Texas A&M University
Department of Electrical and Computer Engineering

ECEN 326 – Electronic Circuits

Fall 2017

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 <u>one</u> double-sided page of notes and equations for the exam
- Good Luck!

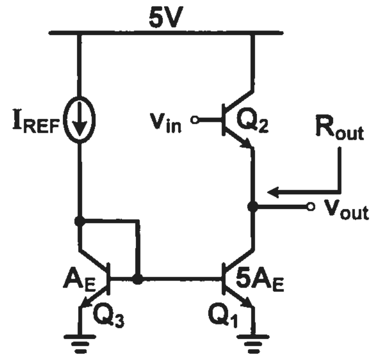
Problem	Score	Max Score
1		50
2		50
Total		**100**

Name: SAM PALERMO

UIN:

Problem 1 (50 points)
For the circuit shown below, assume that all transistors are operating in the active region.

a) Give an expression for the output resistance, R_{out}, as a function of I_{E2}. Assume that $V_A=\infty$.



$$R_{out} = r_{e2} = \frac{V_T}{I_{E2}}$$

b) Give the value of I_{REF} to achieve $R_{out}=25\Omega$. **Make sure to include the impact of mirroring error due to the relevant transistor base currents.** Use the following transistor parameters.
$\beta=100$, $V_{BE}=0.7V$, $V_T=25.9mV$, $V_A=\infty$

$$I_{E2} = \frac{V_T}{R_{out}}$$

$$I_{E2} = I_{C1} = \frac{n I_{REF}}{1+\frac{n+1}{\beta}} = \frac{V_T}{R_{out}}$$

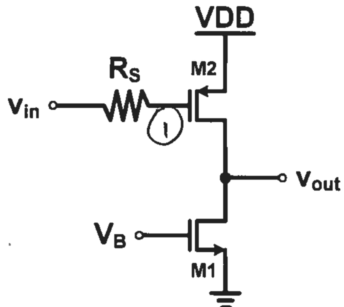
$$I_{REF} = \frac{V_T\left(1+\frac{n+1}{\beta}\right)}{n R_{out}} = \frac{25.9mV\left(1+\frac{5+1}{100}\right)}{5(25\Omega)}$$

$$= 219.6\mu A$$

I_{REF} ($R_{out} = 25\Omega$) = 219.6μA

Problem 2 (50 points)
For the circuit shown below, assume that all transistors are operating in the saturation region and that **$\lambda > 0$**. Obtain expressions for the following

a) Low-frequency gain, $A_v = V_{out}/V_{in}$
b) The circuit's poles, including the appropriate transistor capacitors. Where relevant, **use the Miller approximation to estimate the poles**.
c) Using the answers from part (a) and (b), the circuit's transfer function $V_{out}(s)/V_{in}(s)$. Note, you can ignore any potential zeros in the transfer function.



a. Low frequency gain $= -g_{m2}(r_{o2}||r_{o1})$

b. 2 poles at node ① and V_{out}

Node 1: $|\omega_{p1}| = \dfrac{1}{R_S C_1}$ where $C_1 = C_{GS2} + C_{GD2}\left(1 + g_{m2}(r_{o2}||r_{o1})\right)$

Node V_{out}: $|\omega_{pout}| = \dfrac{1}{(r_{o2}||r_{o1})C_{out}}$ where $C_{out} = C_{DB2} + C_{GD2}\left(1 + \dfrac{1}{g_{m2}(r_{o2}||r_{o1})}\right) + C_{DB1} + C_{GD1}$

c. $$\frac{V_{out}(s)}{V_{in}(s)} = \frac{A_v}{\left(1+\frac{s}{\omega_{p1}}\right)\left(1+\frac{s}{\omega_{pout}}\right)} = \frac{-g_{m2}(r_{o2}||r_{o1})}{\left(1+sR_S C_1\right)\left(1+s(r_{o2}||r_{o1})C_{out}\right)}$$

Scratch Paper