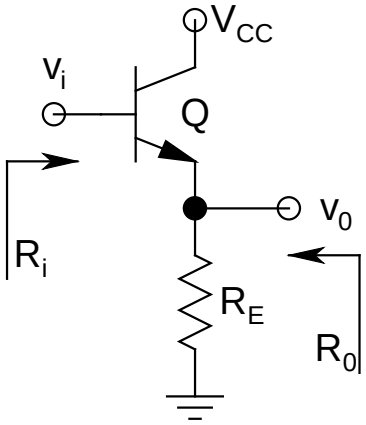
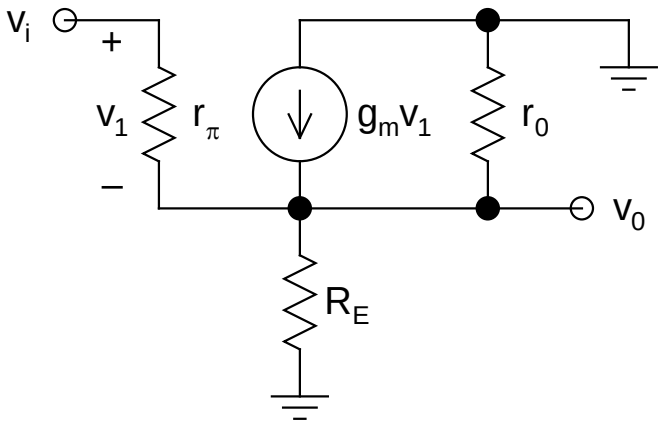
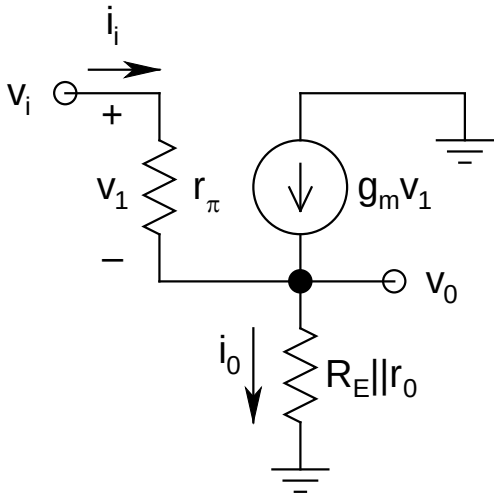
- ***Common-Collector*** (CC):
  - Also known as ***Emitter-Follower***



ac Schematic



ac Low-Frequency Equivalent



Simplified ac Low-Frequency Equivalent

- ***Biasing circuit not shown***

- ***Voltage Gain***:

$$A_v = \frac{v_0}{v_i} = \frac{i_0\left(R_E \parallel r_0\right)}{v_1 + v_0} = \frac{(\beta+1) i_i \left(R_E \parallel r_0\right)}{i_i r_\pi + (\beta+1) i_i \left(R_E \parallel r_0\right)}$$

$$= \frac{R_E \parallel r_0}{r_\pi/(\beta+1) + R_E \parallel r_0} = \frac{R_E \parallel r_0}{r_E + R_E \parallel r_0}$$

- Now, in general, $r_0 >> R_E$

  $\Rightarrow A_v = R_E/(r_E + R_E)$

- ***Two important observations***:
  - $A_v \leq 1$
  - ***No phase shift between v_i and v_0***

- ***Current Gain***:

$A_i = i_e/i_b = \beta + 1$ (***large***)

- ***Input Resistance***:

$$R_i = \frac{v_i}{i_i} = \frac{i_i r_\pi + i_0 \left(R_E \,||\, r_0\right)}{i_i}$$

$$= \frac{i_i r_\pi + \left(\beta + 1\right) i_i \left(R_E \,||\, r_0\right)}{i_i}$$

$$= r_\pi + \left(\beta + 1\right)\left(R_E \,||\, r_0\right)$$

  - If $r_0 >> R_E$, $R_i = r_\pi + (\beta + 1)R_E$

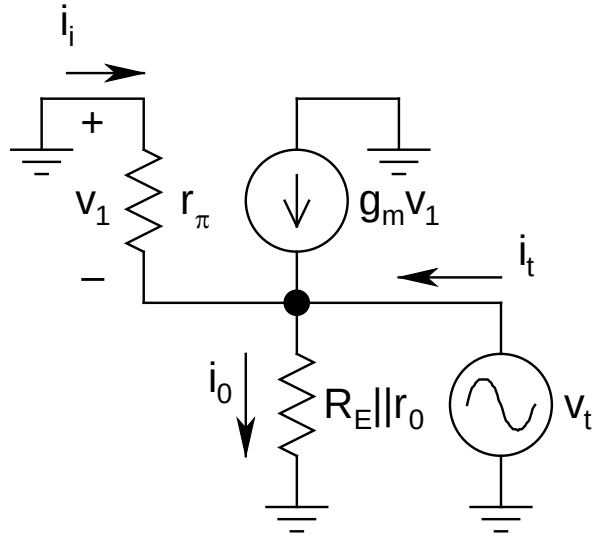
- Note that this result could have been written from ***inspection*** from the ***ac schematic*** using the technique of ***Resistance Transformation***

➢ ***Output Resistance***:

$$i_t = i_0 - g_m v_1 - i_i$$

$$= \frac{v_t}{R_E \,||\, r_0} + g_m v_t + \frac{v_t}{r_\pi}$$

$$\Rightarrow \; R_0 = R_E||r_0||r_E||r_\pi \approx r_E$$



- Note that this expression also could have been written by ***inspection***

- ***Output excited by a test voltage source v_t***:
  - ***The current has two parallel paths***: ***one going through the parallel combination of r_0 and R_E***, and ***the other into the emitter of Q***
  - The ***resistance in the base lead of Q is r_π***, which ***needs to be transformed to emitter by dividing it by $(\beta+1)$*** $\Rightarrow$ ***yields r_E***
  - Thus, ***R_0 becomes a parallel combination of r_0, R_E, and r_E***, which will be ***typically equal to r_E***, since, in general, ***it's the least among the three***
- ***Understand the inspection technique, it will become immensely useful to analyze circuits***