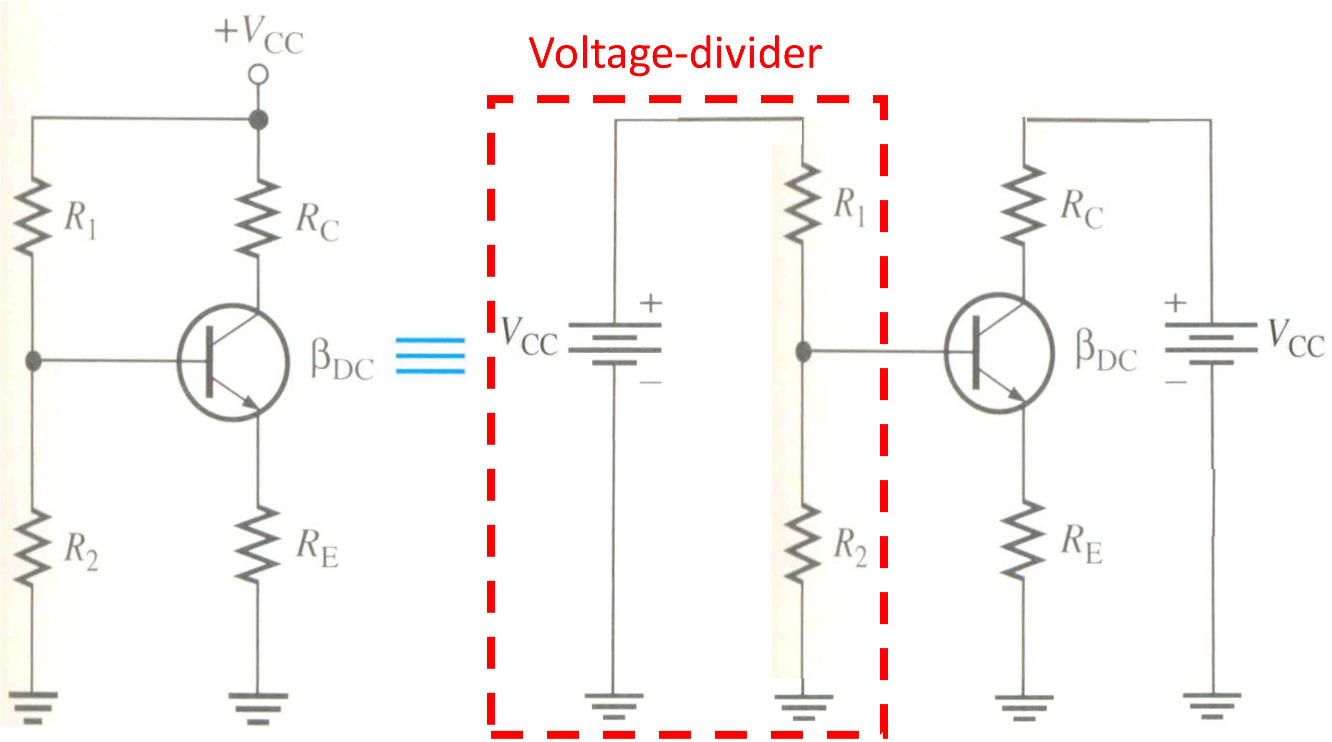
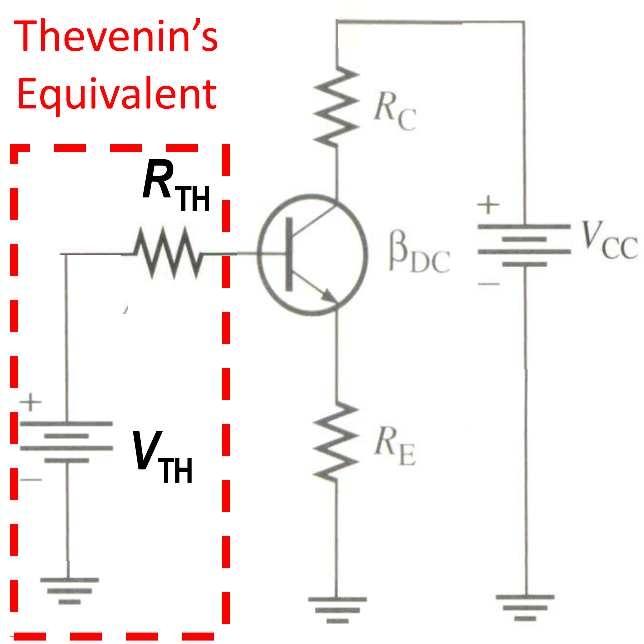
Lecture 26: Bipolar Junction Transistors (3)

Different Bias Networks, BJT as an Amplifier, Examples

Voltage Divider Bias



Voltage Divider Bias



$$V_{TH} = \left(\frac{R_2}{R_1 + R_2} \right) V_{CC}, \quad R_{TH} = R_1 \| R_2$$

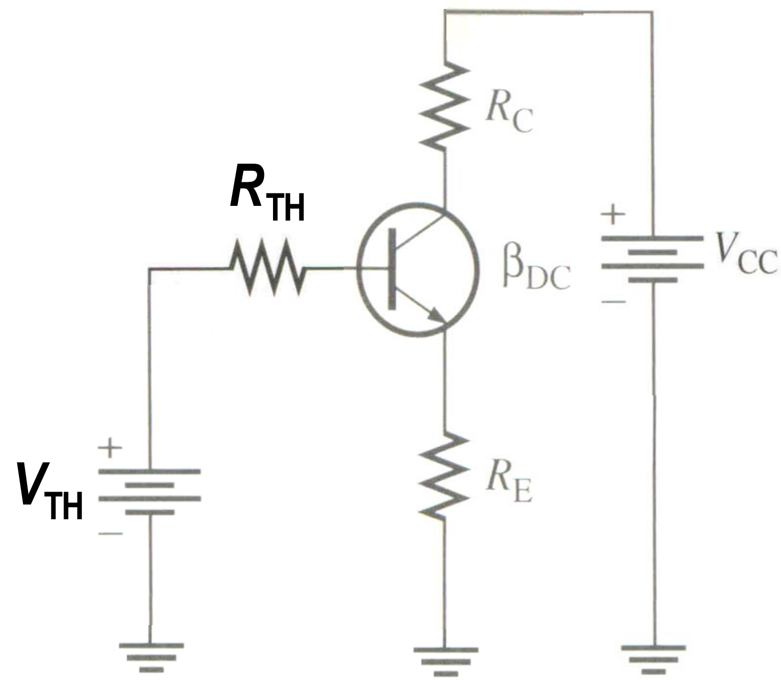
Voltage Divider (Cont'd)

$$V_{\text{TH}} = I_{\text{E}} R_{\text{E}} + V_{\text{BE}} + I_{\text{B}} R_{\text{TH}}$$

$$\cong I_{\text{C}} R_{\text{E}} + V_{\text{BE}} + I_{\text{C}} R_{\text{TH}} / \beta_{\text{DC}}$$

$$\therefore I_{\text{C}} = \frac{V_{\text{TH}} - V_{\text{BE}}}{R_{\text{E}} + R_{\text{TH}} / \beta_{\text{DC}}},$$

$$V_{\text{CE}} = V_{\text{CC}} - I_{\text{C}} \left(R_{\text{C}} + R_{\text{E}} \right)$$

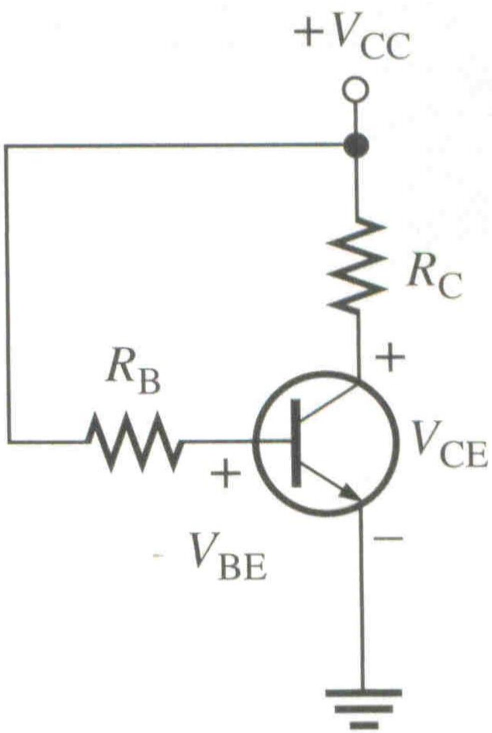


Base Bias

$$V_{CC} = V_{BE} + I_B R_B = V_{BE} + \frac{I_C}{\beta_{DC}} R_B$$

$$\therefore I_C = \frac{V_{CC} - V_{BE}}{R_B / \beta_{DC}} = \beta_{DC} \frac{V_{CC} - V_{BE}}{R_B},$$

$$V_{CE} = V_{CC} - I_C R_C$$

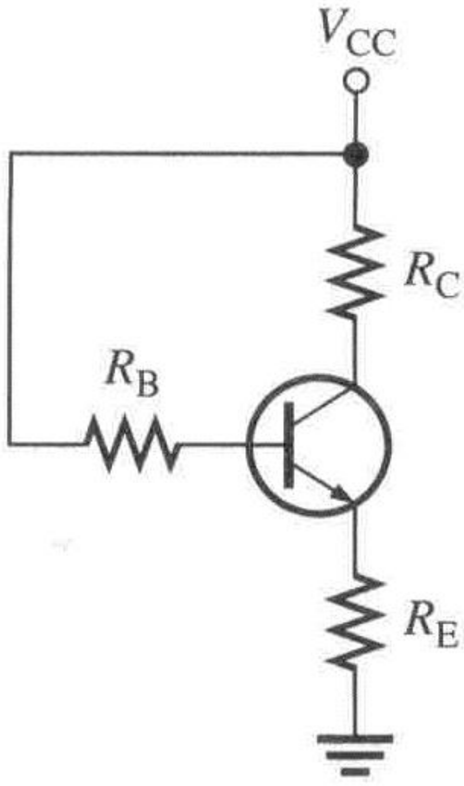


This circuit is used often as a switch

Emitter Feedback

if an emitter resistor R_E is added to the base bias circuit, the result is the emitter-feedback bias circuit shown

the Q-point of this circuit can be obtained as follows:



$$V_{CC} = I_E R_E + V_{BE} + I_B R_B$$

$$\cong I_C R_E + V_{BE} + \frac{I_C}{\beta_{DC}} R_B$$

$$\therefore I_C = \frac{V_{CC} - V_{BE}}{R_E + R_B / \beta_{DC}},$$

$$V_{CE} = V_{CC} - I_C \left(R_E + R_C \right)$$

Collector Feedback

this bias method is also similar to the base bias, except for connecting R_B directly to the collector rather than to V_{CC}.

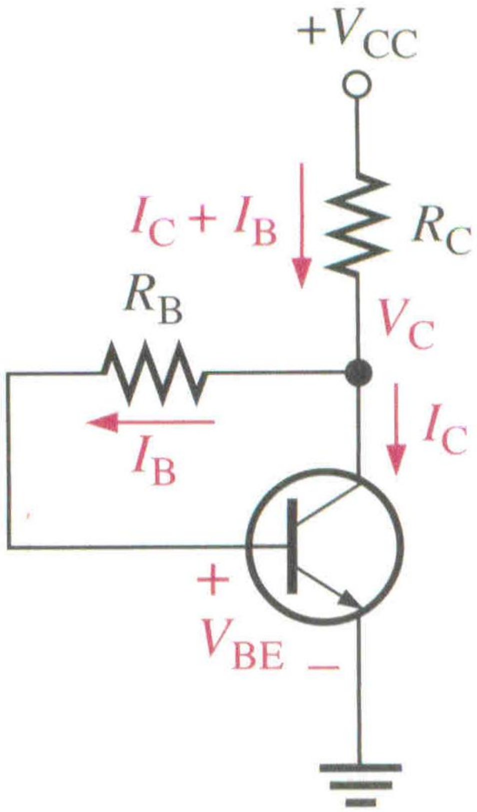
the Q-point can be obtained as follows:

$$V_{CC} = V_{BE} + I_B R_B + (I_C + I_B) R_C$$

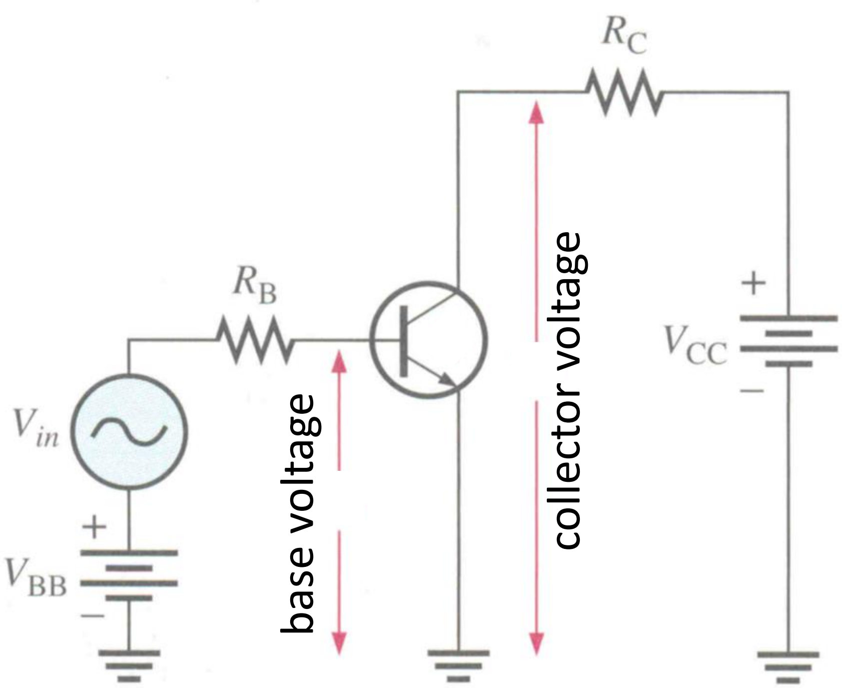
$$\cong V_{BE} + \frac{I_C}{\beta_{DC}} R_B + I_C R_C$$

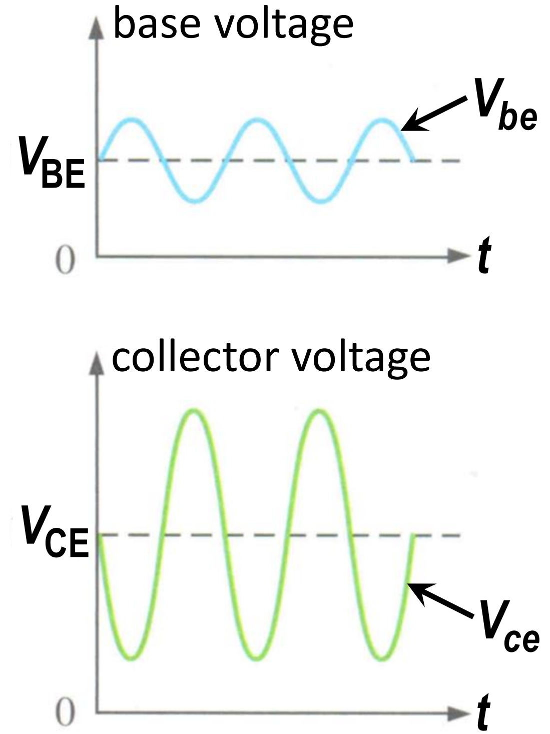
$$\therefore I_C = \frac{V_{CC} - V_{BE}}{R_C + R_B / \beta_{DC}}$$

$$V_{CE} = V_{CC} - I_C R_C$$



BJT Circuits with AC and DC Sources





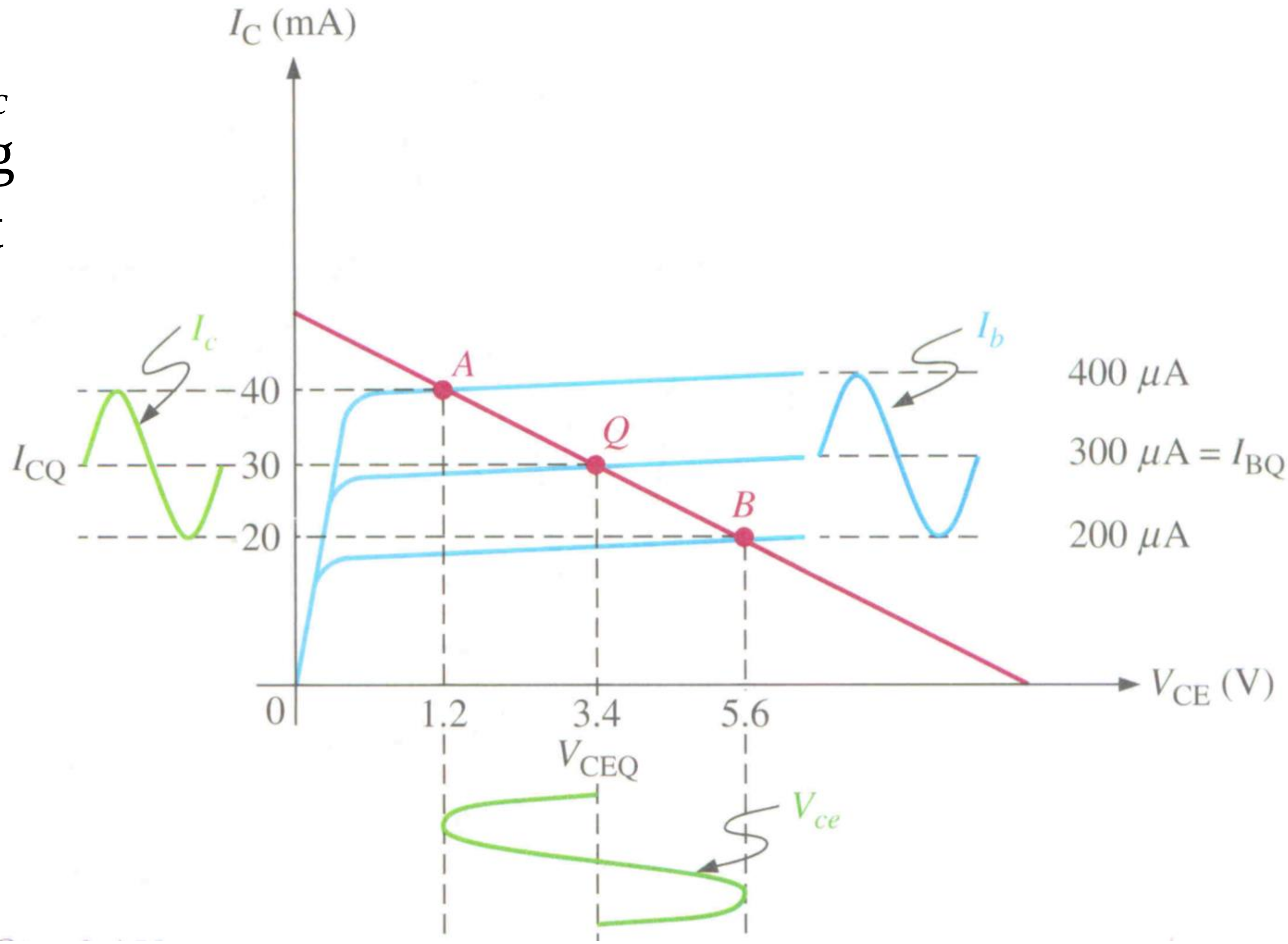
$$\text{base voltage} = \underset{\text{DC}}{V_{BE}} + \underset{\text{AC}}{V_{be}}, \qquad \text{collector voltage} = \underset{\text{DC}}{V_{CE}} + \underset{\text{AC}}{V_{ce}}$$

$$\text{base current} = \underset{\text{DC}}{I_B} + \underset{\text{AC}}{I_b}, \qquad \text{collector current} = \underset{\text{DC}}{I_C} + \underset{\text{AC}}{I_c}$$

Graphical AC Analysis

we solve graphically for I_c and V_{ce}, knowing the applied input signal I_b.

the Q-point can be considered as the center of the domain of variation of the transistor's currents and voltages.

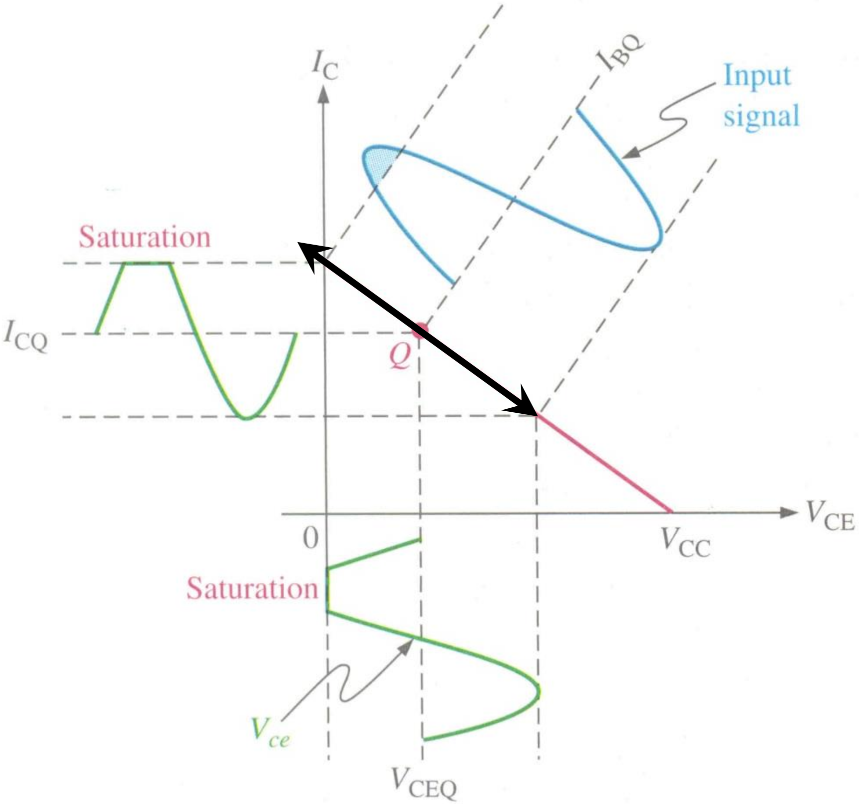


Waveform Distortion

Q-point is close to saturation

the projection of the +ve peak of I_b on the DC load line lies outside the active region

I_c and V_{ce} waveforms are one-side distorted.

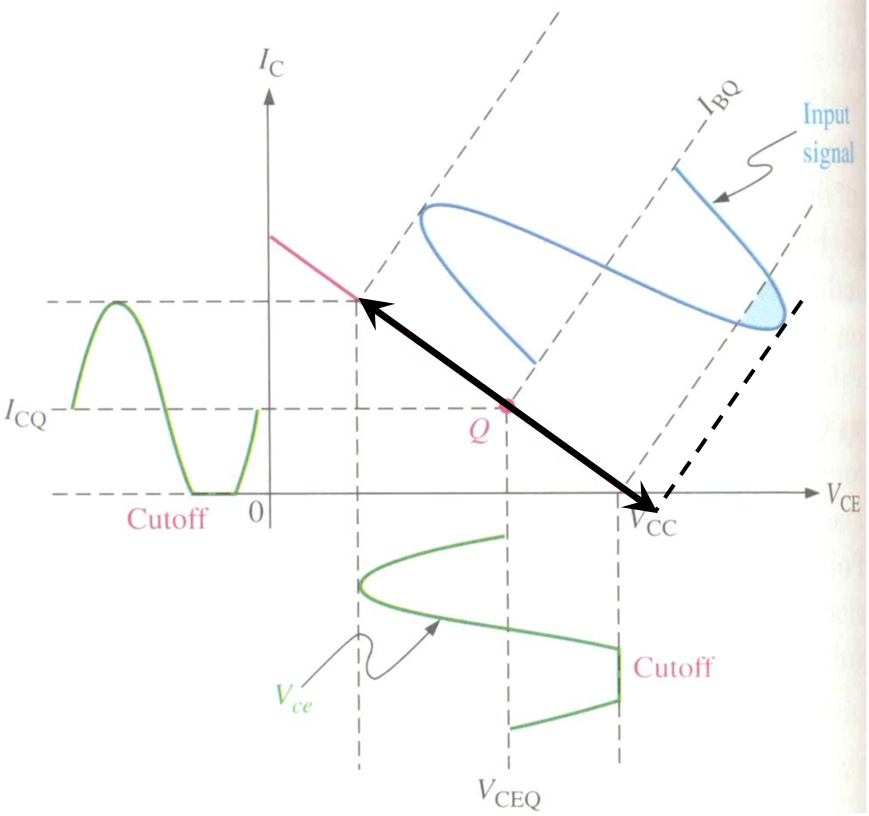


Waveform Distortion (Cont'd)

Q-point is close to cutoff

the projection of the -ve peak of I_b on the DC load line lies outside the active region

I_c and V_{ce} waveforms are one-side distorted



Waveform Distortion

amplitude of I_b is relatively large

the projections of both the +ve and -ve peaks of I_b on the DC load line lie outside the active region

I_c and V_{ce} waveforms are distorted in both sides

waveform distortion is undesired for amplifiers