

# CSM51A/EE 16 Fall 2018: Quiz 1

Duration: 30 minutes

Name: [REDACTED]

UID: [REDACTED]

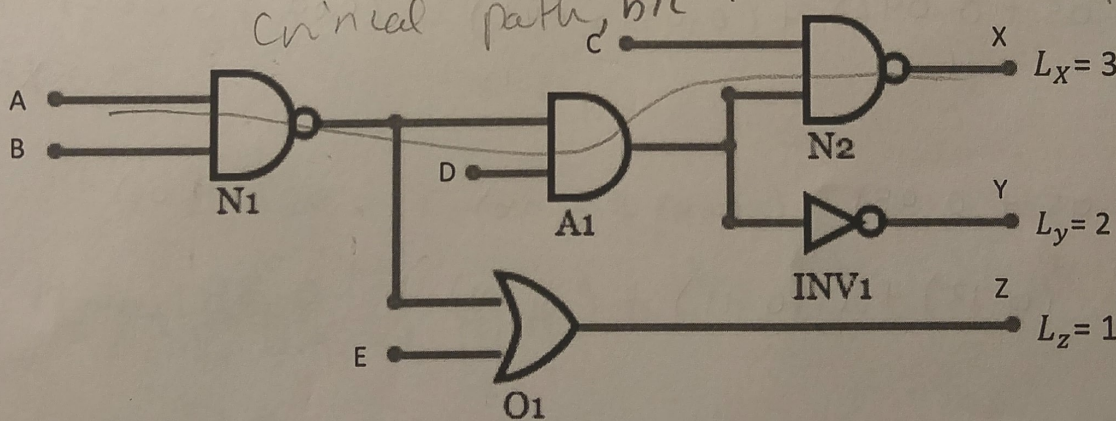
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## Problem 1

(5 points)

Given the circuit shown below:



Determine the critical delay of the circuit in terms of  $t_{pLH}$  and  $t_{pHL}$ . Provide all the necessary calculations. The necessary gate characteristics are given below:

| Gate | Fan-In | $t_{pLH}$      | $t_{pHL}$      | Load Factor |
|------|--------|----------------|----------------|-------------|
| AND  | 2      | $0.2 + 0.04L$  | $0.2 + 0.02L$  | 1           |
| NOT  | 1      | $0.03 + 0.04L$ | $0.05 + 0.02L$ | 1           |
| NAND | 2      | $0.05 + 0.04L$ | $0.08 + 0.02L$ | 1           |

$t_{pLH} = 0.53 \text{ ns}$

$t_{pHL} = 0.38 \text{ ns}$

(or whatever unit of time)



Blank space for calculation

$$\begin{aligned}t_{p_{LH}} &= t_{p_{HL}} (\text{Nand-1}) + t_{p_{HL}} (\text{And-2}) + t_{p_{LH}} (\text{Nand-2}) \\ &= (0.08 + 0.02L_1) + (0.2 + 0.02L_2) + (0.05 + 0.04L_3) \\ &= (0.08 + 0.04) + (0.2 + 0.04) + (0.05 + 0.12) \\ &= (0.12) + (0.24) + (0.17) = 0.53 \text{ units}\end{aligned}$$

$$\begin{aligned}t_{p_{HL}} &= t_{p_{LH}} (\text{Nand-2}) + t_{p_{LH}} (\text{And-2}) + t_{p_{HL}} (\text{Nand-2}) \\ &= (0.05 + 0.04L_1) + (0.03 + 0.04L_2) + (0.08 + 0.02L_3) \\ &= (0.05 + 0.08) + (0.03 + 0.08) + (0.08 + 0.06) \\ &= (0.13) + (0.11) + (0.14) = 0.38 \text{ units}\end{aligned}$$



## Problem 2

(5 points)

Write the minimized 'Sum of Products' expression that implements the following function:

$Z = |A + B - C|$  (Here, the vertical bars '||' represent the absolute value of the expression)

$$A \in \{0,1,2\}$$

$$B \in \{0,1\}$$

$$C \in \{0,1\}$$

Note: Represent A, B, C and Z in binary representation.

With

|       |           |               |   |       |   |               |   |       |   |               |   |
|-------|-----------|---------------|---|-------|---|---------------|---|-------|---|---------------|---|
|       | $A_1 A_0$ |               |   |       |   |               |   |       |   |               |   |
| $A =$ | 00        | $\rightarrow$ | 0 | $B =$ | 0 | $\rightarrow$ | 0 | $C =$ | 0 | $\rightarrow$ | 0 |
|       | 01        | $\rightarrow$ | 1 |       | 1 | $\rightarrow$ | 1 |       | 1 | $\rightarrow$ | 1 |
|       | 10        | $\rightarrow$ | 2 |       |   |               |   |       |   |               |   |

and

|       |           |               |   |
|-------|-----------|---------------|---|
| $Z =$ | $Z_1 Z_0$ |               |   |
|       | 00        | $\rightarrow$ | 0 |
|       | 01        | $\rightarrow$ | 1 |
|       | 10        | $\rightarrow$ | 2 |
|       | 11        | $\rightarrow$ | 3 |

$$Z_0 = A_1' A_0' B' C + A_1' A_0' B C' + A_1' A_0 B' C' + A_1' A_0 B C + A_1 A_0' B' C$$

=

$$Z_1 = A_1' A_0 B C' + A_1 A_0' B' C' + A_1 A_0' B C' + A_1 A_0' B C$$

=



Blank space for calculation

A: 2bit binary  
 00  
 01  
 10

B, C: 1 bit binary  
 0  
 1

$$Z = |A + B - C|$$

A BC

$$Z_0: (A_1' A_0' B' C) +$$

$$(A_1' A_0' B C') +$$

$$(A_1' A_0' B' C') +$$

$$(A_1' A_0 B C) +$$

$$(A_1 A_0' B' C)$$

$$Z_1: (A_1' A_0 B C') +$$

$$(A_1 A_0' B' C') + (A_1 A_0' B C')$$

$$(A_1 A_0' B C)$$

$$Z_2: (A_1 A_0' B C')$$

$$Z_3: (A_1' A_0) (B C + B C') +$$

| A <sub>1</sub> | A <sub>0</sub> | B | C | Z <sub>2</sub> | Z <sub>1</sub> | Z <sub>0</sub> |
|----------------|----------------|---|---|----------------|----------------|----------------|
| 0              | 0              | 0 | 0 | 0              | 0              | 0              |
| 0              | 0              | 0 | 1 | 0              | 0              | 1              |
| 0              | 0              | 1 | 0 | 0              | 0              | 1              |
| 0              | 0              | 1 | 1 | 0              | 0              | 0              |
| 0              | 1              | 0 | 0 | 0              | 0              | 1              |
| 0              | 1              | 0 | 1 | 0              | 0              | 0              |
| → 0            | 1              | 1 | 0 | 0              | 1              | 0              |
| 0              | 1              | 1 | 1 | 0              | 0              | 1              |
| → 1            | 0              | 0 | 0 | 0              | 1              | 0              |
| 1              | 0              | 0 | 1 | 0              | 0              | 1              |
| → 1            | 0              | 1 | 0 | 0              | 1              | 1              |
| → 1            | 0              | 1 | 1 | 0              | 1              | 0              |
| 1              | 1              | 0 | 0 | 1              | 0              | 0              |
| 1              | 1              | 0 | 1 | 1              | 0              | 0              |
| 1              | 1              | 1 | 0 | 1              | 0              | 0              |
| 1              | 1              | 1 | 1 | 1              | 0              | 0              |

