Electronic Devices and Circuits

EME306

(Summer 2021-2022)

Lecture 13

Amplifier Circuits other modes

INSTRUCTOR

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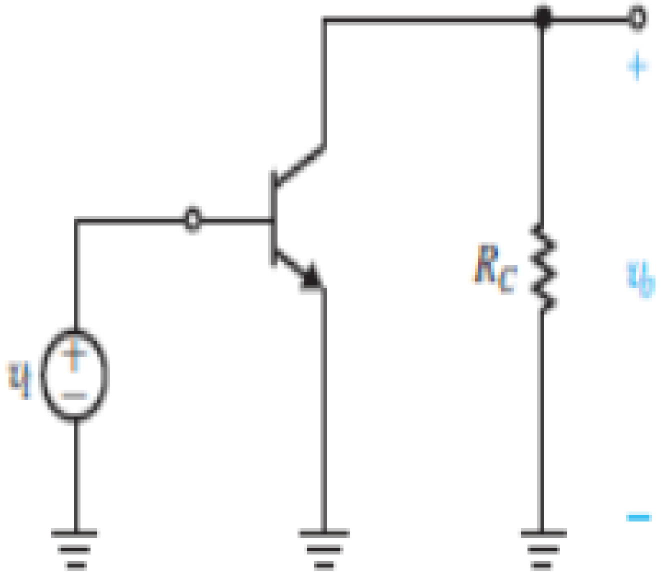
1) The Three Basic Configurations

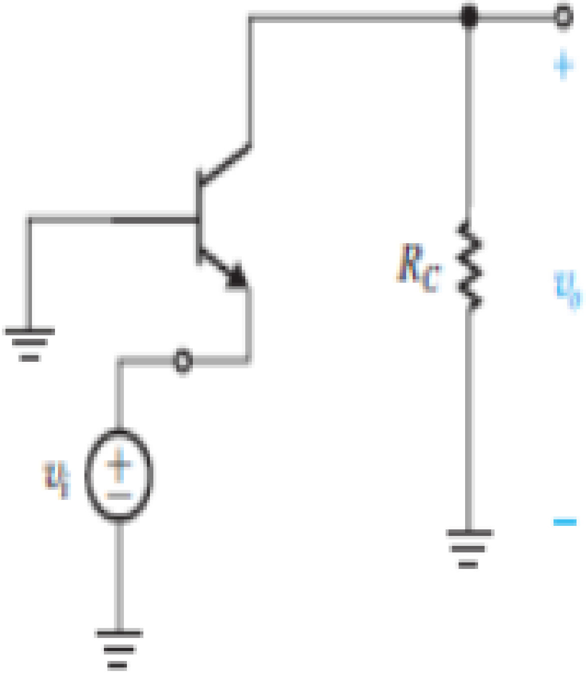
2) The Common-Base (CB) Amplifiers

3) The common collector (Emitter Follower)

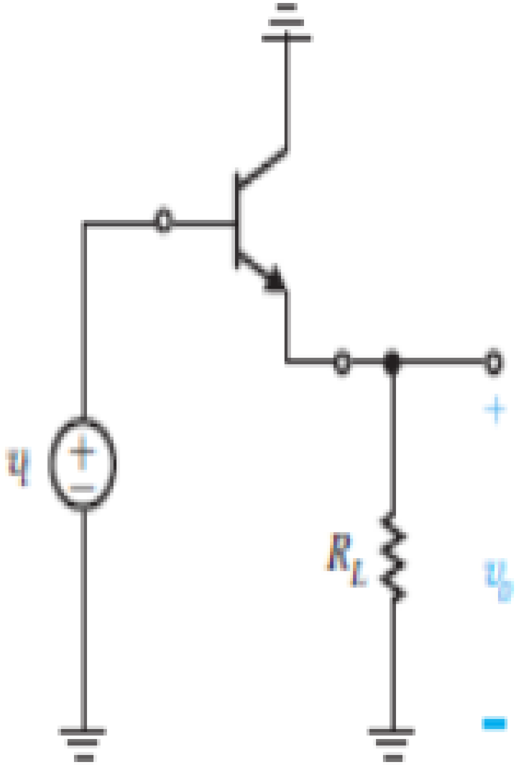
The Three Basic Configurations



(d) Common-Emitter (CE)

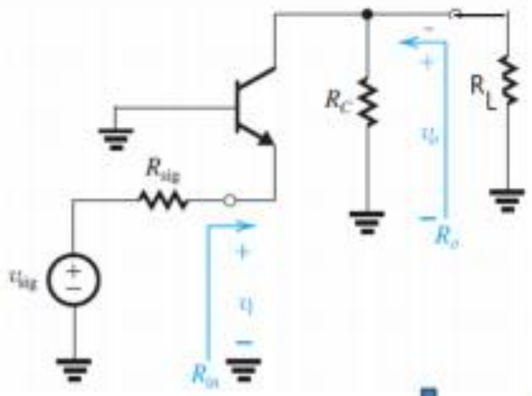


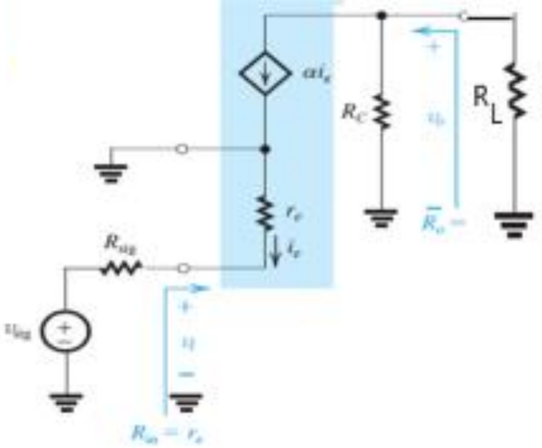
(e) Common-Base (CB)



(f) Common-Collector (CC)
or Emitter Follower

1-The Common-Base (CB) Amplifiers





$$v_i = -\ i_e r_e$$

$$i_i = -\ i_e$$

$$R_{in} = \frac{v_i}{i_i} = r_e = \frac{\alpha}{g_m}$$

$$v_o = -\alpha i_e (R_c \,//\, R_L)$$

$$v_{oo} = -\alpha i_e (R_c)$$

$$A_{vo} = \frac{v_{oo}}{v_i} = -\alpha \frac{R_c}{r_e} = -g_m R_c$$

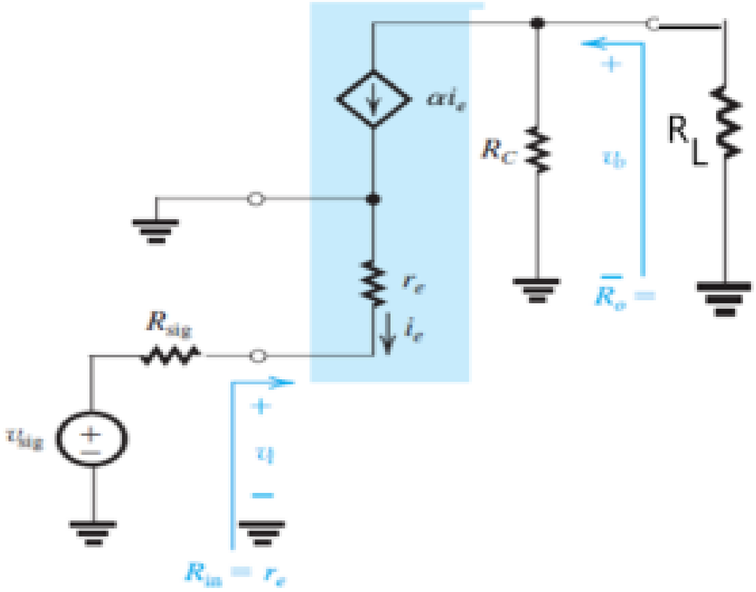
$$A_v = \frac{v_o}{v_i} = -\alpha \frac{R_c \,//\, R_L}{r_e} = -g_m (R_c \,//\, R_L)$$

$$R_{in} = \frac{v_i}{i_i} = r_e = \frac{\alpha}{g_m}$$

$$A_{vo} = \frac{v_{oo}}{v_i} = -\alpha\frac{R_c}{r_e} = -g_m R_c$$

$$A_v = \frac{v_o}{v_i} = -\alpha\frac{R_c // R_L}{r_e} = -g_m(R_c // R_L)$$

$$v_i = \frac{v_{sig} R_{in}}{R_{sig} + R_{in}} \Rightarrow \frac{v_i}{v_{sig}} = \frac{R_{in}}{R_{sig} + R_{in}}$$



$$G_v = \frac{v_o}{v_i}\frac{v_i}{v_{sig}} = -g_m(R_c // R_L).\frac{R_{in}}{R_{sig} + R_{in}} = -g_m(R_c // R_L)\frac{r_e}{R_{sig} + r_e} = -\frac{\alpha(R_c // R_L)}{R_{sig} + r_e}$$

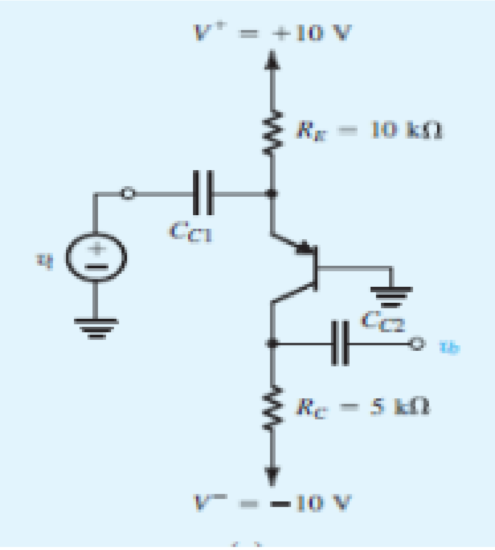
$$G_{vo} = \frac{v_{oo}}{v_i}\frac{v_i}{v_{sig}} = -g_m R_c.\frac{R_{in}}{R_{sig} + R_{in}} = -g_m R_c\frac{r_e}{R_{sig} + r_e} = -\frac{\alpha R_c}{R_{sig} + r_e}$$

$$R_o = R_c$$

Example

For the circuit shown, determine the voltage gain and the signal waveforms at various points. Given β=100.

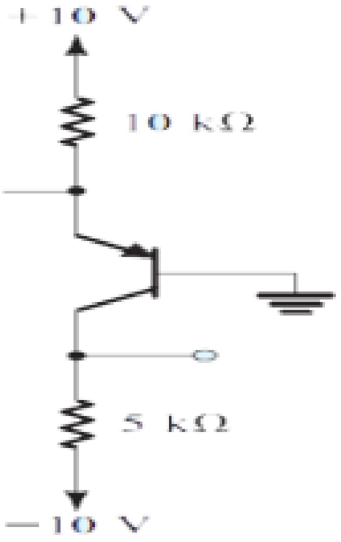
Sketch the o/p when vi=10mv sinusoidal



Dc analysis

- All capacitors are Open circuits
- All ac voltage are short circuit
- All ac currents are open circuits

Assume Active



$$V_B = 0, \qquad V_E = 0.7$$

$$I_E = \frac{10-0.7}{10} = 0.93mA$$

$$I_c = \alpha I_E = (100/101)*0.93 = 0.9208mA$$

$$V_c = -10 + 5 * I_c = -5.396v$$

$$r_e = \frac{V_t}{I_E} = \frac{0.025}{0.93} = 0.0269K\Omega$$

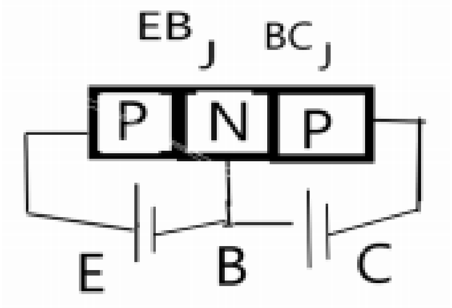
Check

V_E= 0.7v , V_B=0v, V_c = -5.396v

Since $V_E > V_B$, Then EB_J is Forward

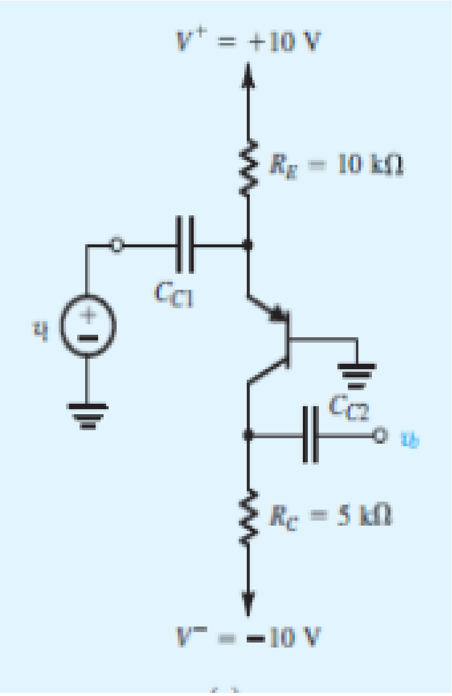
Sine $V_B > V_C$, Then BC_J is reverse

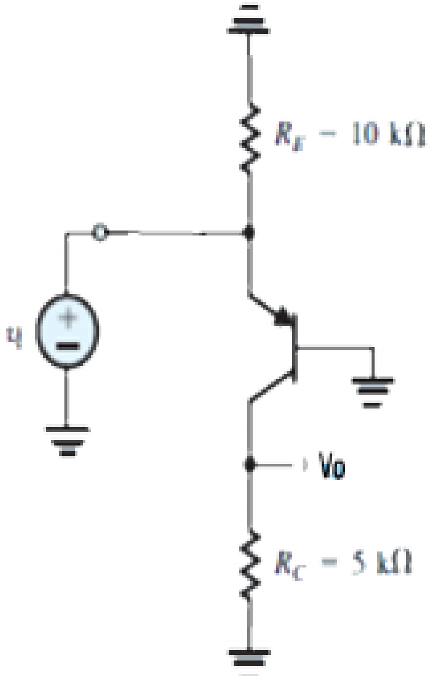
Then Transistor operates in Active



ac analysis

- All capacitors are short circuits
- All Dc voltage are short circuit (grounded)
- All Dc currents are open circuits
- Replace transistor by equivalent model





$$v_o = -\alpha i_e * R_c$$

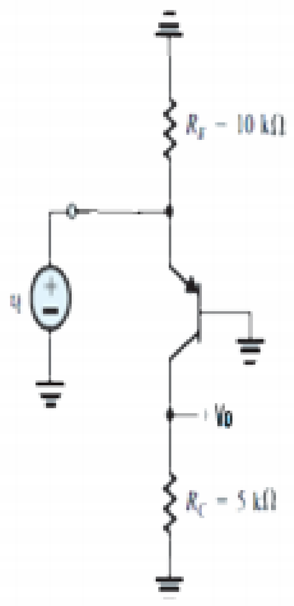
$$v_i = -i_e * r_e$$

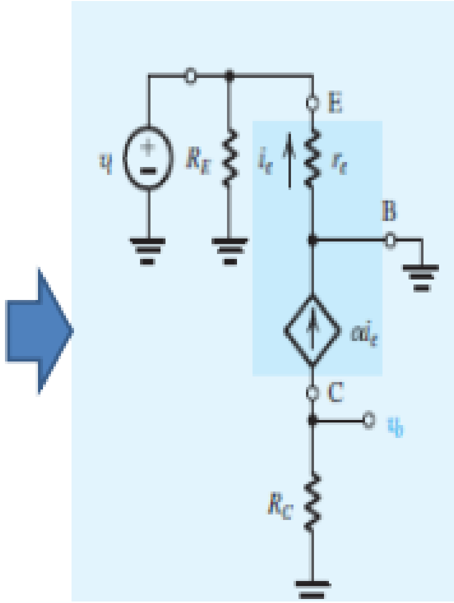
$$\frac{v_o}{v_i} = \frac{\alpha R_c}{r_e} = \frac{(100/101)*5}{0.0269} = 184.03 v/v$$

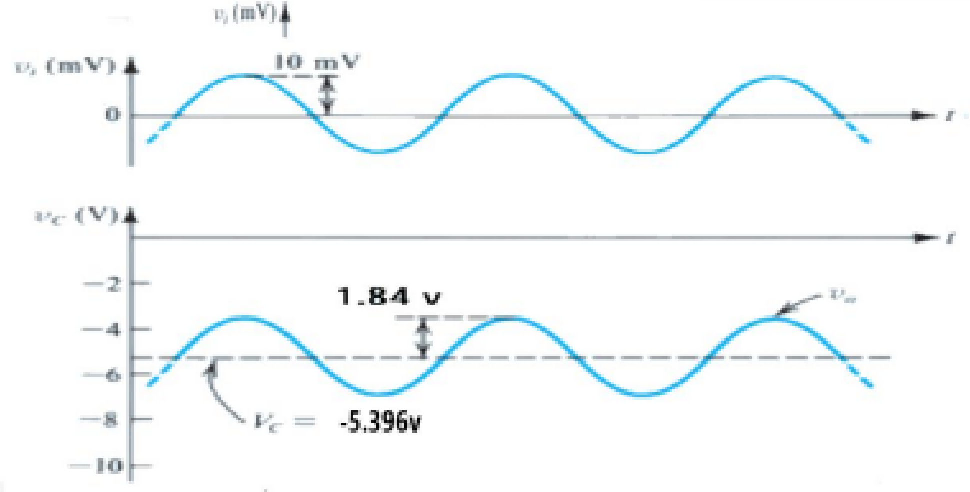
When v_i=10 mv, then

v_o=10mv*184.03=1.8403v

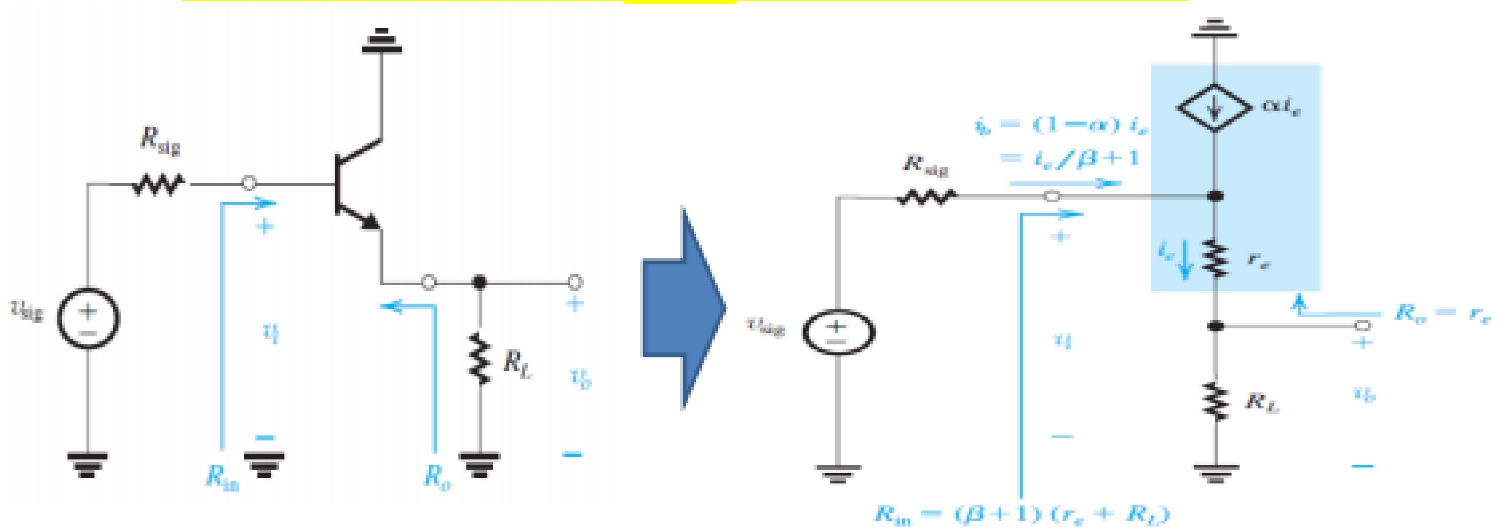
$$V_C = -5.396v \quad v_o = 1.84v$$







2-The common collector (Emitter Follower)

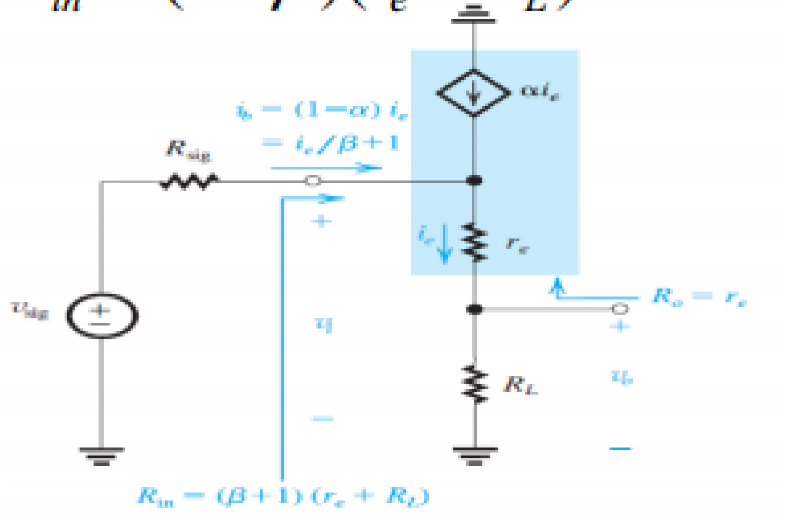


$$v_i = i_e(r_e + R_L) = (1+\beta)i_b(r_e + R_L) \qquad i_i = i_b$$

$$R_{in} = \frac{v_i}{i_i} = (1+\beta)(r_e + R_L) \qquad v_o = i_e R_L$$

$$A_v = \frac{v_o}{v_i} = \frac{R_L}{(r_e + R_L)} \cong 1$$

$$A_v = \frac{v_o}{v_i} = \frac{R_L}{(r_e + R_L)} \cong 1 \qquad R_{in} = (1+\beta)(r_e + R_L)$$



$$v_i = \frac{v_{sig}.R_{in}}{(R_{sig} + R_{in})}$$

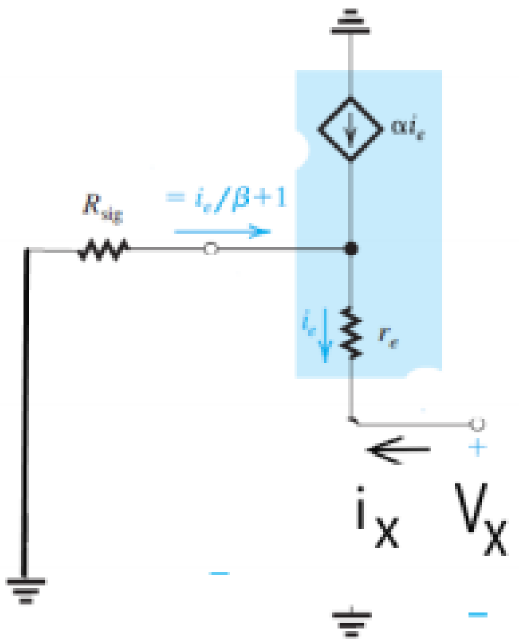
$$\frac{v_i}{v_{sig}} = \frac{R_{in}}{(R_{sig} + R_{in})}$$

$$G_v = \frac{v_o}{v_i}\frac{v_i}{v_{sig}} = \frac{R_L}{r_e + R_L} . \frac{R_{in}}{R_{sig} + R_{in}} = \frac{(1+\beta)R_L}{R_{sig} + (1+\beta)(r_e + R_L)}$$

Because the gain is nearly =1 , so any change in input will be followed by a change in output, so it is **called emitter follower**

Calculation of R_o C

When make S.C on V_i, then ⟹ $R_o = r_e$



When make S.C on V_{sig} then

1- Make short circuit on supply v_{sig}

2- Apply source V_x pass current I_x

$$V_X = -i_e r_e + -\frac{i_e}{1+\beta} R_{sig}$$

$$i_x = -i_e$$

$$R_o = \frac{V_X}{i_x} = r_e + \frac{R_{sig}}{1+\beta}$$


Thank you