PROBLEM SET #10

Issued: Friday, November 2, 2018

Due: Friday, November 16, 2018, at 12:00 noon via Gradescope.

1. Sedra & Smith, Problem 8.98
2. For the amplifier in Figure PS10.1, assume that Q_1 and Q_2 have the properties listed in Table PS10.1. First, find values for each of the BJT internal capacitances C_μ, C_π. Then find the voltage gain $A_v(\frac{v_{out}}{v_s})$, input and output resistances R_{in} & R_{out}, and upper and lower corner frequencies f_L & f_H.

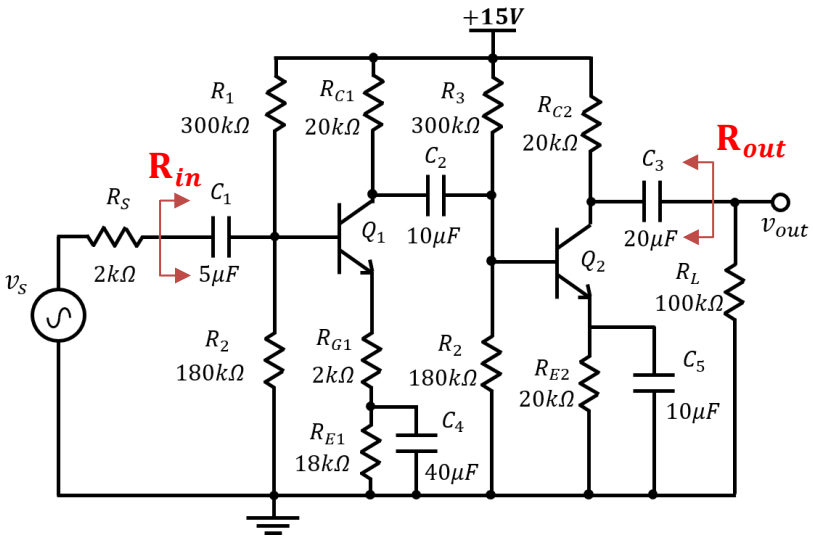

Figure PS10.1

PARAMETER	*VALUE*	*UNIT*
β	100	A/A
V_A	70	V
$V_{bi,e}$	0.9	V
$V_{bi,c}$	0.5	V
L_{ov}	0.05	μm
$C_{jc,0}$	4	pF
$C_{je,0}$	8	pF
τ_F	350	ps

Table PS10.1

3. For the amplifier in Figure PS10.2, assume that M_1 and M_2 have the parameters listed in Table PS10.2. Find $A_v(\frac{v_{out}}{v_s})$, R_{in}, R_{out}, f_L, and f_H.

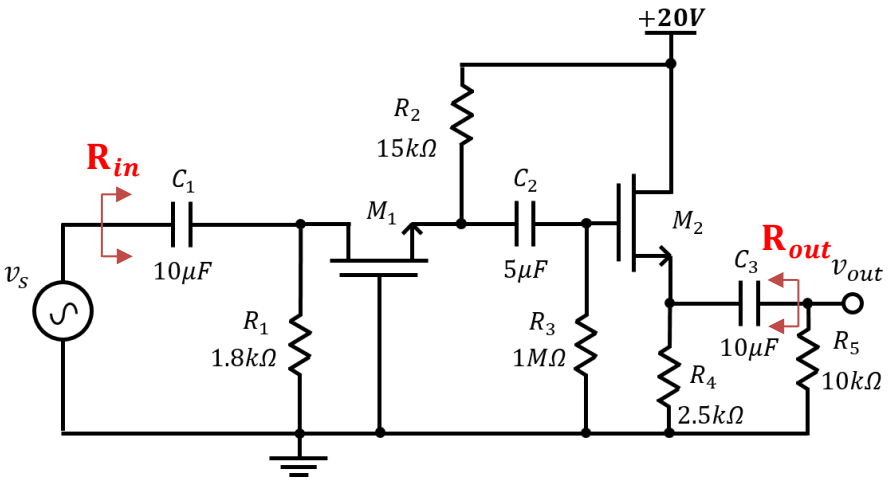

Figure PS10.2

PARAMETER	*VALUE*	*UNIT*
W	200	μm
L	1.2	μm
μ_n	450	$cm^2/(V \cdot s)$
μ_p	250	$cm^2/(V \cdot s)$
C_{ox}''	0.5	$fF/\mu m^2$
V_{tn}	-2	V
V_{tp}	4	V
L_{ov}	0.1	μm
C_{db0}	20	fF
C_{sb0}	20	fF
V_0	0.7	V
λ	0.02	V^{-1}

Table PS10.2

4. For the amplifier in Figure PS10.3, assume that M_1 has the properties listed in Table PS10.2, and that Q_1 has the properties listed in Table PS10.1. Find $A_v(\frac{v_{out}}{v_s})$, R_{in}, R_{out}, f_L, and f_H.

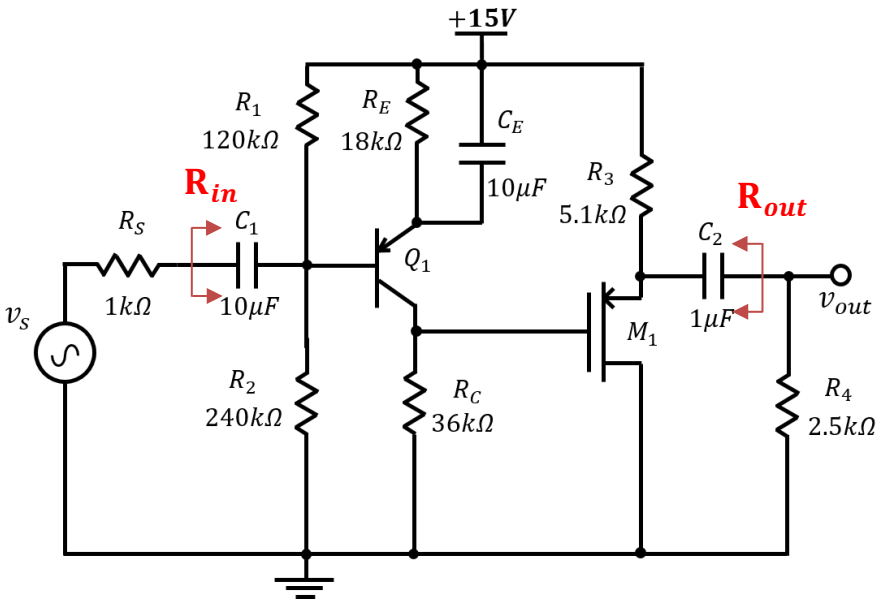

Figure PS10.3

5. For the amplifier in Figure PS10.4, assume that Q_1 and Q_2 have the properties listed in Table PS10.1. Find $A_v(\frac{v_{out}}{v_s})$, R_{in}, R_{out}, f_L, and f_H.

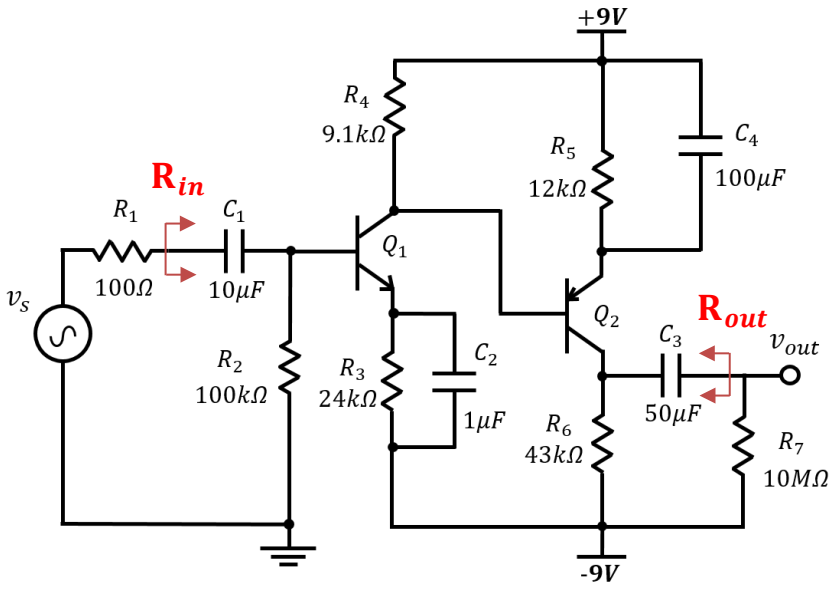

Figure PS10.4

6. Find the Q-points of the transistors in Figure PS10.2 if C_2 is replaced with a short circuit and the $1M\Omega$ resistor is removed from the circuit.

7. For the circuit shown in Figure PS10.5, X_1 is an ideal OpAmp and assume M_1 and M_2 have the properties listed in Table PS10.2. Assume Q_2 has the properties listed in Table PS 10.1. Q_1 is a parallel combination of four npn transistors having the properties listed in Table PS 10.1. Find the expression of $\mathbf{V_P}$ and $\mathbf{V_C}$. [Hint: You may assume both Q_1 and Q_2 are biased in forward active region. In addition, this is a case where you cannot just assume the diodes' turn-on voltage is $V_{BE(on)}$. You will need to be more accurate.]

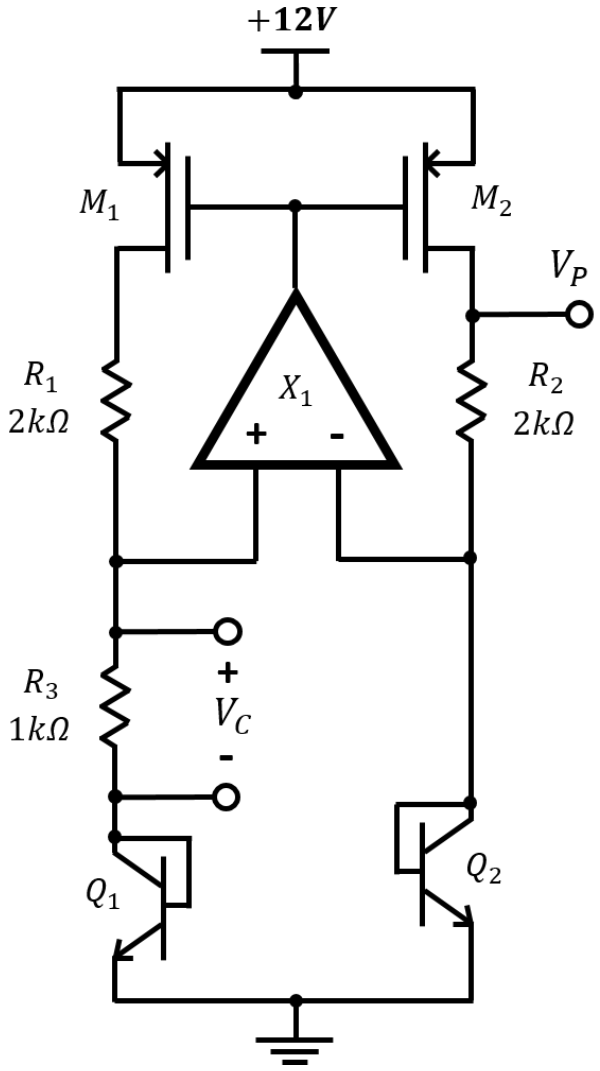

Figure PS10.5

8. For the circuit shown in Figure PS10.6. Q_1, Q_2 and Q_3 have the same properties, and Q_4 and Q_5 have the same properties. $V_{BE,on,Q1} = 0.7V$, $V_{BE,on,Q4} = 0.65V$. Solve of V_{REF}. Neglect early effect.

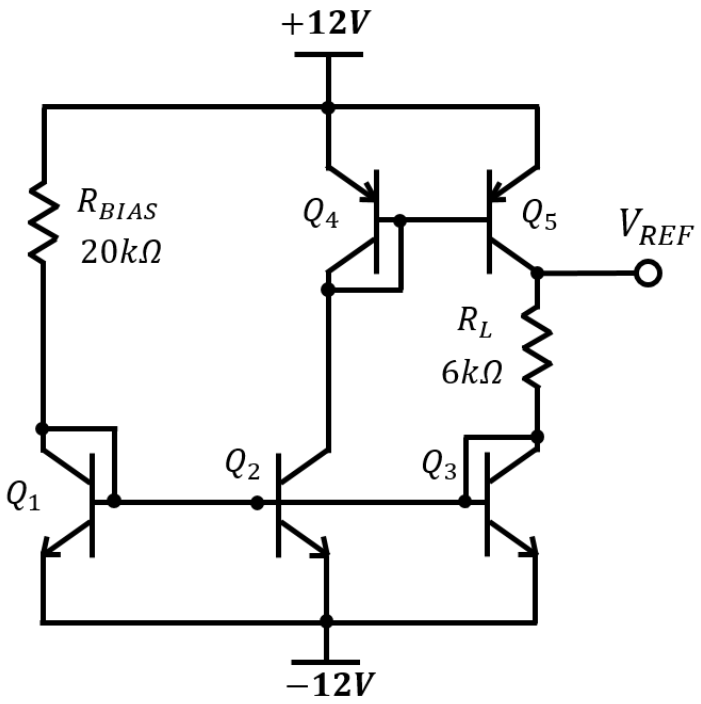

Figure PS10.6