Electronic Circuits for Mechatronics (ELCT 609)

Spring 2021

Lecture 6: BJT Amplifiers Configurations

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BJT Amplifier Configurations

Basic Configurations and their Characteristics

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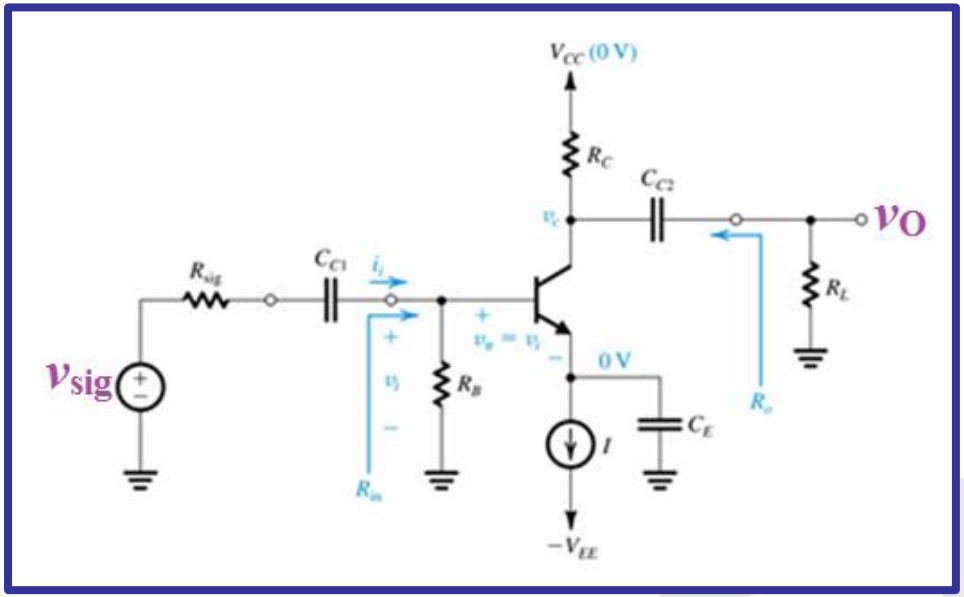
Analysis of BJT Amplifiers

- **Objective:** Calculate the **Voltage gain**, **Input Resistance** and **Output Resistance**
- **Solution Steps:**
  1. DC Analysis: Determine the DC operating Point (Deactivate AC signals & All External Capacitors impedances are considered open Circuit)
  2. Calculate the small signal model parameters: g_m, r_π
  3. Replace the BJT with its small signal model (DC sources are deactivated& All External Capacitors impedances are considered Short Circuit) (AC Analysis)
  4. Analyze the circuit to calculate the voltage gain, Input and Output Resistances

Common Emitter Amplifier

- **Objective:** Calculate the voltage gain, Input and Output Resistances
  - Input terminal **Base**
  - Output Terminal **Collector**



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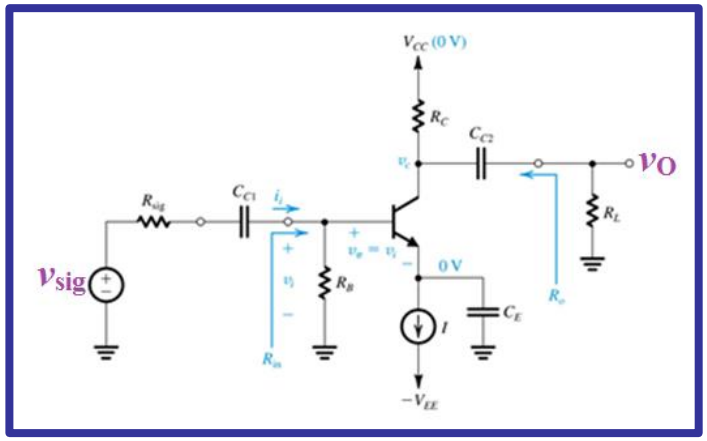
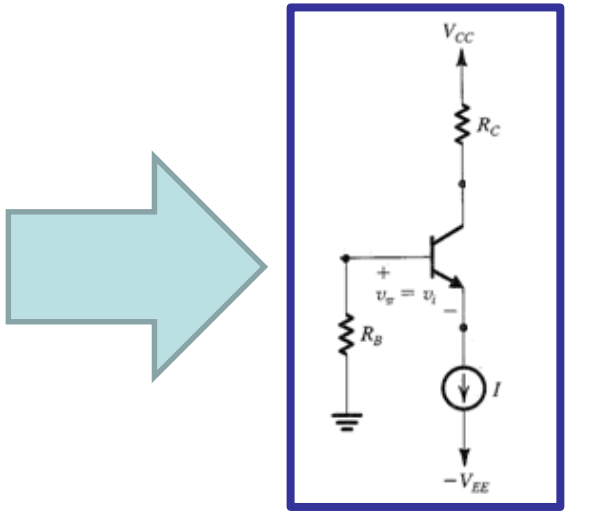
Common Emitter Amplifier

1. **Calculate the DC Current (DC Analysis)**



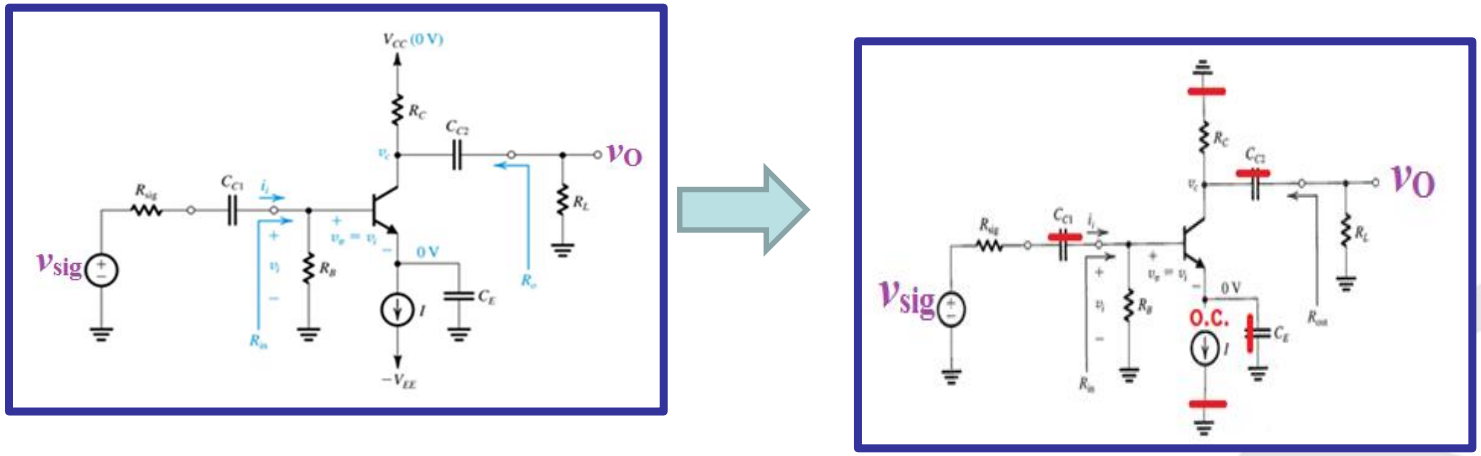


$$I_C = \frac{\beta}{1+\beta} I \cong I$$

2. **Calculate g_m and r_π**

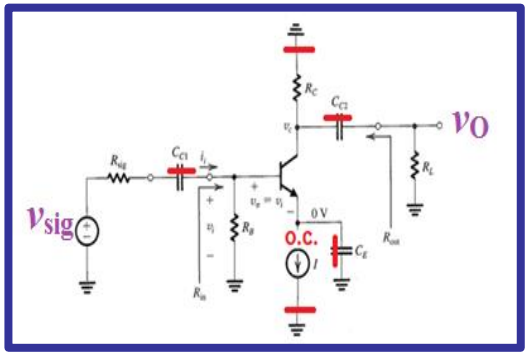
Common Emitter Amplifier

3. **AC Analysis: Draw the equivalent small signal model** (Include r_o if given)



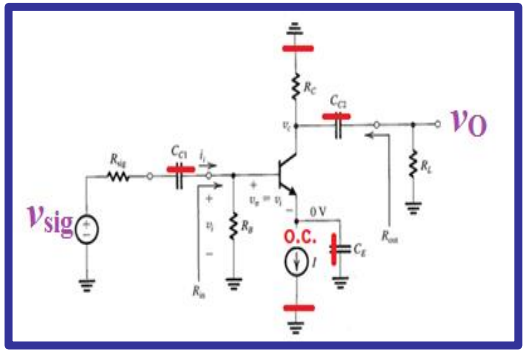
Common Emitter Amplifier

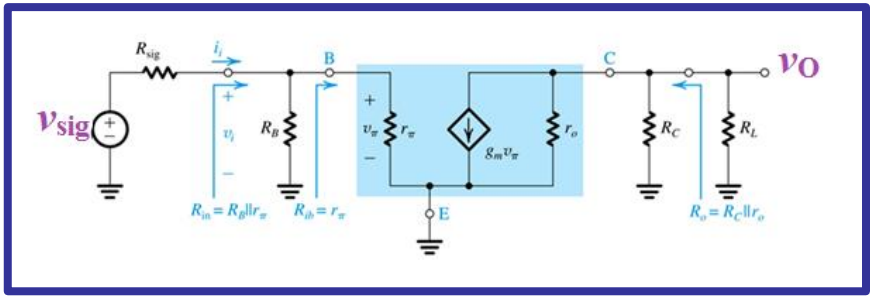
3. **AC Analysis: Draw the equivalent small signal model** (Include r_o if given)
4. **Calculate the gain, input and output Resistance**



Common Emitter Amplifier

- **Calculate the gain, input and output Resistance**





$$A_v = \frac{v_O}{v_{sig}} = -g_m(r_o \,//\, R_C \,//\, R_L)\frac{R_B \,//\, r_\pi}{R_B \,//\, r_\pi + R_{sig}}$$

$$R_{in} = R_B \,//\, r_\pi \qquad R_{out} = r_o \,//\, R_C \,//\, R_L$$

Common Emitter Amplifier

- **Notes on Common Emitter Configuration:**
  - **Inverting Amplifier**
  - **Modulus of Gain is greater than one**
  - **High Input Resistance**
  - **High Output Resistance**

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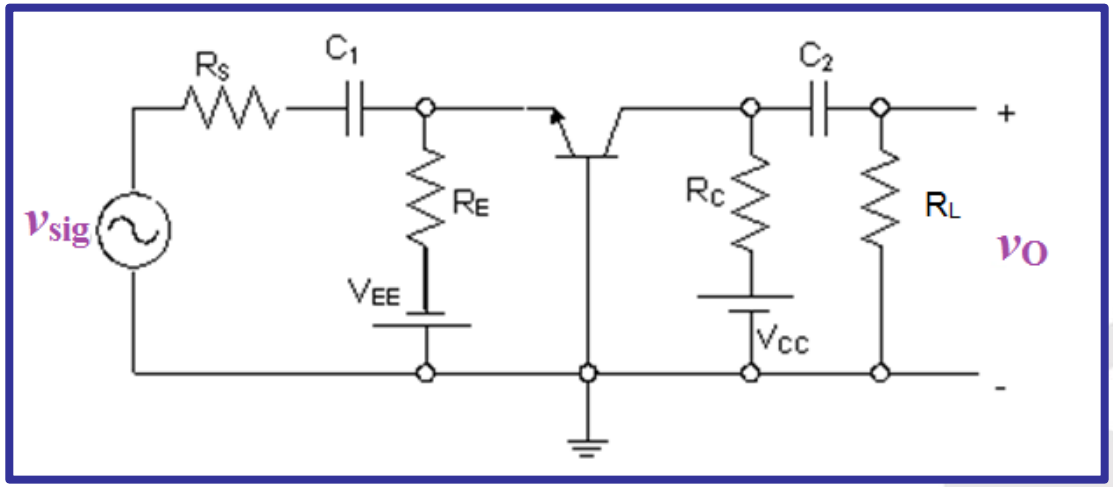
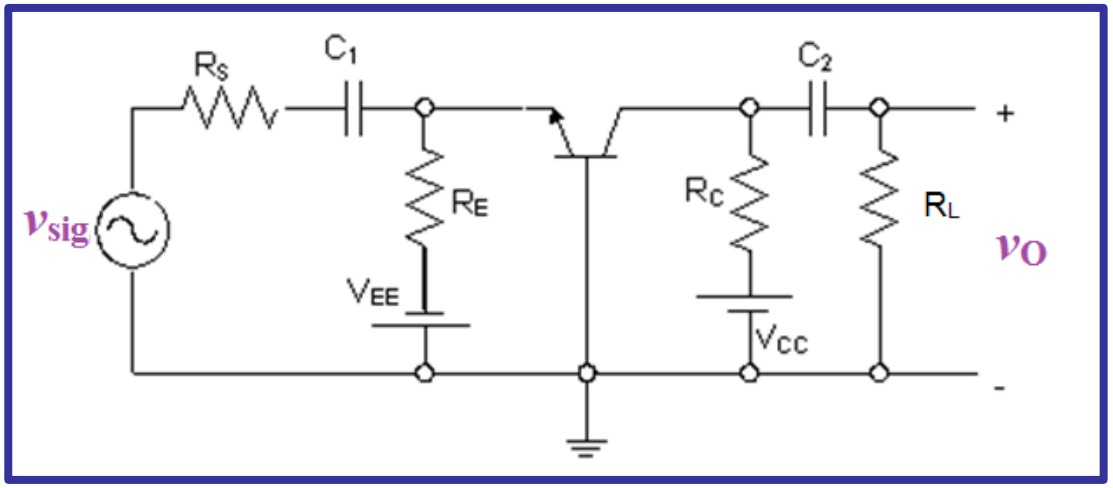
Common Base Amplifier

- **Objective:** Calculate the voltage gain, Input and Output Resistances
  - Input terminal **Emitter**
  - Output Terminal **Collector**



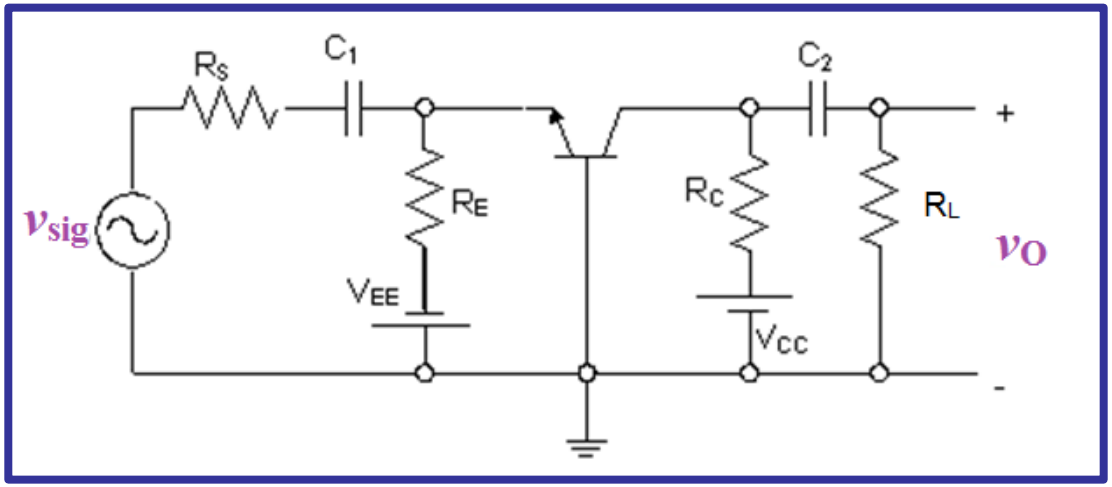
Common Base Amplifier

- **Step 1: DC Analysis**



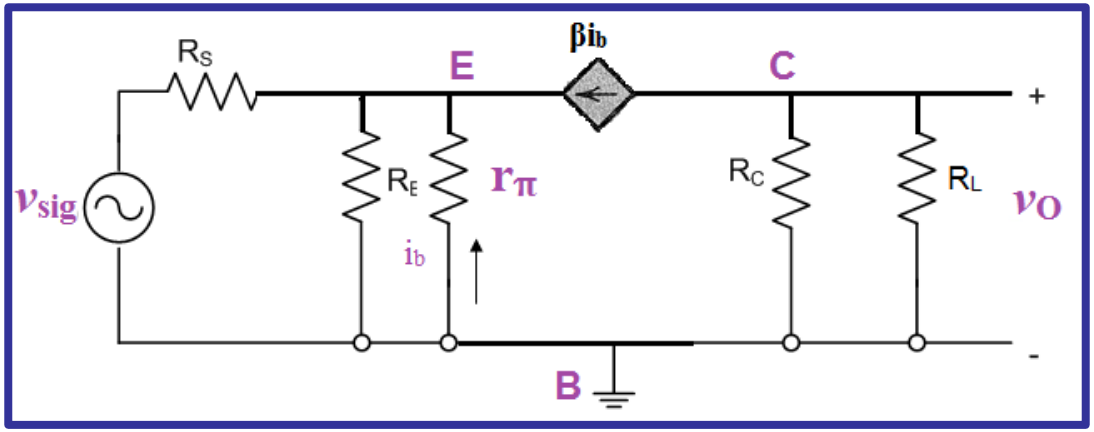
Common Base Amplifier

- **Step 2 :Draw small signal model**



Common Base Amplifier

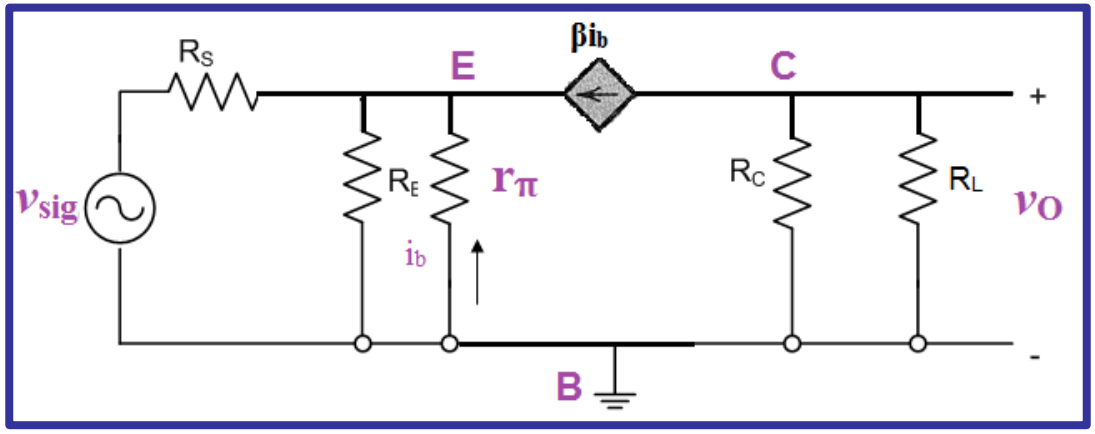
- **Voltage gain** (r_o is neglected)



$$A_v = \frac{v_O}{v_{sig}} = \frac{g_m(R_C \,//\, R_L)}{1 + \dfrac{R_S}{(R_E \,//\, \dfrac{r_\pi}{1+\beta})}}$$

Common Base Amplifier

- **Input and Output Resistance** (r_o is neglected)



$$R_{in} = R_S + (R_E // \frac{r_\pi}{1+\beta})$$

$$R_{out} = R_C // R_L$$

Common Base Amplifier

- **Notes on Common Base Configuration:**
  - **Non-Inverting Amplifier**
  - **Gain is greater than unity**
  - **Low Input Resistance**
  - **High Output Resistance**

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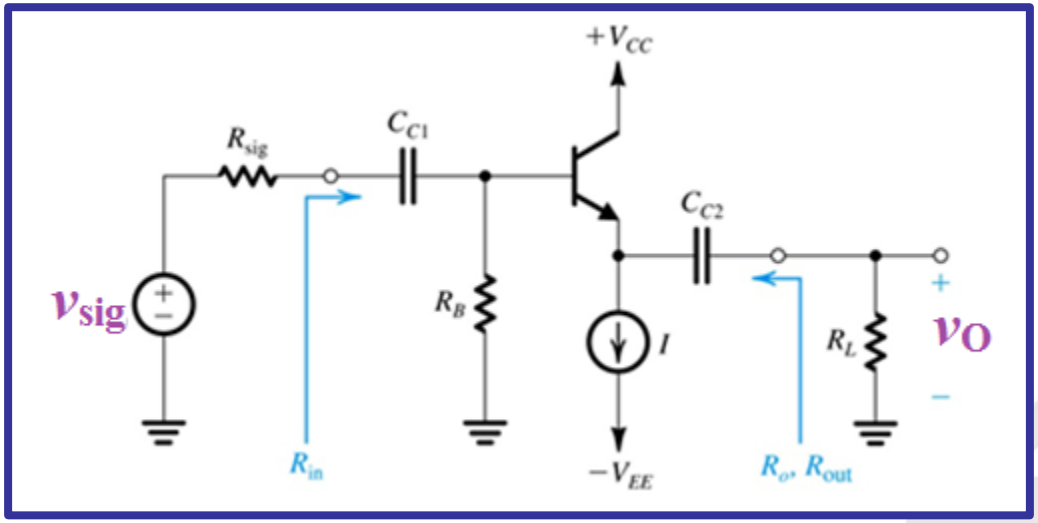
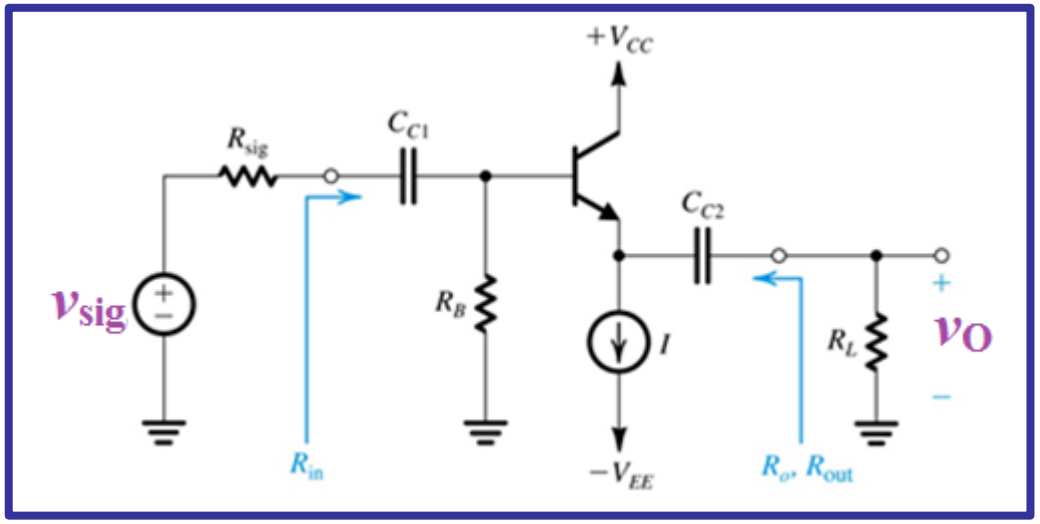
Common Collector Amplifier

- **Objective:** Calculate the voltage gain, Input and Output Resistances
  - Input terminal **Base**
  - Output Terminal **Emitter**



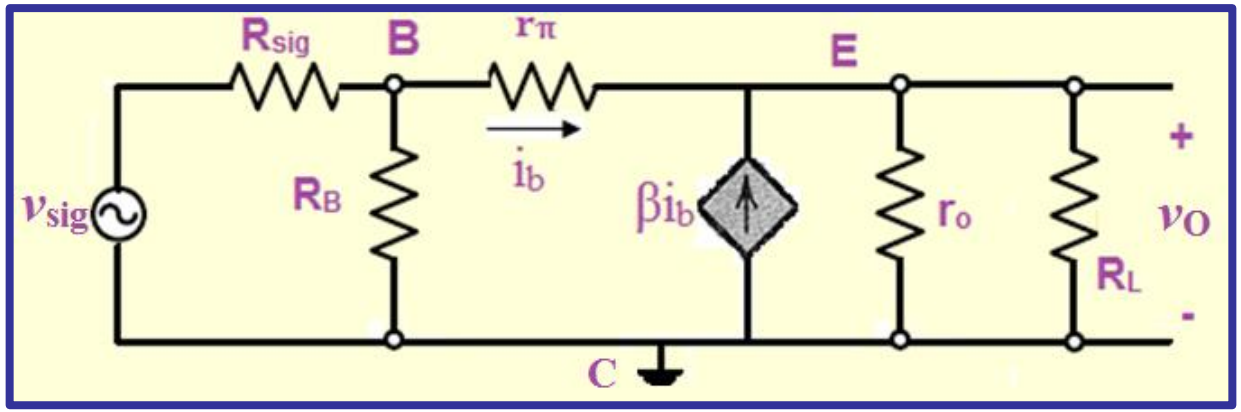
Common Collector Amplifier

- **Step 1 and 2:**



Common Collector Amplifier

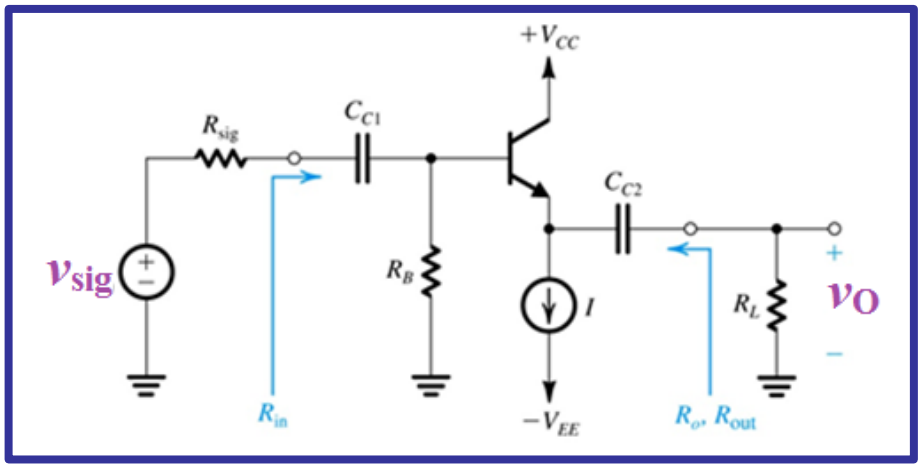
- **Voltage gain**



$$A_v = \frac{v_O}{v_{sig}} = \frac{(1+\beta)\,(r_o \,//\, R_L)}{(r_\pi + (1+\beta)\,(r_o \,//\, R_L))\left(1 + \frac{R_{sig}}{R_B}\right) + R_{sig}}$$

Common Collector Amplifier

❑ Input and Output Resistance



$$R_{in} = R_B \,//\, \left(r_\pi + (1+\beta)(r_o \,//\, R_L)\right)$$

$$R_{out} = r_o \,//\, \left(\frac{r_\pi + (R_B \,//\, R_{sig})}{1+\beta}\right)$$

Common Collector Amplifier

- **Notes on Common Collector Configuration:**
  - **Non-Inverting Amplifier**
  - **Gain is less than unity**
  - **Source Follower (Buffer)**
  - **High Input Resistance**
  - **Low Output Resistance**

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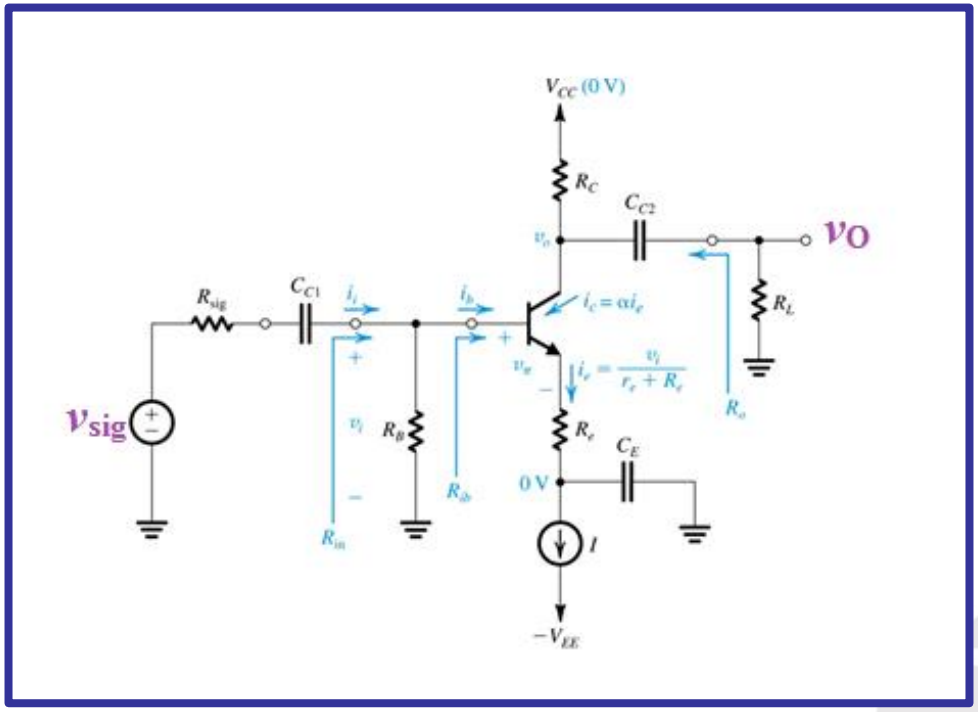
Common Emitter with emitter Resistance

- **Exercise:**
  - Find the Voltage gain, input and Output Resistance



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