IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Microelectronics: Devices to Circuits

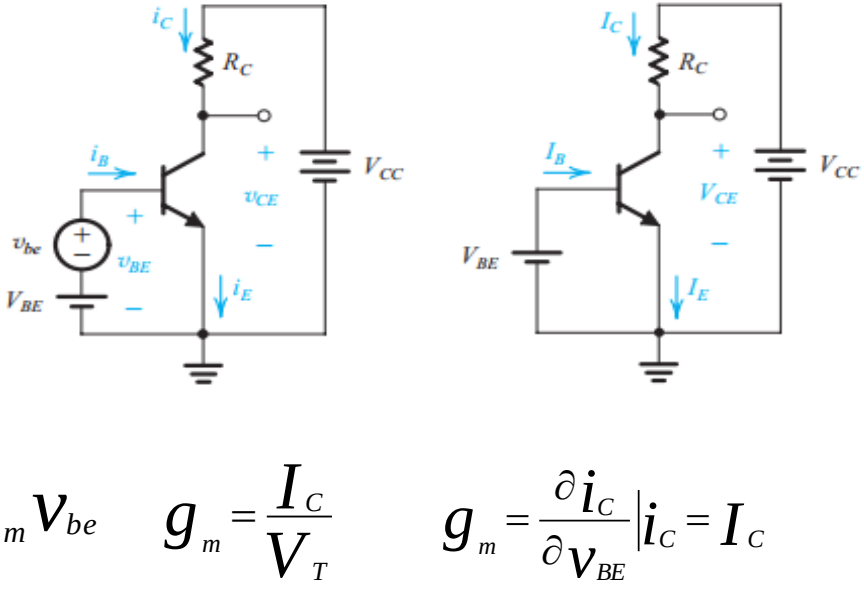
BJT : Small Signal Circuit Model

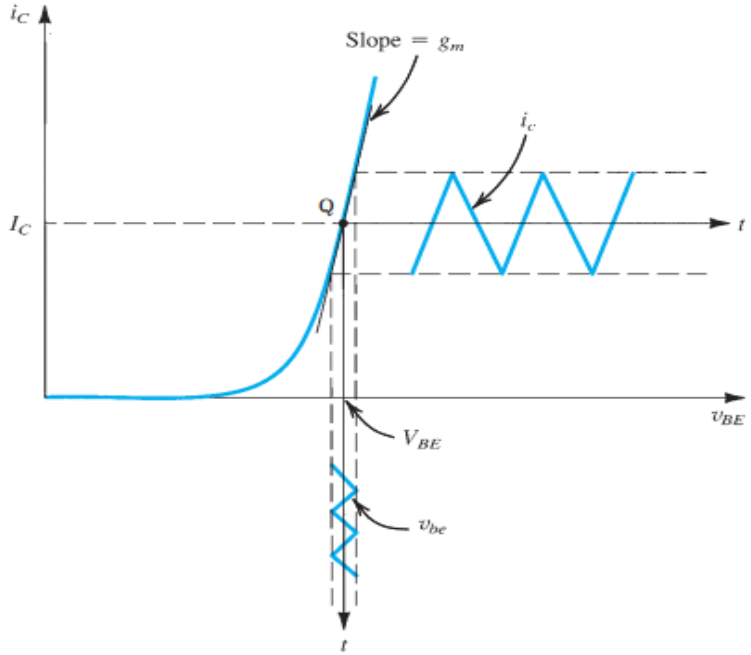
SUDEB DASGUPTA

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



Small-signal operation and Model





$$i_C = g_m v_{be} \qquad g_m = \frac{I_C}{V_T} \qquad g_m = \frac{\partial i_C}{\partial v_{BE}} \Big| i_C = I_C$$

gm is the trans-conductance of the amplifier

Fig.4. Operation of transistor as an amplifier and linear operation of amplifier under the small signal - condition

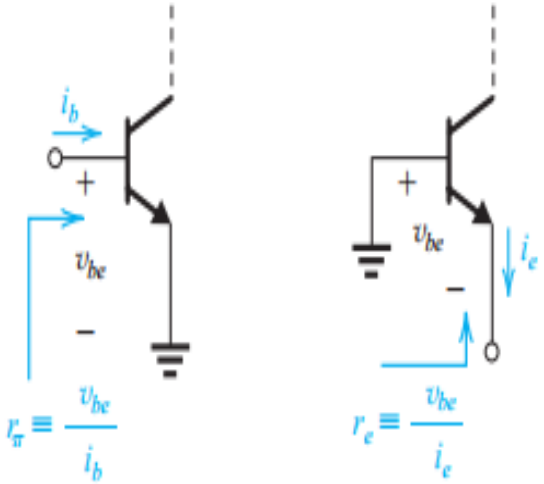
Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

- Small-signal input resistance between base and emitter, looking into the base denoted by r_π .
- Small-signal input resistance between base and emitter, looking into the emitter denoted by r_e .

$$r_\pi = \frac{v_{be}}{i_b} \qquad r_e = \frac{v_{be}}{i_e}$$

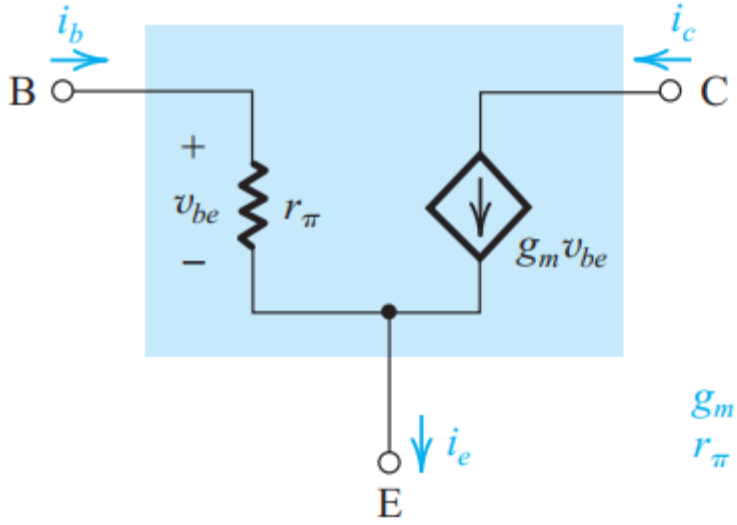
$$r_\pi = \frac{\beta}{g_m} \qquad r_e = \frac{V_T}{I_E} \qquad r_\pi = (\beta+1) r_e$$

$$r_\pi = \frac{V_T}{I_B} \qquad r_e = \frac{1}{g_m}$$



Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Hybrid-π Model



$$g_m = I_C / V_T$$
$$r_\pi = \beta / g_m$$

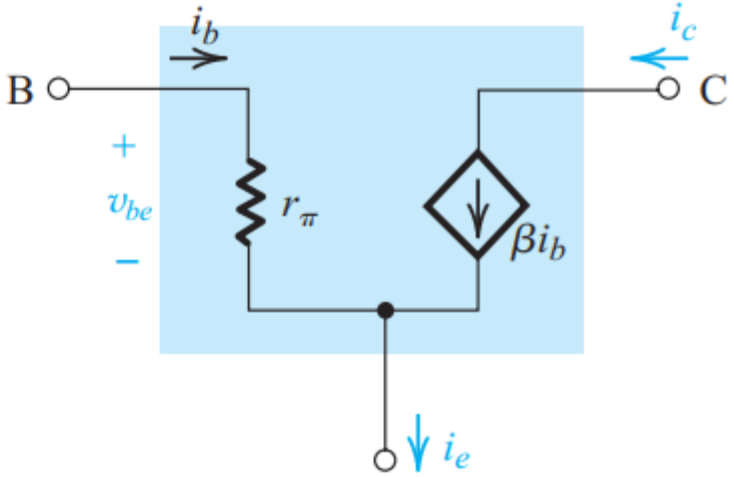
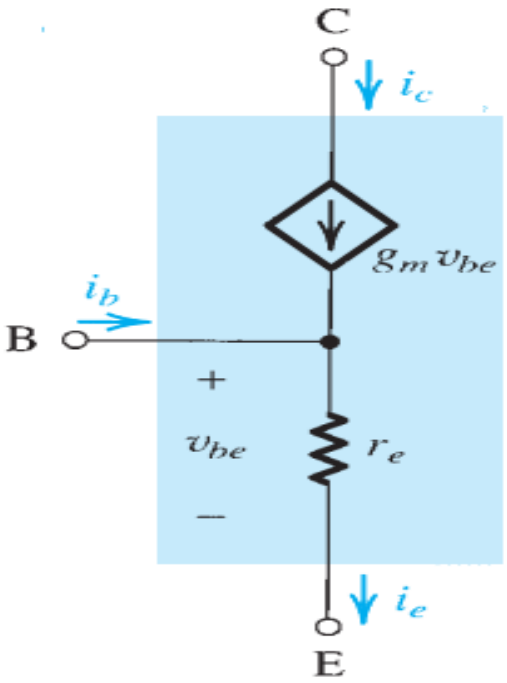


Fig.5. Hybrid –π model for the small signal operation of BJT.

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

T- Model



$$g_m = I_C / V_T$$

$$r_e = \frac{V_T}{I_E} = \frac{\alpha}{g_m}$$

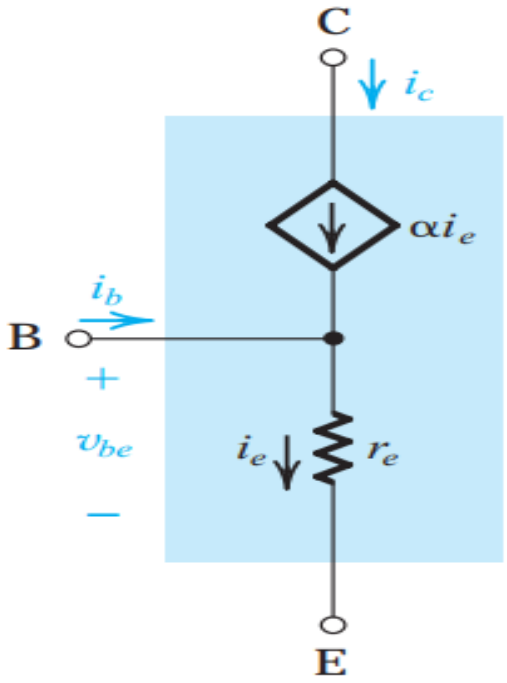
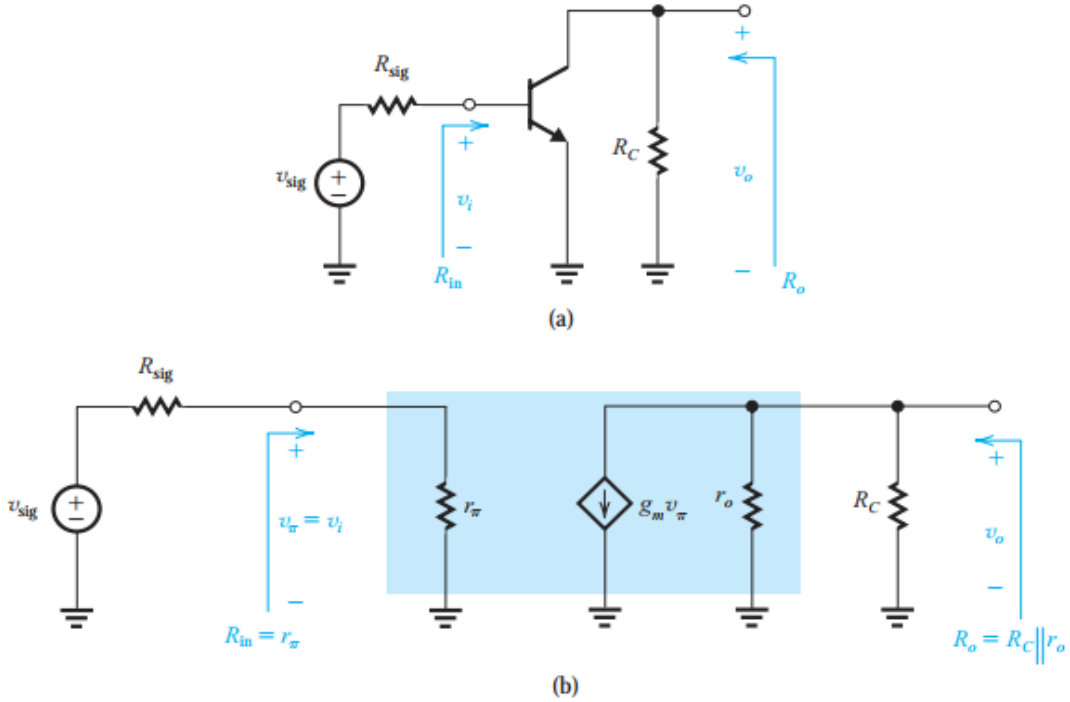


Fig.6. T model for the small signal operation of BJT.

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Common –emitter configuration



$$R_{in} = r_\pi$$

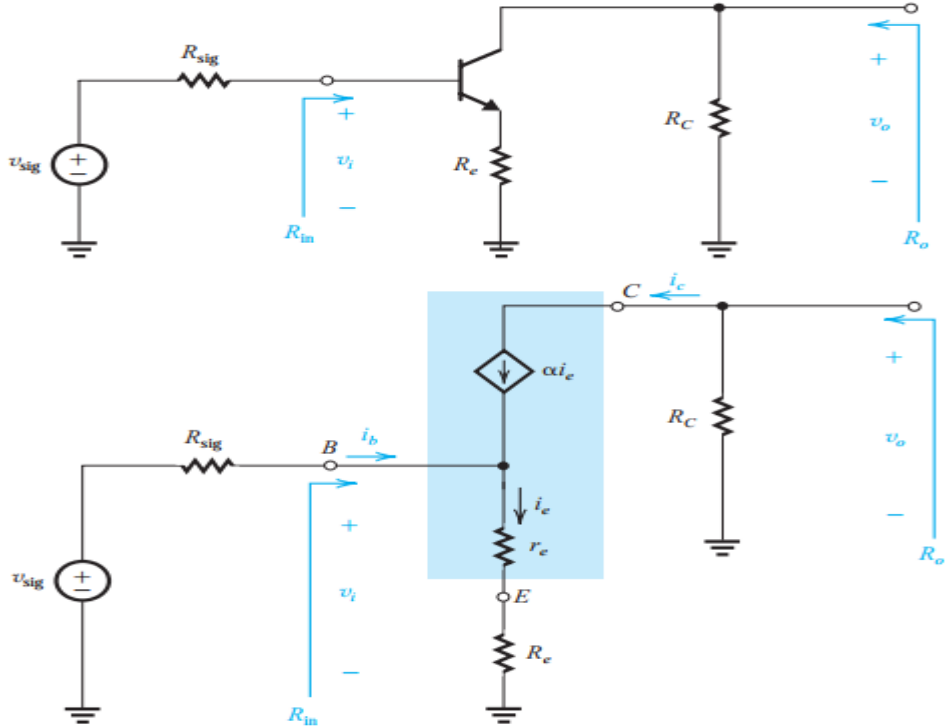
$$v_o = -(g_m v_\pi)(R_C \| r_o)$$

$$R_0 = (R_C \| r_o)$$

Fig.7. Common –emitter amplifier

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Common –emitter configuration with emitter resistance



$$R_{in} = (\beta + 1)(r_e + R_e)$$

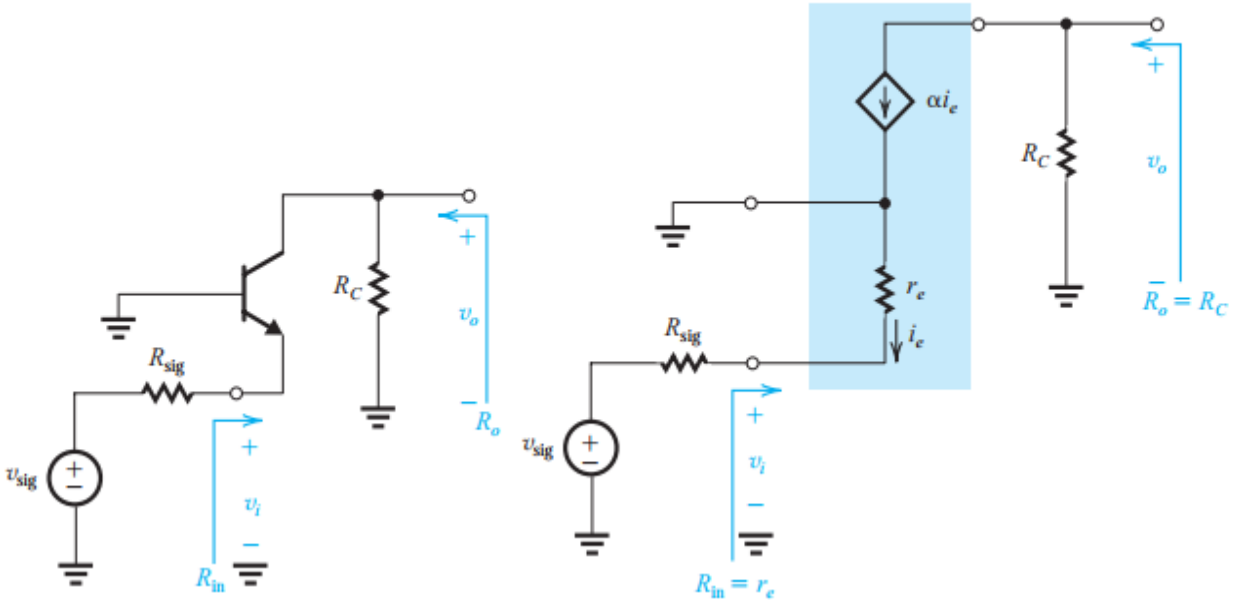
$$A_{vo} = -\frac{g_m R_C}{1 + g_m R_e}$$

$$R_0 = R_C$$

Fig.7. Common –emitter amplifier with emitter resistance

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Common –base Amplifier



$$R_{in} = r_e$$

$$A_{vo} = g_m R_C$$

$$R_0 = R_C$$

Fig.7. Common –base amplifier

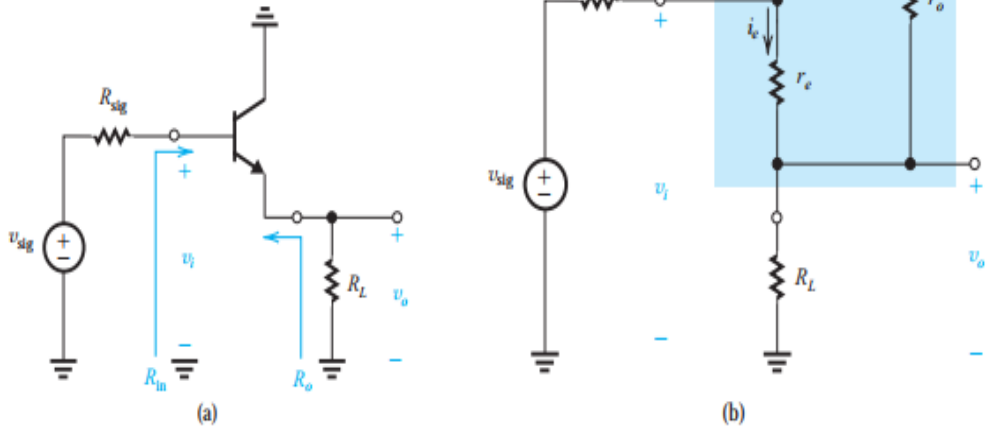
Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Common –collector Amplifier or emitter follower

$$R_{in} = (\beta + 1)(r_e + R_L)$$

$$R_o = r_e$$

$$A_{vo} = 1$$



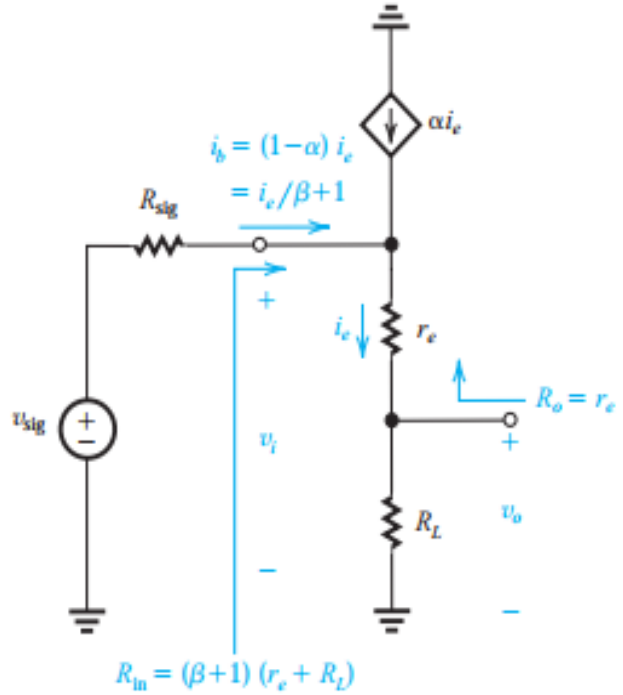


Fig.7. Common –collector amplifier

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Recapitulation

- The CE configuration is the one best suited for realizing the bulk of gain required in an amplifier.
- The CB amplifier use as a high frequency amplifier due to low input resistance.
- The emitter follower finds application as a voltage buffer for connecting a high source to a low-resistance load.

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

Thank You