ECE 342
Electronic Circuits

Lecture 17
Common Emitter - Part 1

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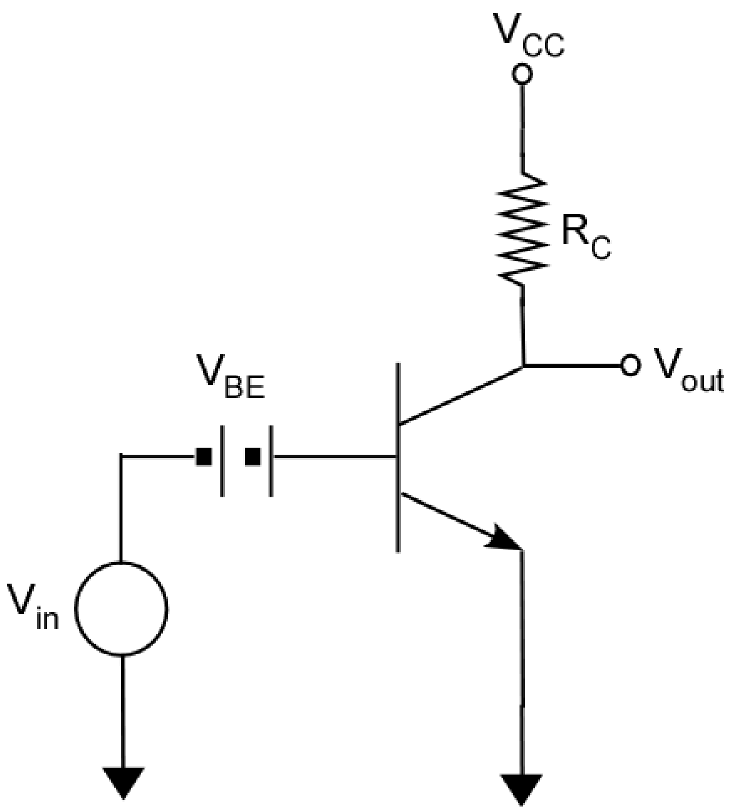
Common Emitter Configuration



The emitter current I_E can be approximated as:

$$I_E \simeq I_S e^{V_{BE}/V_T}$$

An incremental conductance g_e can be defined as

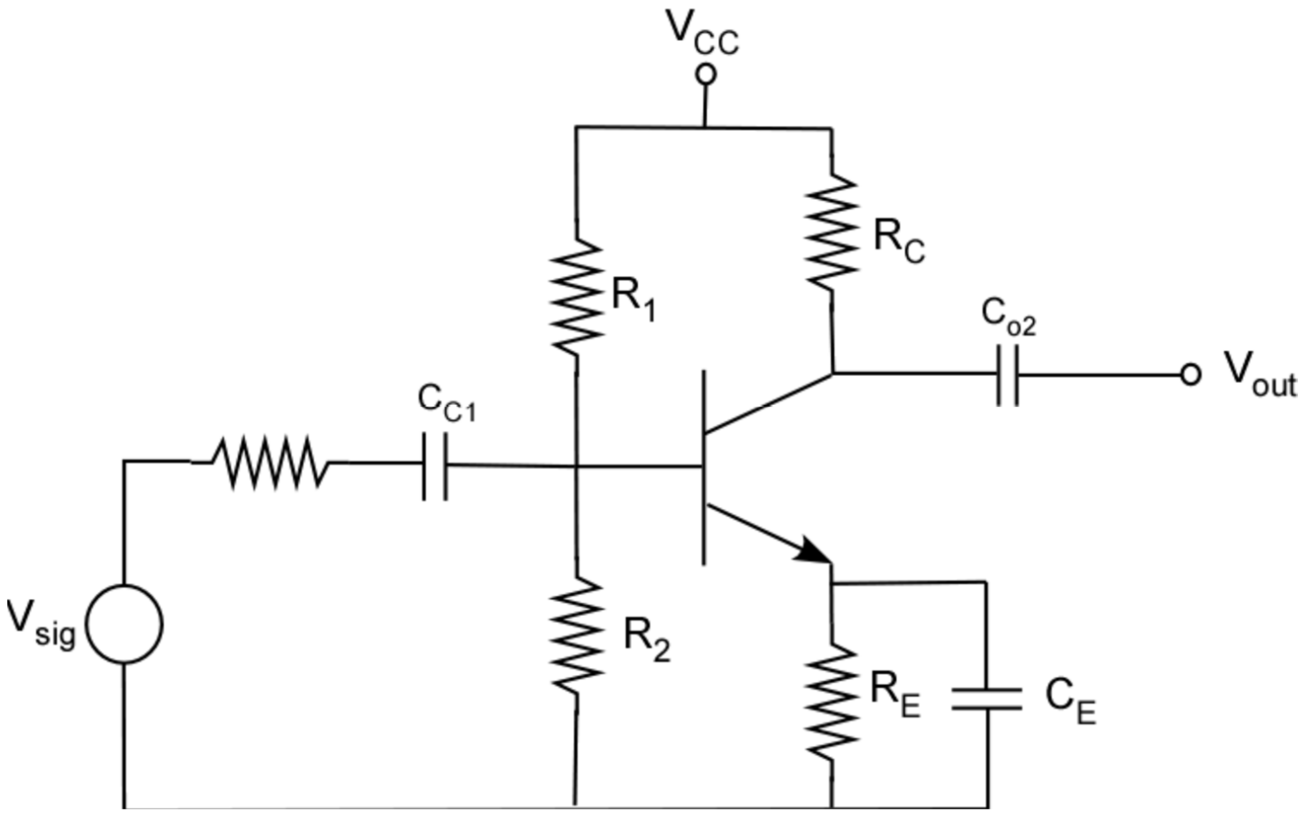
$$g_e \equiv \frac{\partial I_E}{\partial V_{BE}} = \frac{I_S}{V_T} e^{V_{BE}/V_T} = \frac{I_E}{V_T}$$

From which we get: $$r_e = \frac{1}{g_e} = \frac{V_T}{I_E}$$

Emitter resistance

$$\text{Usually}, V_T = 26\ mV \Rightarrow r_e = \frac{26\ mV}{I_E}$$

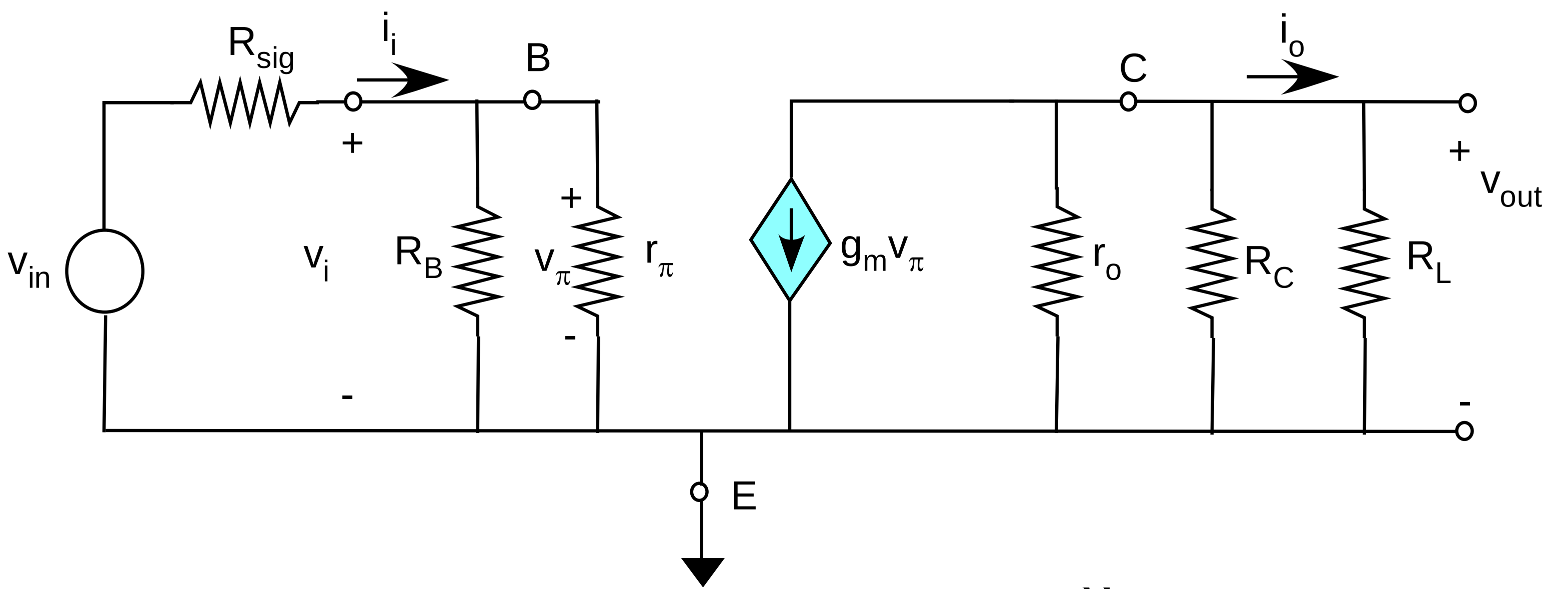
Common Emitter (CE) Amplifier



<u>Bias</u>: Choose R_1 & R_2 to set V_B → V_E is then set. Choose R_E to set $I_E \sim I_C$. Quiescent point of V_{out} will be determined by R_C. Emitter is an AC short.

Incremental Model for CE Amplifier

Hybrid-π model (ignoring *r*$_x$)



$$R_B = R_1 \,||\, R_2$$

$$R_{in} = \frac{v_i}{i_i} = R_B \,||\, r_\pi$$

$$Sometimes\ R_B \gg r_\pi \ and\ R_{in} \simeq r_\pi$$

CE Amplifier

$$v_i = \frac{v_{sig} R_{in}}{R_{in} + R_{sig}} = \frac{v_{sig} R_B \,||\, r_\pi}{\left(R_B \,||\, r_\pi\right) + R_{sig}}$$

$$and\ if\ R_B \gg r_\pi,\ v_i \simeq \frac{v_{sig} r_\pi}{r_\pi + R_{sig}}$$

$$v_o = -g_m v_{sig} \frac{R_B \,||\, r_\pi \left(r_o \,||\, R_C \,||\, R_L\right)}{\left(R_B \,||\, r_\pi\right) + R_{sig}}$$

$$v_o = -g_m v_\pi \left(r_o \,||\, R_C \,||\, R_L\right)$$

$$v_i = v_\pi$$

$$A_v = \frac{v_o}{v_i} = -g_m \left(r_o \,||\, R_C \,||\, R_L\right)$$

gain from base to collector

CE Amplifier

Open-circuit voltage gain:

$$A_{vo} = -g_m \left(r_o \,||\, R_C \right)$$

In most cases $r_o \gg R_C \Rightarrow A_{vo} = -g_m R_C$

$$G_v = -\frac{\left(R_B \,||\, r_\pi \right)}{\left(R_B \,||\, r_\pi \right) + R_{sig}} g_m \left(r_o \,||\, R_C \,||\, R_L \right)$$

and for the case where $R_B \gg r_\pi$

$$G_v = -\frac{\beta \left(r_o \,||\, R_C \,||\, R_L \right)}{r_\pi + R_{sig}}$$

CE Amplifier

Output Impedance

$$R_{out} = R_C \parallel r_o$$

$$If\ \ r_o \gg R_C,\ \ R_{out} \simeq R_C$$

$$from\ which\ A_v = A_{vo}\left(\frac{R_L}{R_L + R_o}\right)$$

It can be seen that if $R_{sig} >> r_\pi$, the gain will be highly dependent on β. This is not good because of β variations

$$If\ \ R_{sig} \ll r_\pi,\ \ \ G_v \simeq -g_m\left(R_C \parallel R_L \parallel r_o\right)$$