Logic Design – Tutorial 05

#	Student ID	Student Name	Grade (10)
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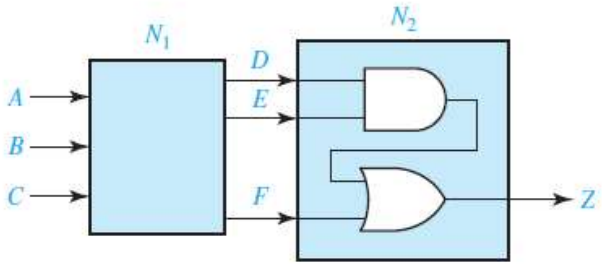
Q1	Represent each of the following sentences by a Boolean equation. (a) The company safe should be unlocked only when Mr. Jones is in the office or Mr. Evans is in the office, and only when the company is open for business, and only when the security guard is present. (b) You should wear your overshoes if you are outside in a heavy rain and you are wearing your new suede shoes, or if your mother tells you to. (c) You should laugh at a joke if it is funny, it is in good taste, and it is not offensive to others, or if it is told in class by your professor (regardless of whether it is funny and in good taste) and it is not offensive to others. (d) The elevator door should open if the elevator is stopped, it is level with the floor, and the timer has not expired, or if the elevator is stopped, it is level with the floor, and a button is pressed.
Sol 1	(a) U: Safe unlocked, J: Mr. Jones present, E: Mr. Evans present, B: Normal business hours, S: Security guard present $U = (J + E)BS$ (b) O: Wear overshoes, A: You are outside, R: Raining heavily, S: Wearing suede shoes, M: Mother tells you to $O = ARS + M$ (c) L: Laugh at joke, F: It is funny, G: Good taste, O: Offensive, P: Told by professor $L = FGO' + PO'$ (d) D: Elevator door opens, S: Elevator is stopped, F: Level with floor, T: Timer expired, B: Button pressed $D = SFT' + SFB$

Q2

A combinational circuit is divided into two subcircuits N_1 and N_2 as shown. The truth table for N_1 is given. Assume that the input combinations $ABC = 110$ and $ABC = 010$ never occur. Change as many of the values of D, E, and F to don't-cares as you can without changing the value of the output Z.



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

Sol 2

A B C	D E F	Z
0 0 0	1 1 X^3	1
0 0 1	X^2 X^2 1	1
0 1 0	X^1 X^1 X^1	X
0 1 1	X^2 X^2 1	1
1 0 0	X^4 0 0	0
1 0 1	X^2 X^2 1	1
1 1 0	X^1 X^1 X^1	X
1 1 1	X^4 0 0	0

[1] These truth table entries were made don't cares because $ABC = 110$ and $ABC = 010$ can never occur

[2] These truth table entries were made don't cares because when F is 1, the output Z of the OR gate will be 1 regardless of its other input. So changing D and E cannot affect Z.

[3] These truth table entries were made don't cares because when D and E are both 1, the output Z of the OR gate will be 1 regardless of the value of F.

[4] These truth table entries were made don't cares because when one input of the AND gate is 0, the output will be 0 regardless of the value of its other input.

Q3	Each of three coins has two sides, heads and tails. Represent the heads or tails status of each coin by a logical variable (A for the first coin, B for the second coin, and C for the third) where the logical variable is 1 for heads and 0 for tails. Write a logic function $F(A, B, C)$ which is 1 iff exactly one of the coins is heads after a toss of the coins. Express F (a) as a minterm expansion. (b) as a maxterm expansion.
Sol 3	**(a)** Exactly one variable not complemented: $F = A'B'C + A'BC' + AB'C' = \sum m(1, 2, 4)$ **(b)** Remaining terms are maxterms: $F = \prod M(0, 3, 5, 6, 7) = (A + B + C)\,(A + B' + C')\,(A' + B + C')\,(A' + B' + C)\,(A' + B' + C')$

Q4	Given: $F(a, b, c, d) = (a + b + d)\,(a' + c)\,(a' + b' + c')\,(a + b + c' + d')$ (a) Express F as a minterm expansion. (Use m-notation.) (b) Express F as a maxterm expansion. (Use M-notation.) (c) Express F' as a minterm expansion. (Use m-notation.) (d) Express F' as a maxterm expansion. (Use M-notation.)
Sol 4	$F(a, b, c, d) = (a + b + d)\,(a' + c)\,(a' + b' + c')\,(a + b + c' + d')$ $= (a + b + c + d)\,(a + b + c' + d)\,(a' + c + bb' + dd')\,(a' + b' + c' + d)\,(a' + b' + c' + d')\,(a + b + c' + d')$ $= (a + b + c + d)\,(a + b + c' + d)\,(a' + b + c + d)\,(a' + b + c + d')\,(a' + b' + c + d)\,(a' + b' + c + d')$ $(a' + b' + c' + d)\,(a' + b' + c' + d')\,(a + b + c' + d')$

Q5	Given $f(a, b, c) = a(b + c')$. (a) Express f as a minterm expansion (use m-notation). (b) Express f as maxterm expansion (use M-notation). (c) Express f' as a minterm expansion (use m-notation). (d) Express f' as a maxterm expansion (use M-notation).
Sol 5	$f(a, b, c) = a(b + c') = ab + ac' = ab\,(c + c') + a(b + b')\,c' = \underbrace{abc}_{m_7} + \underbrace{abc'}_{m_6} + \underbrace{abc'}_{m_6} + \underbrace{ab'c'}_{m_4}$ $f = \sum m(4, 6, 7) \quad f = \prod M(0, 1, 2, 3, 5)$ $f' = \sum m(0, 1, 2, 3, 5) \quad f' = \prod M(4, 6, 7)$

Q6	Given $F'(A, B, C, D) = \Sigma\, m(0, 1, 2, 6, 7, 13, 15)$. (a) Find the minterm expansion for F (both decimal and algebraic form). (b) Find the maxterm expansion for F (both decimal and algebraic form).
Sol 6	$F(A, B, C, D) = \sum m(3, 4, 5, 8, 9, 10, 11, 12, 14)$ $F = A'B'CD + A'BC'D' + A'BC'D + AB'C'D' + AB'C'D + AB'CD' + AB'CD + ABC'D' + ABCD'$ **(b)** $F(A, B, C, D) = \prod M(0, 1, 2, 6, 7, 13, 15)$ $F = (A + B + C + D)(A + B + C + D')(A + B + C' + D)(A + B' + C' + D)(A + B' + C' + D')(A' + B' + C + D')(A' + B' + C' + D')$