IIT ROORKEE

NPTEL ONLINE CERTIFICATION COURSE

Microelectronics: Devices to Circuits

BJT: Operation in active mode, circuit symbol and conventions

SUDEB DASGUPTA

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



Outline

- NPN Transistor In Forward Active Mode operation
- PNP Transistor In Forward Active Mode operation
- Common-emitter configuration
- Common-base configuration
- Common- collector configuration
- Circuit Symbol and convention
- Recapitulation

NPN Transistor In Forward Active Mode operation

- In active mode of operation base-emitter junction is forward biased and base- collector junction is reverse biased.
- Electron from the emitter are injected across the B-E junction into the base, creating excess minority carrier concentration in the base.
- The B-C junction is reversed biased, electron concentration at the edge of that junction is approximately zero.
- To minimize recombination effect, the width of the neutral base region must be small compared to the minority carrier diffusion length.

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

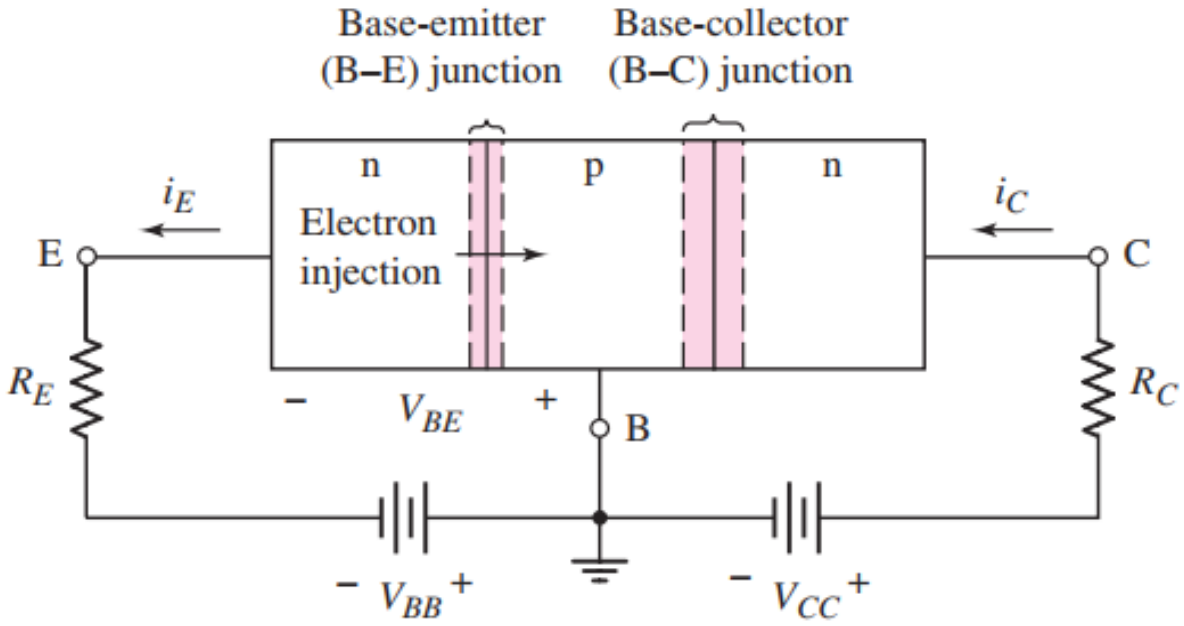


Fig.1. An npn bipolar transistor biased in forward-active mode

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

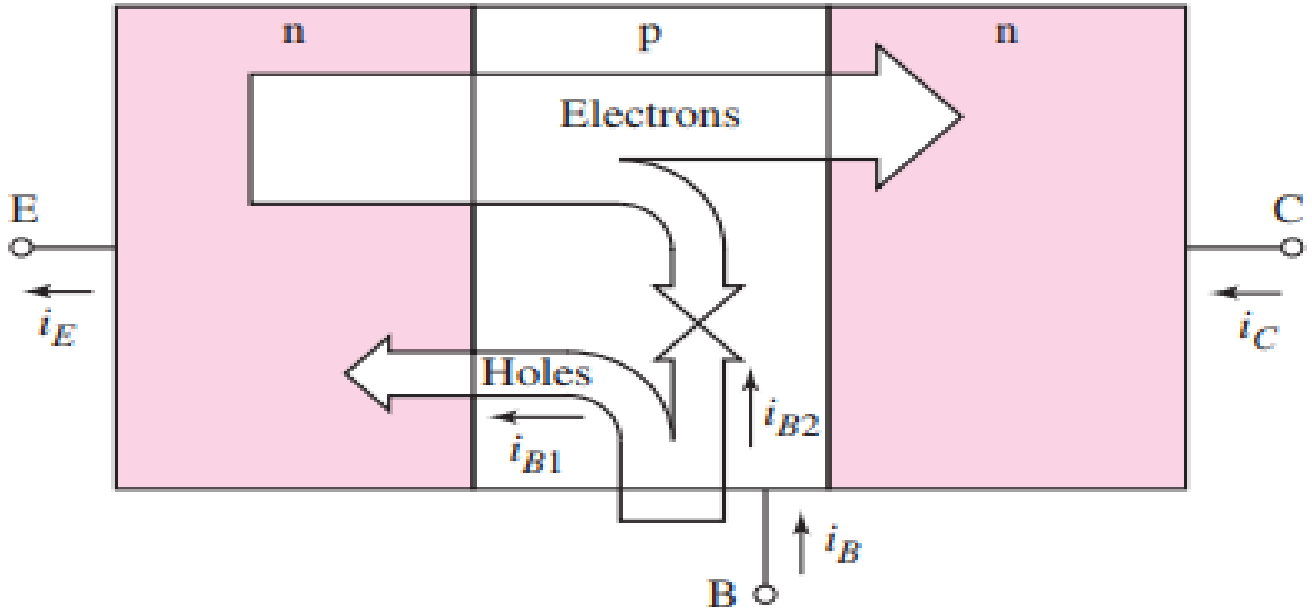


Fig.2.Electron and hole current in npn bipolar transistor biased in forward active-mode

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

PNP Transistor In Forward Active Mode operation

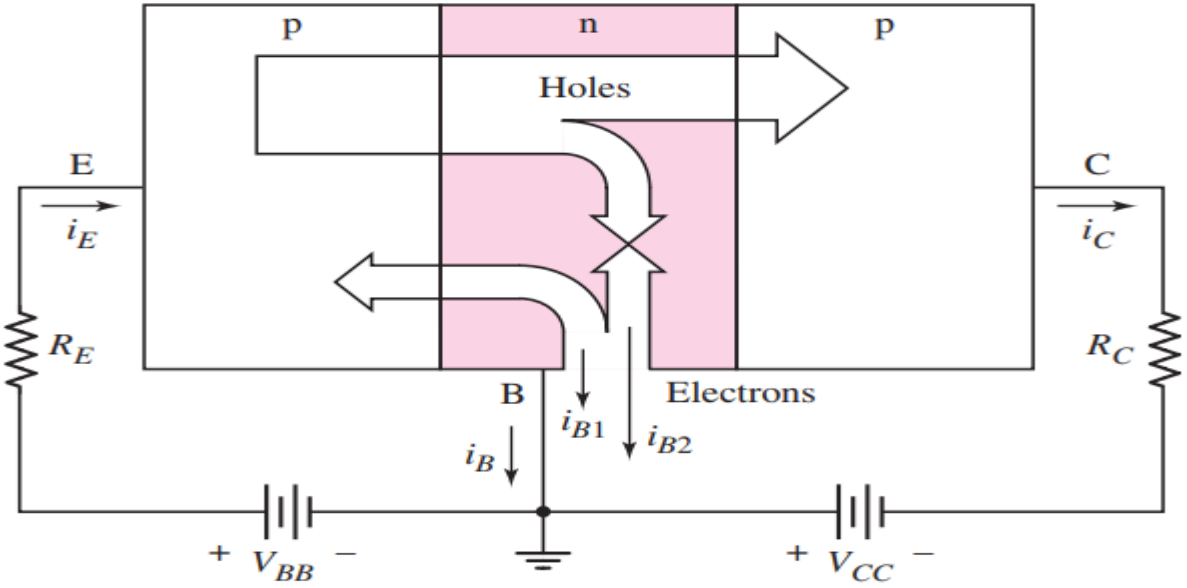


Fig.3.An pnp transistor in forward active mode

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

Common-emitter configuration

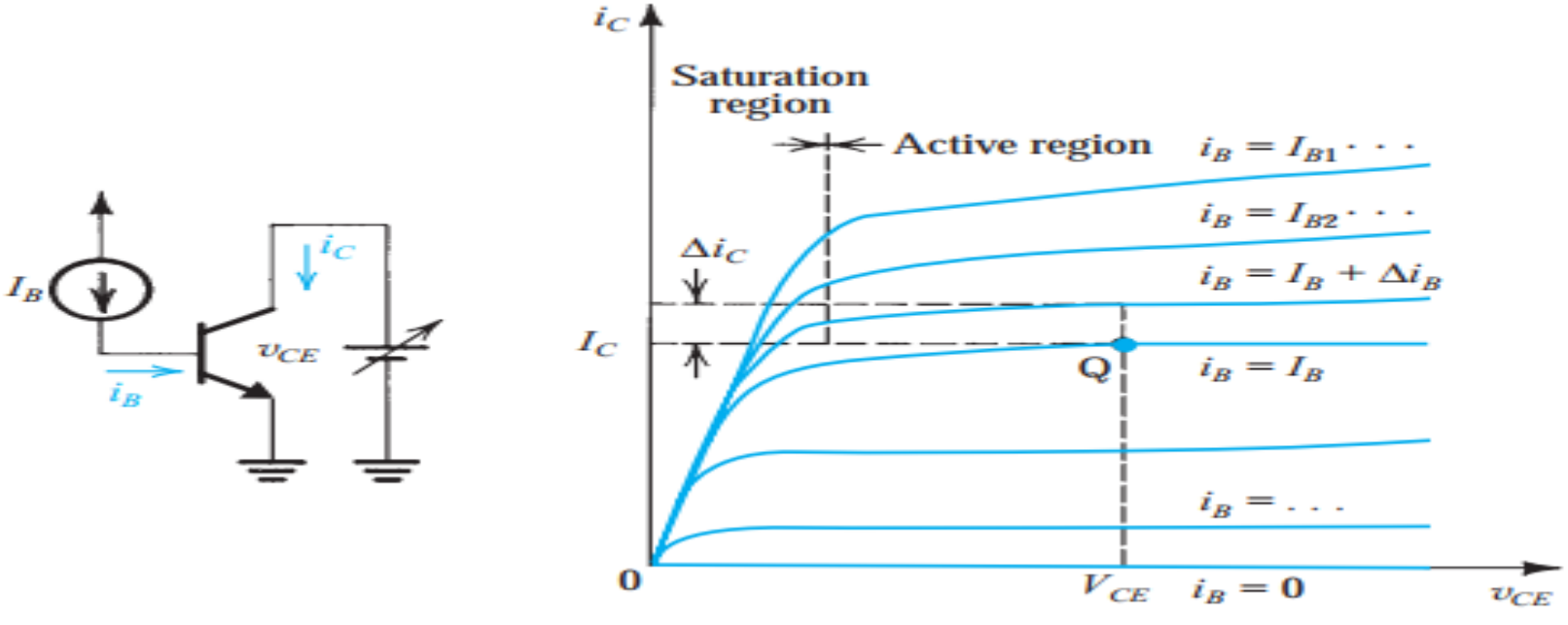


Fig.4. common emitter configuration

Source: Microelectronics Circuits, Sedra and Smith, Fifth edition

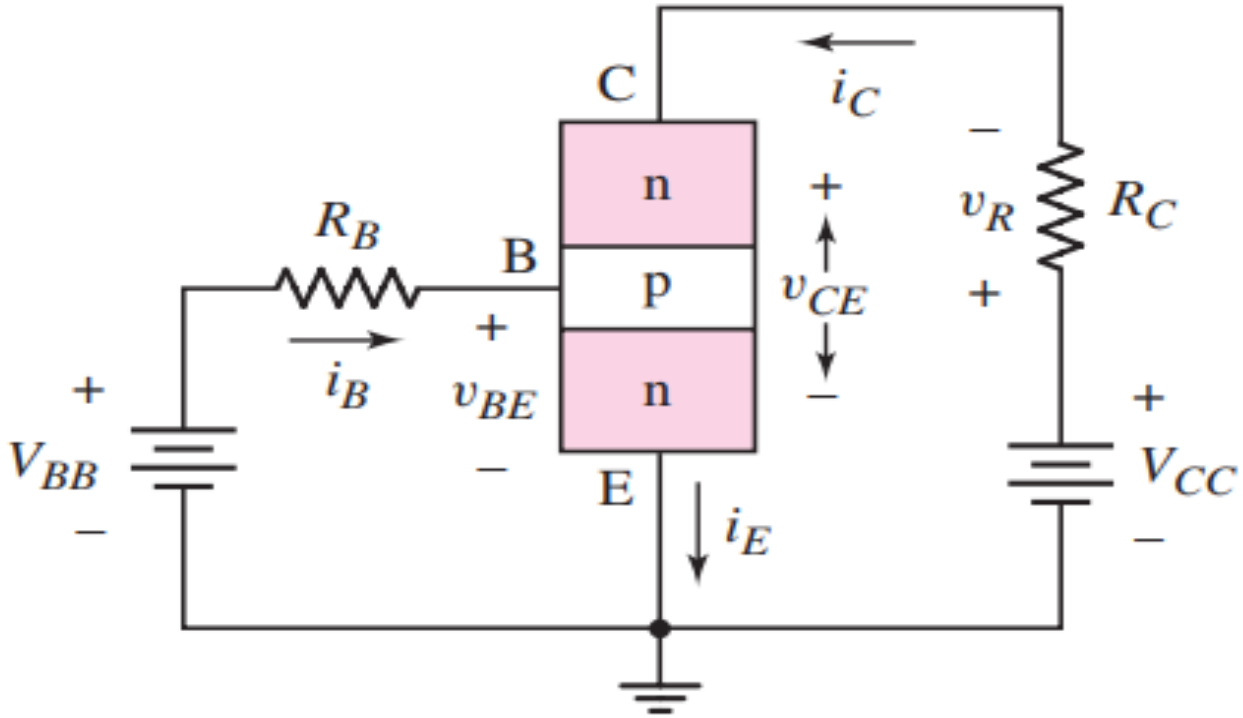


Fig.5.An npn transistor in common –emitter configuration

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

- Emitter is common connection.
- The power supply voltage must be large to keep B-C junction reversed biased.
- The base current established by V_{BB} and R_B.
- If V_{BB} =0 , the B-E junction will have zero applied bias, base current and collector current will be zero, this implies cutoff condition.

$$V_{CC} = v_{CE} + i_C R_C$$

$$i_C = \beta i_B$$

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

- The collector current is a fraction α of the emitter current.
- The base current is a fraction 1/β of the collector current.
- If β>>1, then approx α=1 $i_C \cong i_E$.

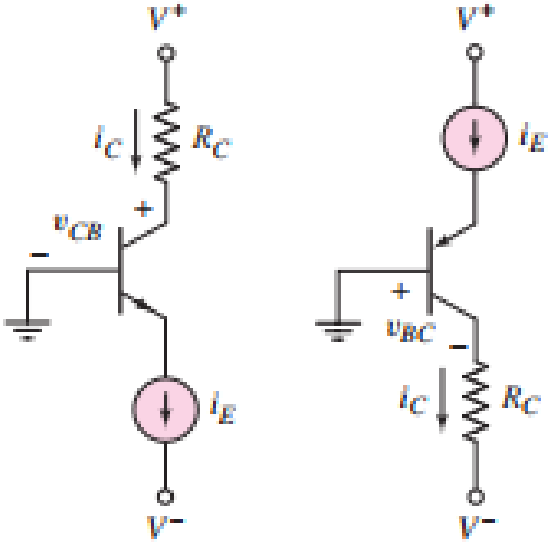
$$I_E = I_c + I_B \qquad i_C = \beta i_B \qquad i_E = (1+\beta) i_B$$

$$i_C = \frac{\beta}{1+\beta} i_E \qquad I_C = \alpha I_E \qquad \alpha = \frac{\beta}{\beta+1}$$

$$\beta = \frac{\alpha}{1-\alpha}$$

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

Common-base configuration



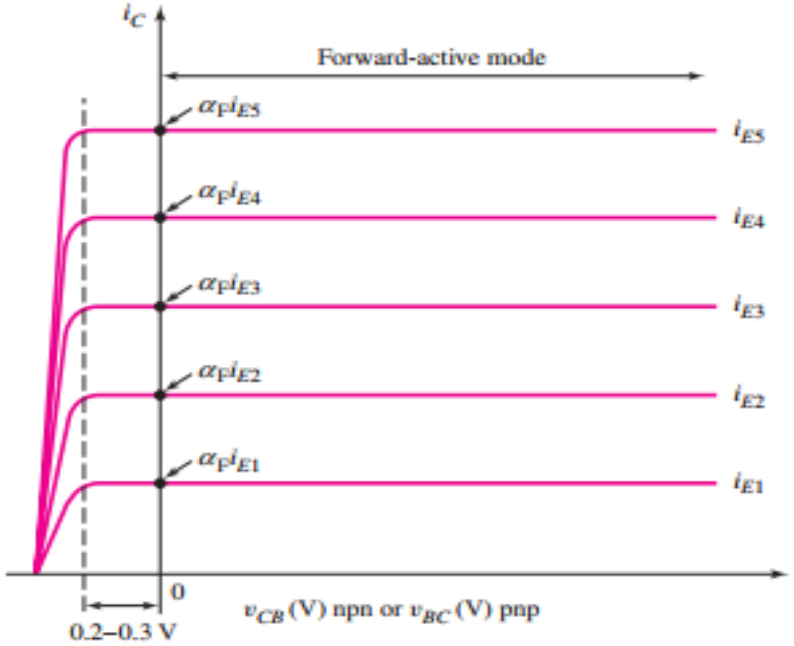


Fig.6. common base configuration

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

Common-collector configuration

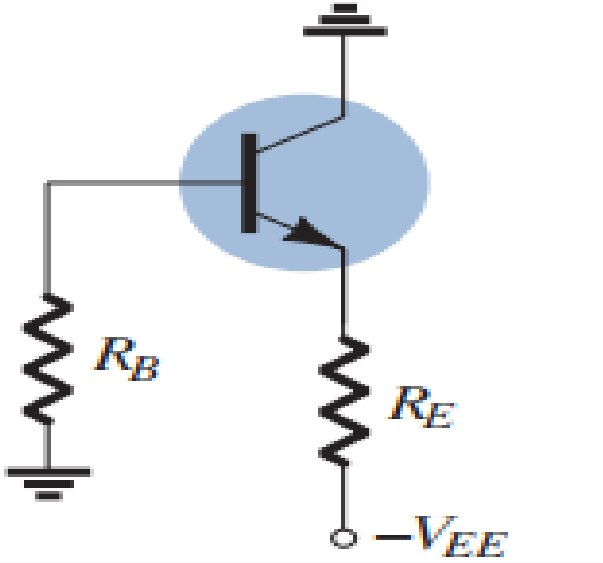


Fig.7. common -collector configuration

$$I_B = \frac{V_{EE} - V_{BE}}{R_B + (\beta + 1)}$$

$$I_C = \beta I_B, I_E = (\beta + 1) I_B$$

$$V_{CE} = V_{EE} - I_E R_E$$

Source: Electronics Devices and circuit Theory, Robert L. Boylested, Eleventh edition

Circuit Symbol and convention

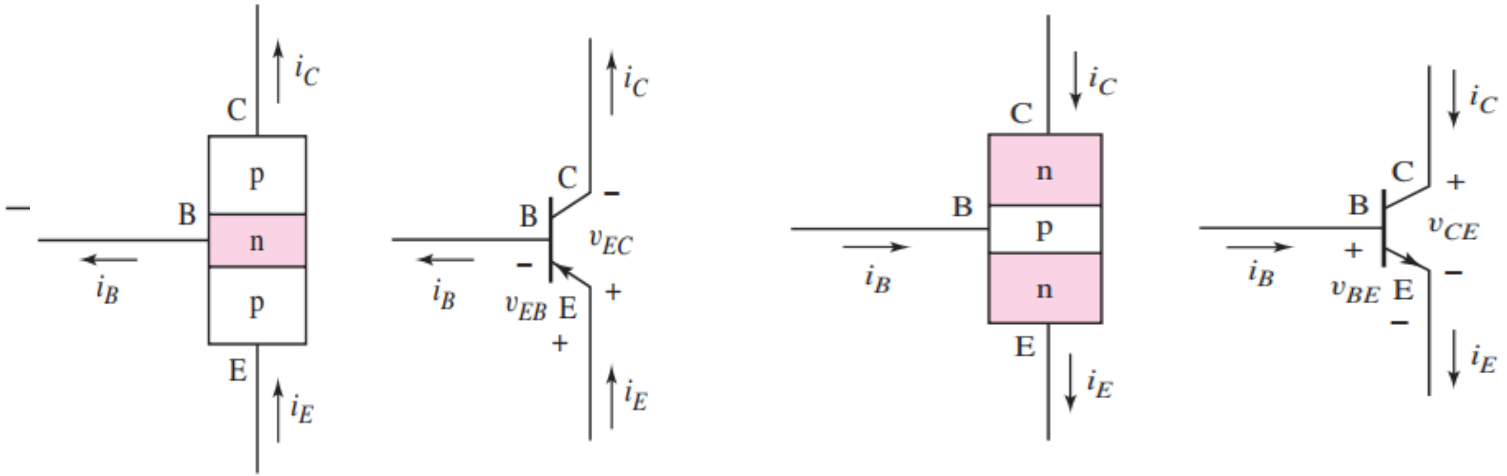


Fig.8. pnp and npn transistor block diagram and symbol

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

Recapitulation

npn	pnp
$i_C = I_S e^{v_{BE}/V_T}$	$i_C = I_S e^{v_{EB}/V_T}$
$i_E = \frac{i_C}{\alpha} = \frac{I_S}{\alpha} e^{v_{BE}/V_T}$	$i_E = \frac{i_C}{\alpha} = \frac{I_S}{\alpha} e^{v_{EB}/V_T}$
$i_B = \frac{i_C}{\beta} = \frac{I_S}{\beta} e^{v_{BE}/V_T}$	$i_B = \frac{i_C}{\beta} = \frac{I_S}{\beta} e^{v_{EB}/V_T}$

For both transistors

$i_E = i_C + i_B$	$i_C = \beta i_B$
$i_E = (1+\beta) i_B$	$i_C = \alpha i_E = \left(\frac{\beta}{1+\beta}\right) i_E$
$\alpha = \frac{\beta}{1+\beta}$	$\beta = \frac{\alpha}{1-\alpha}$

Source: Microelectronics Circuit Analysis and Design Donald A. Neamen, Fourth edition

Thank You