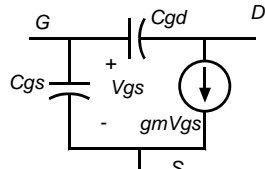
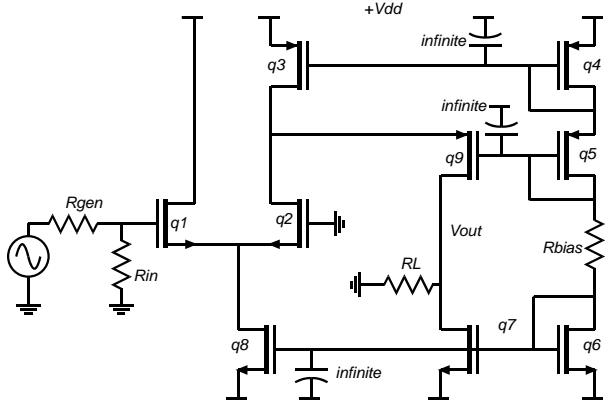


ECE137b problem set 5



The NMOS FETs have 1.0 nm oxide thickness, 90 nm gate length, and a 0.2 V threshold. Mobility is  $400 \text{ cm}^2/(\text{V}\cdot\text{s})$ ,  $v_{sat} = 10^7 \text{ cm/s}$  and  $1/\lambda = \infty$ . The PMOS FETs are the same, except have -0.2 V threshold,  $200 \text{ cm}^2/(\text{V}\cdot\text{s})$  mobility, and  $v_{sat} = 5 \cdot 10^6 \text{ cm/s}$

Problem 1:

$$C_{gs} = \epsilon_r \epsilon_0 W_g L_g / T_{ox} \text{ and } C_{gd} = C_{gs} / 4$$

We will assume the constant velocity model, and will choose all FET widths such that  $|V_{gs}| = 0.5 \text{ V}$ .

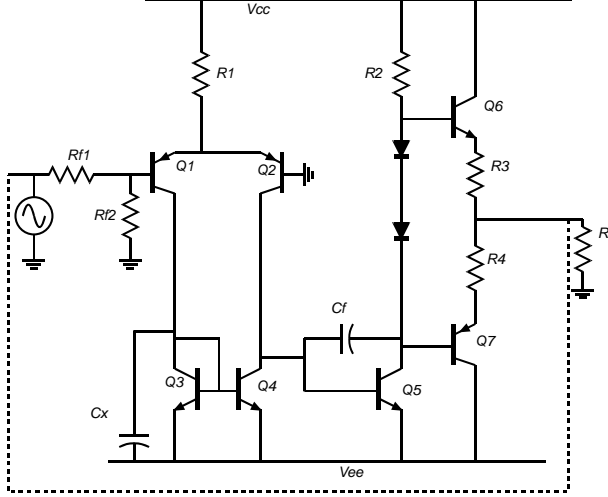
The supplies are +/- 1.5 volts  
Q8,7,6 are to be biased at 0.2 mA

Find Rbias.  
RL=1 MOhm. Rgen=Rin/10=1 kOhm.

To simplify the problem, the indicated capacitors are AC short circuits (do not treat these as capacitors in an MOTC analysis) (a) Find all DC bias conditions (b) find all device capacitances (c) find the circuit gain and (d) Find the all significant poles in the transfer function  $V_{out}/V_{in}$

Problem 2

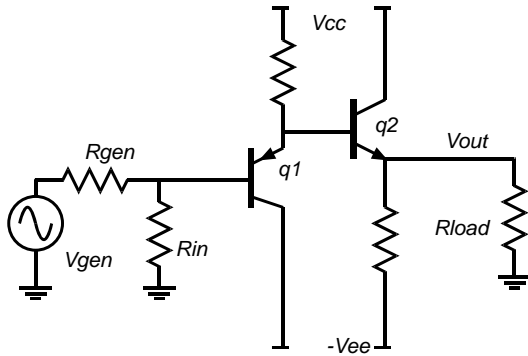
A simple operational amplifier. The power supplies are  $\pm 3 \text{ volts}$ . Pick R1 so that Q1 and Q2 are biased at 0.1 mA. Pick R2 so that Q5 is biased at 1 mA. Pick R3=R4 so that the output transistors are biased at 0.25 mA.



**Assume feedback forces  $V_{out}$  to zero volts DC.** All transistors have the same emitter saturation current, have  $\tau_f = 1 \text{ ps}$ ,  $C_{je} = 10 \text{ fF}$ ,  $C_{cb} = 20 \text{ fF}$  for the NPN and  $\tau_f = 5 \text{ ps}$ ,  $C_{je} = 50 \text{ fF}$ ,  $C_{cb} = 100 \text{ fF}$  for the PNP.  $\beta = 100$ ,  $V_A = \infty$ . The load resistance is  $1 \text{ k}\Omega$ . C is  $10 \text{ pF}$ . In the circuit connection shown ( $R_{f1} = 9 \text{ k}\Omega$  and  $R_{f2} = 1 \text{ k}\Omega$  represent the feedback network), we are calculating the gain around the feedback loop. This is represented by the dotted line, which you should not treat as a connection. Find the gain  $V_{out}/V_{gen}$ . Using MOTC, find the 2 dominant poles in the transfer function.

MAJOR COMMENT. There is a difficulty in that the Q1-Q4 stage has 2

paths from input-output. To simplify this problem, I have added  $C_x$ , a Perfect AC short, to kill one of the 2 paths



**Problem 3.**

Q1 and Q2 have  $\beta=50$  and  $V_A=\infty$ .  $C_{je}=40$  fF,  $C_{cb}=100$  fF and the forward transit time is 2 pS.  $V_{cc}=-V_{ee}=5$  Volts.  $R_{load}=50$  Ohms,  $R_{gen}=500$  Ohms,  $R_{in}=500$  Ohm. Q2 is to be biased at 500 mA and Q1 is to be biased at 100 mA.

- a) Find the DC bias conditions and the voltage gain  $V_{out}/V_{gen}$ .
- b) Use the method of time constants to find the 2 dominant pole frequencies of the circuit.
- d) Draw Bode plots for parts b) and c).