ECE 2C Mid-Term Exam

May 6, 2010

Do not open exam until instructed to.

Closed book: Crib sheet and 1 page personal notes permitted

There are xx problems on this exam, and your have 50 minutes.

Use any and all reasonable approximations (5% accuracy is fine.), AFTER STATING and approximately Justifying them.

Name: _______________________

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Problem 1, 85 points

You will be working on the circuit below:

Q1 is a mobility-limited FET, ie. \( I_d = \left( \mu \frac{C_{ox} W_g}{2L_g} \right) (V_{gs} - V_{th})^2 (1 + \lambda V_{ds}) \) where \( \left( \mu \frac{C_{ox} W_g}{2L_g} \right) = 16 \text{ mA/V}^2 \), \( \lambda = 0.1 \text{ V}^{-1} \), and \( V_{th} = 0.4 \text{ V} \).

\(+V_{cc}=+4.0\text{ volts.}\)

Cin1 and Cout are very big and have negligible AC impedance.

RL=20 kOhm

Rgen=200 kOhm
Part a, 10 points
DC bias.
Q1 is to be biased with 1 mA drain current.
The drain of Q1 is to be biased at 1.5 Volts
The DC current in Rg1 is 1 \( \mu \)A
Ignore \( \lambda \) while solving this part.

Find:  \( \text{Rg1} = \ ) \quad \text{Rg2} = \quad \text{Rd}= \ \ 
Part b, 10 points

DC bias

On the circuit diagram above, label the DC voltages at ALL nodes and the DC currents through ALL resistors.
Part c, 10 points

Find the small signal parameters of Q1. Use the constant-mobility model.

\[ g_m = \quad \]
\[ R_{ds} = \quad \]
Part d, 15 points

Replacing the transistor with its small-signal model, draw a small-signal equivalent circuit diagram for the amplifier. Give values for all elements on the diagram.
Part e, 10 points.

Find the small signal voltage gain \((V_{out}/V_{in})\) of Q1.

\[ V_{out}/V_{in}= \]
Part f, 10 points

Find the *** amplifier *** input resistance, Vin/Vgen, and Vout/Vgen

R_in, amplifier = ______________________

Vin/V_gen = ______________________

(Vout/V_gen) = ______________________
Part g, 15 points

Now you must find the maximum signal swings. Find the output voltage due to the knee voltage and due to cutoff in Q1.

Cutoff of Q1; Maximum ΔVout resulting = ______________________

Knee voltage of Q1; Maximum ΔVout resulting = ____________________
Problem 2, 20 points
Fourier series

The waveform repeats with a period of 6 ns. The voltage values are +1 and -1 volts.

V(t) can be written as a Fourier series like so:

\[ V(t) = V_{dc} + a_1 \cdot \sqrt{2} \cdot \cos(2\pi f_0 t) + a_2 \cdot \sqrt{2} \cdot \cos(2 \cdot 2\pi f_0 t) + a_3 \cdot \sqrt{2} \cdot \cos(3 \cdot 2\pi f_0 t) + \ldots \\
+ b_1 \cdot \sqrt{2} \cdot \sin(2\pi f_0 t) + b_2 \cdot \sqrt{2} \cdot \sin(2 \cdot 2\pi f_0 t) + b_3 \cdot \sqrt{2} \cdot \sin(3 \cdot 2\pi f_0 t) + \ldots \]

where \( f_0 = (1/6\text{ns}) \)

Write an integral which gives the value for for \( a_3 \), and find its numerical value
(10 points each)

integral equation for \( a_3 \)= ____________________________

numerical value for \( a_3 \)= ____________________________