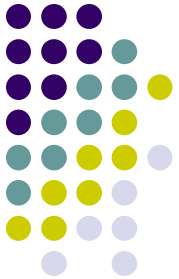
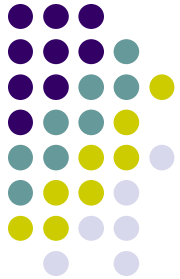


CHAPTER 5
BASIC BJT AMPLIFIERS
(AC ANALYSIS)

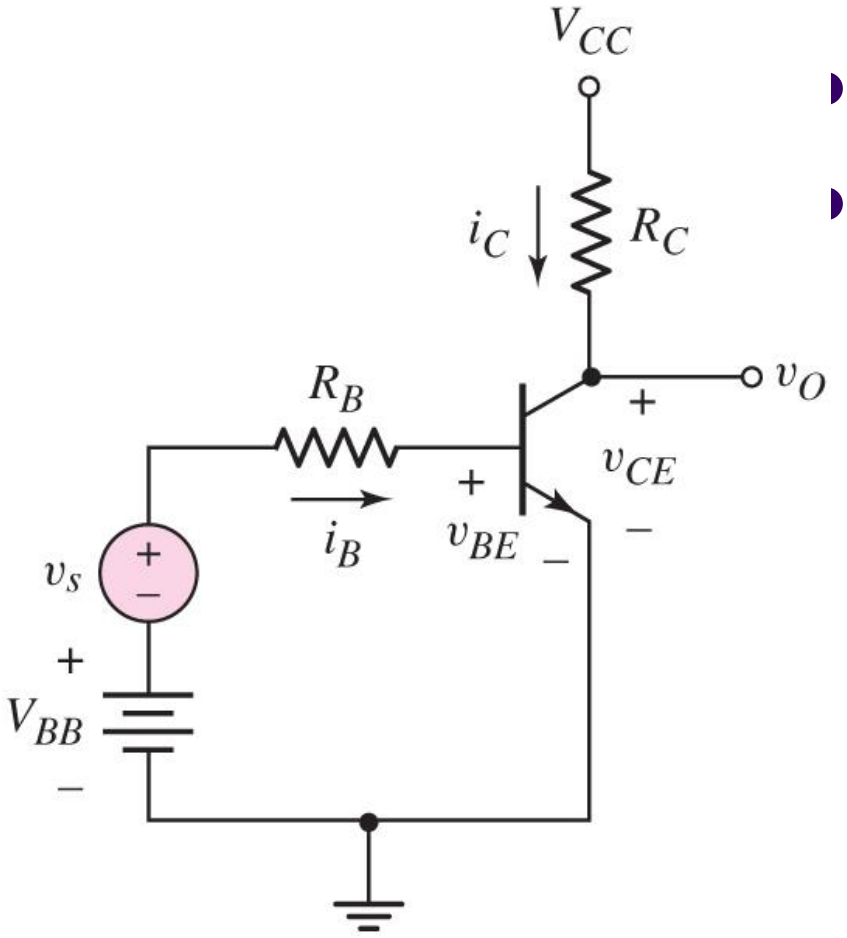
The Bipolar Linear Amplifier



- Bipolar transistors have been traditionally used in linear amplifier circuits because of their relatively high gain.
- To use the circuit as an amplifier, the transistor needs to be *biased with a DC voltage* at a quiescent point (Q-point) such that the transistor is *biased in the forward-active region*.
- If a time-varying signal is superimposed on the dc input voltage, the output voltage will change along the transfer curve producing a time-varying output voltage.
- If the time-varying output voltage is directly proportional to and larger than the time-varying input voltage, then the circuit is a *linear amplifier.*

- The linear amplifier applies superposition principle
  - Response – sum of responses of the circuit for each input signals alone
  - So, for linear amplifier,
    - DC analysis is performed with AC source turns off or set to zero
    - AC analysis is performed with DC source set to zero

EXAMPLE



- i_C , i_B and i_E,
- v_{CE} and v_{BE}

Sum of both ac and dc components

Graphical Analysis and ac Equivalent Circuit

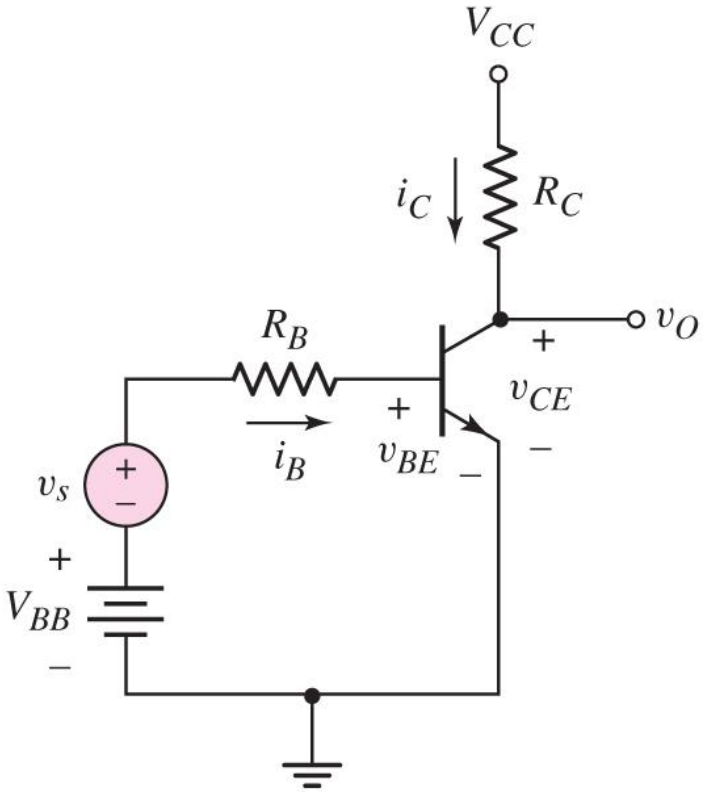
- From the concept of small signal, all the time-varying signals are superimposed on dc values. Then:

$$i_B = I_{BQ} + i_b$$

$$i_C = I_{CQ} + i_c$$

$$v_{CE} = V_{CEQ} + v_{ce}$$

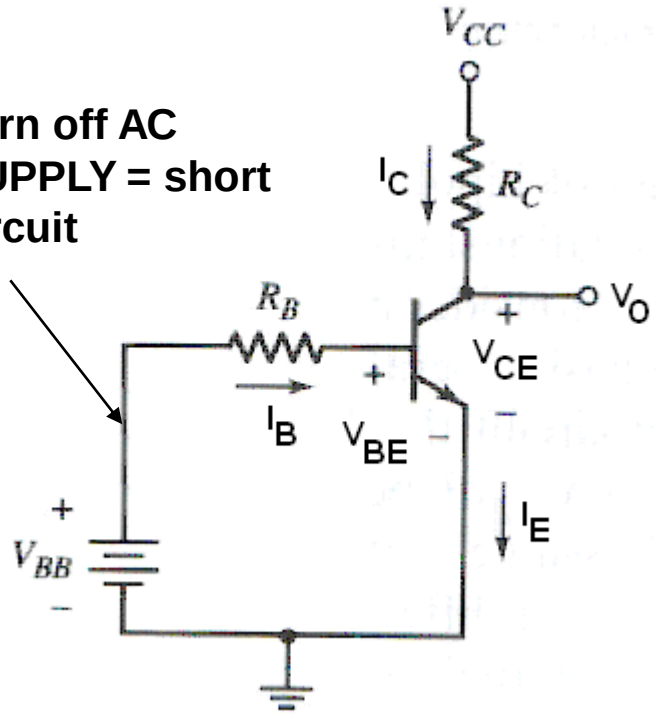
$$v_{BE} = V_{BEQ} + v_{be}$$



PERFORMING DC and AC analysis

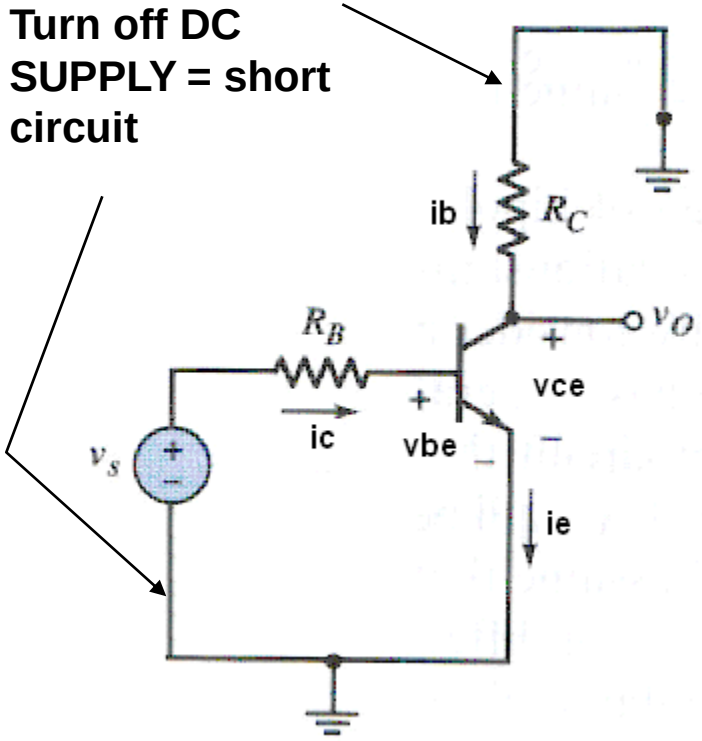
DC ANALYSIS

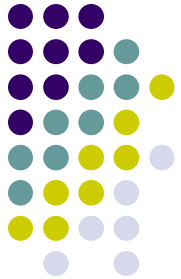
Turn off AC SUPPLY = short circuit



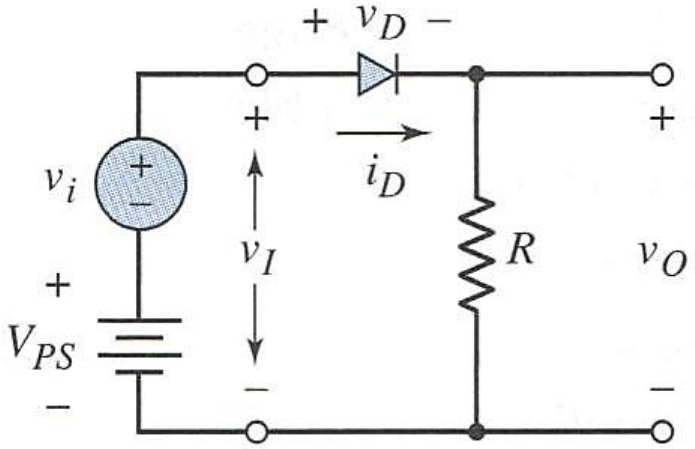
AC ANALYSIS

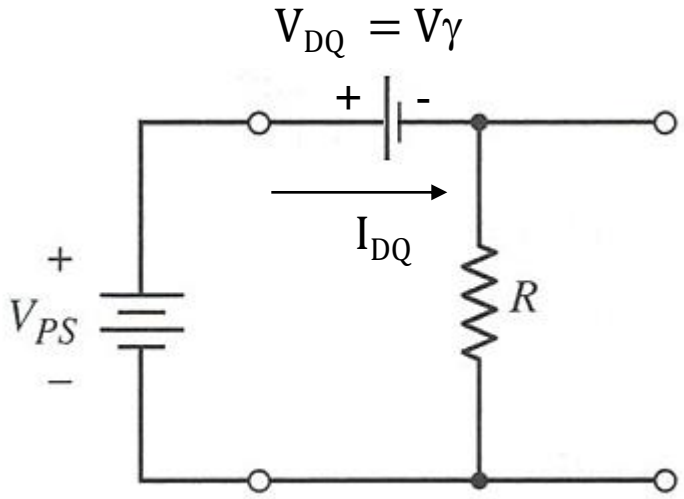
Turn off DC SUPPLY = short circuit



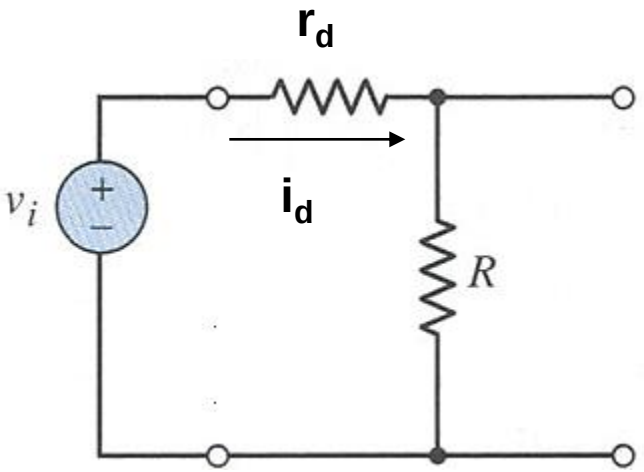


DO YOU STILL REMEMBER?

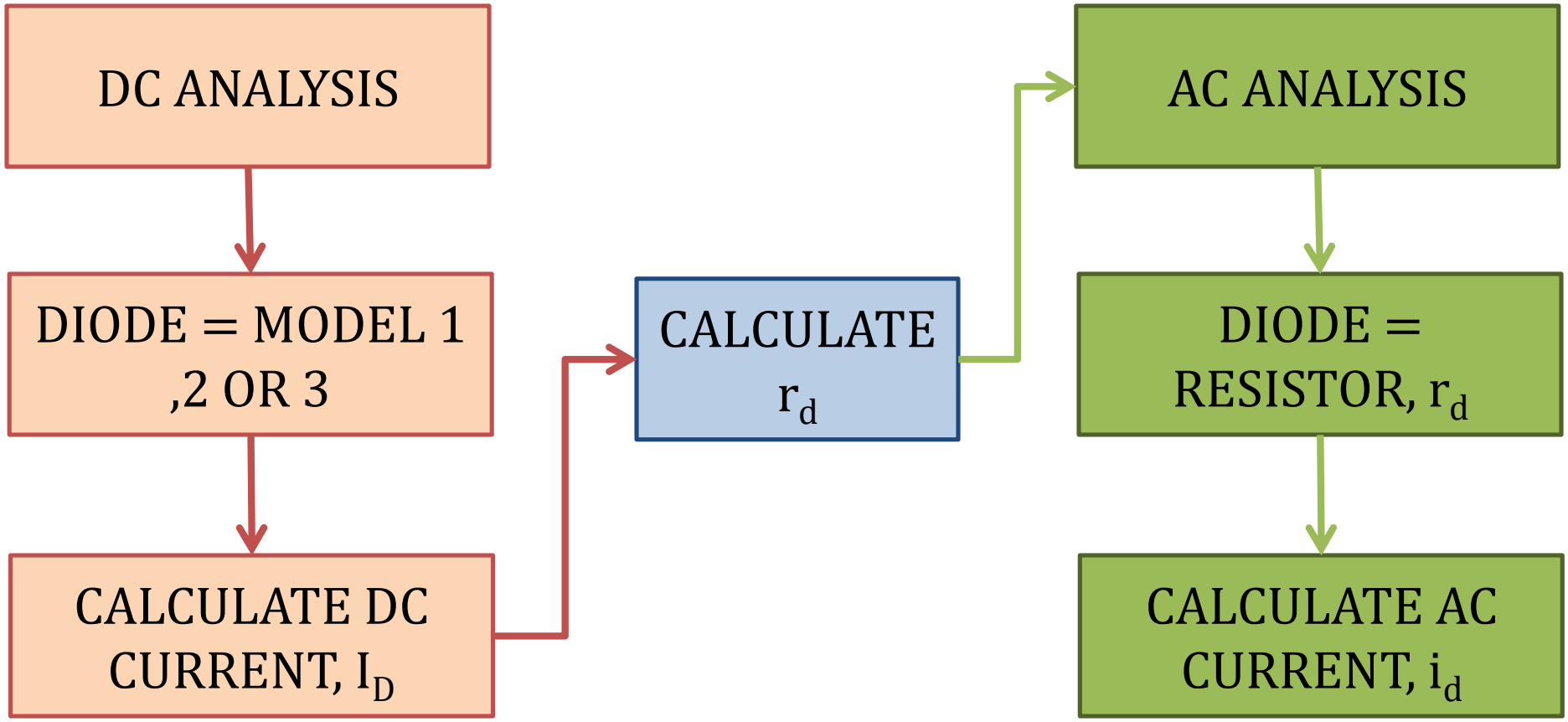


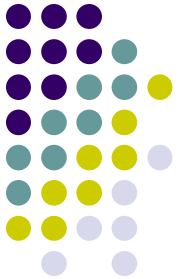


DC equivalent



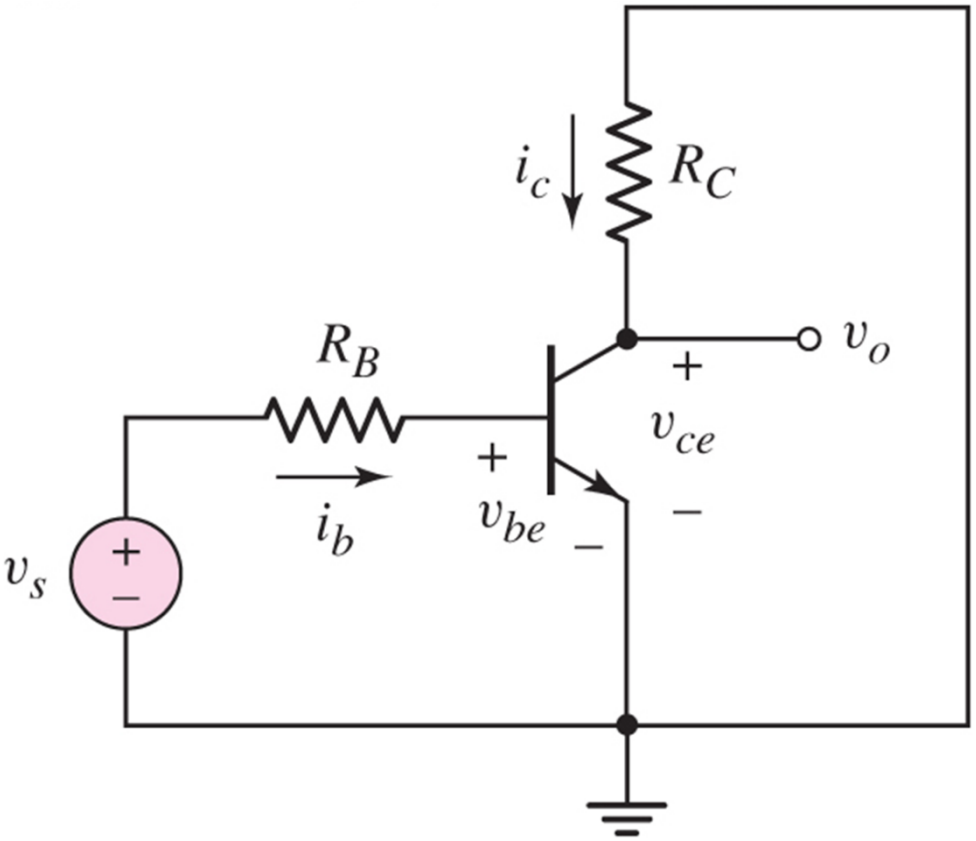
AC equivalent

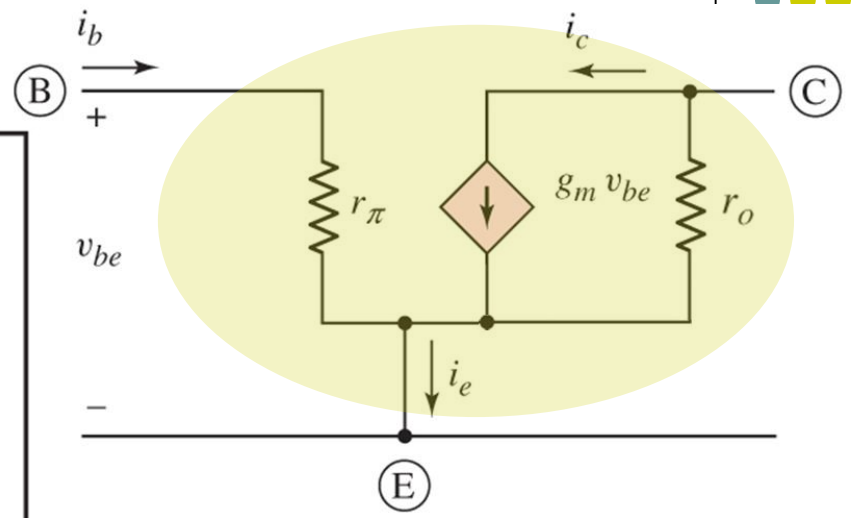

DC ANALYSIS
DIODE = MODEL 1 ,2 OR 3
CALCULATE DC CURRENT, I_D
CALCULATE r_d
AC ANALYSIS
DIODE = RESISTOR, r_d
CALCULATE AC CURRENT, i_d



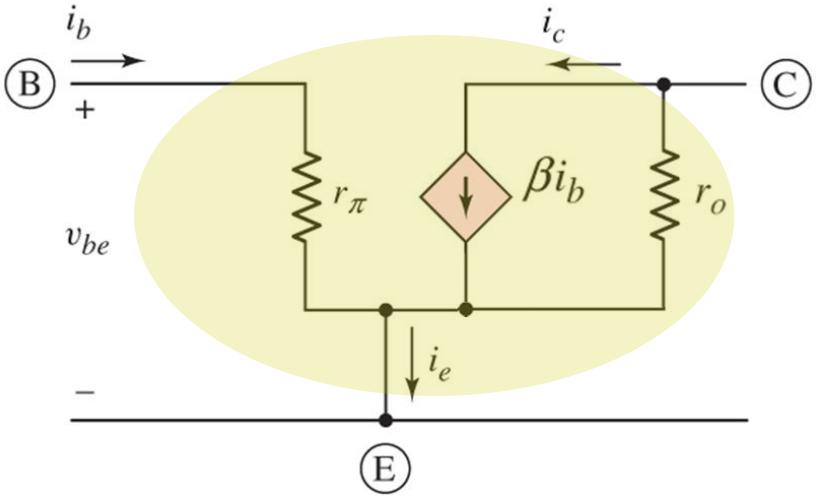
WHAT ABOUT BJT?

AC equivalent circuit – **Small-Signal Hybrid-π Equivalent**





OR



THE SMALL SIGNAL PARAMETERS

$$r_\pi = \frac{V_T}{I_{BQ}} = \frac{\beta V_T}{I_{CQ}}$$

The resistance r_π is called **diffusion resistance** or B-E input resistance. It is connected between Base and Emitter terminals

$$g_m = \frac{I_{CQ}}{V_T}$$

The term g_m is called a transconductance

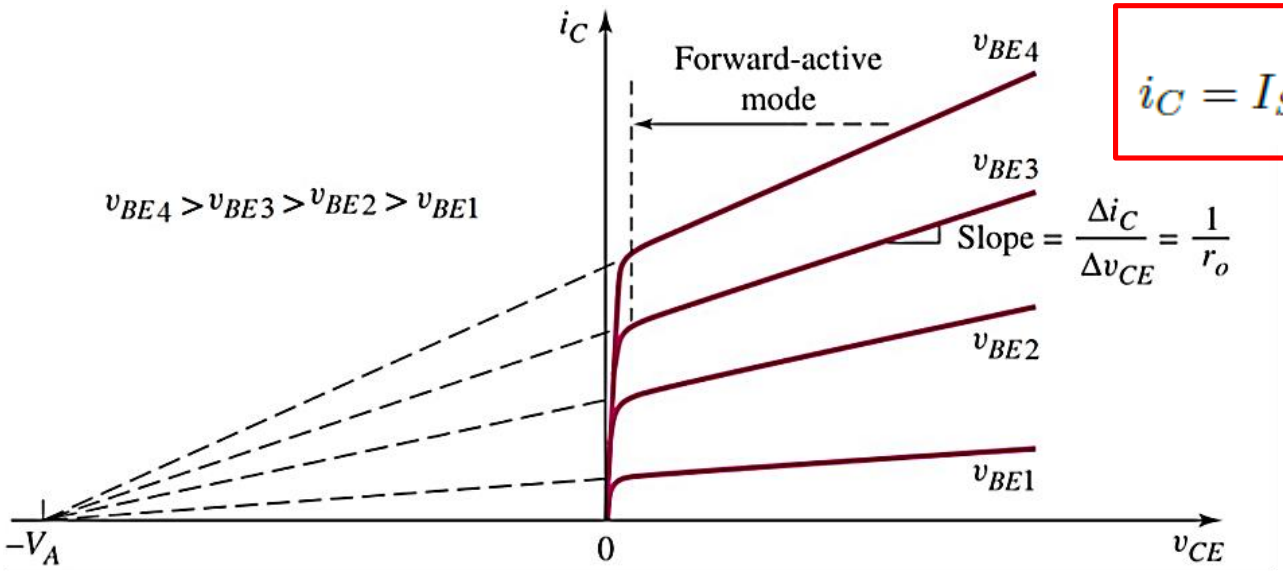
$$r_o = V_A / I_{CQ}$$

r_O = small signal transistor output resistance

V_A is normally equals to $\propto$, hence, if that is the case, $r_O = \propto$ → open circuit

Hence from the equation of the AC parameters, we HAVE to perform DC analysis first in order to calculate them.

Characteristics of Common-Emitter - npn



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

$$\rightarrow \quad r_0 \cong \frac{V_A}{I_C}$$

I-V characteristic of common-emitter BJT circuit, showing Early voltage and the finite output resistance, of the transistor

EXAMPLE

- The transistor parameter are $\beta = 125$ and V_A=200V. A value of g_m = 200 mA/V is desired. Determine the collector current, I_{CQ} and then find r_π and r_o

ANSWERS: $I_{CQ} = 5.2$ mA, $r_\pi = 0.625$ kΩ and $r_o = 38.5$ kΩ