Final Review Problem #1: Common Collector Amplifier (BJT)

otherwise known as "Emitter follower" or "voltage follower"

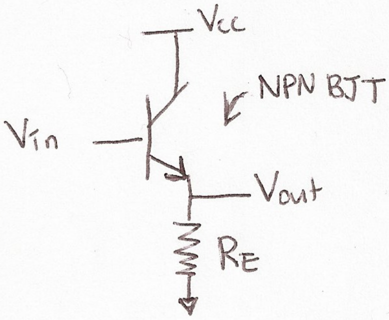
The main objective of this problem is to prove the advantage of using a voltage follower (buffer) in a circuit.

Mainly, a voltage follower has a gain of ≈ 1, which means $\Delta V_{out} \approx \Delta V_{in}$.

A gain of ≈ 1 seems pretty boring. However, it has a very high input impedence and a very low output impedence, which will help us a lot with impedence matching.

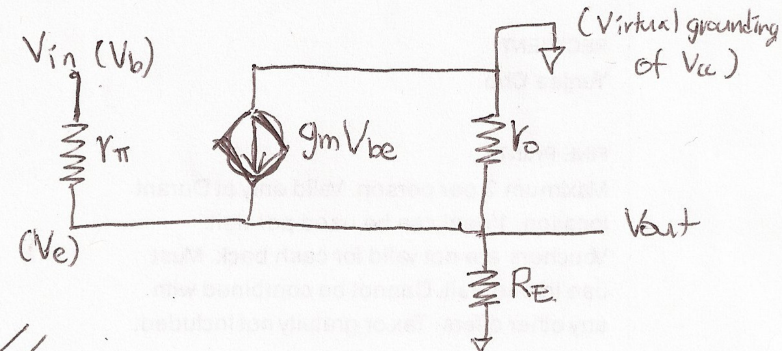
(e.g You can drive an $8\text{-}\Omega$ speaker or a motor with these things if you are careful enough)

So here is the topology:

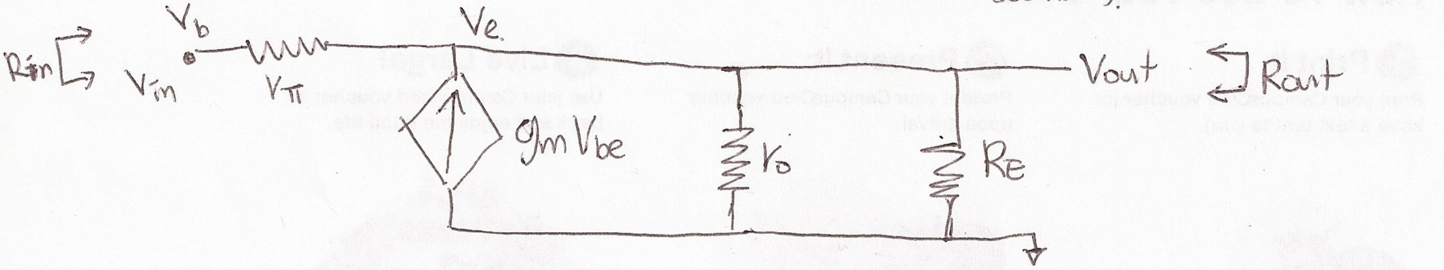


Small Signal Analysis (as taught in EE 105)

You don't need to understand how.



One more Simplication (You should see how).



Easier: ① Write an expression for gain $= \dfrac{V_{out}}{V_{in}}$

Then use these values to approximate the gain: (chosen to make the math easier)

$g_m = \dfrac{I_c}{V_T}$ $\quad r_o = \dfrac{V_A}{I_c}$ $\quad r_\pi = \dfrac{\beta}{g_m}$ $\quad I_c = 1\text{mA}$ $\quad V_T \approx 25\text{mV}$ $\quad V_A = 100\text{V}$ $\quad \beta = 100, R_E = 10\text{k}\Omega$

from here, you can assume: $\frac{1}{g_m} \ll r_o$

Is your gain ≈ 1?

Harder: ② Calculate R_{in}. (You can't ground V_{out}!)

(hint: apply a test source at V_{in} and relate V_b and V_b)

Sanity check: Is your R_{in} big? (greater than $1\text{k}\Omega$).

③ Calculate R_{out}:

(hint: Short V_{in} to GND and apply a test source at V_{out}).

Sanity check: Is your R_{out} small? (smaller than $1\text{k}\Omega$)

If you can solve these problems, you are in an awesome shape for EE105