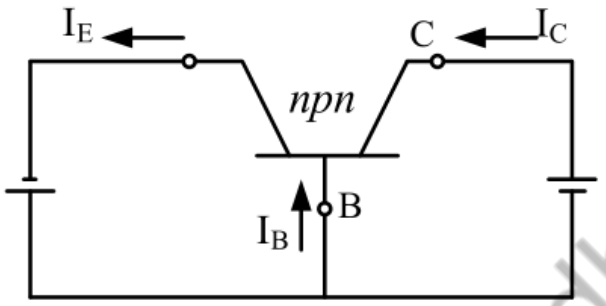
Electrical Science: 2021-22

Lecture 25

BJT Amplifiers-Part1

By Dr. Sanjay Vidhyadharan

BJT Currents in Forward-Active Mode



1. $I_E = I_B + I_C$

2. $I_C = \beta I_B$

3. $\beta = \frac{\alpha}{1-\alpha}$ (20 – 200)

4. $\alpha = \frac{\beta}{1+\beta}$ (0.95 – 0.995)

BJT DC and Small Signal Equivalent

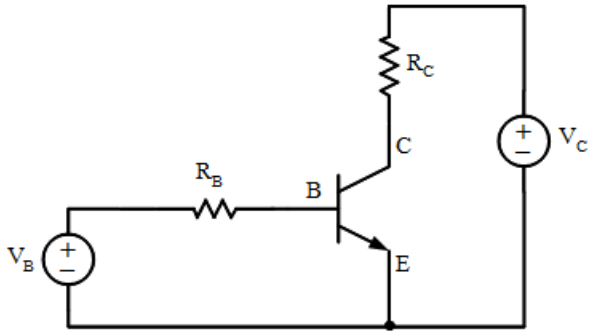
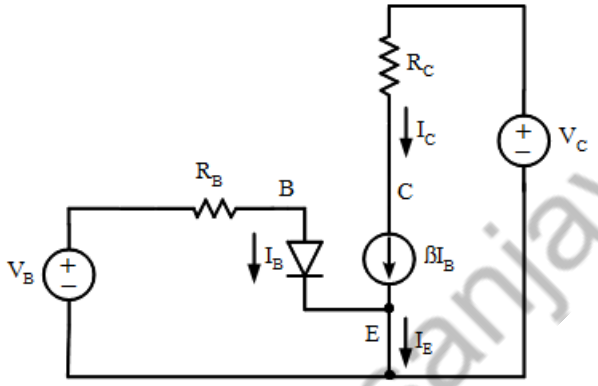
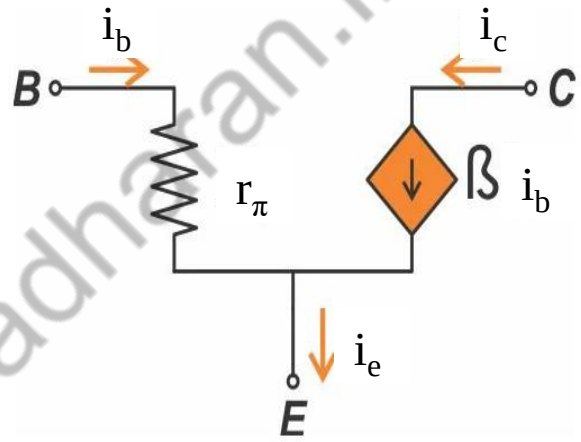
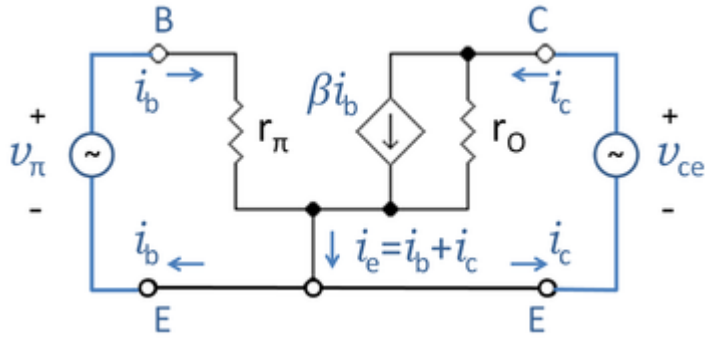


Fig 1: BJT Switch



DC Equivalent Circuit



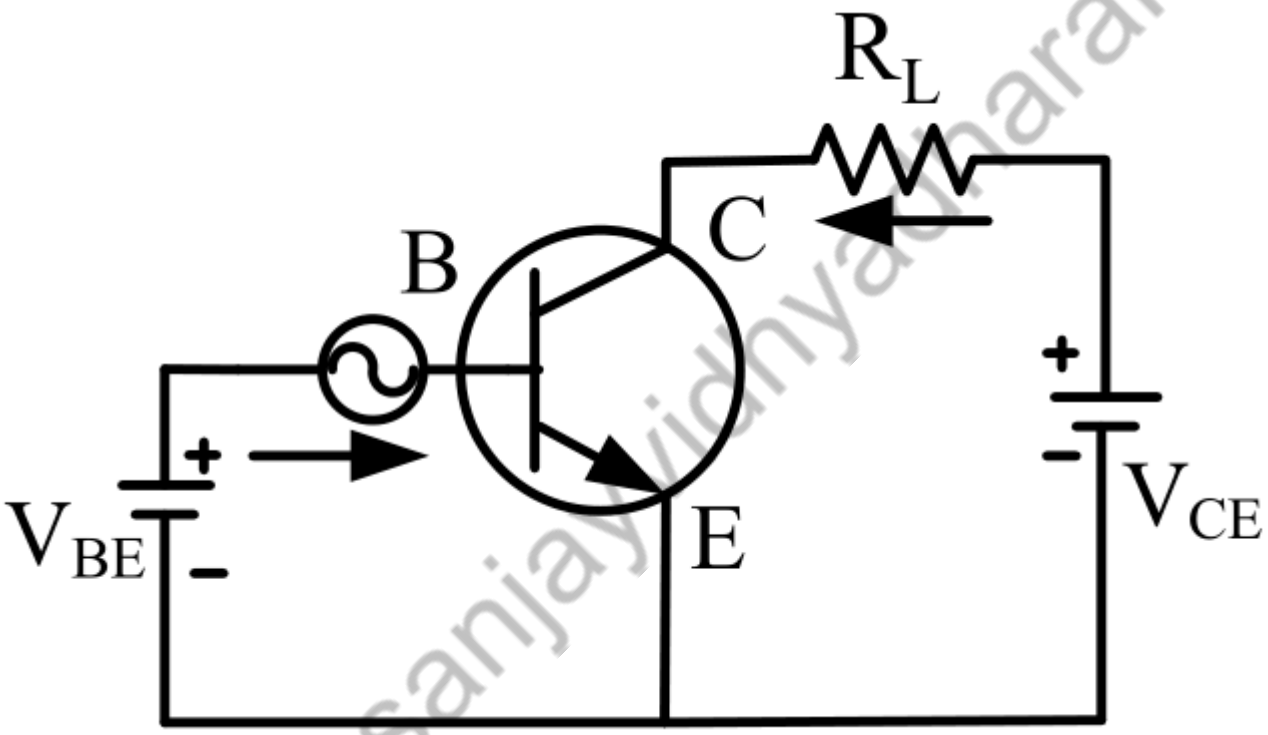


AC Equivalent Circuit

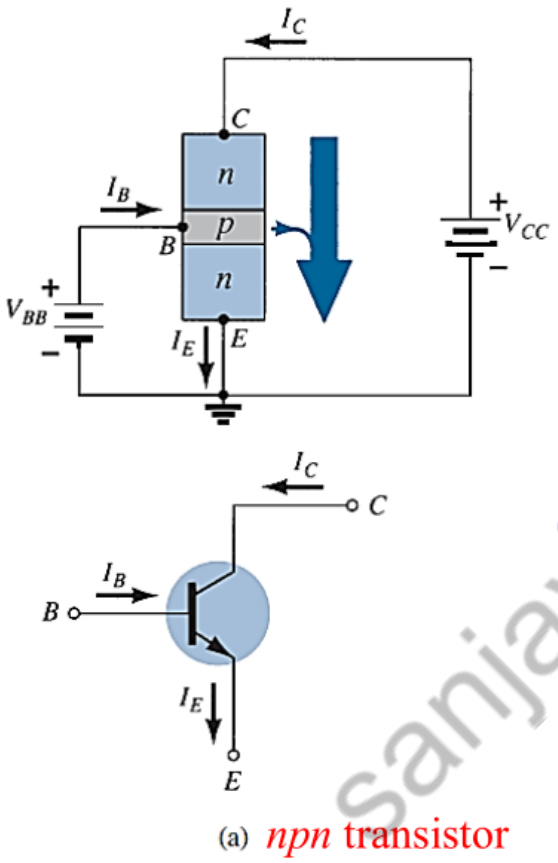
BJT Amplifier/Circuit Configurations

- Common-Emitter Configuration
- Common-Collector Configuration
- Common-Base Configuration

Common-Emitter Configuration

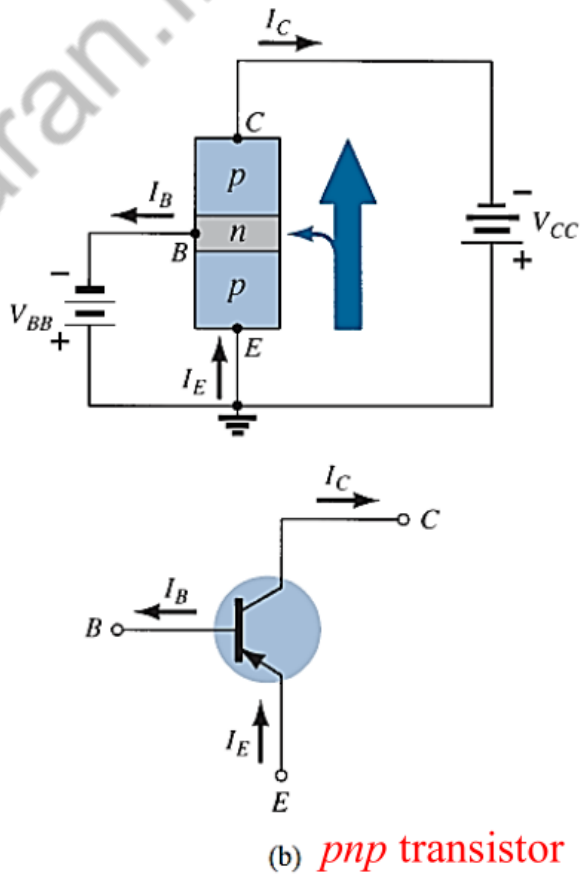


Common-Emitter Configuration



(a) *npn* transistor

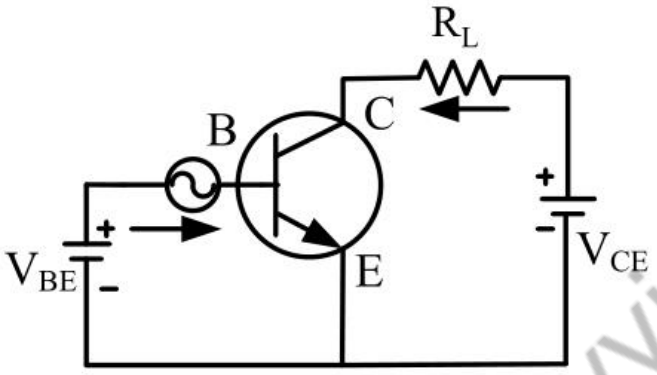
The arrows in the graphics define the direction of current through the device.



(b) *pnp* transistor

Common-Emitter Configuration

Input dc characteristics in Common-Emitter configuration

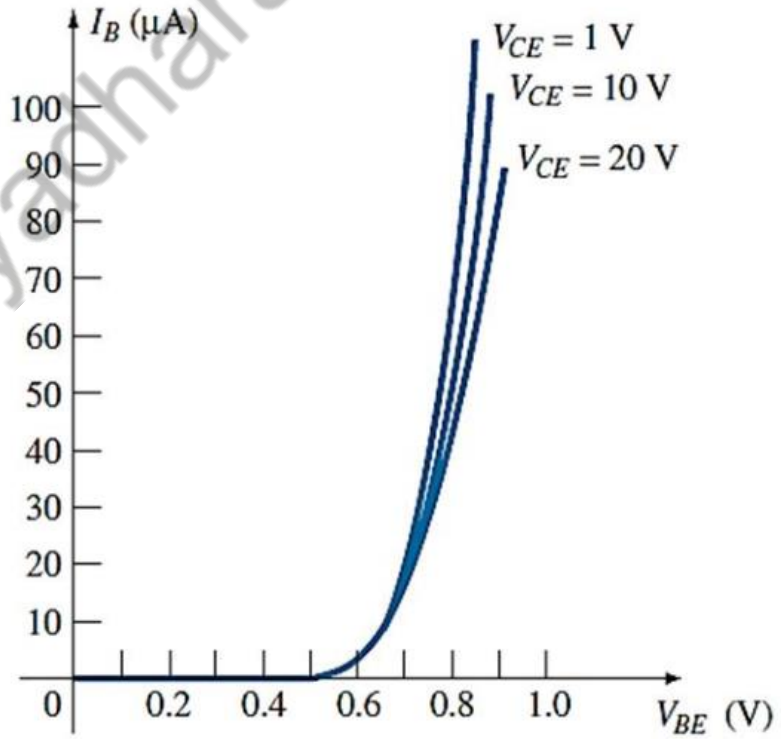


Notation:

Input current (I_B)

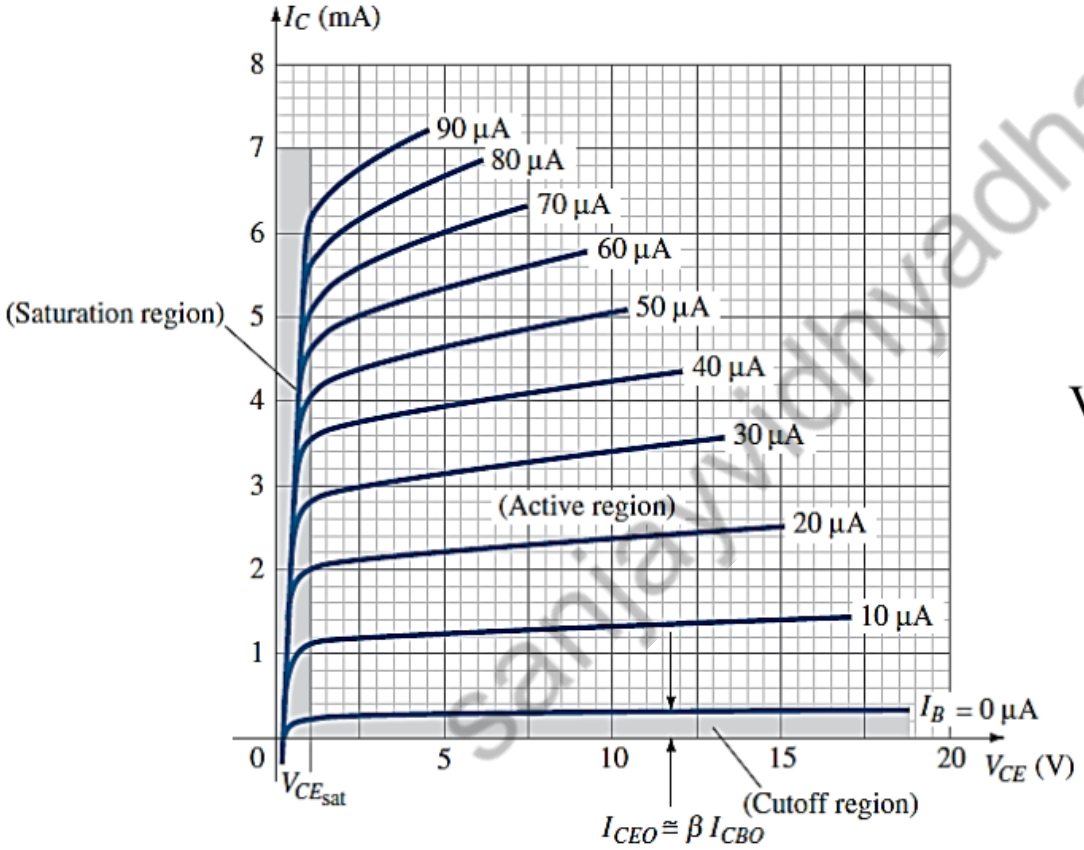
Input voltage (V_{BE})

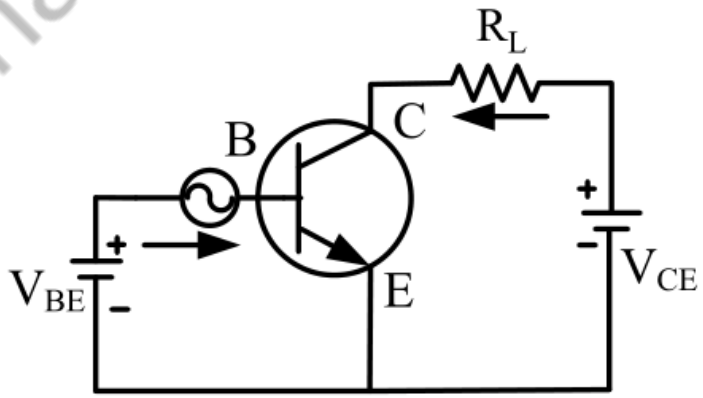
Output voltage (V_{CE})



Common-Emitter Configuration

Output dc characteristics in Common-Emitter configuration





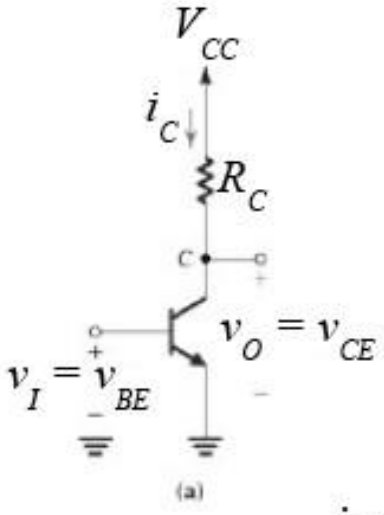
Notation:

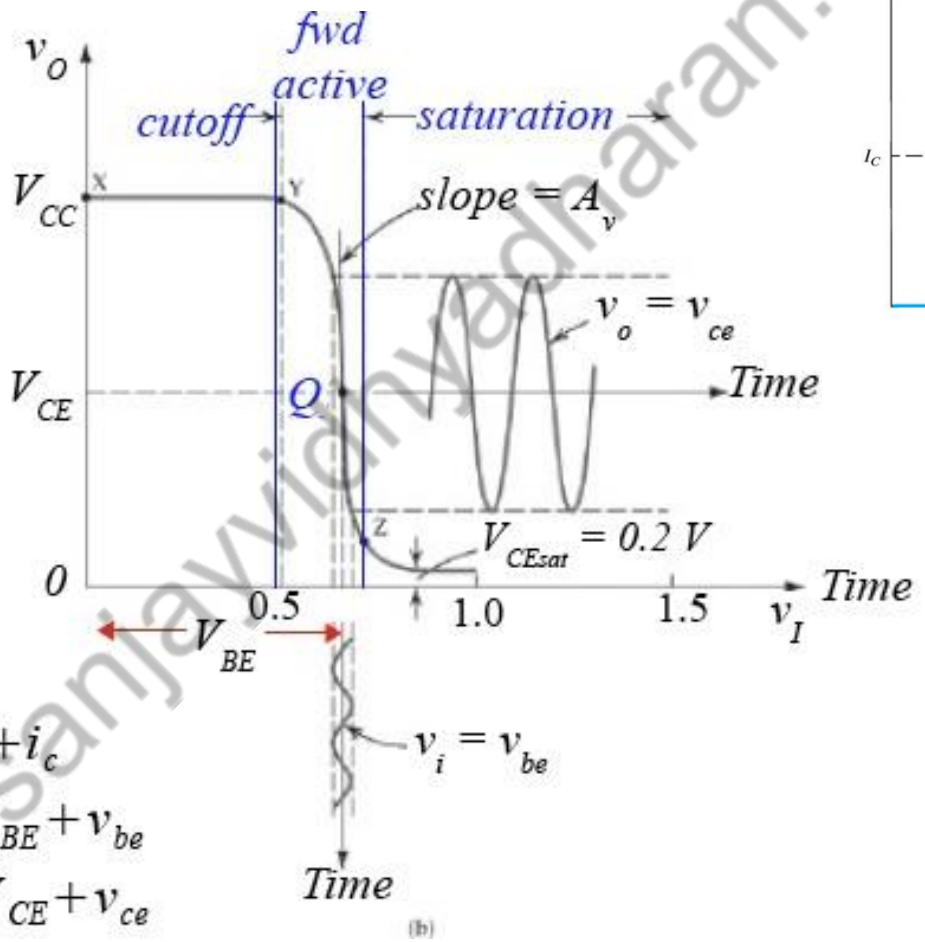
Output current (I_C)

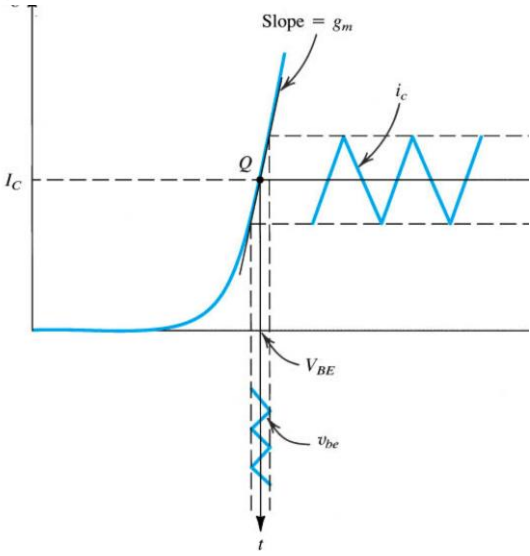
Output voltage (V_{CE})

Input current (I_B)

Common-Emitter Configuration





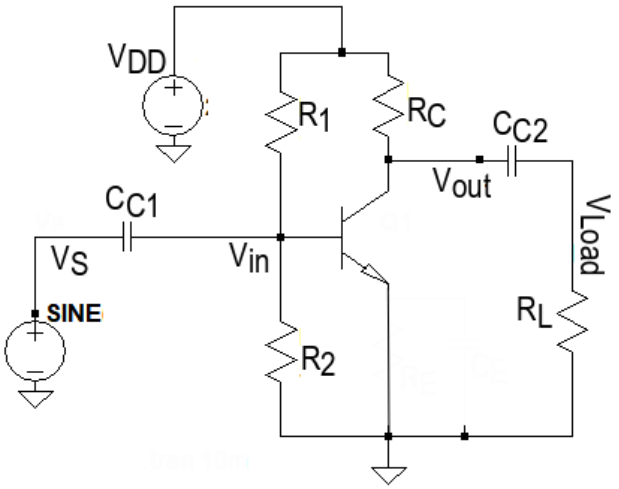


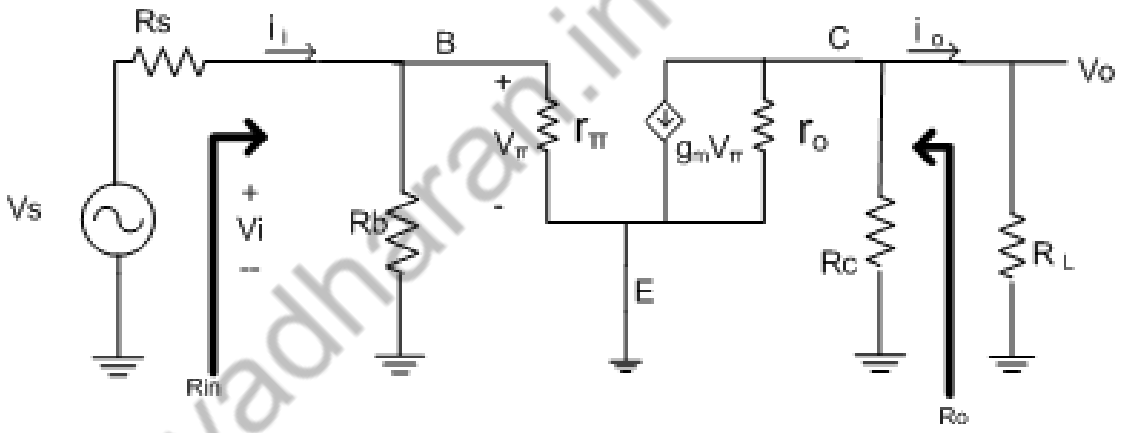
$$i_C = I_C + i_c$$

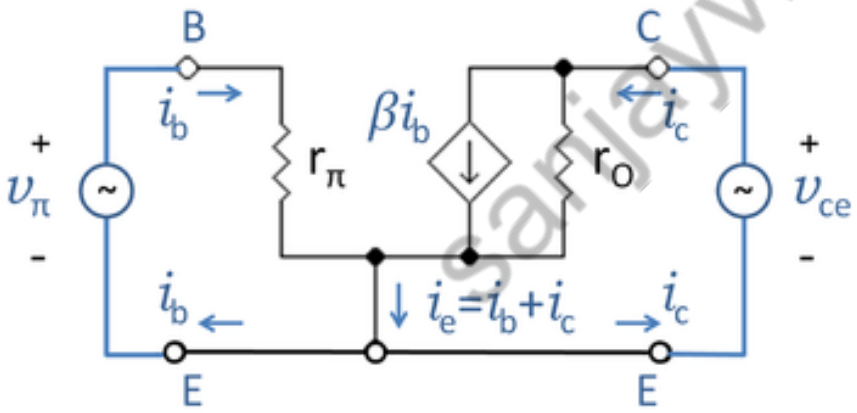
$$v_{BE} = V_{BE} + v_{be}$$

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

Common-Emitter Configuration







$$g_m V_\pi = \beta i_b$$

$$g_m = \frac{\beta i_b}{V_\pi} = \frac{\beta}{r_\pi}$$

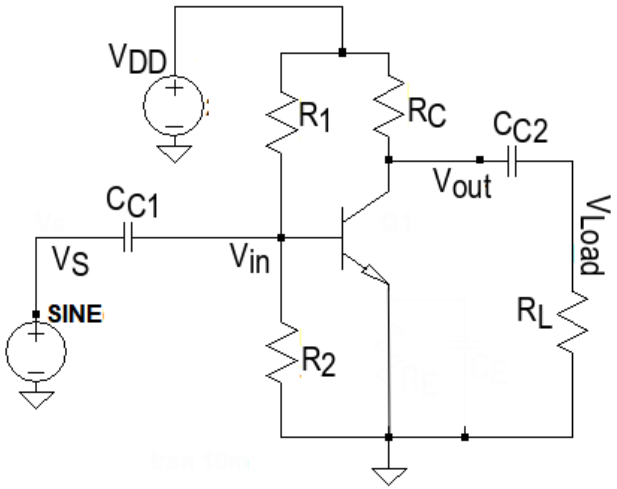
$$V_{in} = i_b r_\pi \quad (Rs \ll r_\pi \ll R_b)$$

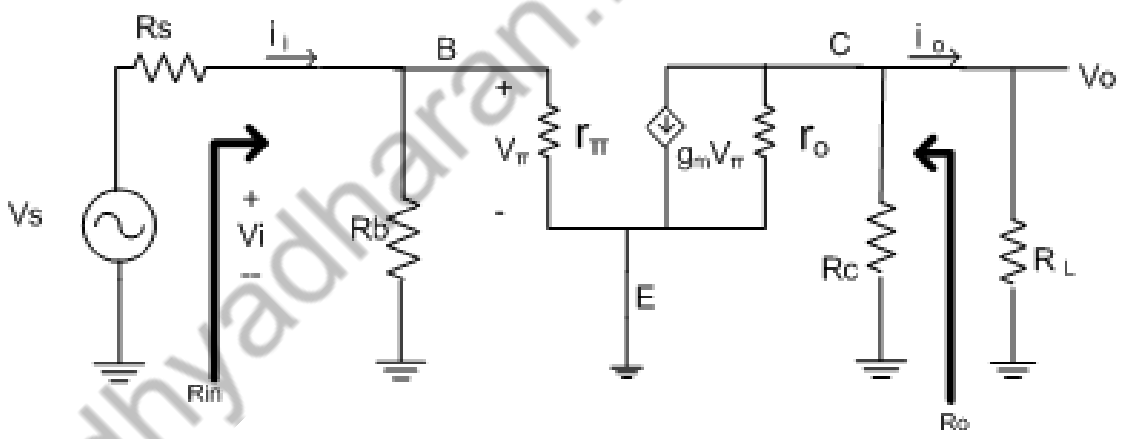
$$i_c = \beta i_b$$

$$V_{out} = -i_c R_C \quad (r_0 \gg R_C, R_L \gg R_C)$$

$$Gain = -\frac{\beta R_C}{r_\pi}$$

Common-Emitter Configuration





$$Input\ Resistance\ h_{ie} = R_b||r_\pi$$

$$Output\ Resistance\ hoe = R_C||r_o$$

$$Input\ Resistance\ h_{ie} = r_\pi\ (R_b \gg r_\pi)$$

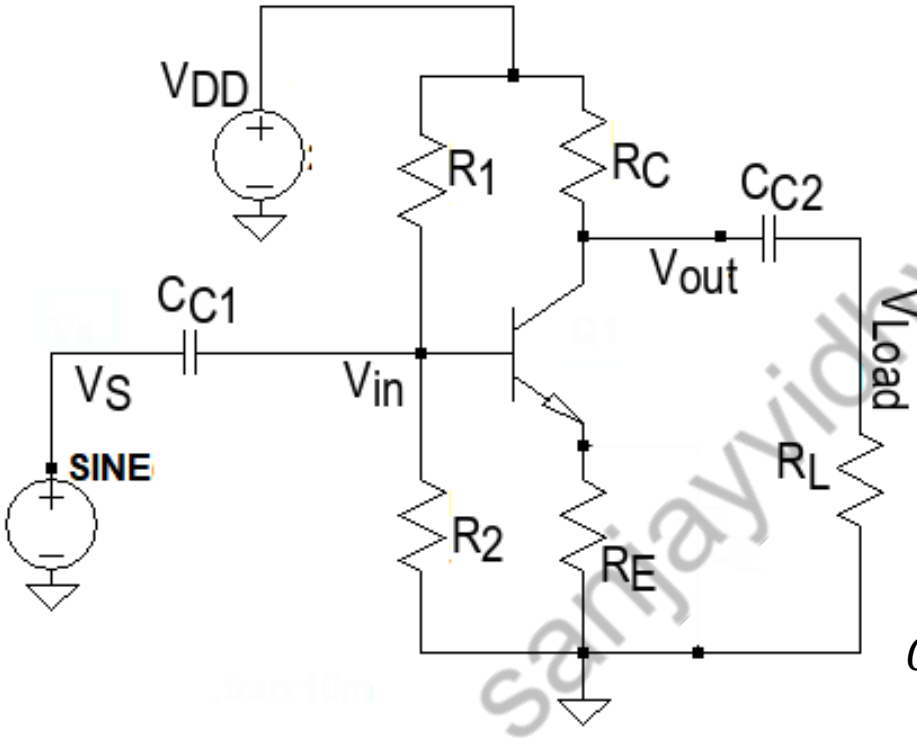
Current Gain

$$Voltage\ Gain\ = -\frac{\beta(R_C||r_o||R_L)}{r_\pi}\ \frac{(R_b||r_\pi)}{(R_b||r_\pi + R_S)}$$

Power Gain

Common-Emitter Configuration

Common-Emitter Configuration with Un-Bypassed Emitter Resistance



$$V_{in} = (r_\pi * i_b) + (i_e * R_E)$$

$$V_{in} = i_b * (r_\pi + (1+\beta)R_E)$$

$$i_b = V_{in}/(r_\pi + (1+\beta)R_E)$$

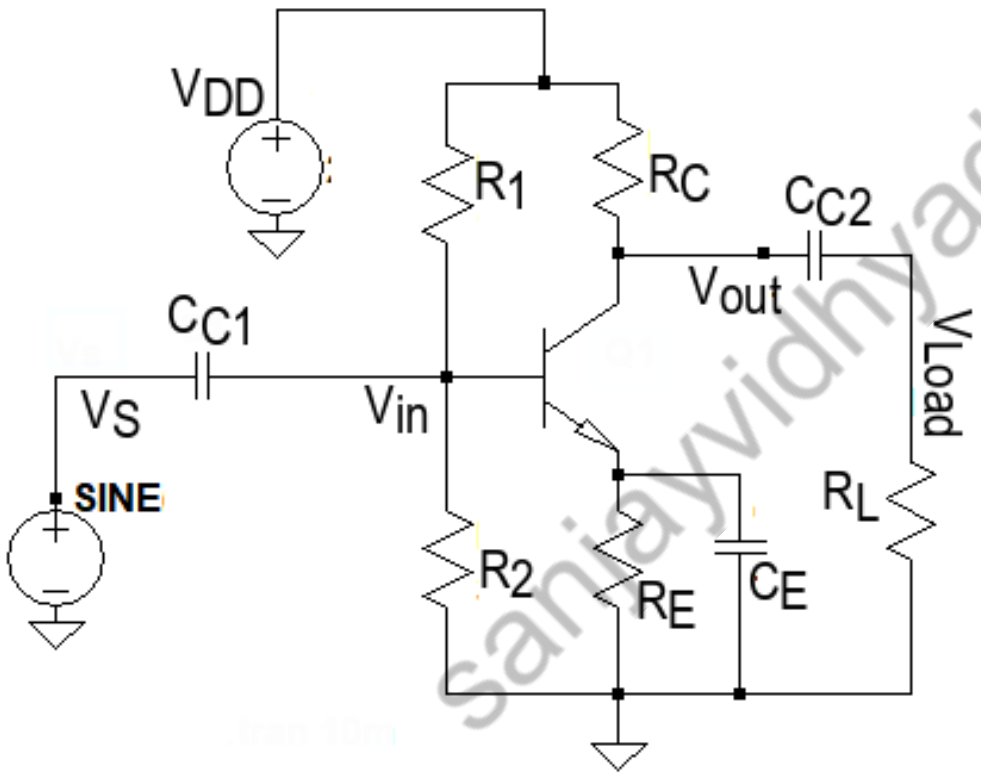
$$Voltage\ Gain = -R_c/R_E$$

$$Input\ Resistance = h_{ie} = r_\pi + (1+\beta)R_E$$

$$Output\ Resistance\ hoe = R_C||(r_o + R_E)$$

Common-Emitter Configuration

Common-Emitter Configuration with Bypassed Emitter Resistance



$$V_{in} = r_\pi * i_b$$

$$i_c = \beta * i_b$$

$$V_{out} = -i_C R_C$$

$$Gain = -\beta\, R_C / r_\pi$$

$$Input\ Resistance\ h_{ie} = R_b || r_\pi$$

$$Input\ Resistance\ h_{ie} = r_\pi\ (R_b \gg r_\pi)$$

$$Voltage\ Gain\ = -\frac{\beta(R_C||r_o||R_L)}{r_\pi}\ \frac{(R_b||r_\pi)}{(R_b||r_\pi + R_S)}$$

$$Output\ Resistance\ hoe = R_C||r_o$$

$$Current\ Gain$$

$$Power\ Gain$$

Common-Emitter Configuration

Design of Amplifier

24 V, 35 AH Battery

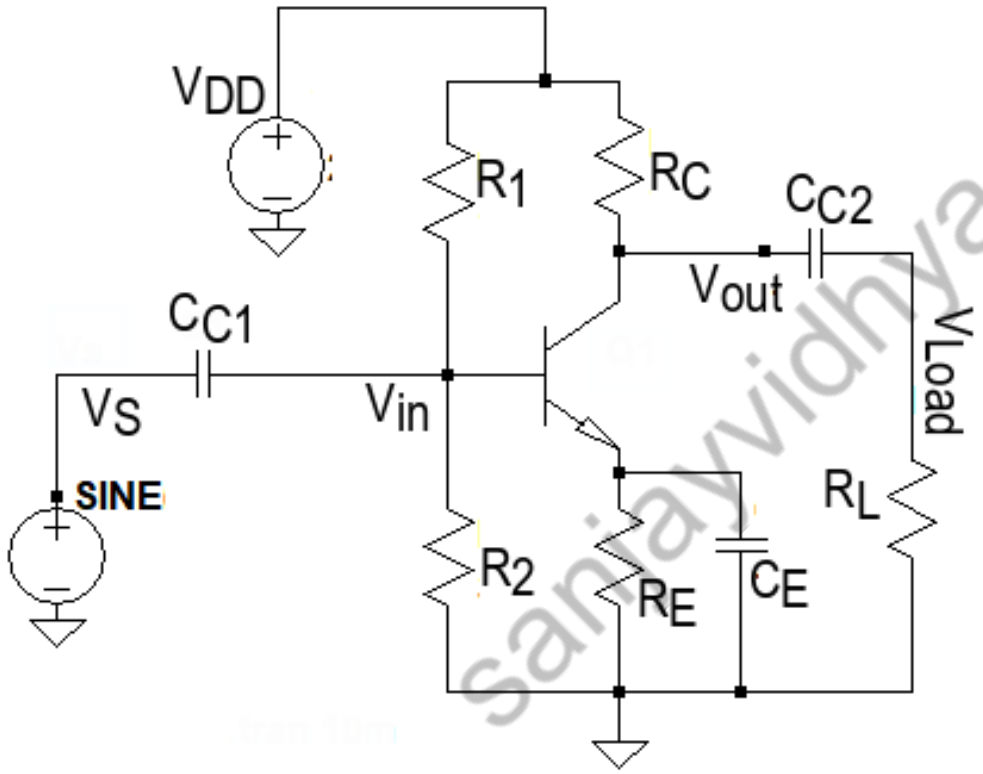
Microphone (10 mV)

Speakers (8 Ohms) 1 V p-p

Gain 100

Audio Amplifier

Common-Emitter Configuration



$$R_C = \frac{24-(2.4+0.2)}{2X1mA} \approx 10\ K$$

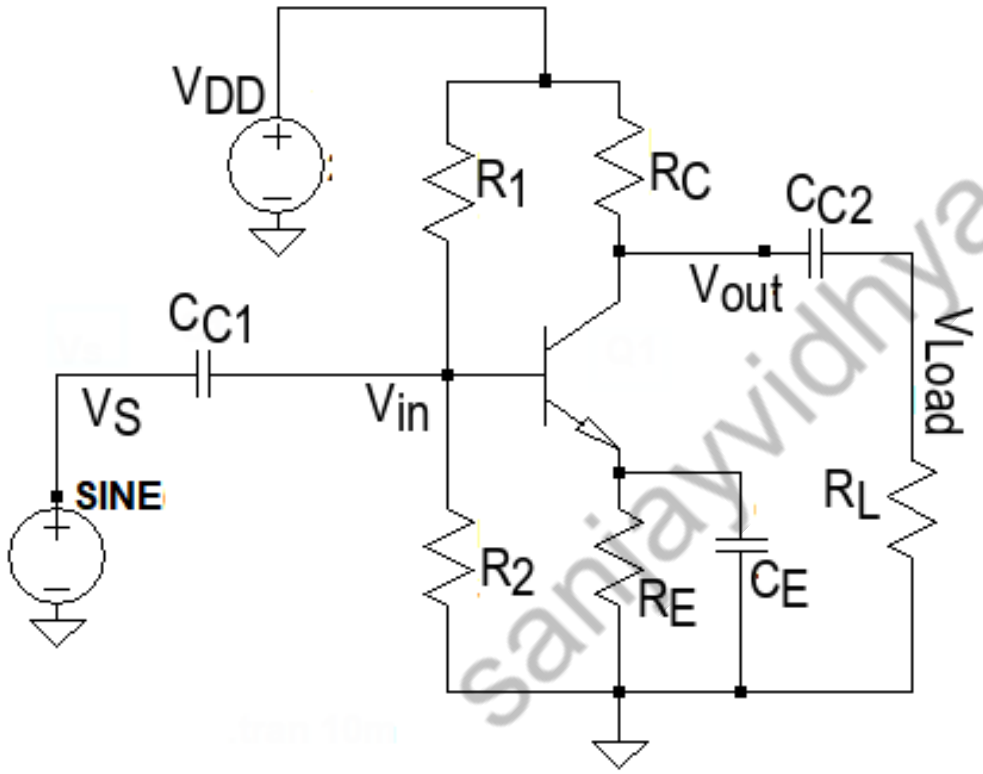
$$R_E = \frac{2.4}{2X1mA} \approx 2.2\ K$$

$$V_{BB} \approx 3.1\ V$$

$$R_2 = \frac{3.1\ x\ 50}{10\ X\ 1mA} \approx 15\ K$$

$$R_1 = \frac{21x\ 50}{10\ X\ 1mA} \approx 220\ K$$

Common-Emitter Configuration



$$R_C = \frac{24-(2.4+0.2)}{2X1mA} \approx 10\ K$$

$$R_E = \frac{2.4}{1mA} \approx 2.2\ K$$

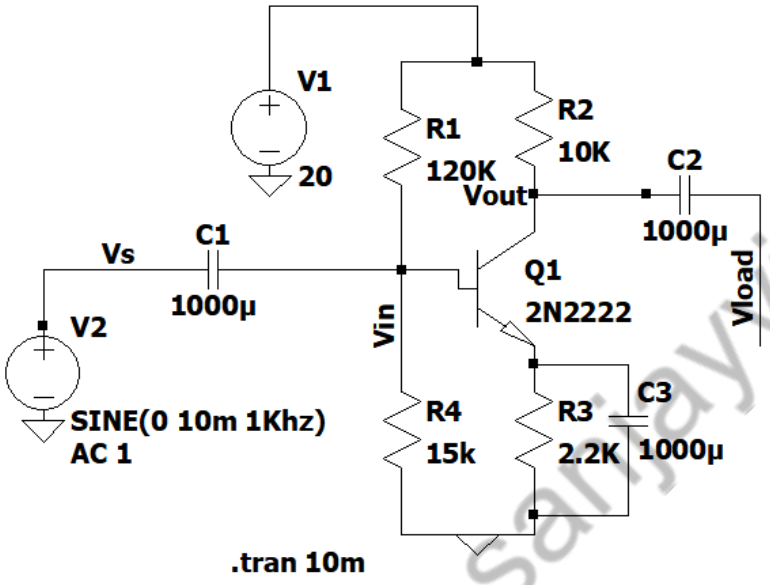
$$V_{BB} \approx 3.1\ V$$

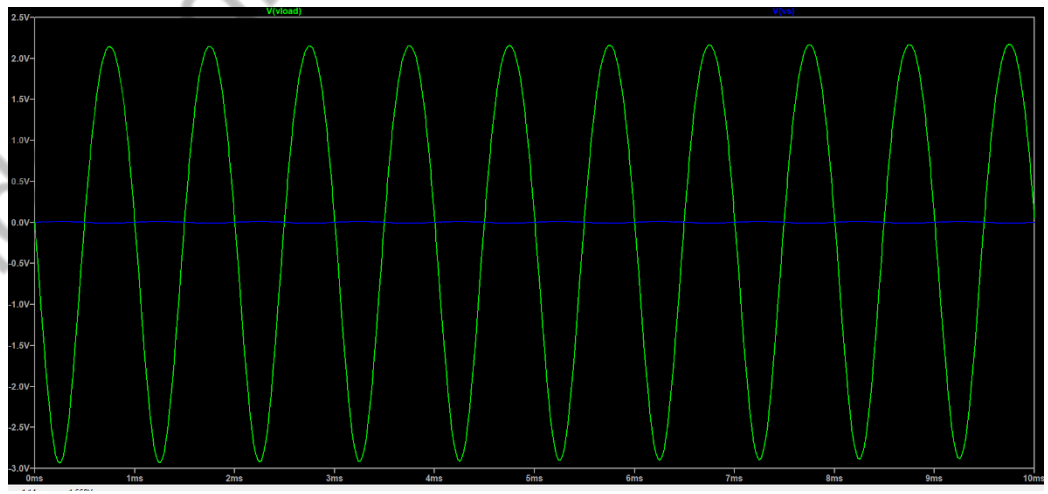
$$R_2 = \frac{3.1\ x\ 50}{10\ X\ 1mA} \approx 15\ K$$

$$R_1 = \frac{21x\ 50}{10\ X\ 1mA} \approx 120\ K$$

Common-Emitter Configuration

Design of Amplifier





$$Gain = -\beta R_C / r_\pi$$

Thank you