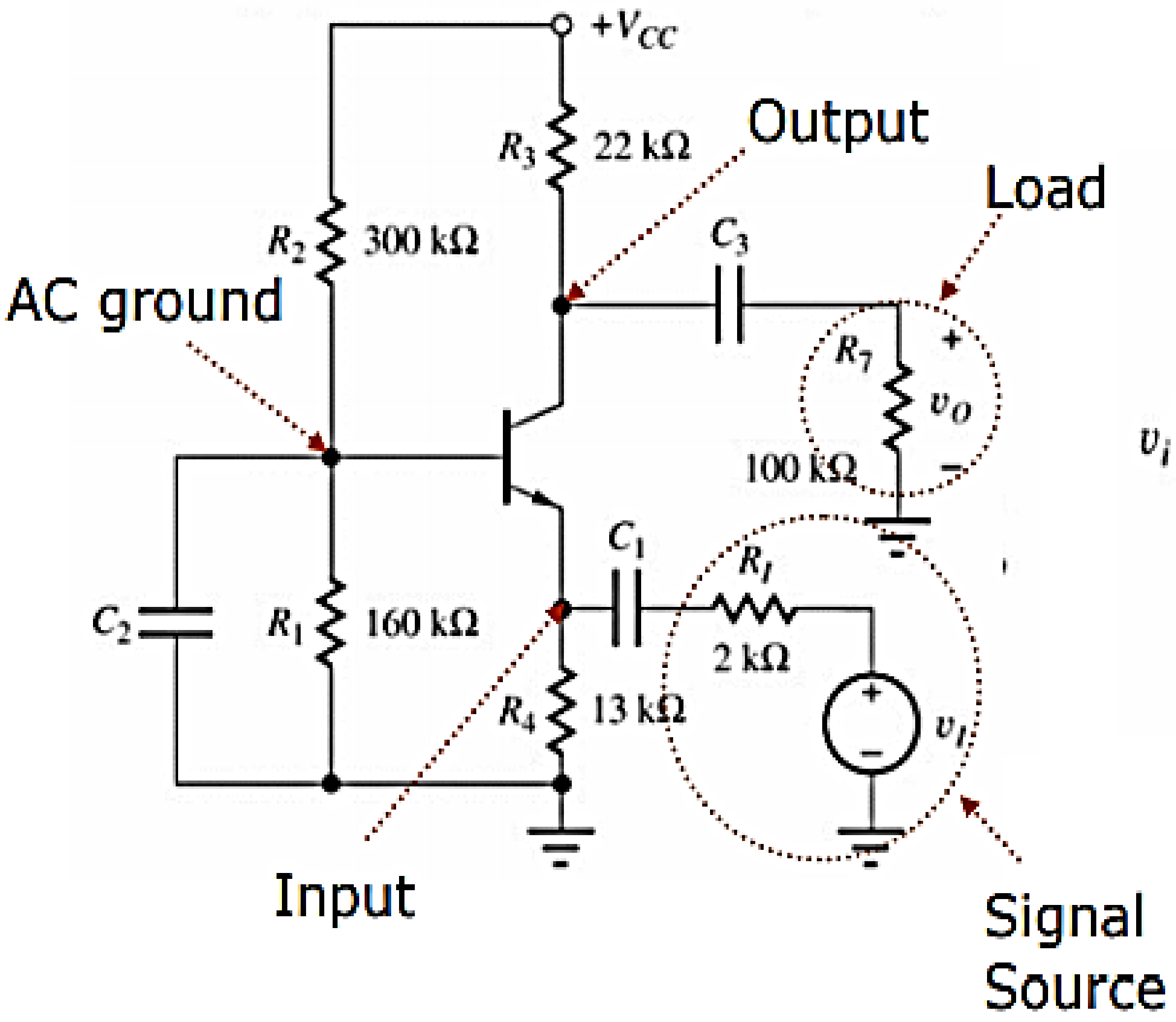
Electronic Devices

Lecture 16
Bipolar Junction Transistor

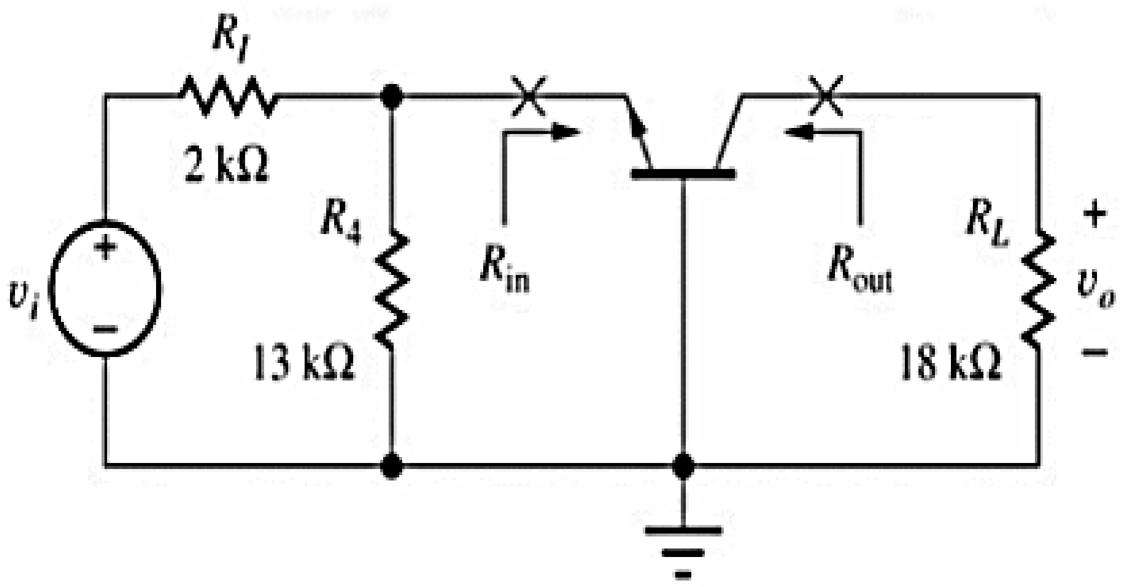
Dr. Roaa Mubarak

Example4 (Common Base Amplifier)

- Common Base Amplifier

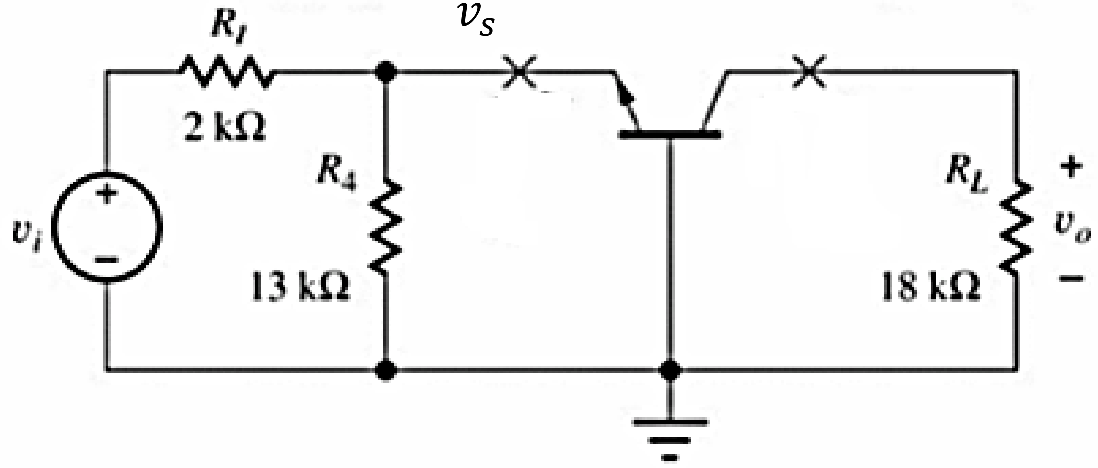


AC/Small-signal equivalent:



$$R_L = R_3 \parallel R_7$$

Example4

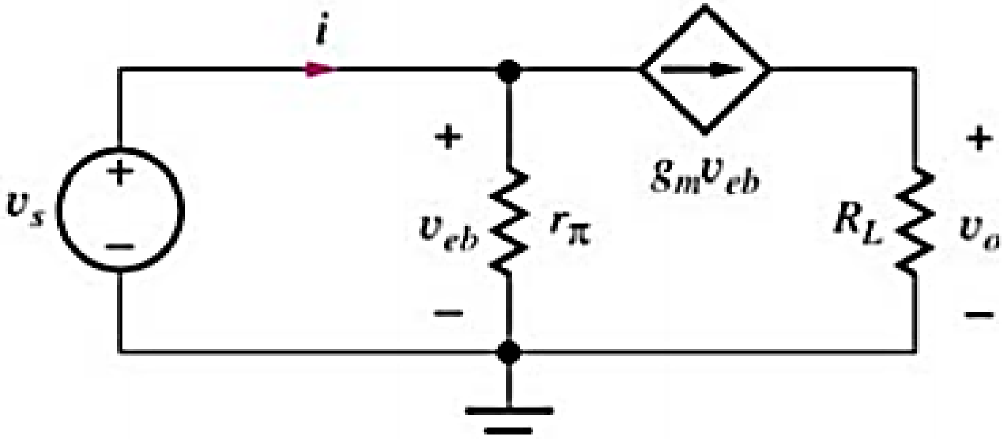


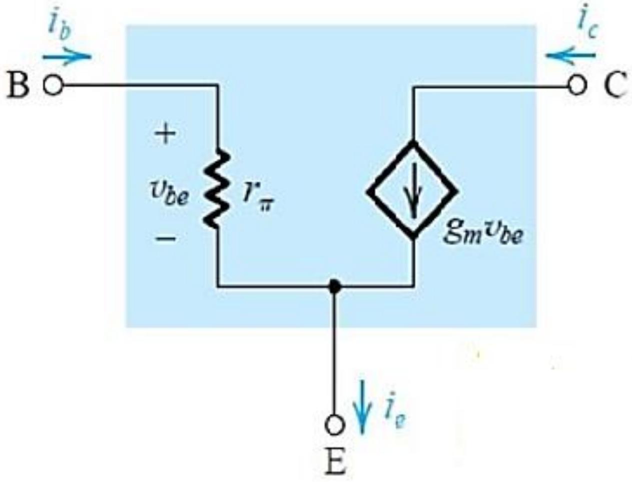
$$v_s = \frac{R_4}{R_I + R_4} v_i \qquad v_s = v_{eb}$$

$$A_{vt} \equiv \frac{v_o}{v_{eb}} = +g_m R_L$$

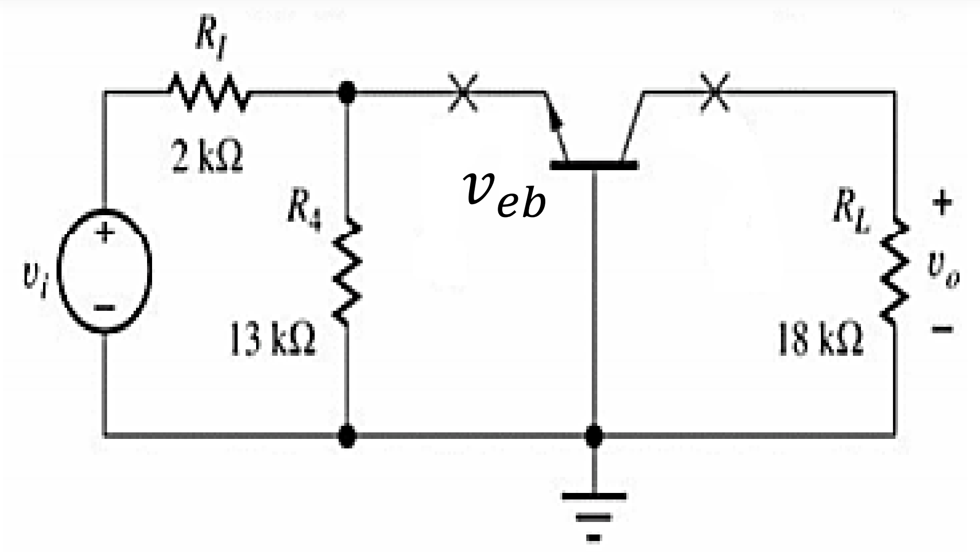
- Non-inverting!
- Magnitude same as the CE amplifier with R_E=0.

Apply test source to input (E)
And use BJT small signal model:





Example4

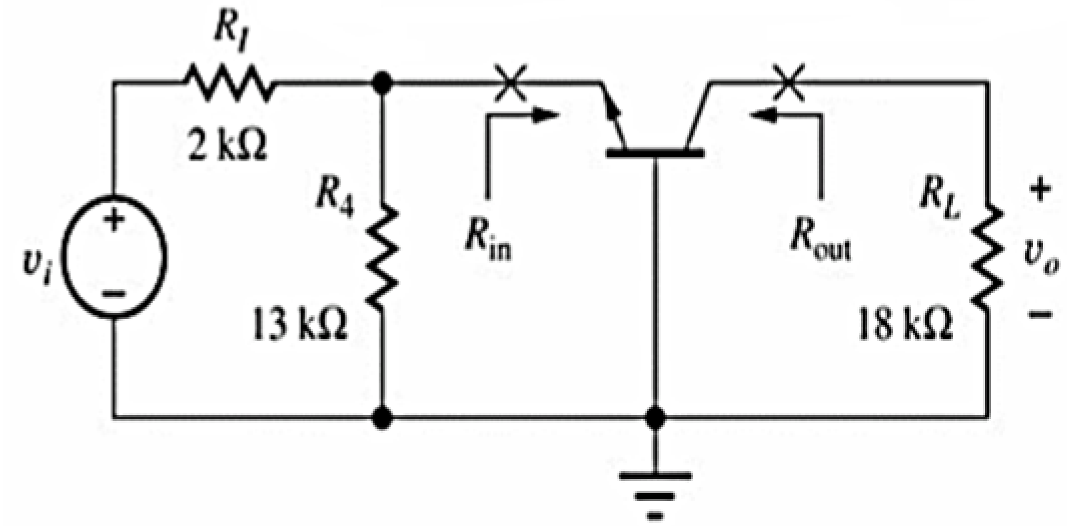


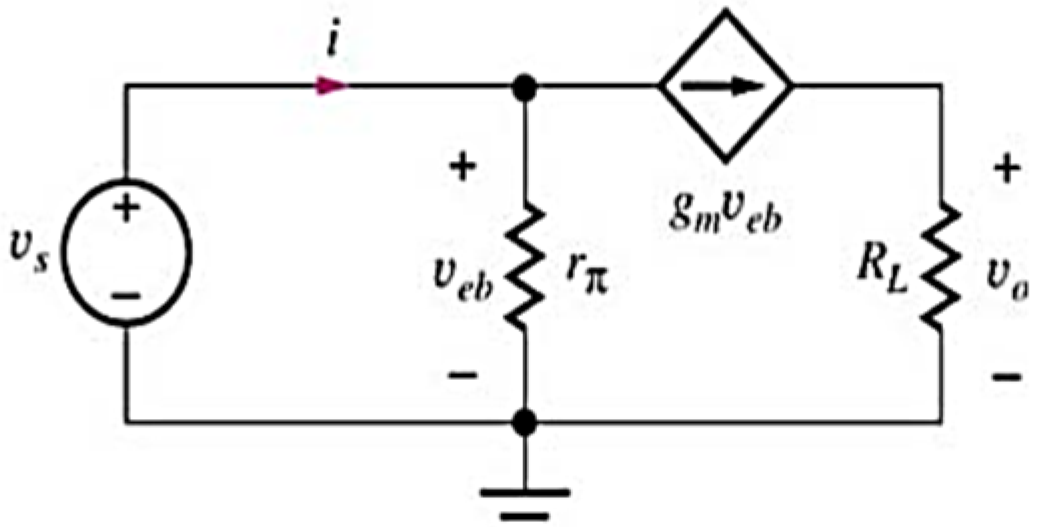
Overall voltage gain is

$$A_v = \frac{v_o}{v_i} = \left(\frac{v_o}{v_{eb}}\right)\left(\frac{v_{eb}}{v_i}\right) = A_{vt}\left(\frac{R_4}{R_I + R_4}\right)$$

- For large voltage gain, a very small R_I is required!
- Not a good candidate for voltage amplifier

Input Resistance





KCL at emitter:

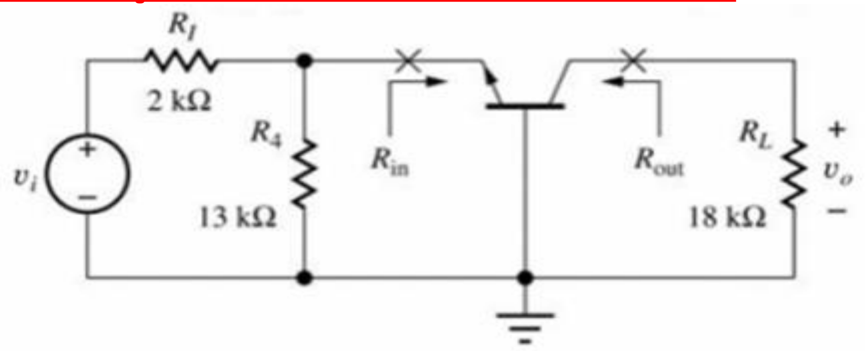
$$i = \frac{v_{eb}}{r_\pi} + g_m\, v_{eb}$$

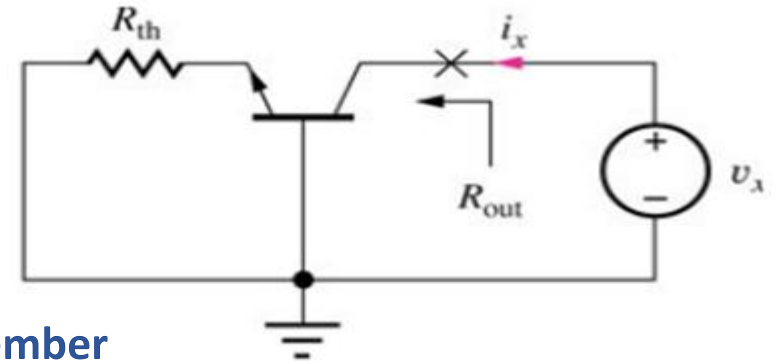
$$R_{in} = \frac{v_{eb}}{i} = \frac{r_\pi}{r_\pi g_m + 1} = r_\pi // \left(\frac{1}{g_m}\right) \cong \frac{1}{g_m}$$

- R_{in} is small (as g_m is usually large)!

($g_m = I_C / V_T$)

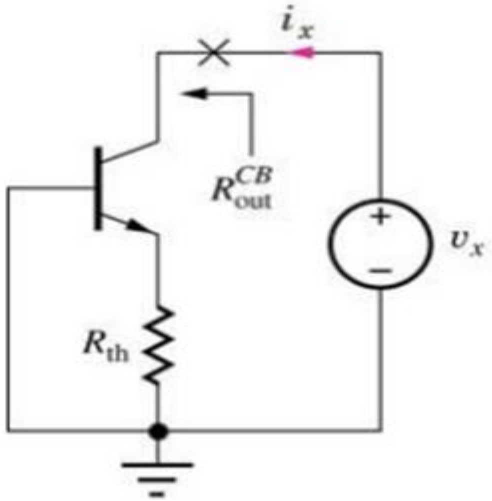
Output Resistance





- Rout here is equivalent to the Rout of CE amplifier with R_E=R_{th} and resistance at base equal to zero.

$$\therefore R_{out} = r_o\left(1 + \frac{\beta R_{th}}{R_{th} + r_\pi}\right)$$

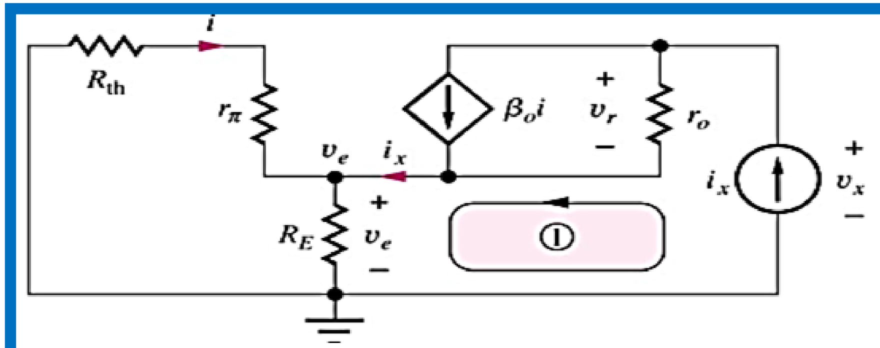


Using $\beta = g_m r_\pi$

$$R_{out} \cong r_o\left(1 + g_m(r_\pi // R_{th})\right)$$

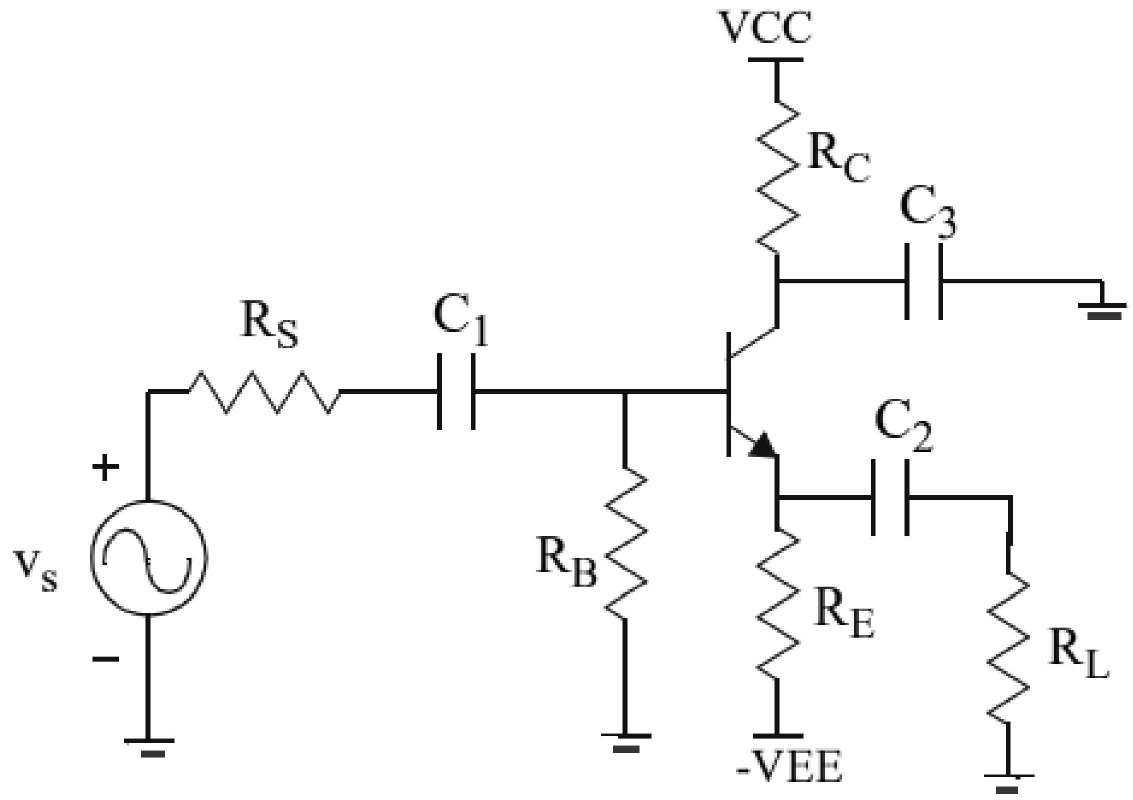
- R_{out} is large.

Remember



$$\therefore R_{out} = \frac{v_x}{i_x} \cong r_o\left(1 + \frac{\beta R_E}{R_E + R_{th} + r_\pi}\right)$$

Common Collector Amplifier (Emitter Follower)



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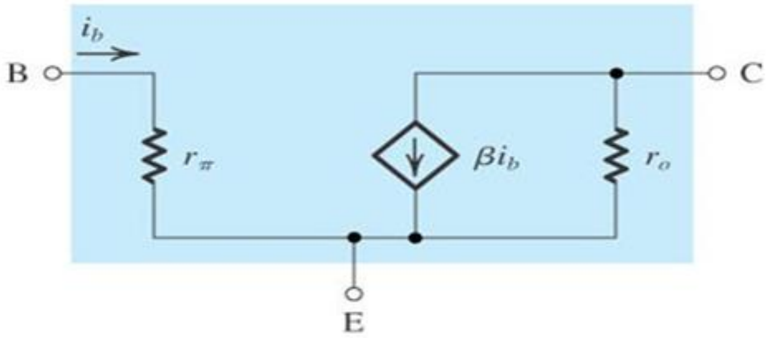
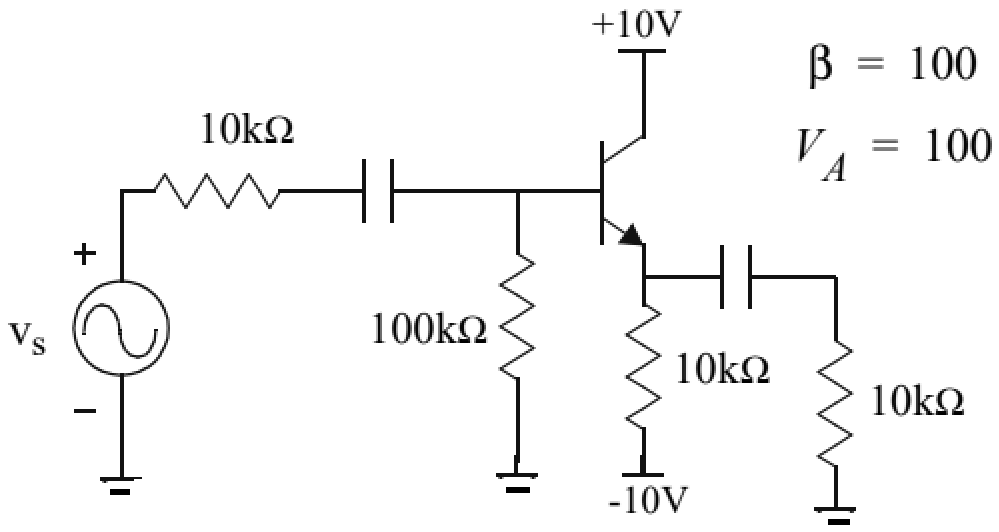
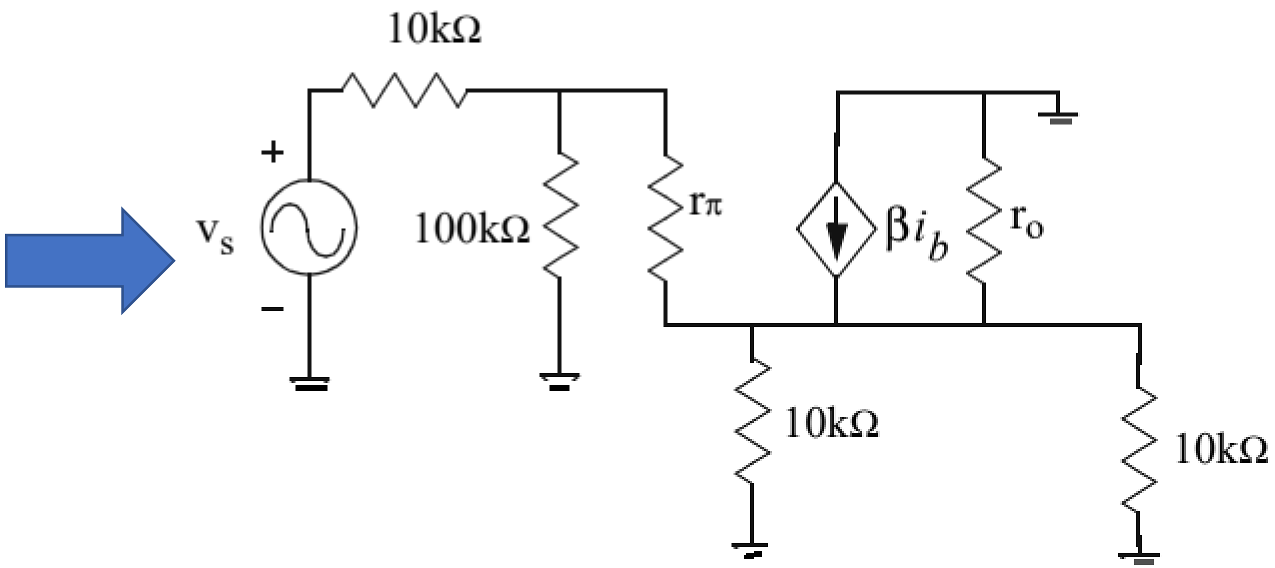






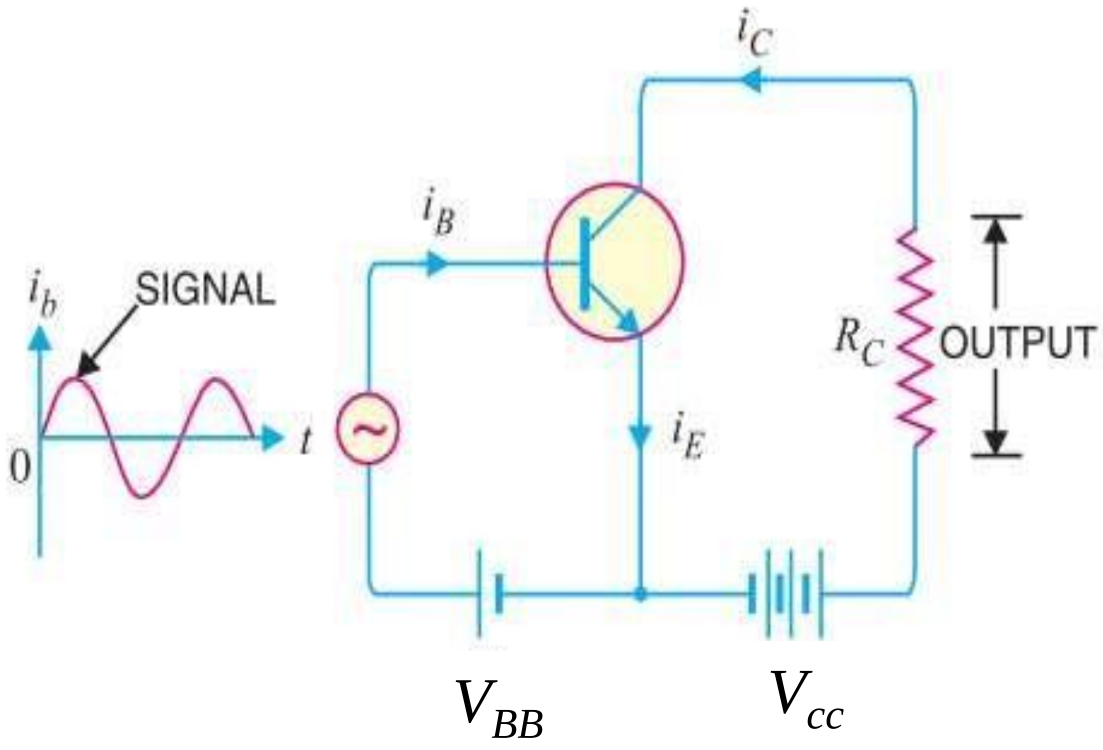
	Common Emitter	Common Base	Common Collector
• Voltage gain	High and inverting	High and noninverting	Unity
• Input Impedance	Low	Low	High
• Output Impedance	High	High	Low
• Current gain	High	Unity	High
• Uses	Voltage amplifier (Re)	Current buffer	Voltage buffer

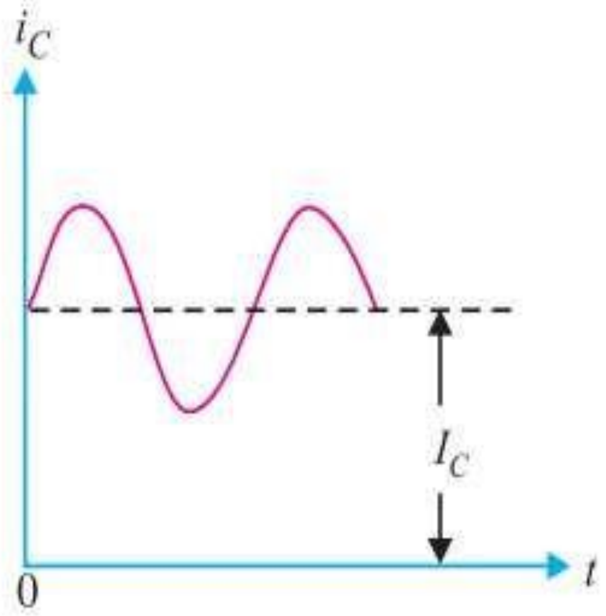
- Effects of the resistor at Emitter:
  - Voltage gain decreased, but more stabilized
  - Input signal range increased
  - Input and output resistance increased

Bipolar Junction Transistor Applications

Transistor as an amplifier in NPN CE

- Battery VBB is connected with base in-order to make base forward biased, regardless of input ac polarity.





- **Transistor as an amplifier in NPN CE**
- During positive half cycle input ac will keep the emitter- base junction more forward biased. So, more carrier will be emitted by emitter, this huge current will flow through load and we will find output amplified signal.

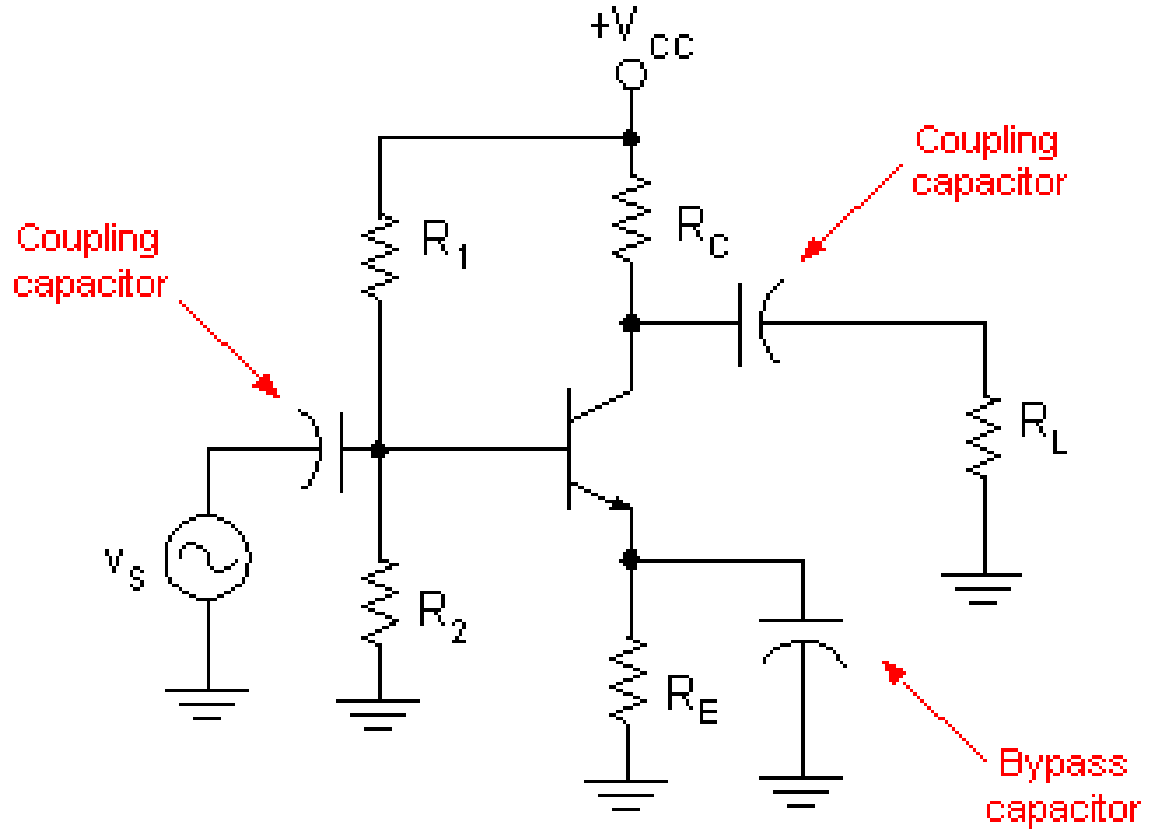
- During negative half cycle input ac will keep the emitter-base junction less forward biased. So, less carrier will be emitted by emitter. Hence collector current decreases.

- This results in decreased output voltage (In opposite direction).

Common Emitter Amplifier

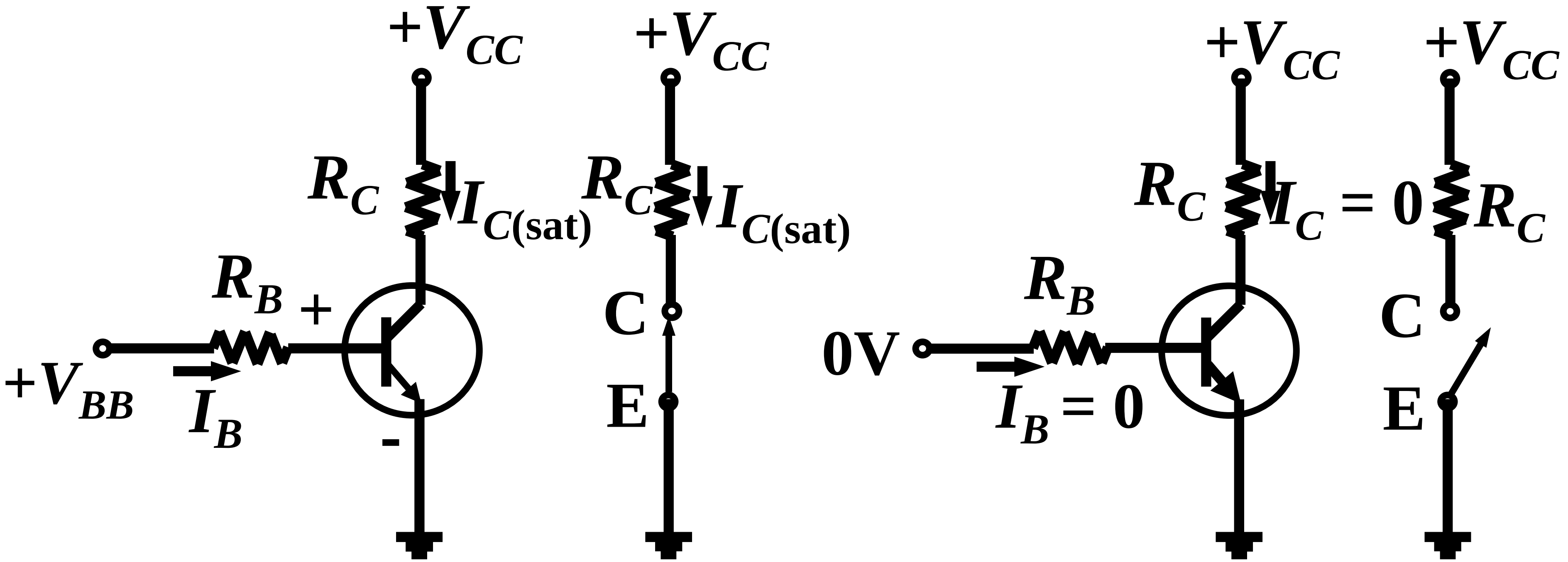
- Coupling capacitors (or dc blocking capacitors) are use to decouple ac and dc signals so as not to disturb the quiescent point of the circuit when ac signals are injected at the input.

Bypass capacitors are used to force signal currents around elements by providing a low impedance path at the frequency.



• Transistor as a switch in NPN CE

A transistor can be used as a switch, when it is normally operated alternately in cutoff and saturation.



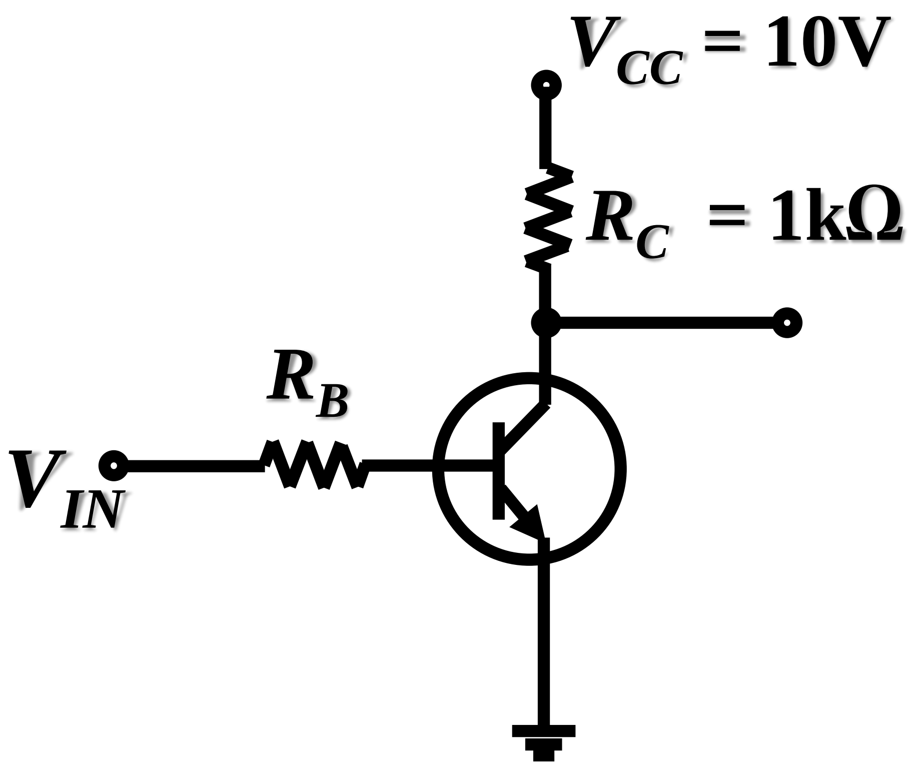
Saturation –Closed switch **Cutoff – open switch**

Example 3

(a) For the transistor circuit in the above figure, what is V_{CE} when $V_{IN} = 0$ V?

(b) What minimum value of I_B is required to saturate this transistor if β_{DC} is 200? Neglect $V_{CE(sat.)}$

(c) Calculate the maximum value of R_B when $V_{IN} = 5$ V



Solution

(a) When V_{IN} = 0 V, the transistor is in cutoff (acts like an open switch) and

$$V_{CE} = V_{CC} = 10\text{V}$$

(b) Since $V_{CE(sat)}$ is neglected (0 V),

$$I_{C(sat)} = \frac{V_{CC}}{R_C} = \frac{10V}{1K\Omega} = 10\text{mA}$$

$$I_{B(\min)} = \frac{I_{C(sat)}}{\beta_{dc}} = \frac{10\text{mA}}{200} = 50\mu\text{A}$$

(c) When the transistor is on, V_{BE} = 0.7 V. The voltage across R_B is

$$V_{R_B} = V_{IN} - V_{BE} = 5\text{V} - 0.7\text{V} = 4.3\text{V}$$

the maximum value of R_B needed to allow a minimum I_B *is*

$$R_{B(\text{max})} = \frac{V_{R_B}}{I_{B(\text{min})}} = \frac{4.3\text{V}}{50\mu\text{A}} = 86\text{k}\Omega$$