Digital Electronics Spring 2014 Midterm Exam 05/02/2014

Name: ID#

1. (10%) A cellphone incorporates a 2.4GHz oscillator whose frequency is defined by the resonance frequency of an *LC* tank If the tank capacitance is realized as the *pn* junction of Example 2.15, calculate the change in the oscillation frequency while the reverse voltage goes from 0 to 1.5 V. Assume the circuit operates at 2.4 GHz at a reverse voltage of 0 V, and the junction area is 2500 μm^2.

$$f_{res} = \frac{1}{2\pi}\frac{1}{\sqrt{LC}}, C_j = 0.265\,fF/\mu m^2 \;,\; C_{j,tot} = \frac{C_{j0}}{\sqrt{1+\frac{V_R}{V_0}}},\; V_0 = 0.73\text{V}$$

Ans:

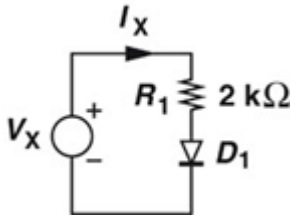
2. (10%). An NMOS device with λ=0.1V^{-1} must provide a $g_m r_o$ of 20 with V_{DS}=1.5V. Determine the required value of W/L if I_D=0.5mA. Assume $\mu_n C_{ox}$=200uA/V^2, and V_{TH}=0.4V. $I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2$,

$$g_m = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D} \qquad r_o = \frac{1}{\lambda I_D}$$

Ans:

3. (10%) Suppose D_1 must sustain a voltage 850 mV for V_X = 2.0 V. R_1 = 2.0 kΩ. Calculate the required I_S.

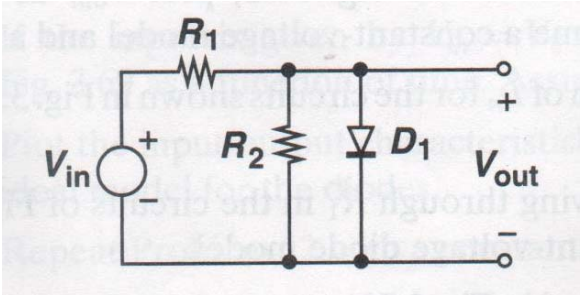
$V_T = 26\text{mV},\; I_D = I_S \exp^{\frac{V_D}{V_T}}$



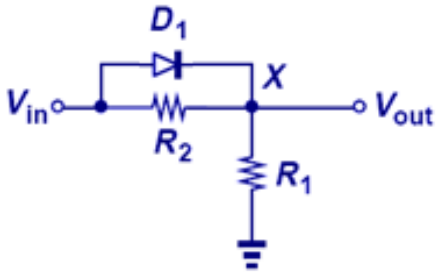
4. (10%) In the following circuit, determine the value of R_1 such that this resistor carries 0.5 mA. Assume $I_S = 5 \times 10^{-16}$ A for each diode. $V_T = 26\text{mV},\; I_D = I_S \exp^{\frac{V_D}{V_T}}$

5. (10%) Please plot the input/output characteristic of the circuit assuming a constant voltage model ($V_{D,on}$).

Ans:

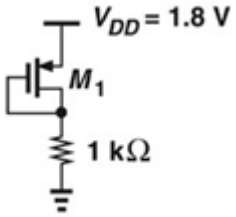


6. (10%) Using the constant voltage mode, plot the input/output characteristic of the following circuit.



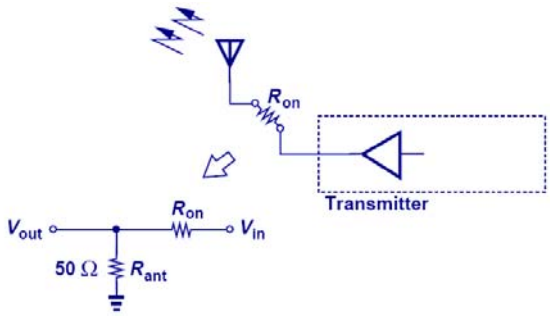
Ans:

7. (10%) If W/L =10/0.18 and λ=0, determine the operating point of M_1 in the following circuit. $\mu_p C_{ox}$=100uA/V^2, and V_{TH}=-0.4V. $I_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(|V_{GS}|-|V_{TH}|)^2$



Ans:

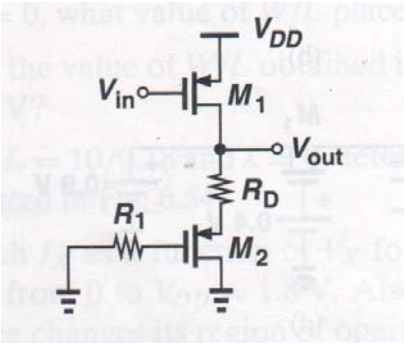
8. (5%) The switch connecting the transmitter to the antenna attenuates the signal by no more than 10%. If $\mu_n C_{ox}$=200uA/V^2, and V_{TH}=0.4V, and the W/L is 1500, determine the minimum required V_{GS} of the switch. Assume the antenna can be model as a 50Ω resistor. $R_{on} = \frac{1}{\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})}$



Ans:

9.

10. (5%) Construct the small signal model of circuit, if all transistor operate in saturation and $\lambda \neq 0$.



Ans:

11.(10%) This circuit employs two identical diodes with $I_S = 5 \times 10^{-16}$ A. Calculate the voltage across R_1 for I_X = 2mA. Assume R_1 = 2.0 kΩ.