Bipolar Junction Transistors - I
(BJT-I)

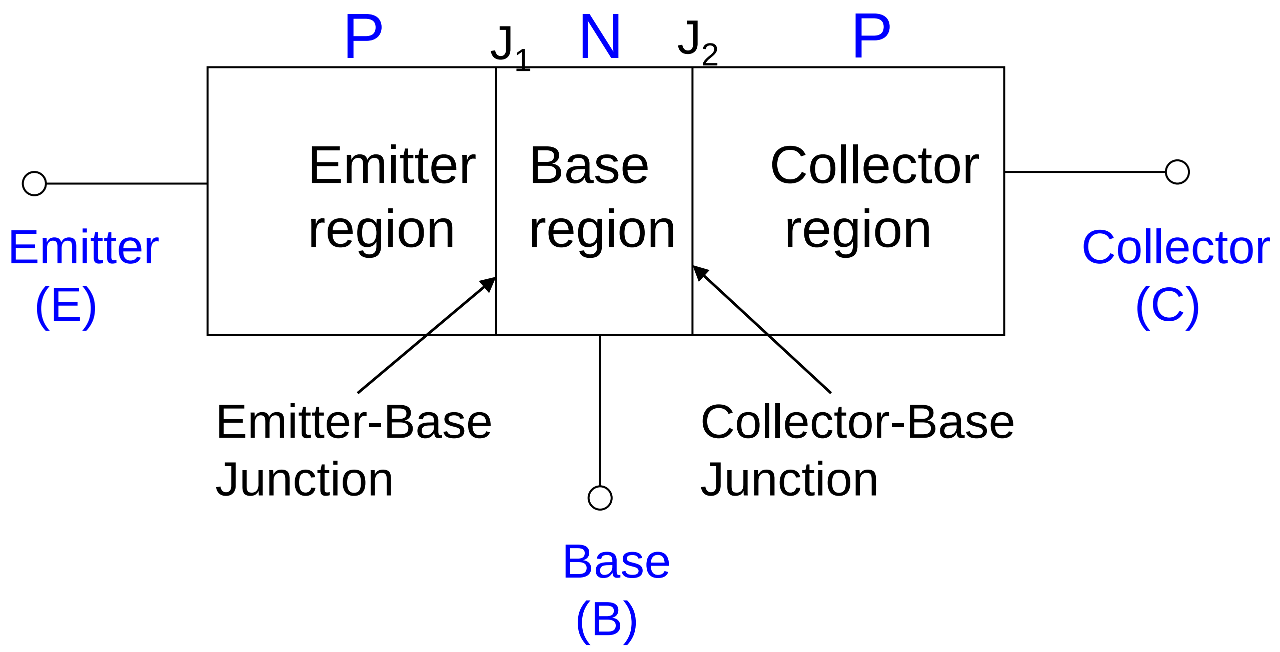
BASICS

- A bipolar junction transistor (BJT) is a three terminal device constructed of doped semiconductor material

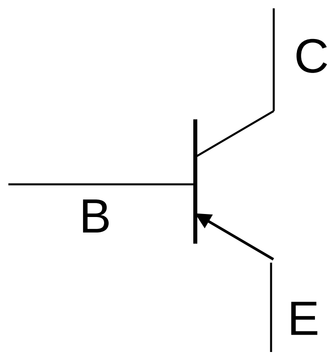
- BJT is used in amplifying or switching applications, in discrete circuits and in IC design, both in analog and digital domain

- Bipolar Junction Transistors are so named because their operation involves both electrons and holes which are negative and positive charge carriers

Physical Structure of PNP Transistor

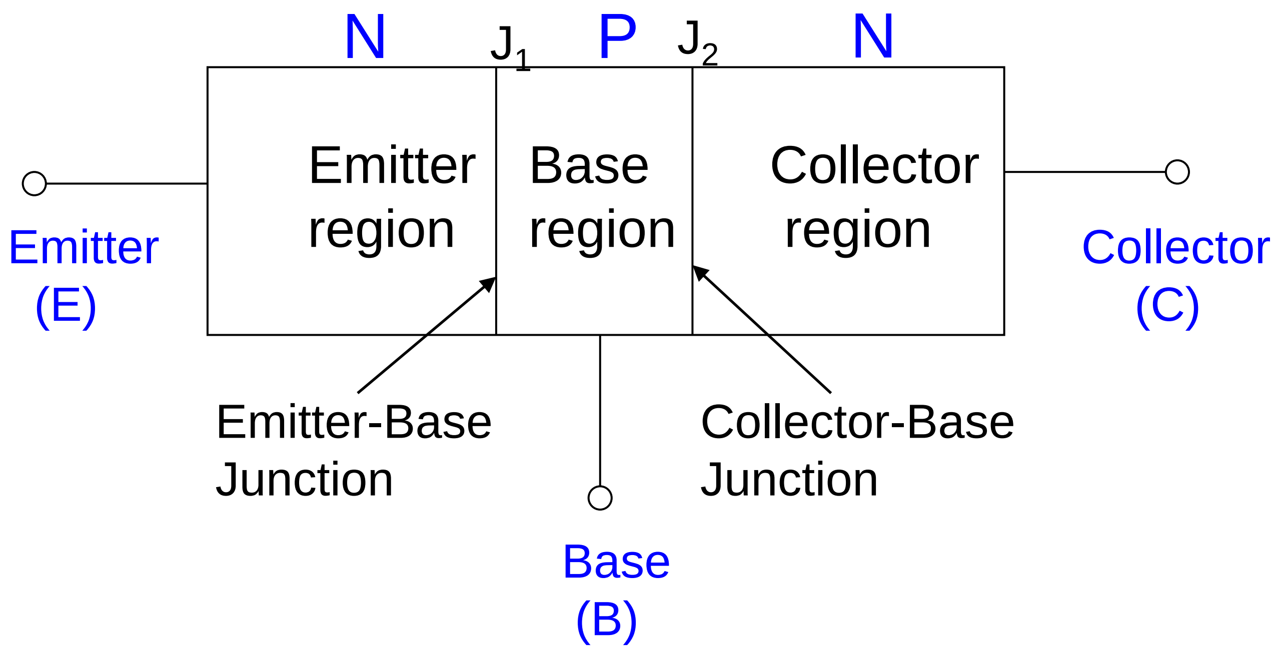


Symbol

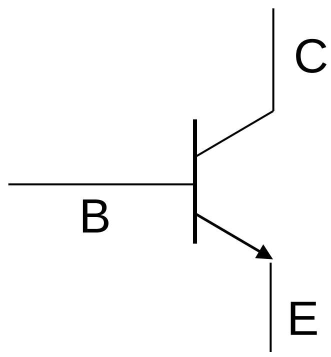


Arrow indicates the direction in which the current flows in the emitter

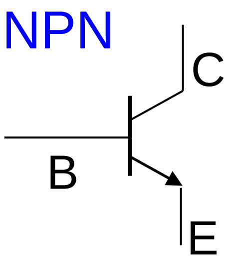
Physical Structure of NPN Transistor

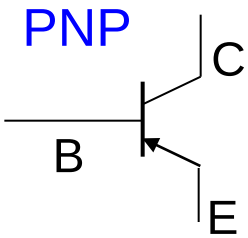


Symbol



Arrow indicates the direction in which the current flows in the emitter





	Mode of Operation	B-E Junction	B-C Junction
Amplifier	**Active**	Forward Biased	Reverse Biased
Switch	**Saturation**	Forward Biased	Forward Biased
	Cut-Off	Reverse Biased	Reverse Biased

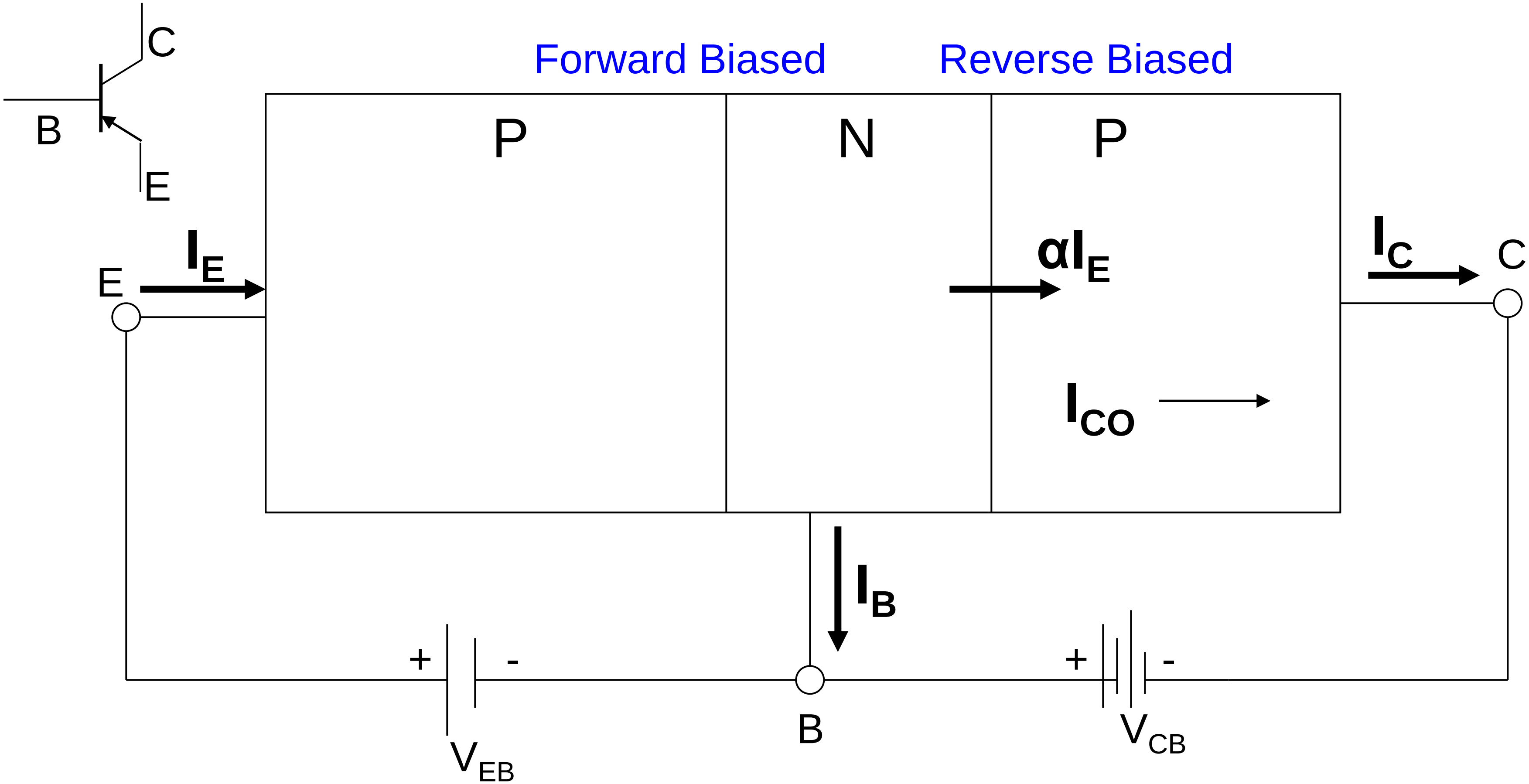
Amplifier: Signal voltage (or current) is amplified

Output AC signal power is more than input AC signal power

Switch: At Saturation, very low resistance between C and E

At Cut-Off, No current flow from C to E

Operation of a PNP Transistor in the Active mode

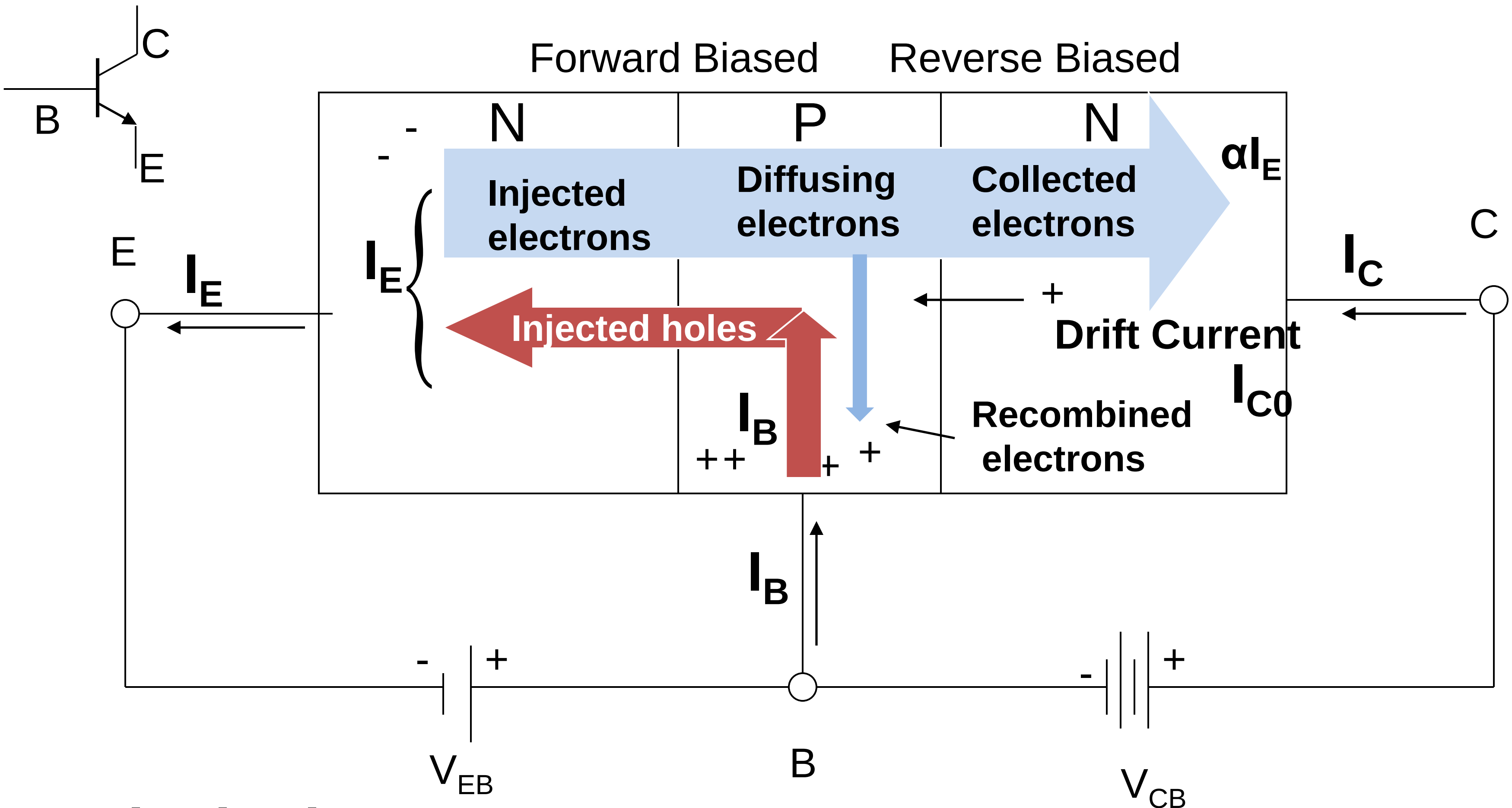


$I_E = I_B + I_C$

$I_C = \alpha I_E + I_{CO}$

α is the fraction of the total emitter current which goes from the emitter, across the base, to the collector

Operation of an NPN Transistor in the Active mode



$$I_E = I_B + I_C$$

$$I_C = \alpha I_E + I_{CO}$$

$$I_C = \alpha I_E + I_{CO} \qquad I_E = I_B + I_C$$

$$I_C = \alpha(I_B + I_C) + I_{CO}$$

$$(1-\alpha)I_C = \alpha I_B + I_{CO}$$

Transistor in Active Mode

$$I_C = \frac{\alpha}{1-\alpha} I_B + \frac{1}{1-\alpha} I_{CO}$$

Define $\beta = \dfrac{\alpha}{1-\alpha}$

$$I_C = \beta I_B + (\beta + 1) I_{CO}$$

Different Transistor configurations –

A Transistor may be operated in three different configurations :

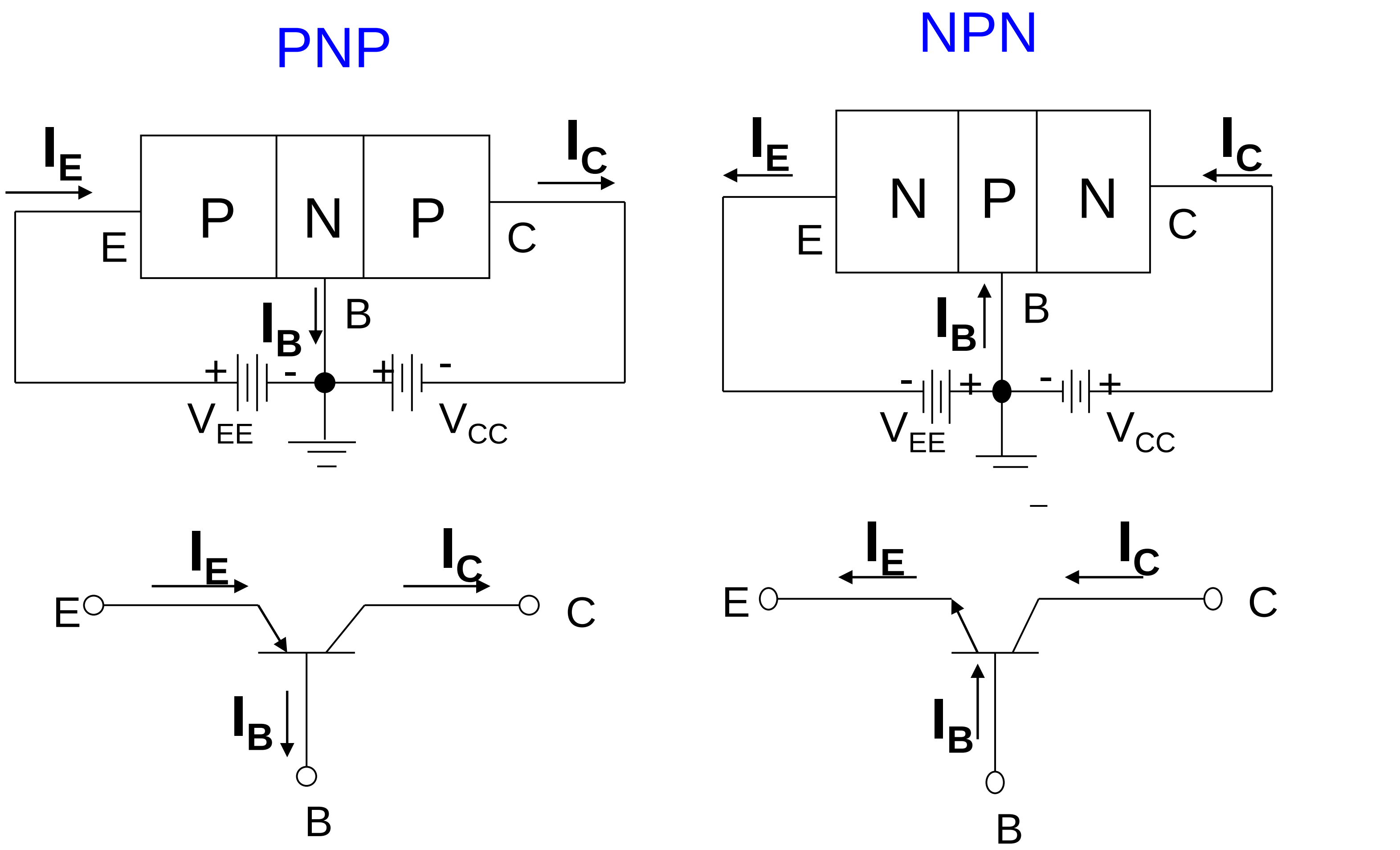
Common Base (CB)

Common Emitter (CE)

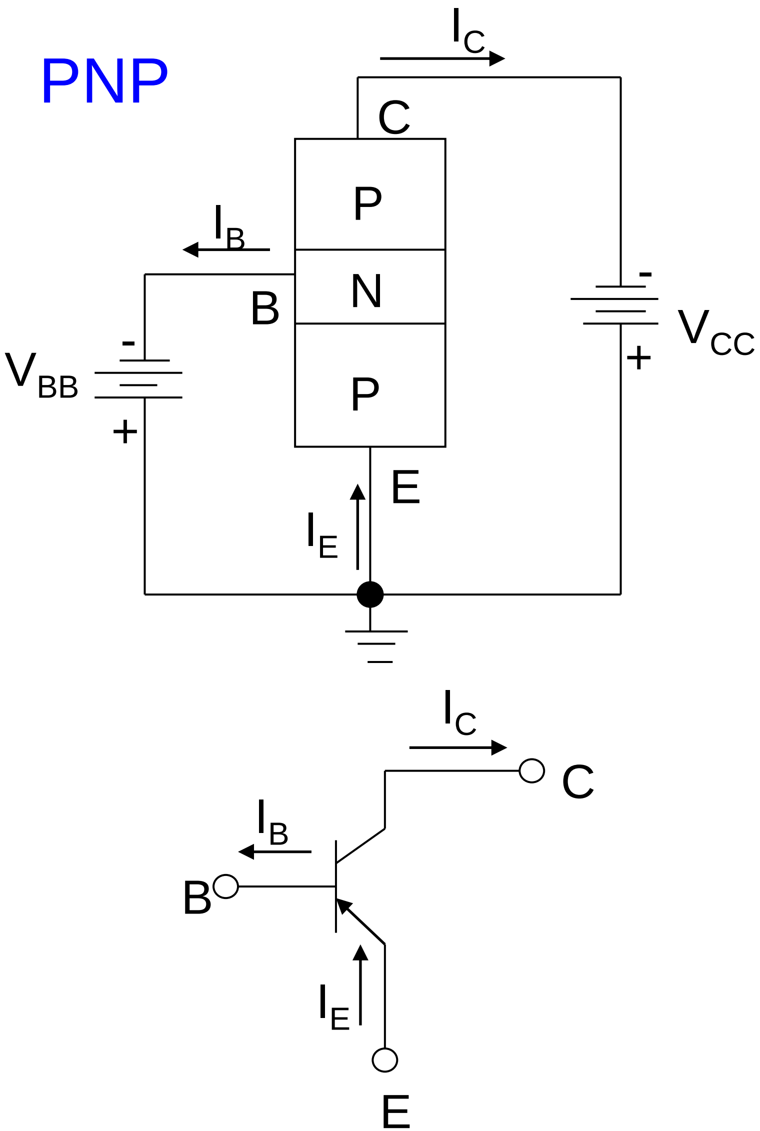
Common Collector (CC)

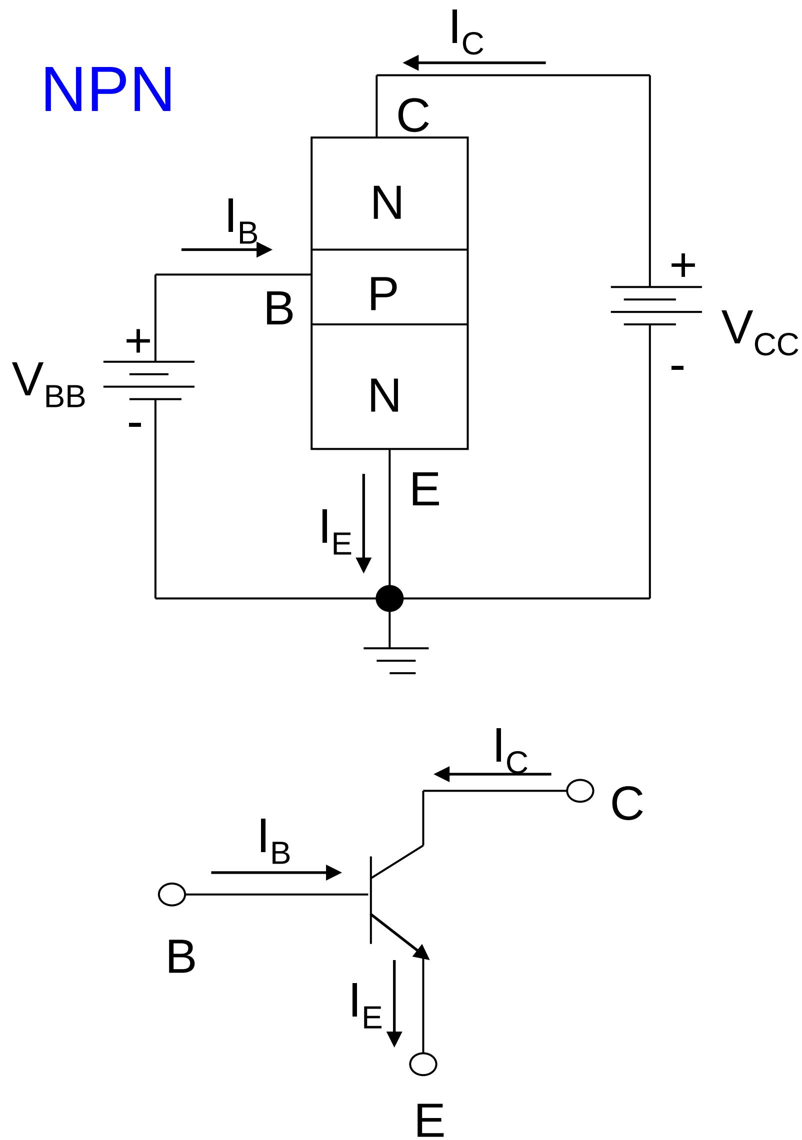
AMPLIFIER TYPE	COMMON BASE	COMMON EMITTER	COMMON COLLECTOR
INPUT/OUTPUT PHASE RELATIONSHIP	0°	180°	0°
VOLTAGE GAIN	HIGH	MEDIUM	LOW
CURRENT GAIN	LOW	MEDIUM	HIGH
POWER GAIN	LOW	HIGH	MEDIUM
INPUT RESISTANCE	LOW	MEDIUM	HIGH
OUTPUT RESISTANCE	HIGH	MEDIUM	LOW

Common Base (CB) Transistor Configuration

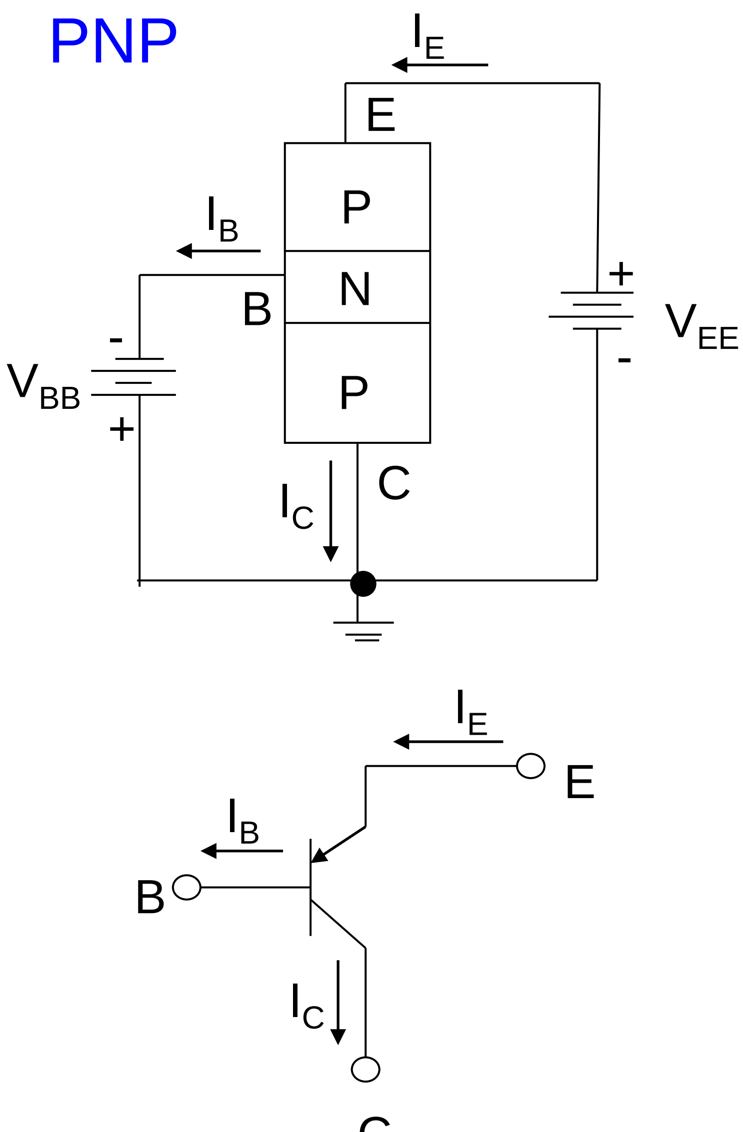


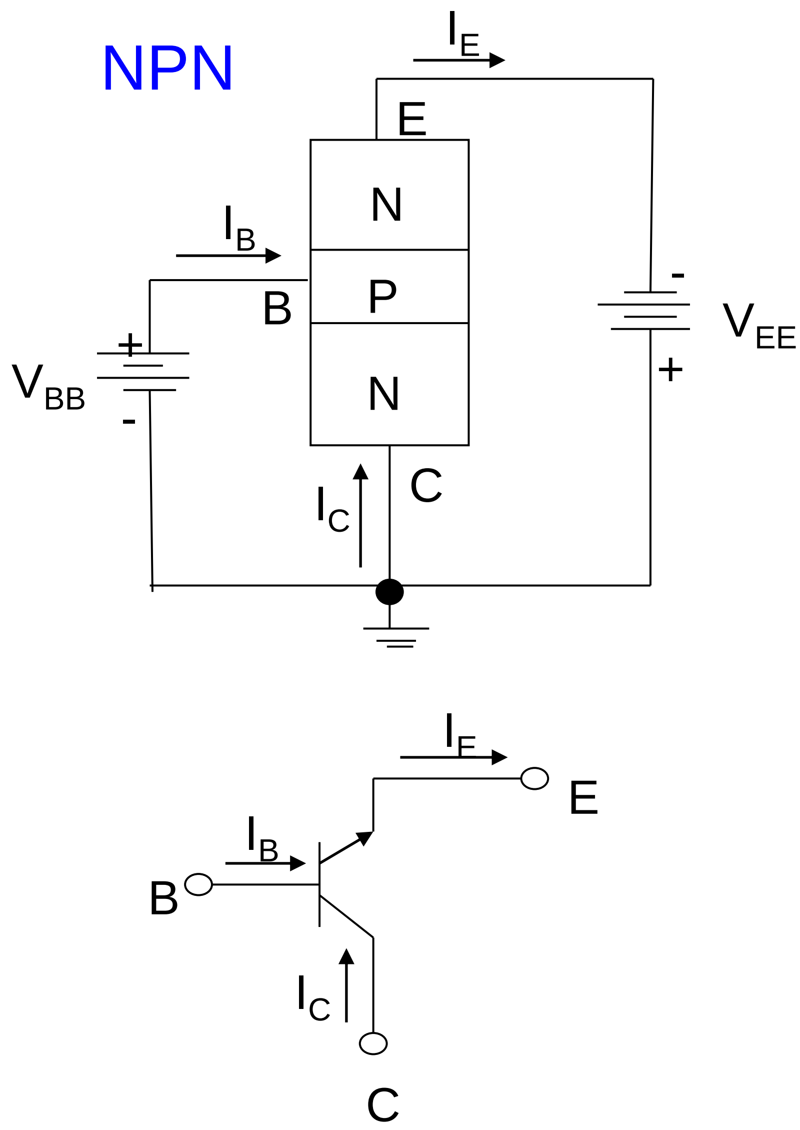
Common Emitter (CE) Transistor Configuration





Common Collector (CC) Transistor Configuration

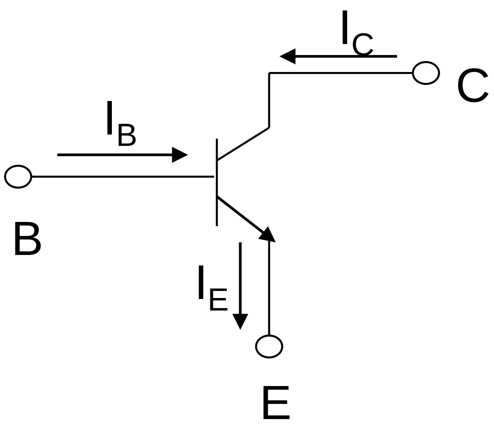




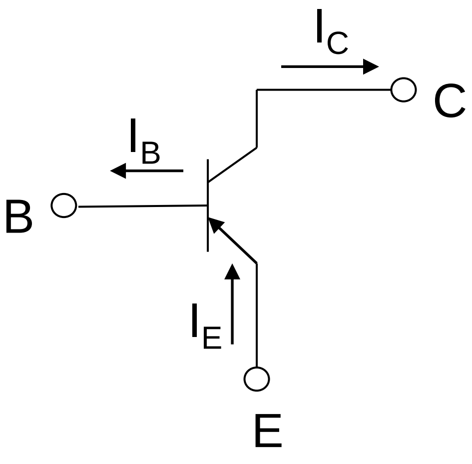
The Common Emitter (CE) configuration is the most common configuration for using a transistor.

We will discuss this in more detail in our subsequent slides concentrating mainly on the way in which this can be used as an amplifier.

To keep things simple, we will mainly look at circuits using an NPN transistor but the usage of a PNP transistor will be very similar (just use voltage supplies of opposite polarity!).



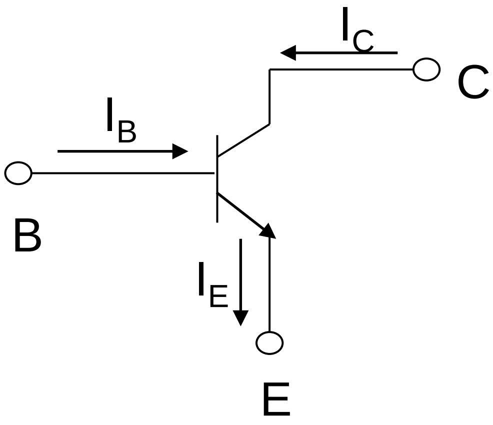
NPN



PNP

Common Emitter Configuration (NPN Transistor)

Transistor in Active Mode



$$I_C = \beta I_B + (\beta + 1) I_{CO}$$

$$I_C \cong \beta I_B \qquad \textit{ignoring } I_{CO}$$

$$I_C + i_c \cong \beta(I_B + i_b)$$

$$\underset{\text{DC}}{I_C} + \underset{\text{AC}}{i_c} \cong \underset{\text{DC}}{\beta I_B} + \underset{\text{AC}}{\beta i_b}$$

AC Amplifier $\quad i_c \cong \beta i_b \quad$ AC current gain