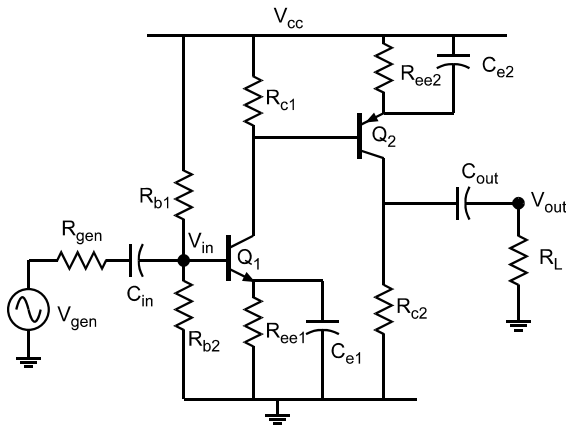


**ECE137A Problem set #5**

**Problem 1**



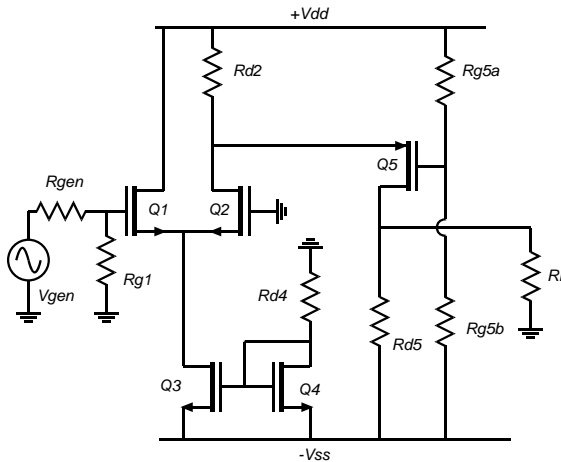
- (b) Find the small signal gain and the input impedance of Q2 ( $V_{c2}/V_{b2}$ ) and  $R_{in2}$
- (c) Find the small signal gain and the input impedance of Q1 ( $V_{c1}/V_{b1}$ ) and  $R_{in1}$

The transistors Q1 and Q2 have  $\beta=50$  and  $V_a=50$  V,  $V_{cc}=+5$  Volts,  $R_{gen}=1$  kOhm,  $R_L=1$  kOhm. Bias Q1 at 1 mA collector current, Q2 at 5 mA collector current, bias the emitter of Q2 at 4V, the Q2 collector at 1 V, and the Q1 emitter at 1 V. The parallel combination of  $R_{b1}$  and  $R_{b2}$  is to be 10 kOhm.

(a) Find all unspecified resistor values.

- (d) Find the input impedance \*\*\* of the amplifier \*\*\*\*,  $V_{in}/V_{gen}$ ,  $V_{out}/V_{in}$ , and  $V_{out}/V_{gen}$

**Problem 2**



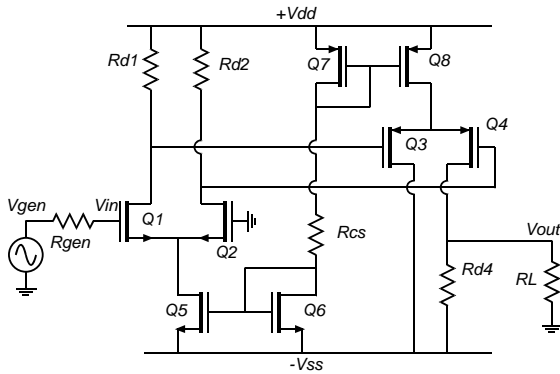
- (c) find the small signal gain  $V_{d2}/V_{s2}$  and input impedance of Q5.
- (d) find the small signal gain  $V_{d2}/V_{s2}$  and input impedance of Q2.
- (e) find the small signal gain  $V_{s1}/V_{g1}$  and the input impedance of Q1.

The NMOS FETS have 1.2 nm oxide thickness, 250 nm gate length, and a 0.4 V threshold. Mobility is  $400 \text{ cm}^2/(\text{V}\cdot\text{s})$ .  $\lambda=0 \text{ V}^{-1}$ . The PMOS FETS are the same, except have -0.4 V threshold and  $200 \text{ cm}^2/(\text{V}\cdot\text{s})$  mobility. All FETs are to operate with  $|V_{gs}|=0.6$  V, the  $I_{d3}=I_{d4}=2$  mA,  $I_{d5}=1$  mA. The supplies are  $\pm 2$  V. The gate of Q5 is at +1 V.  $R_{g1}=10$  MegOhm,  $R_L=1$  MOhm,  $R_{g5a}=100$  kOhm,  $R_{gen}=1$  MOhm.

- (a) find all resistor values and FET widths.
- (b) find the drain currents, and the drain, gate, and source voltages of all transistors
- (f) find  $V_{in}/V_{gen}$ ,  $V_{out}/V_{in}$ , and  $V_{out}/V_{gen}$  of the amplifier.
- (g) find the maximum signal swing of the amplifier. This will involve finding the maximum signal swings of Q1, Q2, and Q5, and scaling each by the appropriate gains.

**Problem 3**

The NMOS FETS have 1.2 nm oxide thickness, 250 nm gate length, and a 0.4 V threshold. Mobility is  $400 \text{ cm}^2/(\text{V}\cdot\text{s})$ .



- (c) find the small signal gain of the differential pair Q3/Q4  
 (d) find the small signal gain of the differential pair Q1/Q2. Note that because both outputs (the drains of both Q1 & Q2) are used, the gain is doubled.

$\lambda = 0 \text{ V}^{-1}$ . The PMOS FETs are the same, except have  $-0.4 \text{ V}$  threshold and  $200 \text{ cm}^2/(\text{v}\cdot\text{s})$  mobility. The FETs are to all operate at  $|V_{gs}| = 0.6 \text{ V}$ .  $I_{d5} = I_{d6} = I_{d7} = I_{d8} = 0.5 \text{ mA}$ . The supplies are  $\pm 2 \text{ V}$ .  $V_{d1} = V_{d2} = +0.5 \text{ V}$ .  $V_{out} = 0 \text{ V}$ .  $R_L = 10 \cdot R_{d4}$ .

- (a) find all resistor values,  
 (b) find the drain currents, and the drain, gate, and source voltages of all transistors  
 (c) find  $V_{in}/V_{gen}$ ,  $V_{out}/V_{in}$ , and  $V_{out}/V_{gen}$  of the amplifier.  
 (d) Do not at this time find the maximum signal swings