Corrected 1/14/03: 1a and IIb

EECS 42 – Introduction to Digital Electronics

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Midterm # 2

(November 6th, 2003)

Closed Book, Closed Notes
Device Equations on Device Problem
Write on the Exam paper

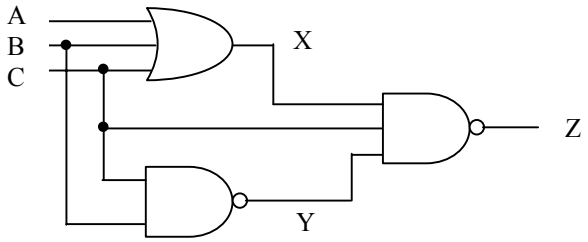
Print Your Name:_____

Sign Your Name:_____

Show your work so that the method as well as the answer can be graded for correctness and completeness. Correct answers alone are only worth 70% of full credit.

Problem	Possible	Score
I	25	
II	25	
III	28	
IV	22	
Total	100	

I (25 Points) Logic and Timing Diagrams



Inputs:			
$A_0 = 0$	$A_F = 0$	$X_0 = 1$	$X_F = 1$
$B_0 = 1$	$B_F = 0$	$Y_0 = 1$	$Y_F = 1$
$C_0 = 0$	$C_F = 1$	$Z_0 = 1$	$Z_F = 0$

a) (9 points) Using the inputs in the diagram, determine the initial and final values of X, Y, Z.

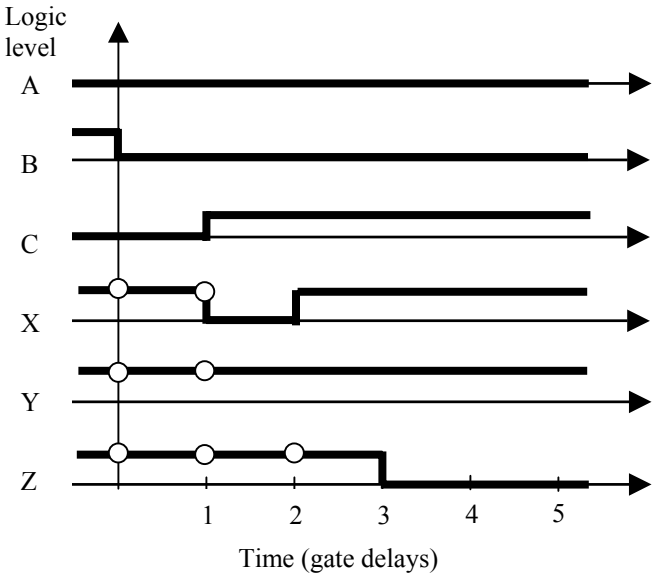
Initial	1, **1**, 1	
Final	1, **1**, 0	

$$X = A + B + C$$

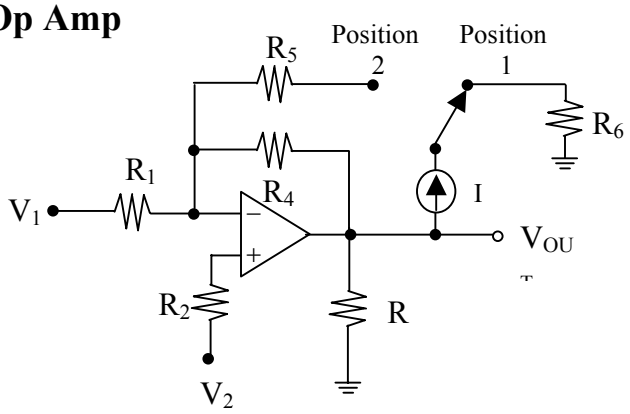
$$Y = \overline{BC}$$

$$Z = \overline{XCY}$$

b) (16 points) For each of the outputs, circle (with an "o") when new information is received and complete the timing diagram.



II (25 Points) Op Amp



a) (10 points) Find V_{OUT} in terms of V_1, V_2, and I, and the resistors R_1, R_2, R_3, R_4, R_5, R_6 when the switch is in position 1.

$$\frac{V_2 - V_1}{R_1} + \frac{V_2 - V_{OUT}}{R_4} = 0$$

$$V_{OUT} = \frac{-R_4}{R_1} V_1 + \left(\frac{R_4}{R_1} + 1 \right) V_2$$

b) (15 points) Assume the switch is now in position 2.

1. Give an equation that could be solved to find the new V_{OUT}.

$$\frac{V_2 - V_1}{R_1} + \frac{V_2 - V_{OUT}}{R_4} - I = 0$$

2. Specify those and only those sources and resistances that will appear in the answer.

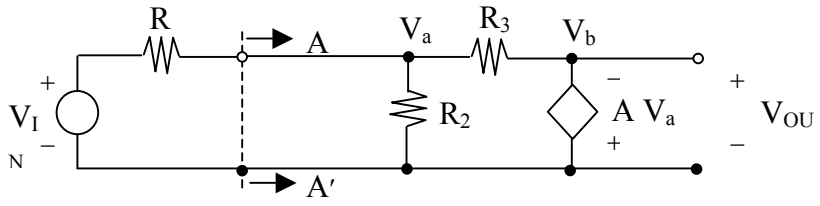
$V_1, V_2, I \qquad R_1 \;\; R_4$

Note: R_5 does not appear because R_5 does not affect the current.

3. State if the proportionality between V_{OUT} and V_1 will change or not. Briefly explain your answer.

No, the current just shifts the output by $I\,R_4$.

III (28 Points) Dependent Source Analysis



a) (10 points) Find one equation between V_{IN} and V_{OUT} with no other voltages.

$$\frac{V_a - V_1}{R_1} + \frac{V_a}{R_2} + \frac{V_a - V_b}{R_3} = 0 \qquad V_b = V_{OUT} \qquad V_a = -\frac{V_{OUT}}{A}$$

$$\frac{-V_{OUT}}{AR_1} - \frac{V_1}{R_1} - \frac{V_{OUT}}{AR_2} - \frac{V_{OUT}}{AR_3} - \frac{V_{OUT}}{R_3} = 0$$

b) (12 points) Find the equivalent resistance looking to the right of the AA′ cut-line.

$$\text{Apply } V_{TEST} \qquad \text{Test} = \frac{V_{TEST}}{R_2} + \frac{V_{TEST} + AV_{TEST}}{R_3}$$

$$\frac{V_{TEST}}{i_{TEST}} = \frac{1}{\frac{1}{R_2} + \frac{1+A}{R_3}} = R_2 \left\| \frac{R_3}{1+A} \right.$$

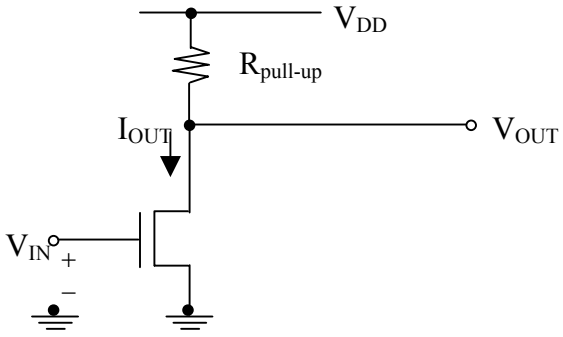
c) (6 points) If A is large and if R_1 and R_2 are similar, will the equivalent resistance found in part b) be much larger, the same, or much smaller than R_1 and R_2 by themselves? Give an intuitive explanation.

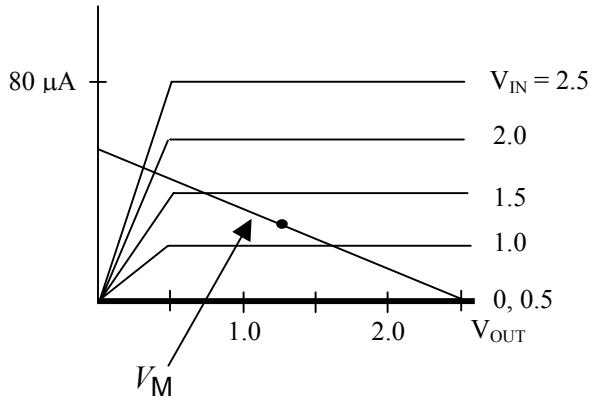
Will be much smaller.

Since V_b is negative and proportional to V_a, the current in R_3 is multiplied by $(1+A)$, making R_3 smaller by $(1+A)$.

IV (22 Points) Logic Circuit with an EE42 Device

Use the I versus V curves shown to the right and assume $V_{DD} = 2.5V$.





a) (10 points) Choose a pull-up resistance that will make $V_{OUT} = V_{IN} = V_{MID} = 1.25V$.

Graphical solution. $\frac{80(1.25-0.5)}{2.5-0.5} = 30\mu A$

$$\frac{\Delta V}{\Delta t} = \frac{2.5-1.25}{30\mu A} = 42k\Omega$$

b) (12 points) Assuming, (W/L) =4, find V_{Tn}, $V_{SAT\_SAT\_n}$, and k′ for this NMOS device graph?

From spacing: $V_{T_n} = 0.5V$

From saturation point: $V_{SAT\_SAT\_n} = 0.5V$

$$80 = k_n'(4)(2.5-0.5)(0.5)$$

$$k_n' = \frac{20\mu A}{V^2}$$