Output Impedance

- Looking into the collector and base terminals, the ac collector resistance r_c' appears in parallel with R_C .

$$R_{out} \approx R_C$$

Current Gain

- The current gain is the output current I_c divided by the input current I_e .
- Since $I_c = I_e$

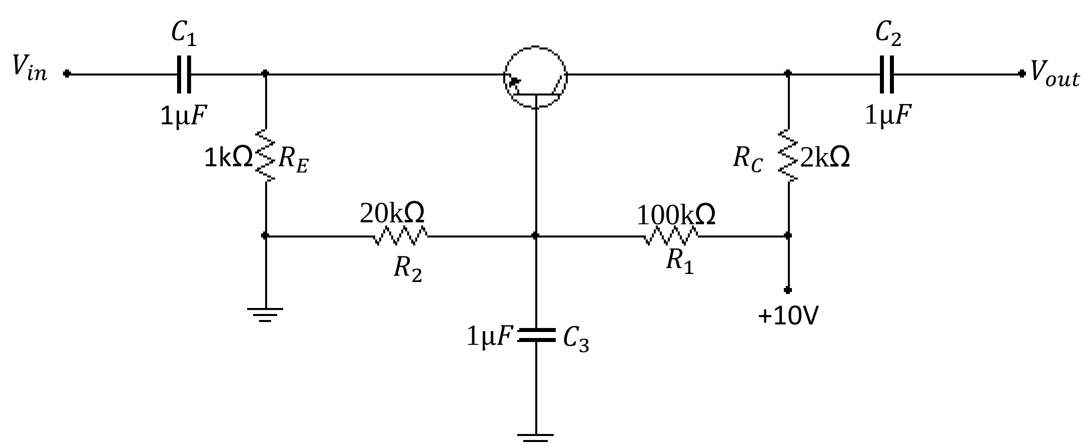
$$A_i \approx 1$$

Power gain

Since the current gain is approximately 1, power gain is approximately voltage gain .

$$A_p \approx A_v$$

Example: Find the input impedance , voltage gain, current gain, and power gain.
$\beta_{dc} = 200.$



$$\beta_{dc} R_E \gg R_2$$

$$V_B = \left(\frac{R_2}{R_1 + R_2}\right) V_{CC}$$

$$= \left(\frac{20k\Omega}{120k\Omega}\right) 10V = 1.67V$$

$$V_E = V_B - 0.7V = 1.67V - 0.7V = 0.97V$$

$$I_E = \frac{V_E}{R_E} = \frac{0.97V}{1k\Omega} = 0.97mA$$

Input impedance $R_{in} \approx r_e' = \frac{25mV}{0.97mA} = 25.77\Omega$

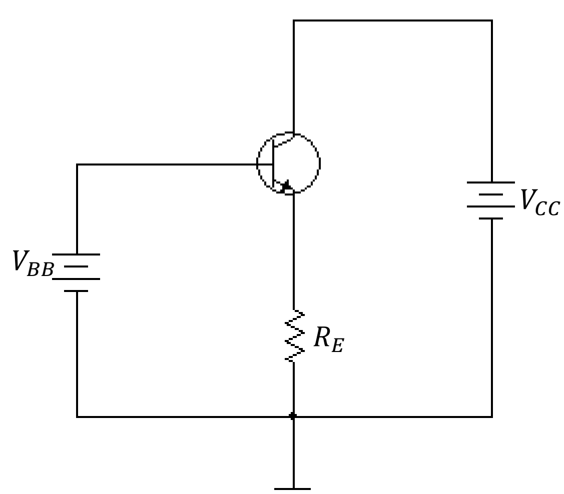
The ac voltage gain is :

$$A_v = \frac{R_C}{r_e'} = \frac{2k\Omega}{25.77\Omega} = 77.6$$

Also $A_i \approx 1$

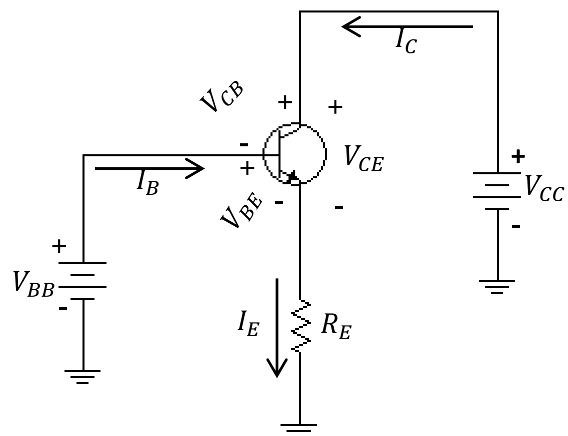
And $A_p = A_v = 77.6$

C: Common-Collector Configuration



- When a transistor is connected with the collector as the common (grounded) terminal, it is common collector connection (Emitter Follower).
- The collector is not at ac ground.
- Because V_{CC} has zero resistance (ideally) to an ac signal, therefore it is the ac ground.

Current Gain



I_E Is the output current , I_B is the input current , so

$\beta_{dc} = \frac{I_E}{I_B}$ if , then $I_C \approx I_E$ is current gain .

dc analysis

$$I_E = \frac{V_E}{R_E}$$

$$I_E = \frac{V_{BB} - V_{BE}}{R_E}$$

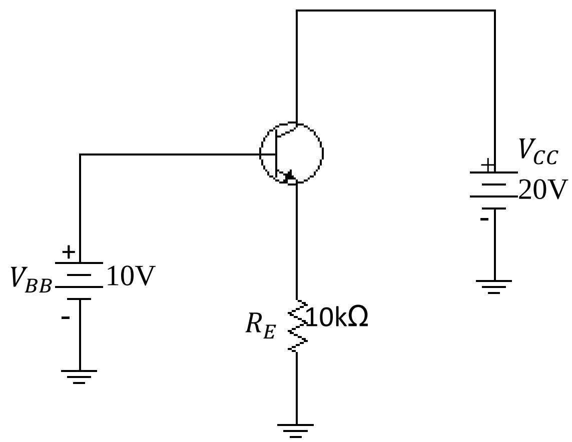
Assuming $I_C \cong I_E, I_B = \frac{I_E}{\beta_{dc}}$

$$V_{CE} = V_{CC} - V_E$$

$$V_{CE} = V_{CC} - I_E R_E$$

$$V_{CB} = V_{CC} - V_E - V_{BE}$$

Example: Determine I_B , I_C and I_E and the voltage at each transistor terminal with respect to ground (V_E , V_B *and* V_C). $\beta_{dc} = 200$.



$$I_E = \frac{V_{BB} - V_{BE}}{R_E}$$

$$= \frac{10V - 0.7V}{10k\Omega} = 0.93mA$$

$$I_C \cong I_E = 0.93mA$$

$$I_B \cong \frac{I_E}{\beta_{dc}} = \frac{0.93\ mA}{200} = 4.65\ \mu A$$

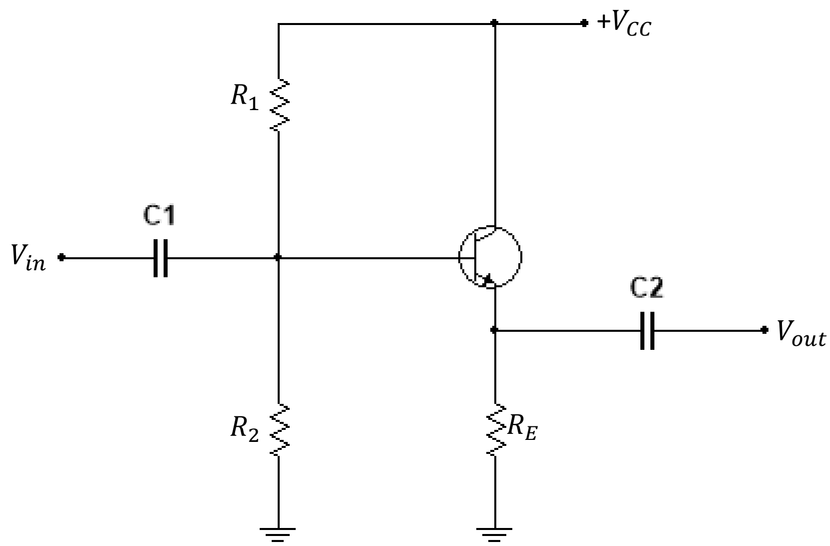
$$V_C = V_{CC} = 20V$$

$$V_B = V_{BB} = 10V$$

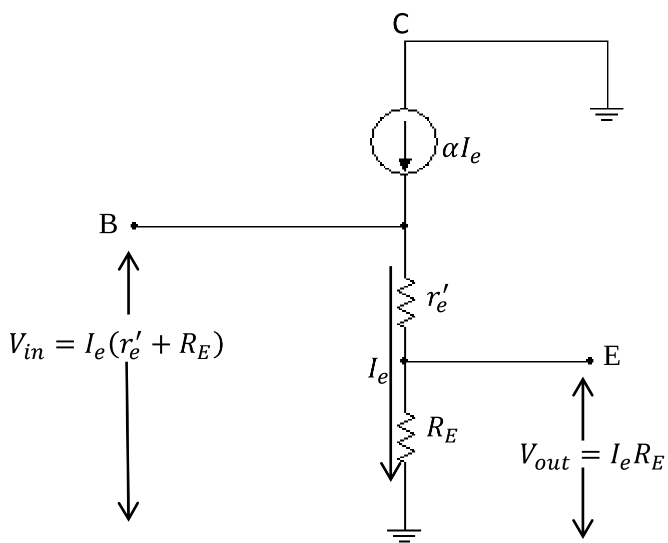
$$V_E = I_E R_E = (0.93mA)(10k\Omega) = 9.3V$$

C1: Common-Collector Amplifier

- The common collector amplifier is usually referred to as an emitter follower.



Voltage Gain



$$V_{out} = I_e R_E$$

$$V_{in} = I_e(r_e' + R_E)$$

$$A_V = \frac{I_e R_E}{I_e(r_e' + R_E)}$$

$$A_V = \frac{R_E}{(r_e' + R_E)}$$

- Notice that the voltage gain is slightly less than 1,
  If $R_E \gg r_e'$, then $A_V \cong 1$

Input Impedance

- The emitter-follower is characterized by high input impedance. This what makes a very useful circuit. Because of the high input impedance, it can be used as a buffer to minimize loading effects when one circuit is driving another.

$$R_{in(base)} = \frac{V_b}{I_b} = \frac{I_e(r_e' + R_E)}{I_b}$$

$$= \frac{\beta I_b(r_e' + R_E)}{I_b}$$

$$= \beta(r_e' + R_E)$$

If $R_E \gg r_e'$

$$R_{in(base)} = \beta R_E$$

$$R_{in} = R_1 \parallel R_2 \parallel R_{in(base)}$$