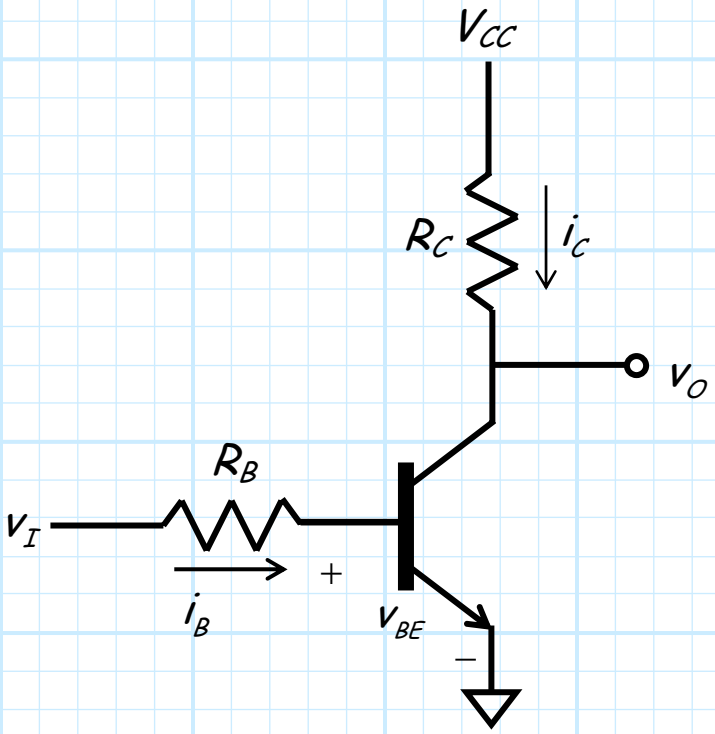
Example: Calculating the Small-Signal Gain

For this circuit, we have **now** determined (**if** BJT is in active mode), the **small-signal equations** are:



1) $v_i = i_b R_B + v_{be}$

2) $i_c = \beta i_b$

3) $v_o = -R_c i_c$

4) $i_c \cong g_m v_{be}$

Q: *So, can we now determine the **small-signal** open-circuit voltage **gain** of this amplifier? I.E.:*

$$A_{vo} = \frac{v_o(t)}{v_i(t)}$$

A: Look at the **four** small-signal equations—there are **four** unknowns (i.e., i_b, v_{be}, i_c, v_o)!

Combining equations 2) and 4), we get:

$$v_{be} = \frac{\beta}{g_m} i_b = r_\pi i_b$$

Inserting this result in equation 1), we find:

$$v_i = \left(R_B + r_\pi\right) i_b$$

Therefore:

$$i_b = \frac{v_i}{R_B + r_\pi}$$

and since $i_c = \beta i_b$:

$$i_c = \frac{\beta}{R_B + r_\pi} v_i$$

which we insert into equation 3):

$$v_o = -i_c R_C = \frac{-\beta R_C}{R_B + r_\pi} v_i$$

Therefore, the **small-signal gain** of **this** amplifier is:

$$A_{vo} = \frac{v_o(t)}{v_i(t)} = \frac{-\beta R_C}{R_B + r_\pi}$$

Note this is the small signal gain of **this** amplifier—and this amplifier **only**!