FALL 2019

EECS 151
HW 1 KEY

Problem 1: Denard Scaling

Power density stays constant, $\frac{P}{A} = \frac{\alpha C V^2 f}{\text{area}}$

$A' = A/S^2$

all of this assumes $S > 1$ so $S = 1/K$ where $K = 0.7$

so $(\text{Power})' = \alpha C V^2 f (S^2)$ → new power $= (P)(0.7)^2$

$C' = C/S$; can ignore α ; $V' = V/S$

$P' = 9.8W$ (2.5 pts)

so! $P' = \alpha \cdot S \cdot C' \cdot \frac{1}{S^2} \cdot V'^2 \cdot f \cdot S^2$

$P' = \alpha \cdot C' \cdot V'^2 \cdot (f \cdot S)$ so f will scale with S → $f' = f(\frac{1}{0.7}) = 5.7\ GHz$

(2.5 pts)

Problem 2: Noise Margins

answers may vary due to nature of plot, it's just important for the numbers to be generally correct

$V_{OH} = \sim 1.7V$
$V_{OL} = \sim 0.3V$
$V_{IH} = \sim 1.3V$
$V_{IL} = \sim 0.7V$

3 pt

Noise Margin (H) $= NM_H = V_{OH} - V_{IH} = \sim 0.4\ V$
Noise Margin (L) $= NM_L = V_{IL} - V_{OL} = \sim 0.4V$

2 pt

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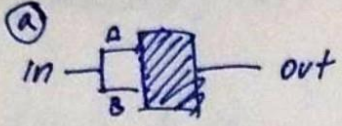
Problem 3

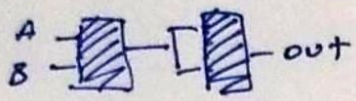
(1) black box implements NAND gate (1 pt)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

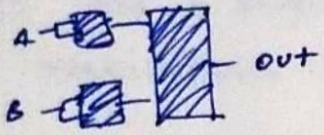
(2) (2 pt)

(a) 

INVERTER

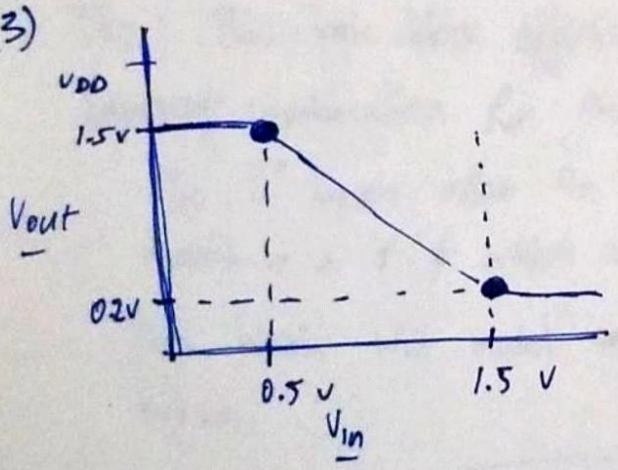
(b) 

AND

(c) 

OR

(3) (1 pt)



sorry for the messiness; it's okay if the don't show V_{DD}. Most important for the students to draw the slope = -1 points (dark dots)

(4) propagation delay is 5 μs

(given number accounts for rise time & 50% & what not)

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Problem 4

(1) • XNOR(A,B) has the following truth table

A	B	Y	
0	0	1	C_0
0	1	0	C_1
1	0	0	C_3
1	1	1	C_2

(2.5 pt)

• BAsed of truth table : $C_0 = 1, C_2 = 1$
$C_1 = 0, C_3 = 0$

Students need to recognize that "$C_\#$" inputs allow them to select which input combinations yield a 0 & which ones yield a 1.

(2) Yes! This logic block effectively models every possible input combination for the inputs (A & B).

- The "C" inputs allow the user to pick which input combination results in a 1 & which combinations result in 0.
- This block will model any combinational function in sum-of-product form.

Any explanation that touches on any of these should get credit

2.5 pts

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Problem 5

(1) STUDENTS may write out entire truth table ... that's too much work for me but great for them. They could also simplify expression first:

~~((AB)(CD+ED))~~

$$\overline{(\bar{A}B)(C\bar{D}+\bar{C}D)(\overline{E+F})} =$$

$$\overline{\bar{A}B} + \overline{(C\bar{D}+\bar{C}D)} + (E+F) =$$

$$A+\bar{B} + (\bar{C}+D)(C+\bar{D}) + E + F =$$

$$A+\bar{B} + \bar{C}\bar{D} + CD + E + F =$$

simpler truth table based off the above expression is

A	B	C	D	E	F	Y
1	X	X	X	X	X	1
X	0	X	X	X	X	1
X	X	0	0	X	X	1
X	X	1	1	X	X	1
X	X	X	X	1	X	1
X	X	X	X	X	1	1
0	1	0	1	0	0	0
0	1	1	0	0	0	0

(2.5 pts)

(2.5 pts)

(2) Could just present the simplified expression from part 1 or can go the following route:

$$\overline{Y} = \bar{A}B\bar{C}D\bar{E}\bar{F} + \bar{A}BCD\bar{E}\bar{F}$$

$$Y = \overline{(\bar{A}B\bar{C}D\bar{E}\bar{F} + \bar{A}BCD\bar{E}\bar{F})}$$

$Y = (A+\bar{B}+C+\bar{D}+E+F)(A+\bar{B}+\bar{C}+D+E+F)$ - then simplify to -

$$Y = A+\bar{B}+\bar{C}\bar{D}+CD+E+F$$

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Problem 6

1) $((\bar{A}\,\bar{B}+C)(A+B)(\overline{\bar{B}+AC})) = \bar{A}BC$

$(\bar{A}\bar{B}\bar{A} + \bar{A}\bar{B}B + AC + BC)(\overline{\bar{B}+AC}) =$ (1.67)

$(AC+BC)(B\bar{A}+B\bar{C}) =$

$AC\bar{A}B + \bar{A}BBC + B\bar{C}AC + B\bar{C}BC =$

$\bar{A}BC = \bar{A}BC$ ✓

2) $\bar{A}\bar{B} + AB + \bar{A}B = \bar{A} + B$

$\bar{A}\bar{B} + \bar{A}B + AB =$ (1.67)

$\bar{A}(\bar{B}+B) + AB = \bar{A} + B$

$\bar{A} + AB + \bar{A}B =$ (Because you can... why not!)

$\bar{A} + B(A+\bar{A}) =$

$\bar{A} + B = \bar{A} + B$ ✓

3) $\bar{A}(A+B) + (B+A\bar{A})(A+\bar{B}) = A + B$

$\bar{A}A + \bar{A}B + (B+A)(A+\bar{B}) =$ (1.67)

$\bar{A}B + AB + B\bar{B} + A + A\bar{B} =$

$(\bar{A}+A)B + A(1+\bar{B}) =$

$A + B = A + B$ ✓