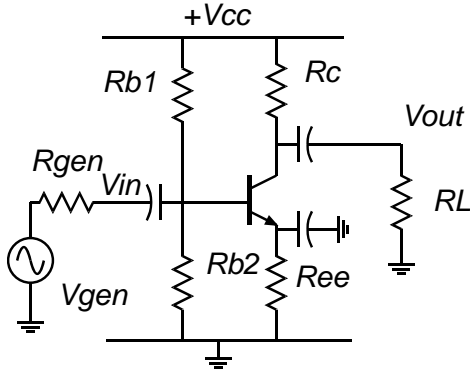


## ECE137A Problem set #2

### Problem 1. Simple common-emitter amplifier



a) The transistor has  $\beta = 200$ .

$V_{cc}$  is +10 Volts.  $R_L = 1000 \text{ Ohm}$ .  $R_{gen} = 1 \text{ kOhm}$ . The transistor has  $V_a = 100 \text{ V}$  and  $V_{cesat} = 0.5 \text{ volts}$

We want the emitter to be biased at +2 volts and the collector to be biased at +4 volts. The DC collector current is to be 1 mA, and the DC current through  $R_{b2}$  is to be 0.1 mA.

Find  $R_{b1}$ ,  $R_{b2}$ ,  $R_c$ ,  $R_{ee}$

b) Find the following small signal transistor parameters:

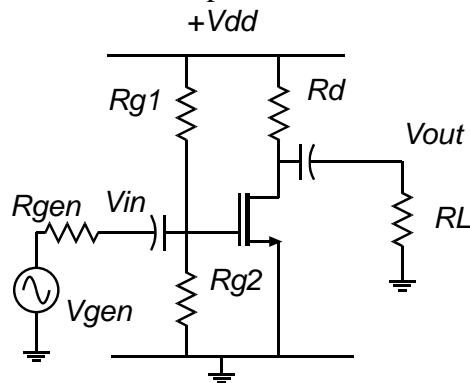
$g_m$ ,  $r_e$ ,  $R_{be}$ ,  $R_{ce}$

d) find the ac small signal input impedance, and the AC voltage gains  $V_{out}/V_{in}$ ,  $V_{in}/V_{gen}$  and  $V_{out}/V_{gen}$ .

c) draw the small-signal equivalent circuit of the amplifier, taking all capacitors as AC shorts and supplies as AC ground.

e) find the maximum AC peak-peak amplifier output before clipping.

### Problem 2. Simple common-source amplifier



a) The transistor -constant mobility model- has a threshold of +0.3 Volts, and  $\lambda$  is  $1/25 \text{ Volts}$ .

The gate length is 90 nm, the oxide thickness 1 nm, the surface mobility is  $300 \text{ cm}^2/(\text{V}\cdot\text{sec})$ .

Find the gate width necessary to carry 1 mA drain current at  $V_{gs} = 0.4 \text{ V}$ .

$V_{dd}$  is +2 volts.  $R_{gen} = 50 \text{ kOhm}$ ,  $R_L = 100 \text{ kOhm}$   
Find the drain resistance  $R_d$  necessary to obtain  $V_d = 1 \text{ V}$ .

We want the \*input impedance to be 1 MOhm.

Find  $R_{g1}$ ,  $R_{g2}$

b) Find the following small signal transistor parameters:  $g_m$ ,  $R_{ds}$

d) find the ac small signal input

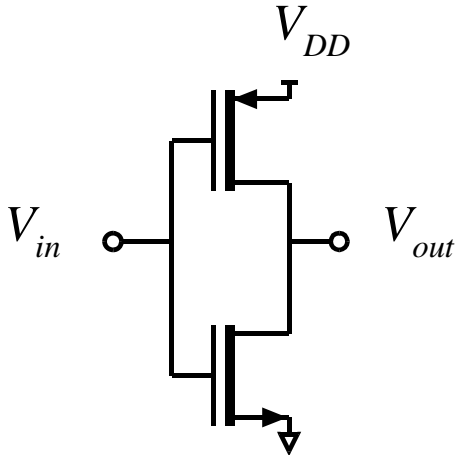
c) draw the small-signal equivalent circuit of the amplifier, taking all capacitors as AC shorts and supplies as AC ground.

e) find the maximum AC peak-peak amplifier

impedance, and the AC voltage gains  $V_{out}/V_{in}$ ,  $V_{in}/V_{gen}$  and  $V_{out}/V_{gen}$ .

output before clipping.

**Problem 3. Another common-source amplifier**



- b) Find the following small signal transistor parameters:  $g_m$ ,  $R_{ds}$  for both transistors.
- d) ac small signal voltage gain  $V_{out}/V_{in}$

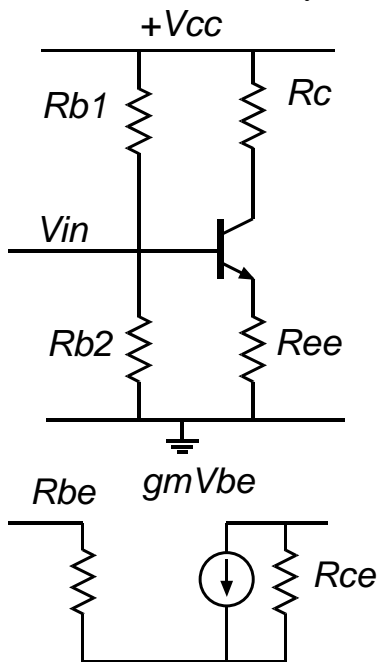
a) Use constant-velocity models. Thresholds are  $\pm 0.3$  V for the NMOS and PMOS FETs.  $\lambda$  is  $1/10$  Volts, the gate length is 90 nm, and the oxide thickness 1 nm. The NMOS FET has  $v_{sat} = 10^7$  cm/s; the value for the PMOSFET is half this. The NMOS FET has 5 microns gate width, the PMOS FET 10 microns.

$V_{DD}$  is 1.2 Volt. The input has 0.6 V DC bias, to which a small-signal input voltage is added.

Compute the DC values of  $V_{out}$  and drain current.  
c) draw the small-signal equivalent circuit of the amplifier.

e) find the maximum AC peak-peak amplifier output before clipping.

**Problem 3. Nodal Analysis**



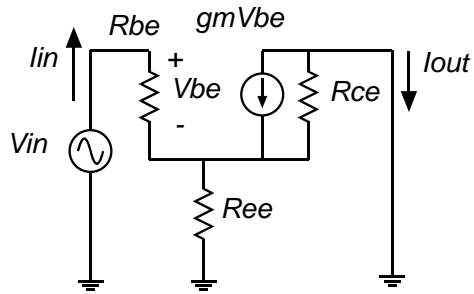
**Problem 4.**

We will frequently need to analyze circuits with resistance in the emitter or source lead.

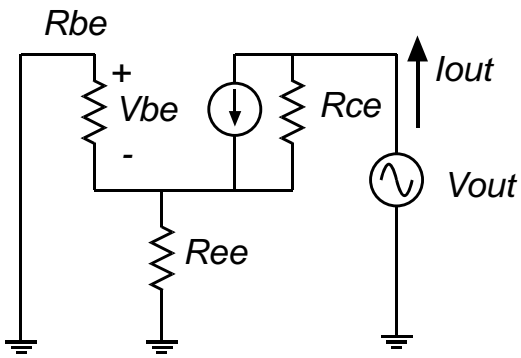
So, this problem is both a tutorial in how these work, and an exercise in nodal analysis, for which much practice is needed.

The overall circuit and the transistor small-signal model are as indicated on the right....

but the problem can be broken into the units below, which is what you must work this week



a) with the network to the right, derive by nodal analysis  
 ...the input impedance  $V_{in}/I_{in}$   
 ...the \*extrinsic\* transconductance  $I_{out}/V_{in}$



b) with the network to the right, derive by nodal analysis  
 ...the output resistance  $V_{out}/I_{out}$