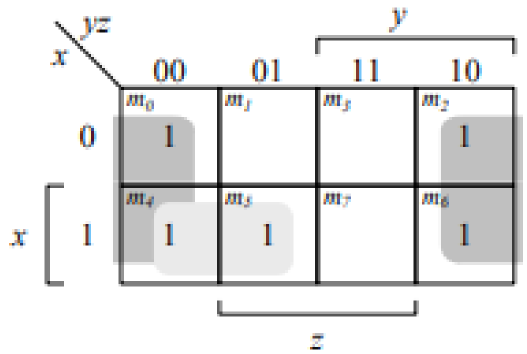
EC 2.101 - Digital Systems and Microcontrollers

Practice Sheet 2 (Lec 1 – Lec 12)

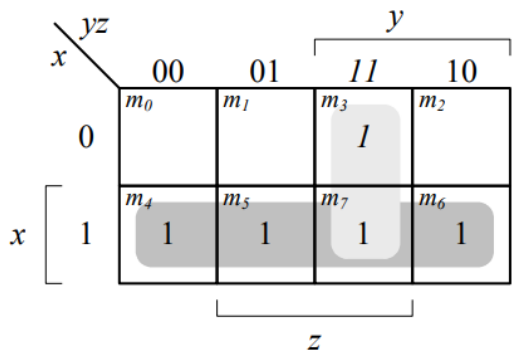
Q1. Three Variable Maps

a. $F(x, y, z) = \sum(0, 2, 4, 5, 6)$



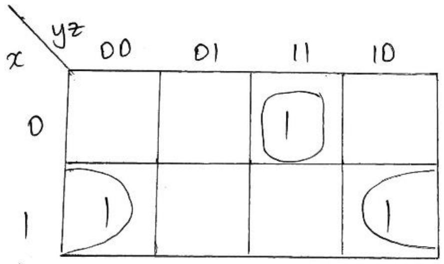
$F = z' + xy'$

b. $F(x, y, z) = \sum(3, 4, 5, 6, 7)$



$F = x + yz$

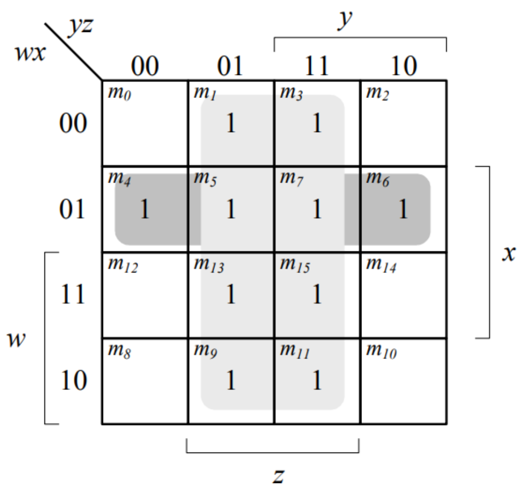
c. $F(x, y, z) = x'yz + xy'z' + xyz'$



$F = x'yz + xz'$

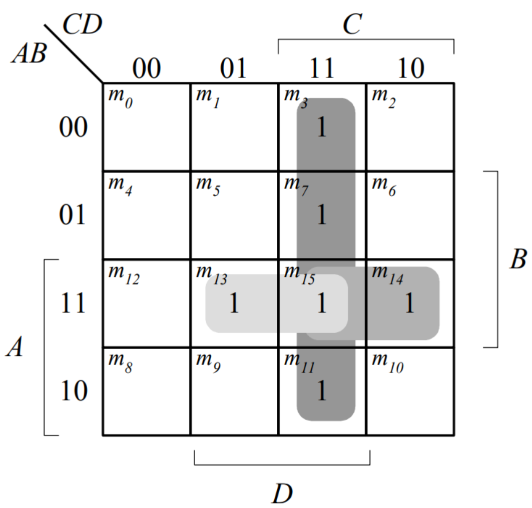
Q2. Four Variable Maps

a. $F(w, x, y, z) = \sum(1, 3, 4, 5, 6, 7, 9, 11, 13, 15)$



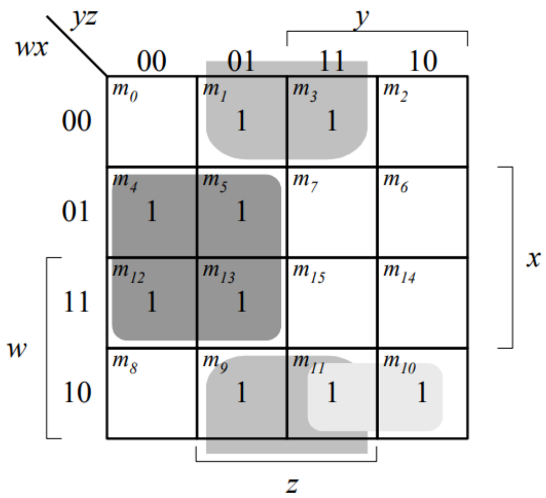
$F = z + xw'$

b. $F(A, B, C, D) = \sum(3, 7, 11, 13, 14, 15)$



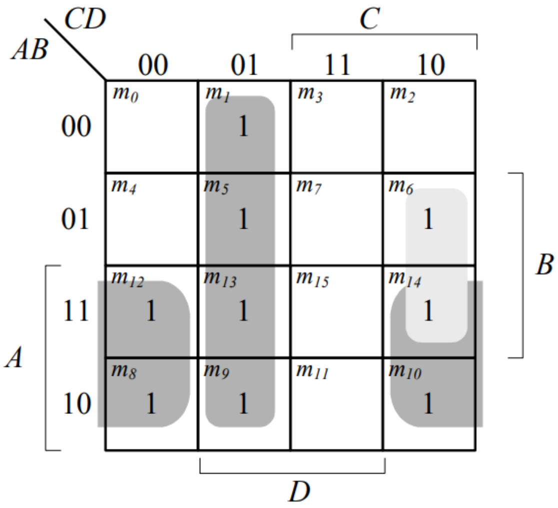
$F = CD + ABD + ABC$

c. $F(w, x, y, z) = x'z + w'xy' + w(x'y + xy')$



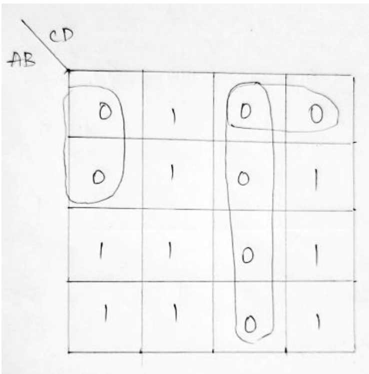
$F = xy' + x'z + wx'y$

d. $F(A, B, C, D) = AD' + B'C'D + BCD' + BC'D$



$F = AD' + C'D + BCD'$

For product of maxterms representation, we need to optimize the zeros and write F' as a sum of minterms and take its complement.



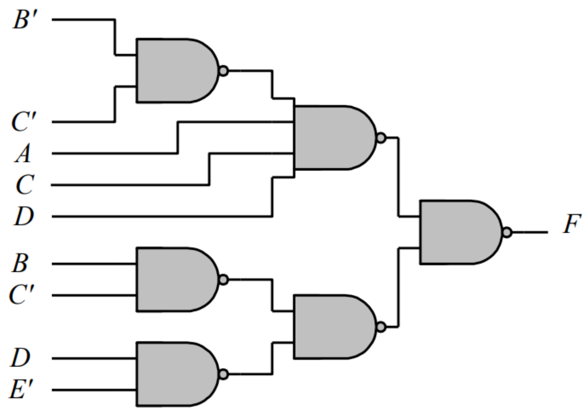
$F' = A'C'D' + A'B'C + CD$

$\Rightarrow F = (A'C'D')' \cdot (A'B'C)' \cdot (CD)' = (A + C + D)(A + B + C')(C' + D')$

Q3. Multi-Level Circuits

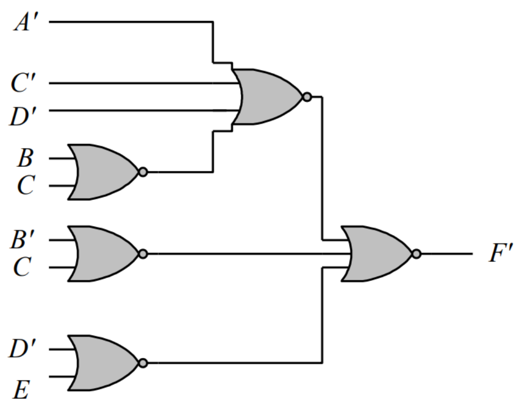
a. $CD(B + C)A + (BC' + DE')$ using only NAND gates

$F = ACD(B + C) + (BC' + DE')$
$F' = [ACD(B + C)]' [BC' + DE']'$
$F' = [ACD(B'C')']' [BC' + DE']'$
$F' = [CD(B'C')'A]' [[(BC')' (DE')]']'$



b. $CD(B + C)A + (BC' + DE')$ using only NOR gates

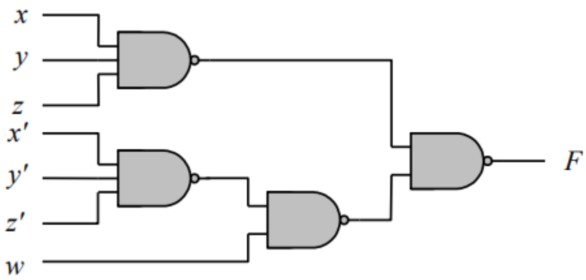
$F = ACD(B + C) + (BC' + DE')$
$F' = [ACD(B + C) + (BC' + DE')]'$
$F' = [(A' + C' + D')'(B + C) + (B' + C)' + (D' + E)']'$
$F' = [((A' + C' + D') + (B + C)')' + (B' + C)' + (D' + E)']'$
$F' = [(A' + C' + D' + (B + C)')' + (B' + C)' + (D' + E)']'$



c. $w(x + y + z) + xyz$ using only NAND gates

$F = w(x + y + z) + xyz$
$F' = [w(x + y + z)]'[xyz]'$

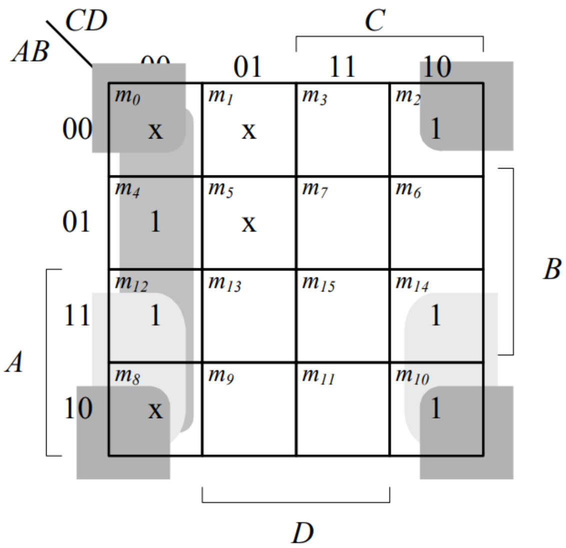
$F' = [w(x'y'z')')]'(xyz)'$



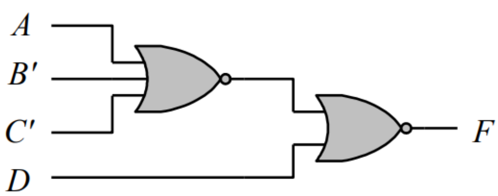
Q4. Implement the following Boolean function F, together with the don't-care conditions d, using no more than two NOR gates:

$$F(A, B, C, D) = \sum(2, 4, 10, 12, 14)$$

$$d(A, B, C, D) = \sum(0,1,5,8)$$



$F = B'D' + AD' + C'D'$
$F' = D + A'BC$
$F = [D + A'BC]'$
$F = [D + (A + B' + C')']'$



Q5. Design a half subtractor with 2 input variables, X(minuend) and Y(subtrahend) and 2 output variables, D(Difference) and B(Borrow)

Input variables		*Output variables*	
X	*Y*	*D*	*B*
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

From the minterms of the above table, it is clear that the Boolean expressions for the D and B are as follows:

$$D = \mathrm{X'Y} + \mathrm{XY'}$$

$$B = \mathrm{X'Y}$$