Texas A&M University
Department of Electrical and Computer Engineering

ECEN 326 – Electronic Circuits

Fall 2022

Exam #2

Instructor: Sam Palermo

- Please write your name in the space provided below
- Please verify that there are 5 pages in your exam
- You may use one double-sided page of notes and equations for the exam
- Good Luck!

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Name: SAM PALERMO

UIN:
Problem 1 (30 points)
For the circuit shown below, assume that all transistors are operating in the saturation region. Give an expression for the output resistance, $R_{out}$. Assume that $\lambda > 0$.

\[
R_{out+} = \frac{1}{R_{top} || R_{bop+}}
\]

\[
R_{top} = r_{02} + r_{01} + r_{01} g_{m2} r_{02}
\]

\[
R_{bop+} = r_{03} + R_S + R_S g_{m3} r_{03}
\]

\[
R_{out+} = \left[ r_{02} + r_{01} + r_{01} g_{m2} r_{02} \right] || \left[ r_{03} + R_S + R_S g_{m3} r_{03} \right]
\]
Problem 2 (30 points)
For the following circuit find the values for $I_{C2}$ and $V_{OUT}$. Assume that all transistors are operating in the active region. **Make sure to include the impact of mirroring error due to the relevant transistor base currents.** Use the following transistor parameters.
NPN: $\beta=50$, $V_{BE}=0.7V$, $V_T=25.9mV$, $V_A=\infty$
PNP: $\beta=50$, $V_{EB}=0.7V$, $V_T=25.9mV$, $V_A=\infty$

\[
I_{C2} = \frac{(200AE)}{AE} \frac{I_{REF}}{1 + \frac{200AE + 1}{AE}} = \frac{200 \times (10\mu A)}{1 + \frac{20}{50^2}} = 1.85mA
\]

\[
I_{C5} = \frac{(AE)}{16AE} \frac{I_{C2}}{1 + \frac{AE + 1}{10AE}} = \frac{(0.1)(1.85mA)}{1 + \frac{1.1}{50}} = 18.1\mu A
\]

\[
V_{OUT} = I_{C5}(10k\Omega) = 1.81V
\]

$I_{C2} = 1.85mA$

$V_{OUT} = 1.81V$
Problem 3 (35 points)
For the circuit shown below, assume that all transistors are operating in the saturation region and that $\lambda > 0$. Using Miller's Theorem, give an expression for the input capacitance, $C_{in}$, including the appropriate transistor capacitors.

\[
C_{in} = C_{g_{d1}} + C_{g_{s1}} \left( 1 - \frac{A_v}{A_v} \right)
\]

\[
A_v = \frac{g_{m1}}{\frac{1}{g_{m1}} || \frac{1}{r_{01}} || \frac{1}{g_{m2}} || r_{02}}
\]

\[
= \frac{g_{m1}}{g_{m1} + g_{01} + g_{m2} + g_{02}}
\]

\[
C_{in} = C_{g_{d1}} + C_{g_{s1}} \left[ \frac{g_{m1} + g_{m2} + g_{02}}{g_{m1} + g_{01} + g_{m2} + g_{02}} \right]
\]