Emitter voltage = -0.7 V, if β=50 find
$I_E$, $I_B$, $I_C$ and $V_C$

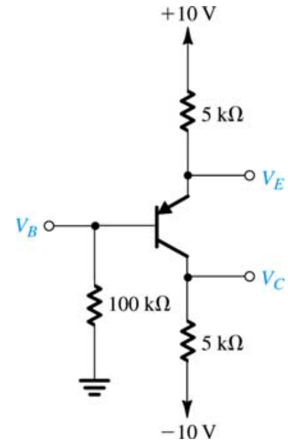


Figure E6.14

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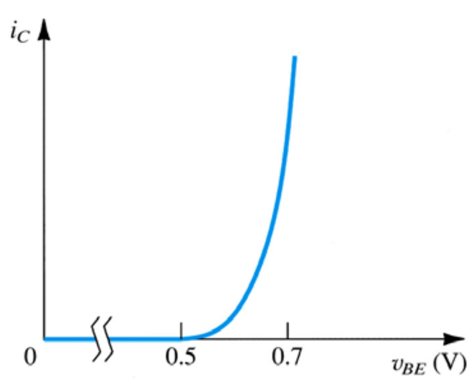
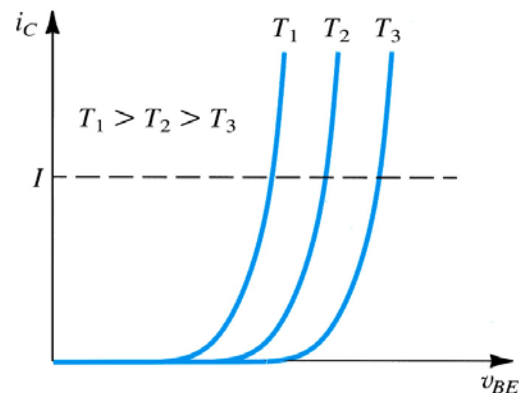
# Graphical Representation

Just like regular diodes, the BE voltage determines the collector current

$$i_C = I_s e^{v_{BE}/V_T}$$



At a constant collector current, the BE voltage decrease by -2 mv/˚C



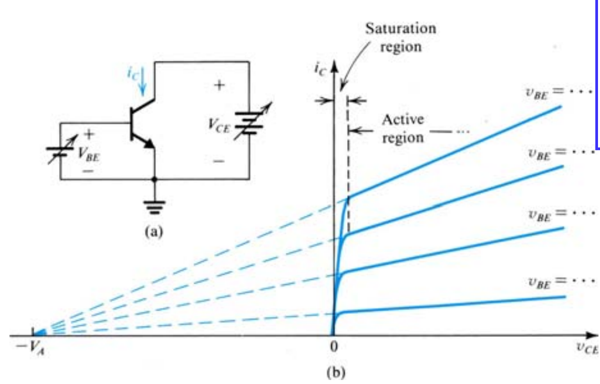

# Common Emitter $I_C$-$V_{CE}$ C/C

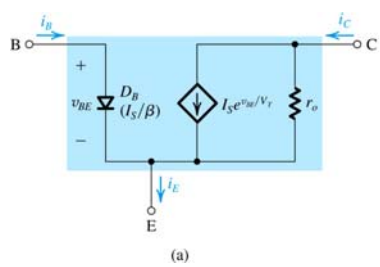
Practically, the collector current is not constant as we change CE voltage.
This is called he **early Effect**.

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

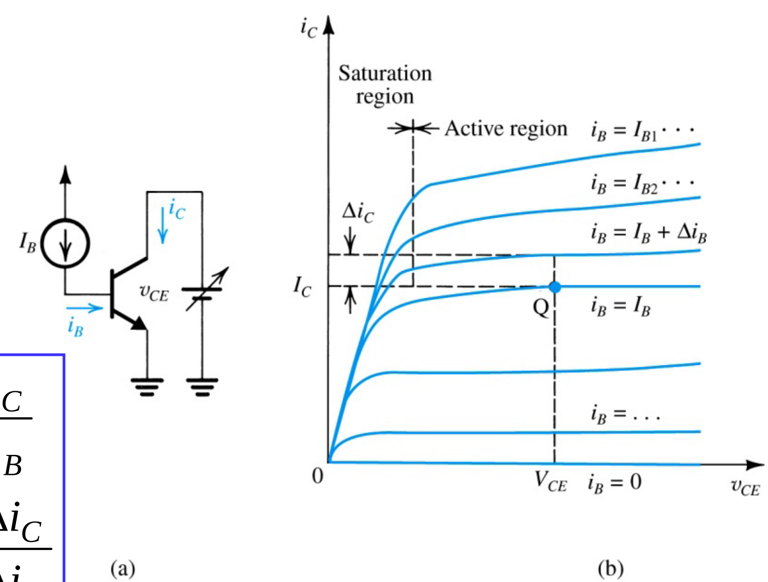
$$r_o = \left[\frac{\partial i_C}{\partial v_{CE}}\bigg|_{v_{BE}\ \mathrm{constant}}\right]^{-1}$$

$$r_o = \frac{V_A + V_{CE}}{I_C} = \frac{V_A}{I_C'}$$



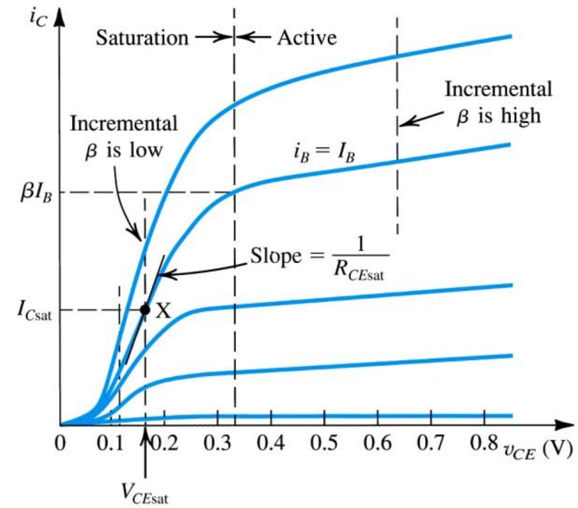





$$\beta_{dc} = \frac{I_C}{I_B}$$

$$\beta_{ac} = \frac{\Delta i_C}{\Delta i_B}$$




(c)

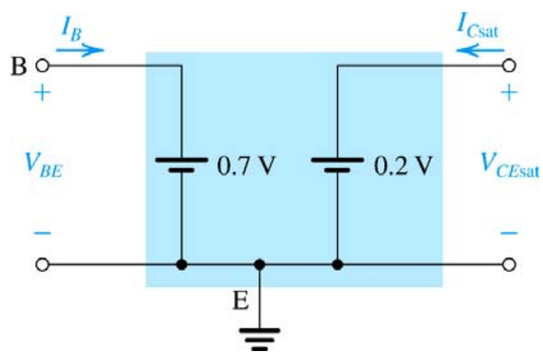



Figure 6.20 A simplified equivalent-circuit model of the saturated transistor.

Find VBB, Assume VBE=0.7V and β=50
(a) Active mode with VCE=5 V
(b) Edge of Saturation
(c) Deep in saturation β=10

(a)

$$V_{BB} = I_B R_B + V_{BE}$$
$$V_{BB} = 0.1*10 + 0.7 = 1.7V$$

$$I_C = (10-5)/1K = 5mA$$

$$I_B = 5mA/50 = 0.1mA$$

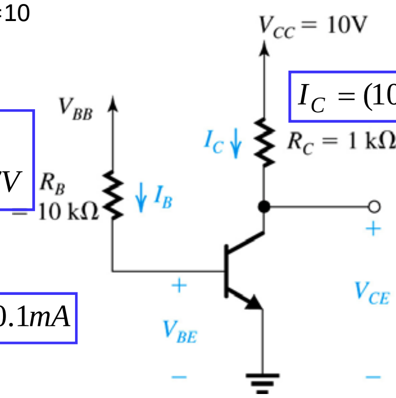



Figure 6.21 Circuit for Example 6.3.

Find VBB, Assume VBE=0.7V and β=50
(a) Active mode with VCE=5 V
(b) Edge of Saturation
(c) Deep in saturation β=10

(b) → $V_{CE}$=0.3V

$$V_{BB} = I_B R_B + V_{BE}$$
$$V_{BB} = 0.194*10 + 0.7 = 2.64V$$

$$I_C = (10-0.3)/1K = 9.7mA$$

$$I_B = 9.7mA/50 = 0.194mA$$

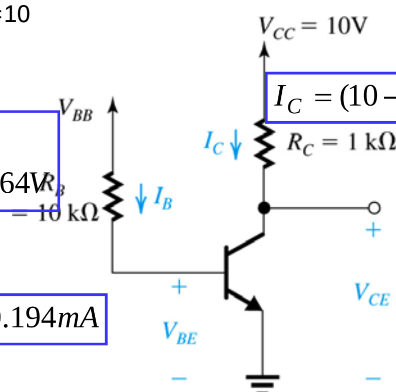



Figure 6.21 Circuit for Example 6.3.

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Find VBB, Assume VBE=0.7V and β=50
(a) Active mode with VCE=5 V
(b) Edge of Saturation
(c) Deep in saturation β=10

(c) → $V_{CE}$=0.2V

$$V_{BB} = I_B R_B + V_{BE}$$
$$V_{BB} = 0.98*10 + 0.7 = 10.5V$$

$$I_C = (10-0.2)/1K = 9.8mA$$

$$I_B = 9.8mA/10 = 0.98mA$$

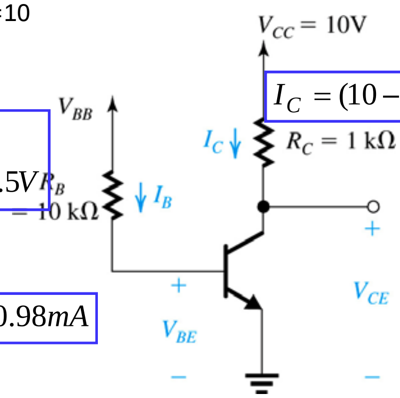



Figure 6.21 Circuit for Example 6.3.

## Cutoff

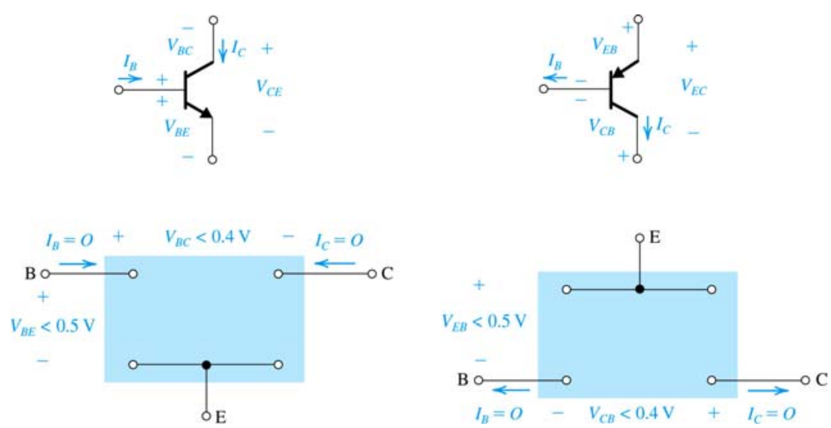
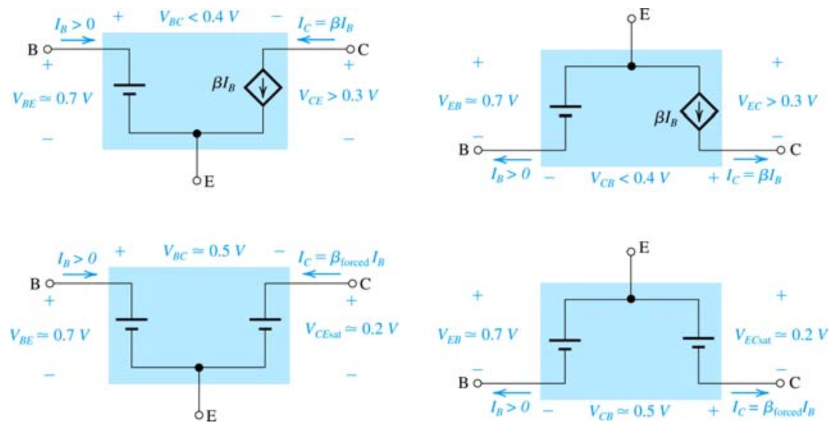



Table 6.3 Conditions and Models for the Operation of the BJT in Various Modes *(continued)*

Active




Saturation

Table 6.3 *(continued)*

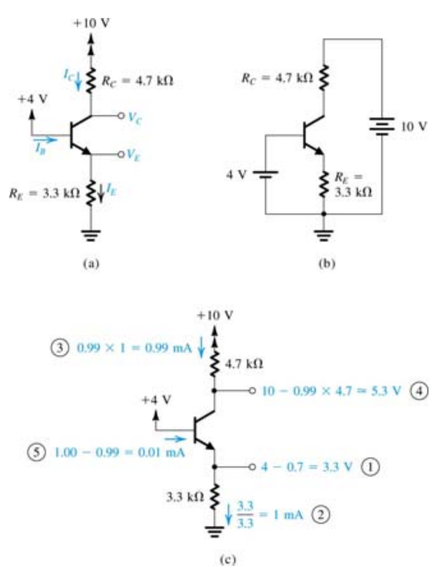



Figure 6.22 Analysis of the circuit for Example 6.4: (a) circuit; (b) circuit redrawn to remind the reader of the convention used in this book to show connections to the power supply; (c) analysis with the steps numbered.

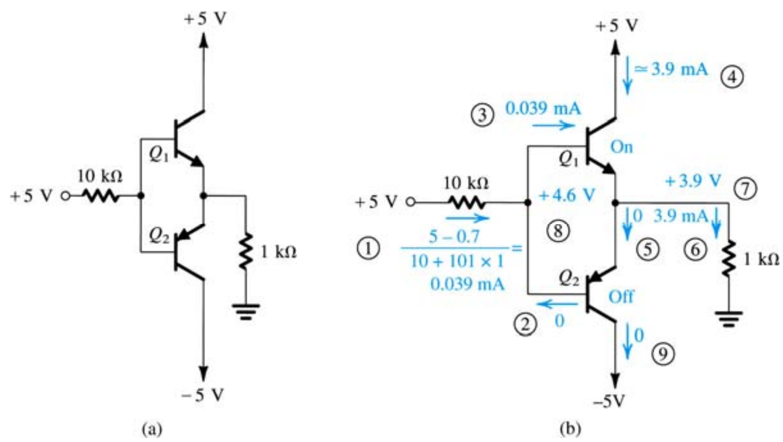
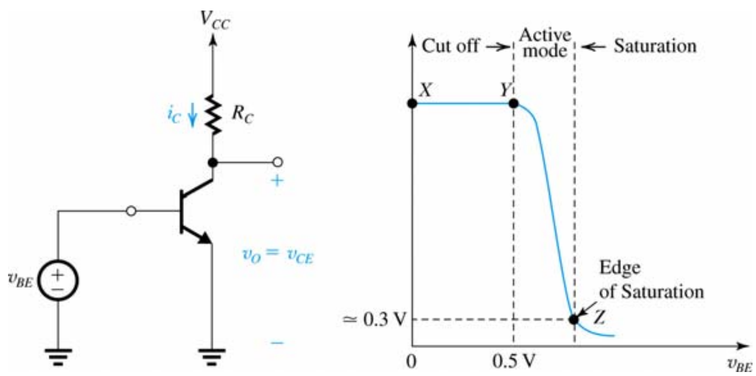



Figure 6.30 Example 6.12: (a) circuit; (b) analysis with the steps numbered.



# BJT as Amplifiers

$$v_o = V_{CC} - R_C I_s e^{v_I / V_T}$$



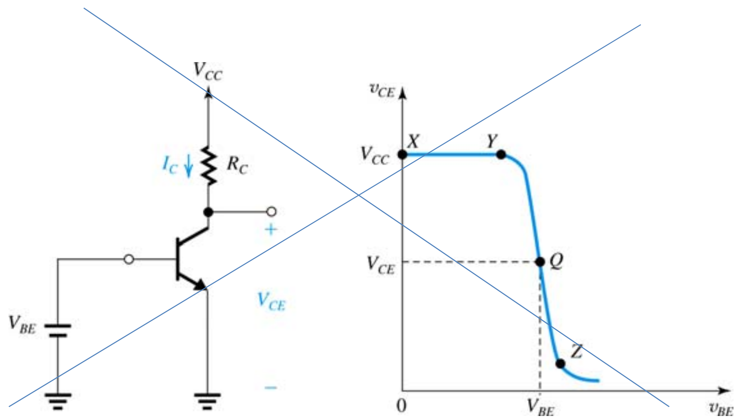


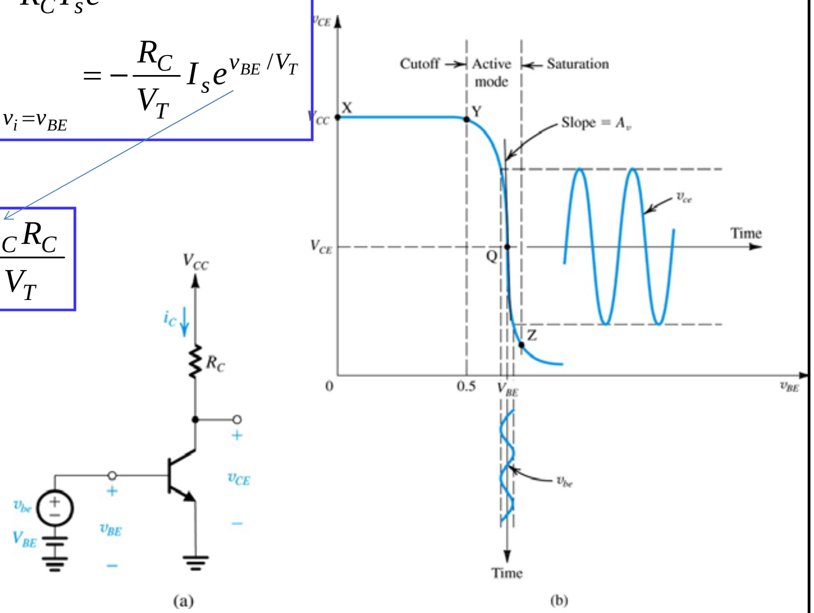

Figure 6.32 Biasing the BJT amplifier at a point Q located on the active-mode segment of the VTC.

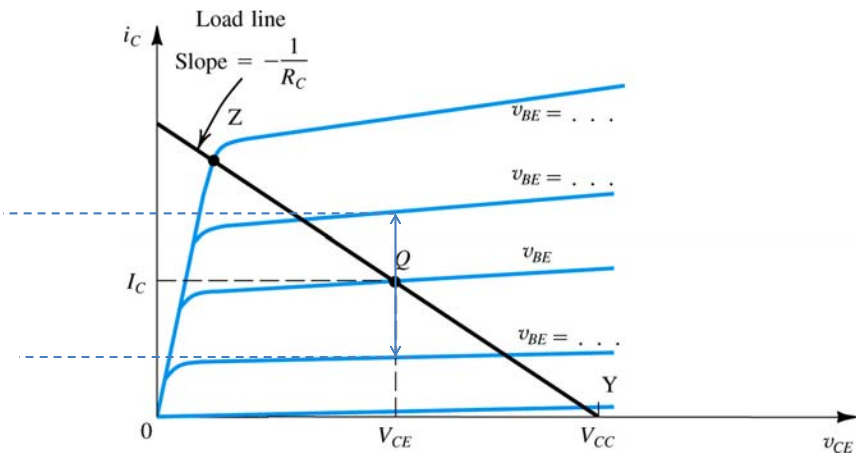
 

$$v_0 = V_{CC} - R_C I_s e^{v_t / V_T}$$

$$A_v = \left.\frac{dv_o}{dv_i}\right|_{v_i = v_{BE}} = -\frac{R_C}{V_T} I_s e^{v_{BE}/V_T}$$

$$A_v = -\frac{I_C R_C}{V_T}$$





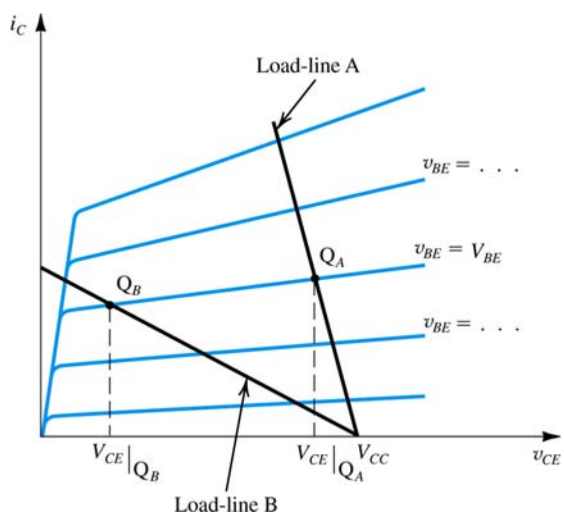




**Figure 6.35** Effect of bias-point location on allowable signal swing: Load line A results in bias point $Q_A$ with a corresponding $V_{CE}$ that is too close to $V_{CC}$ and thus limits the positive swing of $v_{CE}$. At the other extreme, load line B results in an operating point, $Q_B$, too close to the saturation region, thus limiting the negative swing of $v_{CE}$.