NAME SOLUTIONS

MIDTERM #2 FALL, 1997

EECS 140
R.W. BRODERSEN

avg. 46
s.d 10

SHOW YOUR WORK.
GIVE ANSWERS THAT ARE ACCURATE TO WITHIN ±10%.

PLEASE COPY YOUR ANSWERS ONTO THIS PAGE.

(5) 1a) $(W/L)_{M2} = 300$

(5) b) $(W/L)_{M1} = 1200$

(5) c) 15 %

(5) 2a) $V_{OUT,MAX}$ 4.55V

$V_{OUT,MIN}$ $|1|V$ (5)

(5) b) GAIN 450

(10) c) ω_{P1} 50 MRAD/SEC

(5) ω_{P2} 286 MRAD/SEC

(5) 3a) SHUNT-SERIES

(5) b) $f \cdot R4/(R2+R4)$

c) $f \cdot R_1 \| (R_2+R_4)\, g_m (R_3 \| r_{om}) \cdot \frac{1}{1+g_m(R_3\|r_{om})}$

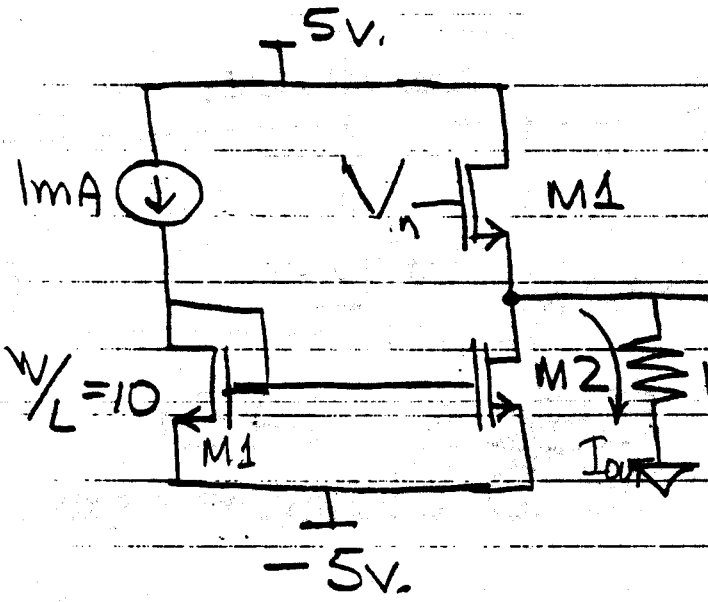
(5) $\cdot \frac{r_o}{r_o + R_2 \| R_4 + R_5}$

d) V_{OUT}/V_{IN} $\frac{R_5}{R_1}\left(1+\frac{R_2}{R_4}\right)$

65 TOTAL

ALL PARTS COUNT 5 POINTS EXCEPT 2C WHICH COUNTS 15 (FOR BOTH PARTS)

1)



$k' = 100\ \mu A/V^2$

$\gamma = 0$

$\lambda = .01$

$V_T = 1V$

$-5V < V_{in} < +5V.$

a) WHAT IS THE W/L OF M2 SO THAT $V_{OUT,MIN} = -3V.$ 300

$I_{DS,M2} = -I_{OUT} = -\frac{-3V}{100\Omega} = 30ma$ $\left(\frac{W}{L}\right)_{M2} = \frac{30ma}{1ma}\left(\frac{W}{L}\right)_{M1}$

$= 300$

b) WHAT IS THE W/L OF M1 SO THAT $V_{OUT,MAX} = +3V$ 1200

$I_{DS1} = 60ma = \frac{k'}{2}\left(\frac{W}{L}\right)_1 (5-1-3)^2$

$= \frac{10^{-4}}{2}\left(\frac{W}{L}\right)_1$ $\left(\frac{W}{L}\right)_1 = 1200$

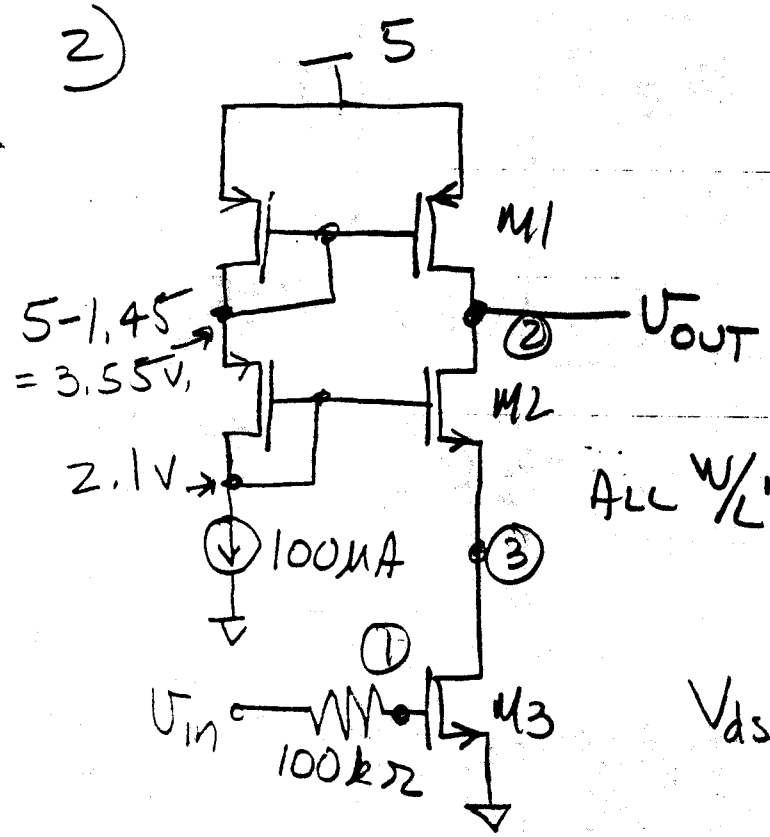
c) WHAT IS THE EFFICIENCY OF THIS CIRCUIT WITH YOUR VALUES FOR M1 & M2

CLASS A $P_{SUPPLY} = 1ma \cdot 10V + 30ma\ 10V. = 310mW$

$P_{LOAD} = \frac{V_{PEAK}^2}{2R} = \frac{9}{2 \cdot 100} = 45mW$

$EFFICIENCY = \frac{45}{310} = 15\%$

2)



$\lambda = .01$
$k' = 100\mu A/V^2$
$\gamma = 0$
$V_{TP} = -1V.$
$V_{TN} = +1V.$
$C_{GS} = 20ff$
$C_{GB} = C_{GD} = C_{DB} = C_{SB} = 5$

ALL W/L's $= 10$

$$V_{dSAT} = \left(\frac{2I_{DS}}{k'W/L}\right)^{1/2} = \left(\frac{2\times10^{-4}}{10^{-4}\cdot10}\right)^{1/2} = .45V.$$

a) WHAT IS THE MAXIMUM & MINIMUM VOLTAGE OVER WHICH THE GAIN IS HIGH?

$V_{OUT,MAX}$ 4.55V $V_{OUT,MIN}$ 1.1V.

$3.55 + V_T = 4.55V.$ $2.1 - V_T = 1.1V.$

b) WHAT IS THE MAXIMUM GAIN? 450

$A = -g_m R_{OUT}$

$g_m = (2k'W/L\, I_{DS})^{1/2} = (2\cdot10^{-4}\cdot10\cdot10^{-4})^{1/2} = .45\times10^{-3}$

$R_{OUT} = r_{O,M1} \| r_{O2}(1+g_{m2}r_{O3}) \approx r_{OM1} = \frac{1}{\lambda I_{DS}} = \frac{1}{.01\times10^{-4}} = 1M\Omega$

c) WHAT ARE THE 2 LOWEST POLES? ω_{P1} 50MRAD/SEC

ω_{P2} 286 MRAD/SEC

① $R = 100k\Omega$

$C = C_{GS3} + C_{GB1} + 2C_{GD} = 35\times10^{-15}$

(2 ↑ GAIN OF −1 TO NODE 3)

$\omega_① = \frac{1}{35\times10^{-10}}$ = MRAD

$R_{M2} \approx \frac{1}{g_m}$

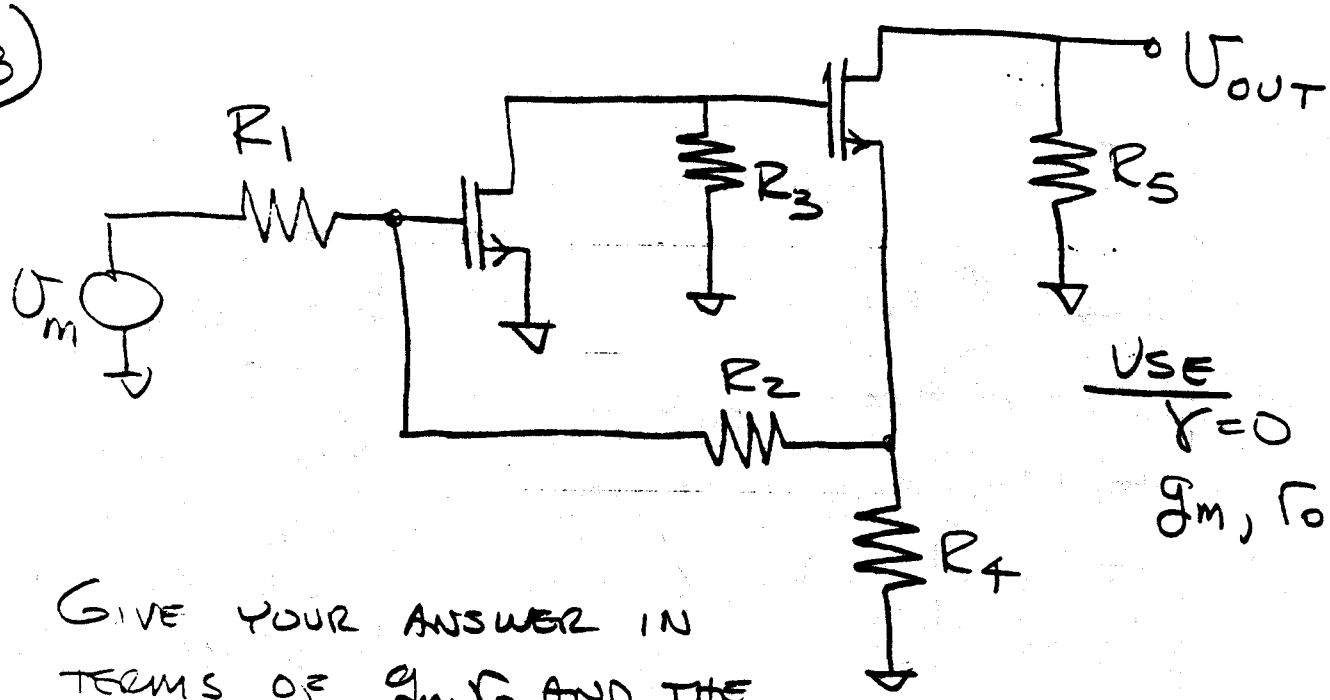
② $R = R_{OUT} = 1M\Omega$

$C = C_{GD1} + C_{DB1} + C_{GD2} + C_{DB2}$

$= 20ff$

$\omega_② = \frac{1}{1M\Omega\ 20\times10^{-15}} = 50M_{RAD}$

3)



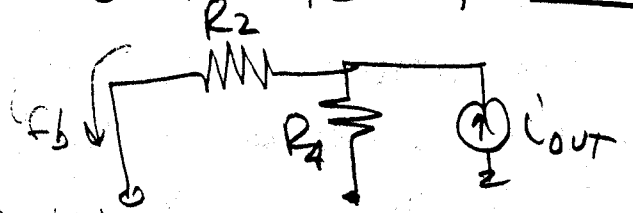
USE $\gamma = 0$

g_m, r_o

GIVE YOUR ANSWER IN TERMS OF g_m, r_o AND THE RESISTORS.

a) WHAT KIND OF ~~FEEDBACK~~ ? SHUNT-SERIES

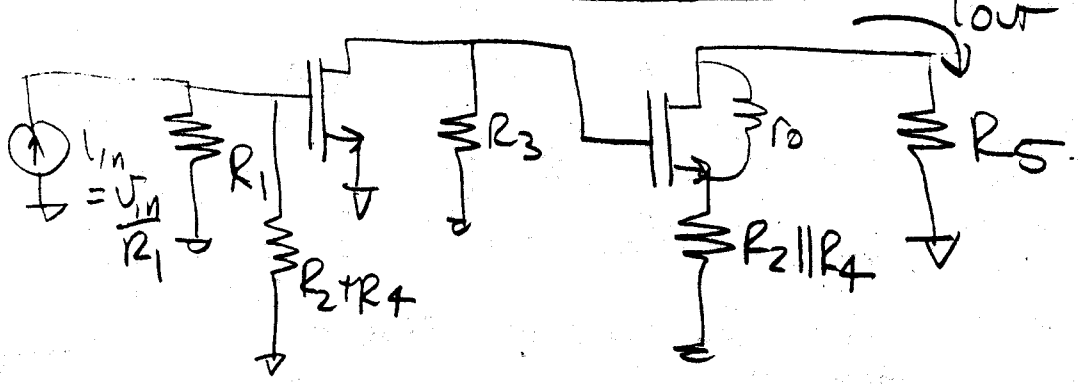
b) WHAT IS $f = \frac{R_4}{R_2+R_4}$?



$$\frac{i_{fb}}{i_{OUT}} = \frac{R_4}{R_2+R_4} = f$$

c) WHAT IS THE LOOPGAIN WITH LOADING, T'

$$T' = R_1 \| (R_2+R_4)\, g_m (R_3 \| r_o) \left(\frac{g_m}{1+g_m(R_2\|R_4)}\right)\left(\frac{r_o}{r_o + R_2\|R_4 + R_5}\right) \cdot f$$



d) WHAT IS THE GAIN, $\frac{U_{OUT}}{U_{in}}$ IF T' IS ASSUMED LARGE $\frac{(R_5/R_1)(1+R_2/R_4)}{}$

$$\frac{i_{OUT}}{i_m} = \frac{1}{f} = 1 + \frac{R_2}{R_4}$$

$U_{OUT} = i_{OUT} R_5$

$U_{in} = i_{in} R_1$

$$\frac{U_{OUT}}{U_m} = \frac{R_5}{R_1}\left(\frac{i_{OUT}}{i_{in}}\right)$$