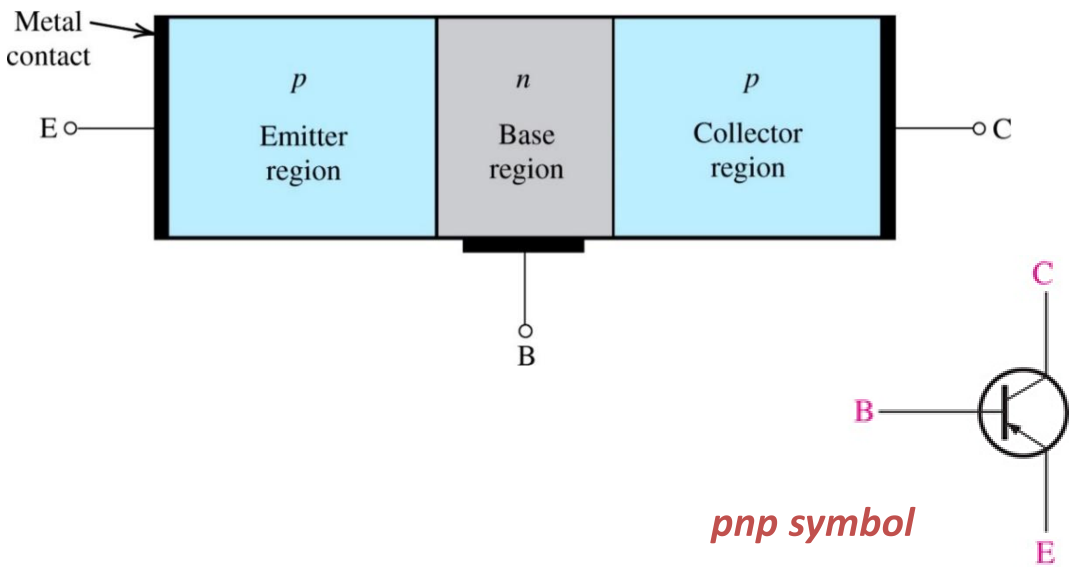
1) Cut-Off
2) Saturation — *used for switching!*
3) Active — *used for amplification!*

- Simplified structure of the *npn* transistor



npn symbol

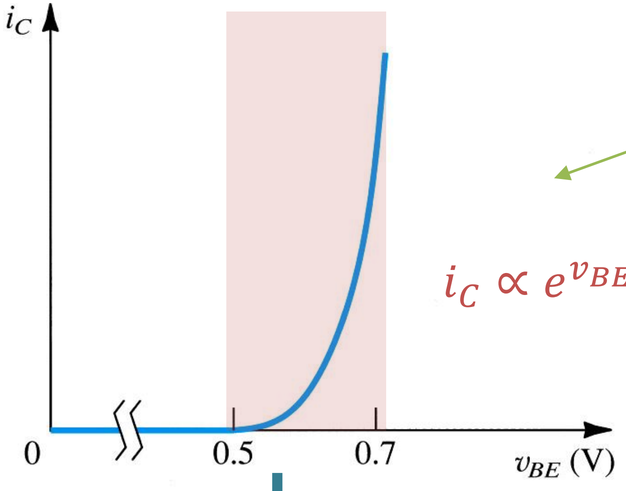
- Simplified structure of the *npn* transistor

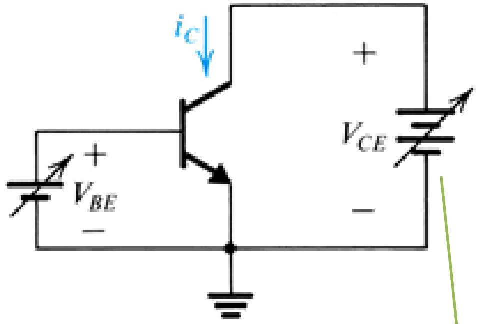


pnp symbol

Last Lecture → BJT (active)

- $i_C = f(v_{BE})$

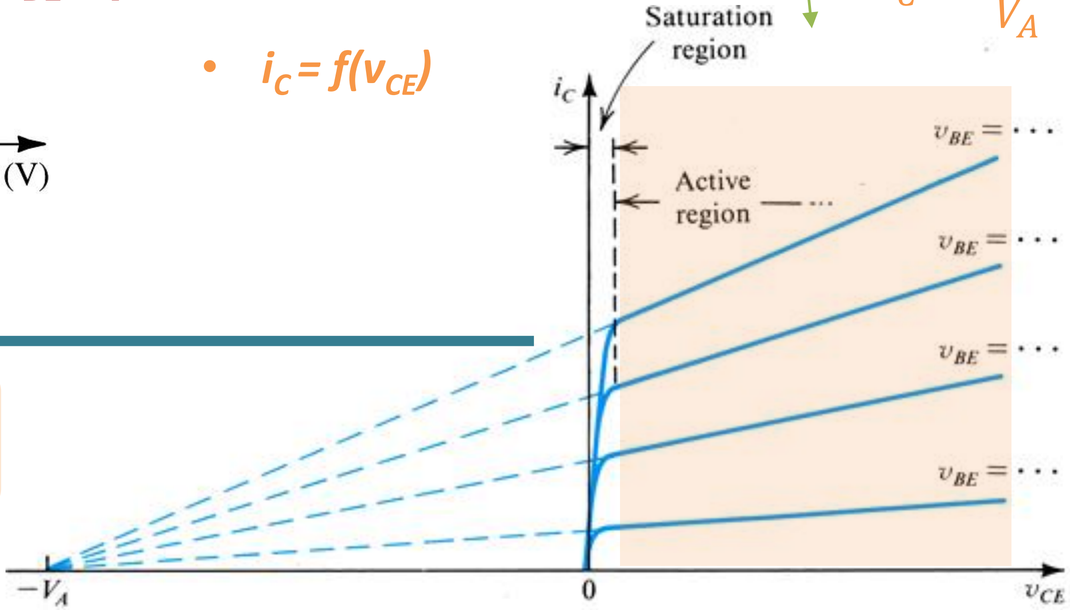




$i_C \propto e^{v_{BE}/V_T}$

- $i_C = f(v_{CE})$

$i_C \propto \frac{v_{CE}}{V_A}$

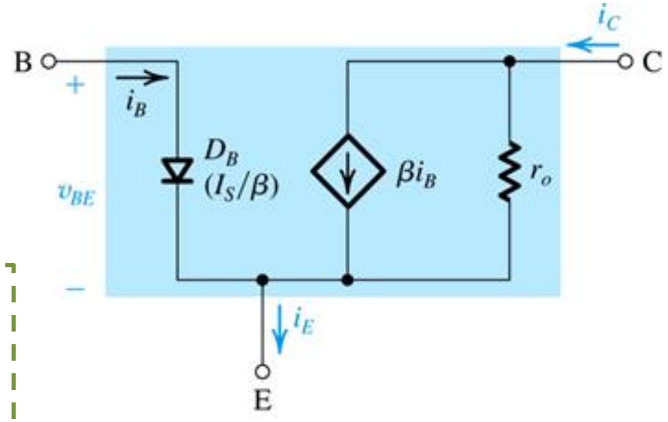


Collector Current

$$i_C = I_S e^{v_{BE}/V_T}\left(1 + \frac{v_{CE}}{V_A}\right)$$

$$\approx I_S e^{v_{BE}/V_T}$$

Large Signal Model



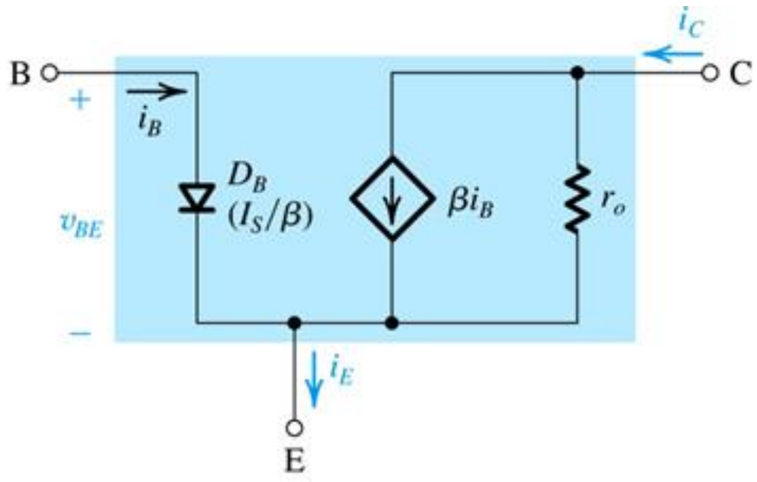
Base / Emitter Currents

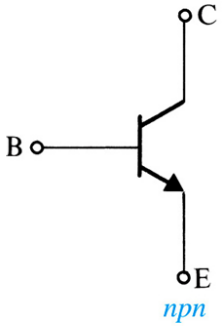
$$i_B = \frac{i_C}{\beta}$$

$$i_E = i_B + i_C = \frac{\beta + 1}{\beta} i_C = \frac{i_C}{\alpha}$$

Large Signal Model → Active-Mode

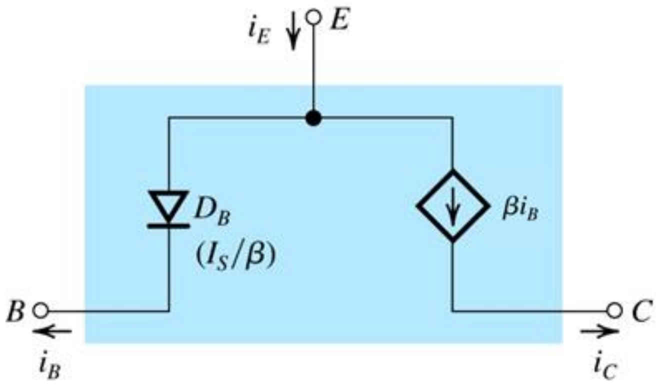
npn - transistor

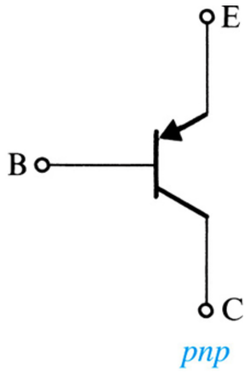




- BE Junction → forward bias
  - ✓ $v_{BE} > 0.5V$
- BC Junction → reverse bias
  - ✓ $v_{CE} > 0.3V$
- $i_C = f(v_{BE})$

pnp - transistor

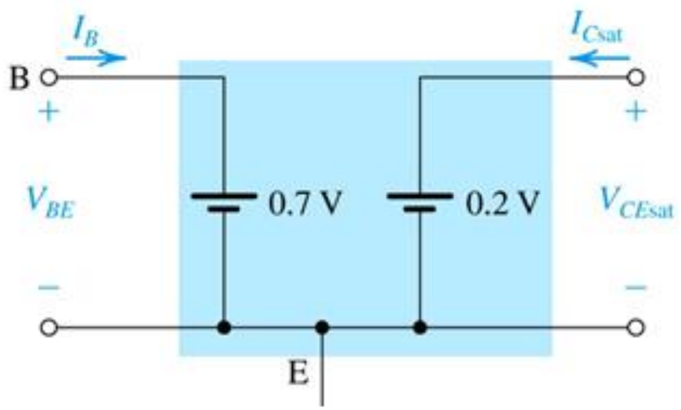


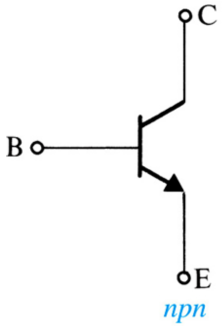


- EB Junction → forward bias
  - ✓ $v_{EB} > 0.5V$
- CB Junction → reverse bias
  - ✓ $v_{EC} > 0.3V$
- $i_C = f(v_{EB})$

Large Signal Model → Active-Mode

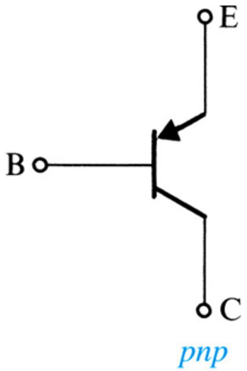
npn - transistor





- BE Junction → forward bias
  - ✓ $v_{BE} > 0.5V$
- BC Junction → reverse bias
  - ✓ $v_{CE} < 0.3V$
- $i_C \neq f(v_{BE})$
  - ✓ $i_C/i_B < \beta$

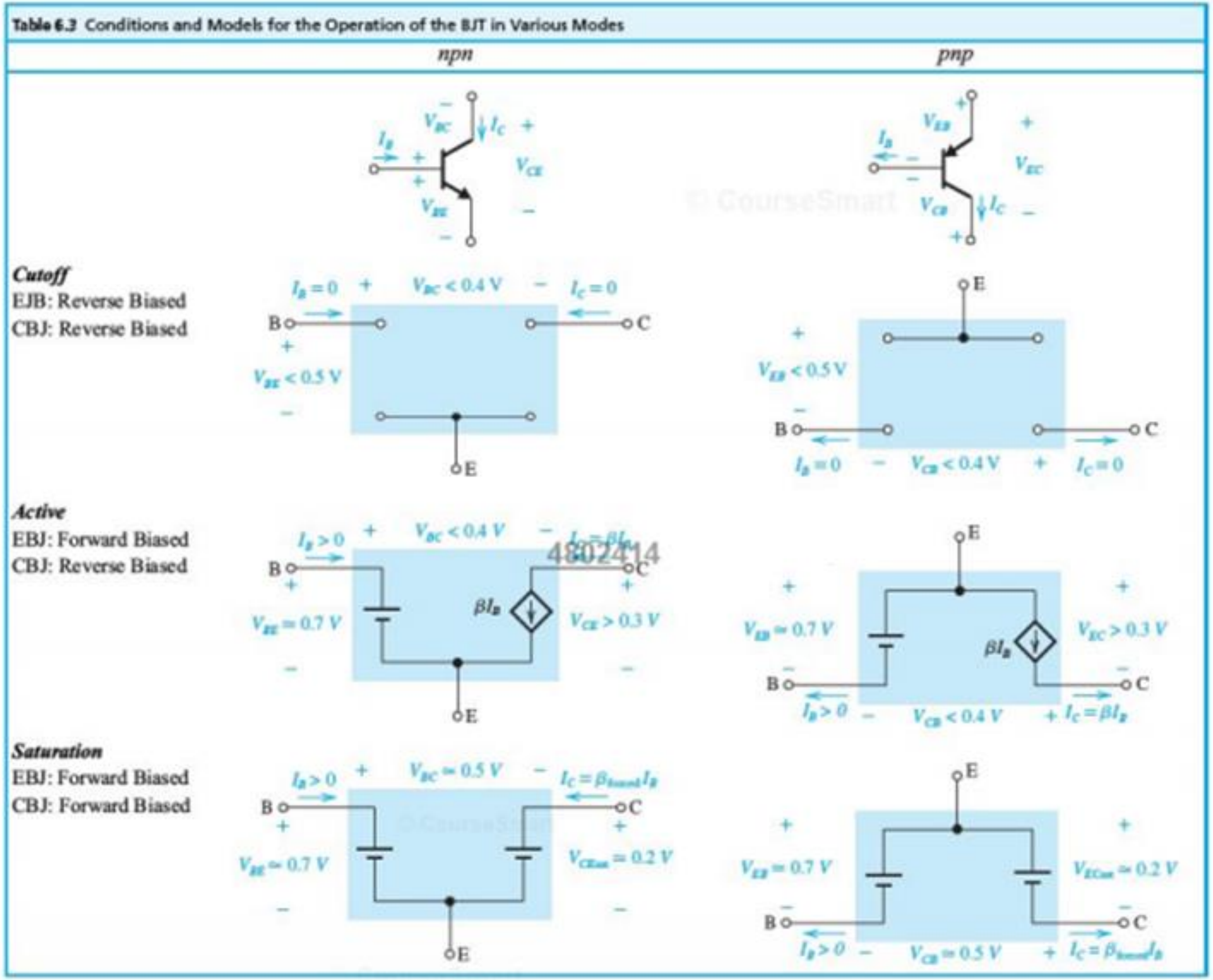
pnp - transistor



- EB Junction → forward bias
  - ✓ $v_{EB} > 0.5V$
- CB Junction → reverse bias
  - ✓ $v_{EC} < 0.3V$
- $i_C \neq f(v_{EB})$
  - ✓ $i_C/i_B < \beta$

Large Signal Models

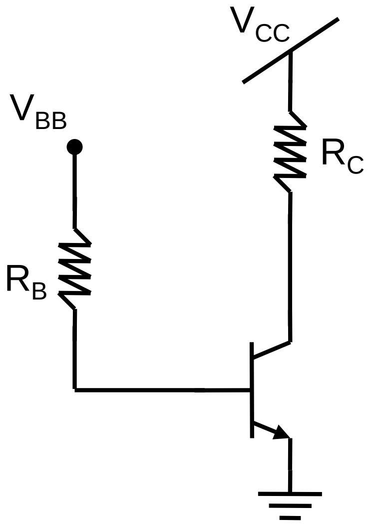
1) Cut-Off
2) Saturation
3) Active



Example 6.3

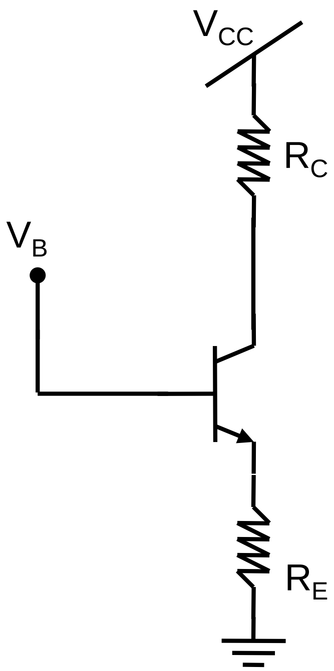
For the given circuit (R_B=10kΩ, R_C=1kΩ, V_{cc}=10V) assuming V_{BE} remains constant at 0.7V and transistor β is specified to be 50, it is required to determine the value of the voltage V_{BB} that results in the transistor operating

a) in the active mode with V_{CE}=5V
b) at the edge of saturation (V_{CEsat} = 0.3V)
c) deep in saturation (V_{CEsat} = 0.2V) with β_{forced}=10.



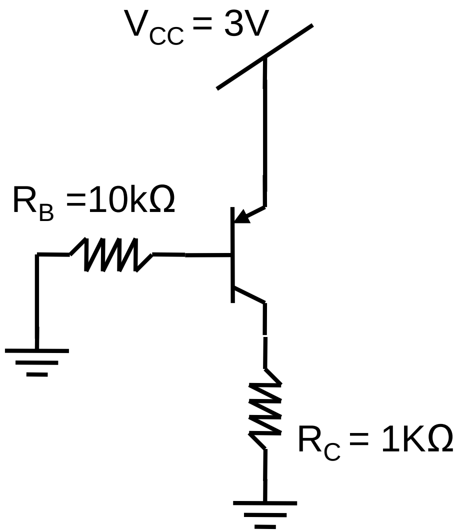
Example 6.5

For the given circuit (R_C=4.7kΩ, R_E=3.3kΩ, V_{cc}=10V, V_B=6V) determine the voltages at all nodes and the currents through all branches. Assume that the transistor β is specified to be at least 50 and V_{BE}=0.7V for all currents.



Problem 6.51

For the following circuit, assuming β=50 and V_{EB}=0.7V for all currents, determine the voltage V_c at the collector terminal. To what value should R_B be increased or decreased in order for the transistor to change operating modes.



Problem

For the following circuit determine the voltages at all nodes and the current through all branches assuming V_{BE}=0.7V, β=100, V_{dd} = -V_{ss} =5V, and V_B =5V.