University of New Mexico
Department of Electrical and Computer Engineering

ECE 523/421 – Analog Electronics (Fall 2010) Exam 1

Name: Answers Date: Oct. 4, 2010

Note: Only calculator, pencils, and pens are allowed.

1. (10 points) True or false:

(a) In a properly biased BJT, the input resistance looking at the emitter terminal has the lowest resistance. (T)

(b) The voltage gain of a source-follower amplifier is slightly larger than 1. (F)

(c) The source-degradation resistor improves the stability of the transistor's bias point. (T)

(d) A BJT with β≈∞ is exactly equivalent to a MOSFET. (F)

(e) The absolute maximum gain (intrinsic gain) of a BJT at room temperature can be expressed as V_A/25mv. (T)

2. (10 points) A PMOS is biased at 100μA. Calculate V_{OV}, g_m, and r_o. Assume that K'_p=50 μA/V^2, (W/L)=10, and V_A=-5V.

$V_{ov} = 0.632^V$

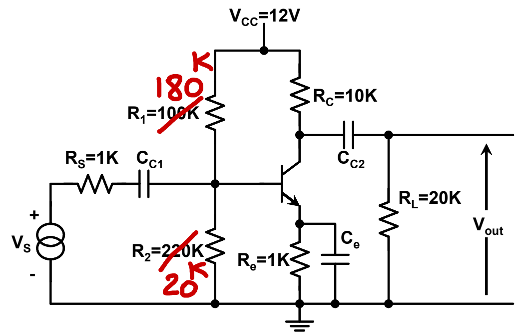
$g_m = 0.316$ mA/V

$r_o = 50$ KΩ

3. (20 points) Consider the common emitter amplifier shown in the circuit below:

(a) Compute the transistor operating point (V_{CE} and I_C). Assume that β=100 for the transistor.

(b) Compute the voltage gain of the amplifier (V_{Out}/V_S). Assume that C_{C1}, C_{C2}, and C_e are very large.



a) $I_C = 0.42\ mA$

$V_{CE} = 7.38\ v$

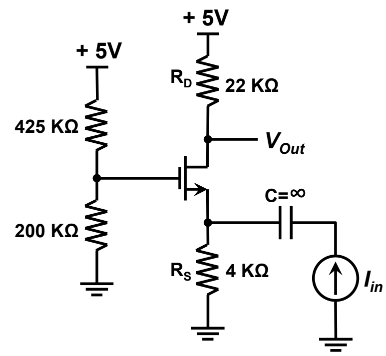
b) $\frac{v_{out}}{v_s} = -91.5$

4. (30 points) The following circuit is a transimpedance amplifier, where the input current is amplified into the output voltage. Assume that K'_n=100 μA/V^2, V_T=1V, and (W/L)=50. Ignore the channel length modulate effect.

(a) Find V_G, V_S, V_D, V_{OV}, I_D, and g_m at the bias point.

(b) Determine the transimpdenace gain V_{out}/i_{in}. (Hint: Use either the T model or the same technique that you learned in the class to directly find the gain)

(c) Compute V_{out}(max) and V_{out}(min) and the total swing. Is the V_D found in part (a) in the middle of the output swing?



a) $V_G = 1.6^V$

$V_S = 0.4^V$

$V_D = 2.8^V$

$V_{ov} = 0.2^V$

$I_D = 0.1^{mA}$

$g_m = 1^{mA/V}$

b) $V_o/i_{in} = 17.6^{K\Omega}$

c) $V_{O_{max}} = 5^V$

$V_{O_{min}} = 0.6^V$

swing $= 4.4^V$

yes.

5. (30 points) We would like to design the following CMOS Cascode circuit to implement a 100 μA current source with the output resistance of 5 MΩ. Assume that $K'_n = 100\ \mu A/V^2$, $V_A = 5V$, and $V_T = 1V$.

(a) Find r_o.

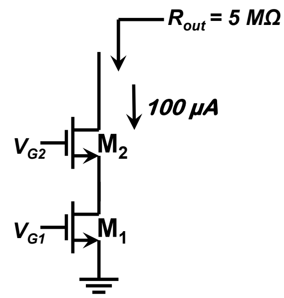
(b) From the output resistance equation in cascode and the result in part (a), determine the g_m that can give us the desired output resistance.

(c) From the result in part (b), find the overdrive voltage, V_{OV}.

(d) From the result in part (c), determine the transistor sizes $(W/L)_1$ and $(W/L)_2$.

(e) To get the maximum output swing, how do you determine the bias point for V_{G1} and V_{G2}?

(f) What is the minimum output voltage that the current source can still work properly?



a) $r_o = 50\ k\Omega$

b) $g_m = 2\ mA/V$

c) $V_{ov} = 0.1^V$

d) $\left(\frac{W}{L}\right)_{1,2} = 200$

e) $V_{G_1} = 1.1^V$, $V_{G_2} = 1.2^V$

f) $V_{o_{min}} = 0.2^V$