Texas A&M University
Department of Electrical and Computer Engineering

ECEN 326 – Electronic Circuits

Fall 2015

Exam #2

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are 4 pages in your exam
- You may use one double-sided page of notes and equations for the exam
- Good Luck!

Problem	Score	Max Score
1		50
2		50
Total		**100**

Name: SAM PALERMO

UIN: ______

Problem 1 (50 points)

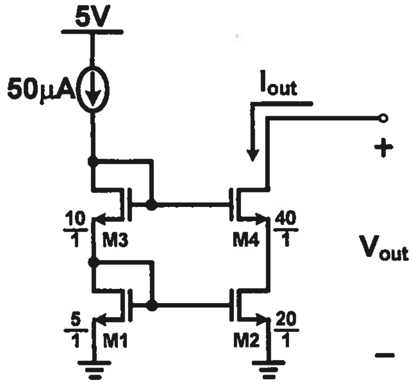
For the circuit shown below, assume that all transistors are operating in the saturation region. Calculate the following using these transistor parameters.

$KP_N=\mu_n C_{ox}=200\mu A/V^2$, $V_{TH,N}=0.4V$, $\lambda=0.1\,V^{-1}$

a) Output current, $\mathbf{I_{out}}$

b) Minimum output compliance voltage, such than all transistors remain in saturation, $\mathbf{V_{out,min}}$.

c) Output resistance, $\mathbf{R_{out}}$



$$I_{OUT} = \frac{(W/L)_2}{(W/L)_1} I_{REF} = \frac{(20/1)}{(5/1)} 50\mu A = 200\mu$$

$$V_{OUT,min} = V_{S4} + V_{DSAT4} = V_{GS1} + V_{DSAT4}$$

$$= \sqrt{\frac{2(50\mu)}{200\mu(5/1)}} + 0.4 + \sqrt{\frac{2(200\mu)}{200\mu(40/1)}}$$

$$= 940mV$$

$$R_{OUT} = r_{o4} + r_{o2} + g_{m4} r_{o4} r_{o2}$$

$$r_{o4} = r_{o2} = \frac{1}{\lambda I_D} = \frac{1}{(0.1V^{-1})(200\mu A)} = 50k\Omega$$

$$g_{m4} = \sqrt{(200\mu)(40/1)(2)(200\mu A)} = 1.79\,mA/V$$

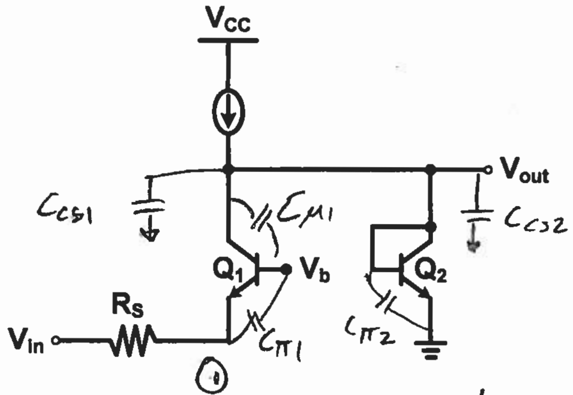
$$R_{OUT} = 50k + 50k + (1.79m)(50k)(50k) = 4.58M\Omega$$

$I_{out} =$ 200μA

$V_{out,min} =$ 940mV

$R_{out} =$ 4.58MΩ

Problem 2 (50 points)
For the circuit shown below, assume that all transistors are operating in the active region and that $V_A=\infty$. Obtain expressions for the following
a) The circuit's poles, including the appropriate transistor capacitors.
b) Low-frequency gain, $A_v=V_{out}/V_{in}$
c) Using the answers from part (a) and (b), the circuit's transfer function $V_{out}(s)/V_{in}(s)$



2 poles at node ① and Vout

Node 1: $|\omega_{p1}| = \frac{1}{(R_s \| r_{e1}) C_1}$

$C_1 = C_{\pi 1}$

Node 2: $|\omega_{p2}| = \frac{1}{r_{e2} C_2}$ where $C_2 = C_{cs1} + C_{\mu 1} + C_{\pi 2} + C_{cs2}$

$$|\omega_{p1}| = \frac{1}{\left(\frac{R_s r_{e1}}{R_s + r_{e1}}\right) C_1} \approx \frac{1}{\left(\frac{R_s}{1+g_{m1} R_s}\right) C_1}, \quad |\omega_{p2}| = \frac{1}{r_{e2} C_2} \approx \frac{g_{m2}}{C_2}$$

$$A_v = \frac{\alpha r_{e2}}{R_s + r_{e1}} \approx \frac{g_{m1}/g_{m2}}{1 + g_{m1} R_s}$$

$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{A_v}{\left(1+\frac{s}{\omega_{p1}}\right)\left(1+\frac{s}{\omega_{p2}}\right)} = \frac{\alpha r_{e2}}{(R_s + r_{e1} + s R_s r_{e1} C_1)(1 + s r_{e2} C_2)}$$

$$\approx \frac{g_{m1}/g_{m2}}{(1 + g_{m1} R_s + s R_s C_1)\left(1 + s \frac{C_2}{g_{m2}}\right)}$$

Scratch Paper