Transistor Modeling……

Common – Base Configuration

Using a PNP transistor the Common-Base configuration and the r_e model:

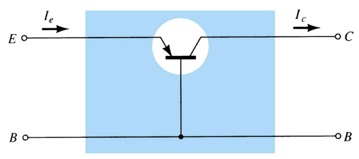
The emitter is the input and the collector is the output.

This model indicates:

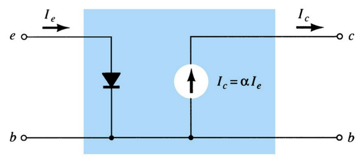
$Ic = \alpha Ie$

$$r_e = \frac{26\text{mV}}{I_E}$$

where I_E is the DC current.



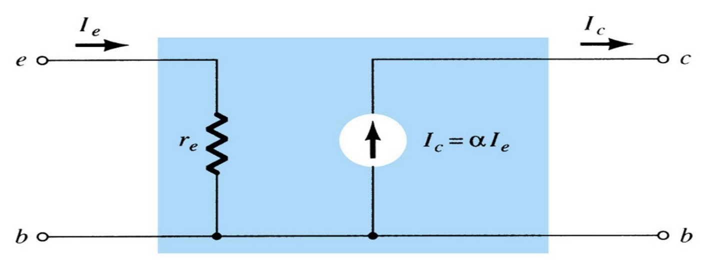
(a)



(b)

Common Base r_e Model

The diode in the previously shown **re** model can be replaced by the resistor r_e.



Impedance in Common-Base Configuration

The r_e model indicates:

The input impedance (Zi) is quite small: $Zi = r_e$

[Formula 7.12]

The output impedance (Zo) is quite large: $Zo \cong \infty\Omega$

[Formula 7.13]

Gain calculations for the Common-Base using the r_e model

Voltage Gain: $Av = \frac{R_L}{r_e} \cong \frac{R_L}{r_e}$

[Formula 7.14]

Current Gain: $Ai = -\alpha \cong -1$

[Formula 7.15]

$$V_o = -I_o R_L = -(-I_c)R_L = \alpha I_e R_L$$

$$V_i = I_e Z_i = I_e r_e$$

$$A_v = \frac{V_o}{V_i} = \frac{\alpha I_e R_L}{I_e r_e}$$

$$\boxed{A_v = \frac{\alpha R_L}{r_e} \cong \frac{R_L}{r_e}}_{CB}$$

$$A_i = \frac{I_o}{I_i} = \frac{-I_c}{I_e} = -\frac{\alpha I_e}{I_e}$$

$$\boxed{A_i = -\alpha \cong -1}_{CB}$$

The phase relationship between input and output is **0** degrees.

The npn transistor will use the same calculation. The only difference is that the voltage polarities and current directions will be the opposite.

Example

For a common-base configuration of Fig. 7.17 with $I_E = 4$ mA, $\alpha = 0.98$, and an ac signal of 2 mV applied between the base and emitter terminals:

(a) Determine the input impedance.

(b) Calculate the voltage gain if a load of 0.56 kΩ is connected to the output terminals.

(c) Find the output impedance and current gain.

Solution

(a) $r_e = \frac{26\text{ mV}}{I_E} = \frac{26\text{ mV}}{4\text{ mA}} = \mathbf{6.5\ \Omega}$

(b) $I_i = I_e = \frac{V_i}{Z_i} = \frac{2\text{ mV}}{6.5\ \Omega} = 307.69\ \mu\text{A}$

$V_o = I_c R_L = \alpha I_e R_L = (0.98)(307.69\ \mu\text{A})(0.56\text{ k}\Omega)$
$= 168.86\text{ mV}$

and $A_v = \frac{V_o}{V_i} = \frac{168.86\text{ mV}}{2\text{ mV}} = \mathbf{84.43}$

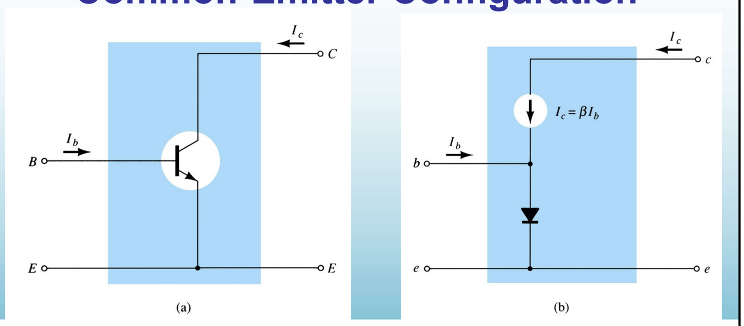
or from Eq. (7.14),

$$A_v = \frac{\alpha R_L}{r_e} = \frac{(0.98)(0.56\text{ k}\Omega)}{6.5\ \Omega} = \mathbf{84.43}$$

(c) $Z_o \cong \infty\ \Omega$

$A_i = \frac{I_o}{I_i} = -\alpha = \mathbf{-0.98}$ as defined by Eq. (7.15)

Common-Emitter Configuration



The base current is the input and the collector is the output.
This model indicates:

$$I_c = \beta I_b$$ [Formula 7.16]

$$I_e = (\beta + 1) I_b$$ [Formula 7.17]

$$I_e \cong \beta I_b$$ [Formula 7.18]

Impedance in Common-Emitter Configuration

The input impedance (Zi): $Zi = \beta r_e$

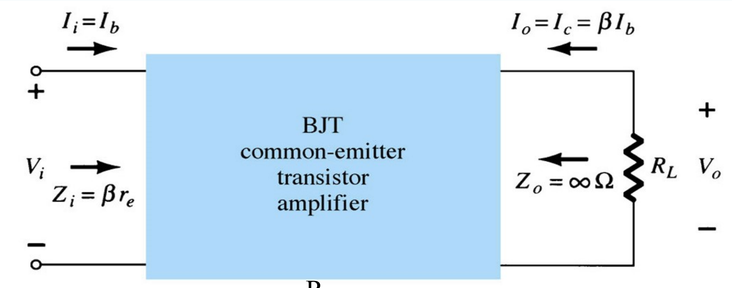
[Formula 7.19]

The output impedance (Zo): $Zo = ro$

$Zo \cong \infty\Omega$

[Formula 7.20]

Gain calculations for the Common-Emitter using the r_e model



Voltage Gain (Av): $Av = -\frac{R_L}{r_e}$ [Formula 7.21]

Current Gain (Ai): $Ai = B \big/ _{ro = \infty\Omega}$ [Formula 7.22]

The Common-Emitter Model is used for Common-Collector.

Types of Amplifier

Three Types of Amplifiers are :

(i) CURRENT amplifiers , with a small load resistance,

(ii) VOLTAGE amplifiers have a high load resistance, and

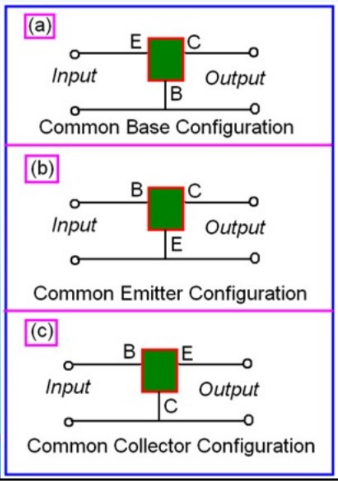
(iii) POWER amplifiers .

Classification of Amplifiers

Type of Signal	Type of Configuration	Classification	Frequency of Operation
Small Signal	Common Emitter	Class A Amplifier	Direct Current (DC)
Large Signal	Common Base	Class B Amplifier	Audio Frequencies (AF)
	Common Collector	Class AB Amplifier	Radio Frequencies (RF)
		Class C Amplifier	VHF, UHF and SHF Frequencies

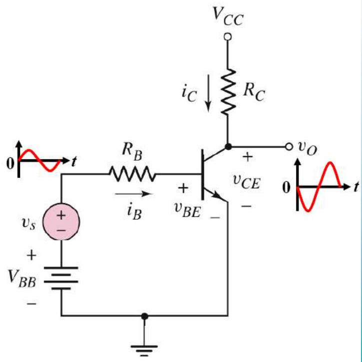
Biasing Configurations in active region

Three configurations in the active region are shown



Basic BJT amplifier

- A BJT needs to be biased by a dc voltage source (V_{BB}) at a suitable Q-point to ensure that it is operating in forward-active mode – the precondition for configuring a BJT as an amplifier.
- A BJT amplifier has a time-varying signal source (v_s) in series with the dc voltage source (V_{BB}).
- A change in v_s causes a change in i_B which, in turn, causes a larger change in i_C ($i_C = \beta\, i_B$) & leads to an inverted & amplified signal (v_o) compared to the original v_s.



Common-Emitter Amplifier

Analysis of BJT amplifiers

Function of each component:

- Capacitors: Acting as an open circuit for a dc operation but a short circuit for an ac operation (If f = 10 kHz & C = 10 μF, then $|Z_C| = (2\pi f C)^{-1} = 8\ \Omega$, which is usually smaller than $R_{TH} = R_1 // R_2$)
- R_1, R_2, R_C & R_E: Setting dc biasing Q-point
- R_C: Converting i_c variation into v_{ce} (or v_o) variation (signal conversion)