Tutorial 2

EC31003: Digital Electronic Circuits

IIT Kharagpur, Autumn Semester 2020-21

19th September 2020

Time limit (25 min.)

Questions

1. Simplify the following Boolean functions using k-map:
   a. $Y(A, B, C, D) = \Sigma m(2, 3, 8, 10, 11, 12, 14, 15)$
   b. $Y(A, B, C, D) = \prod M(0, 1, 2, 5, 6, 8, 10, 13, 14)$
   c. $Y(A, B, C, D) = \Sigma\, m(2, 3, 4, 5) + \Sigma\, d(10, 11, 12, 13, 14, 15)$

2. Consider the function *$F(P, Q, R, S) = \Sigma m(1, 5, 6, 7, 11, 12, 13, 15)$*
   Find the number of:
   a. Prime Implicants
   b. Essential Prime Implicants

3. A digital circuit with three inputs (a, b, and, c) performs the following function:
   $F(a, b, c) = abc'+b'$
   a. Find the min-terms of the output expression F(a, b, c).
   b. Find the min-terms of the expression F'(a, b, c).

Time limit (20 min.)

4. Consider the following truth tables for addition (‘+’), multiplication (‘x’) and division(‘/’) operation,

A+B

A	B	A+B
0	0	0
0	1	1
1	0	1
1	1	1

A x B

A	B	A x B
0	0	0
0	1	0
1	0	0
1	1	1

A/B

A	B	A/B
0	0	0
0	1	0
1	0	X (Don’t care)
1	1	1

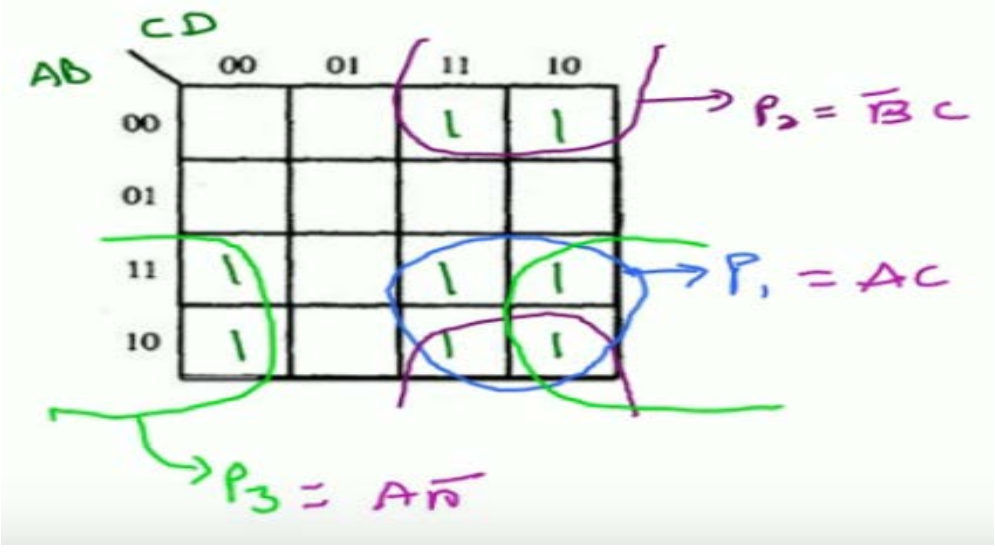
Find the Boolean logic (using k-map minimization) for the expression: *F* = (A+(B x C))/D

5. Solve the POS function of 5 variable K-map using the following expression

f(P,Q,R,S,T) = ∏M(0, 2, 4, 7, 8, 10, 12, 16, 18, 20, 23, 24, 25, 26, 27, 28)

Solution 1 (a)

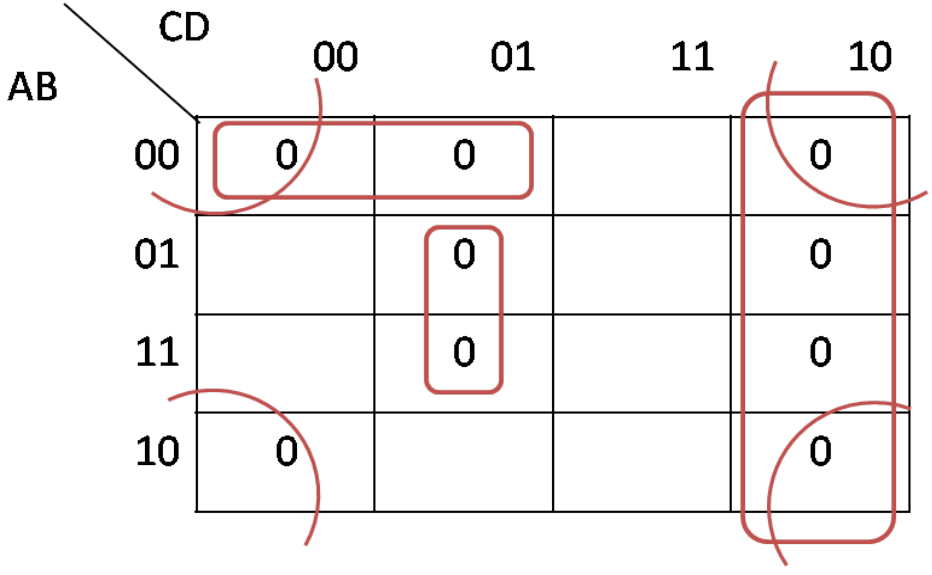
1. a. Y(A, B, C, D) = Σm(2, 3, 8, 10, 11, 12, 14, 15)



Y=AD’+AC+B’C

Solution 1(b)

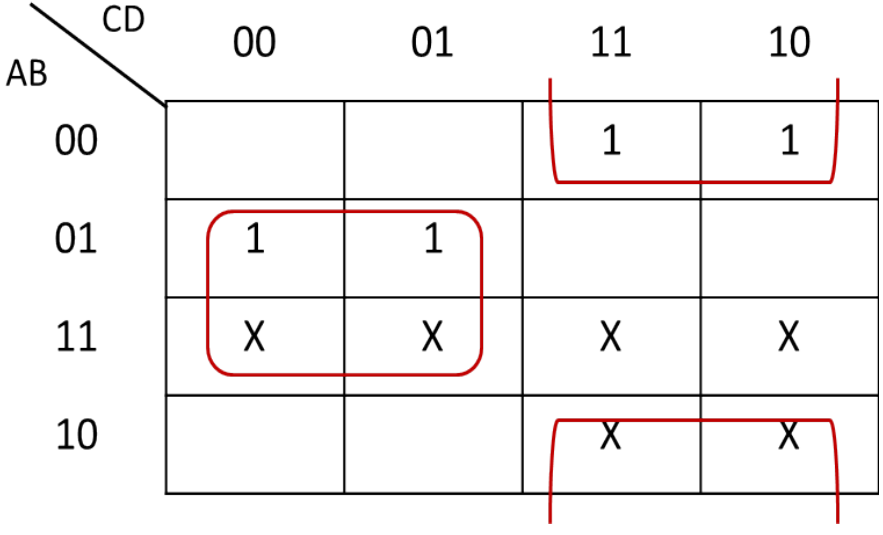
1 b. $Y(A, B, C, D) = \prod M(0,1,2,5,6,8,10,13,14)$



$Y = (A+B+C)(B+D)(B'+C+D')(C'+D)$

Solution 1(c)

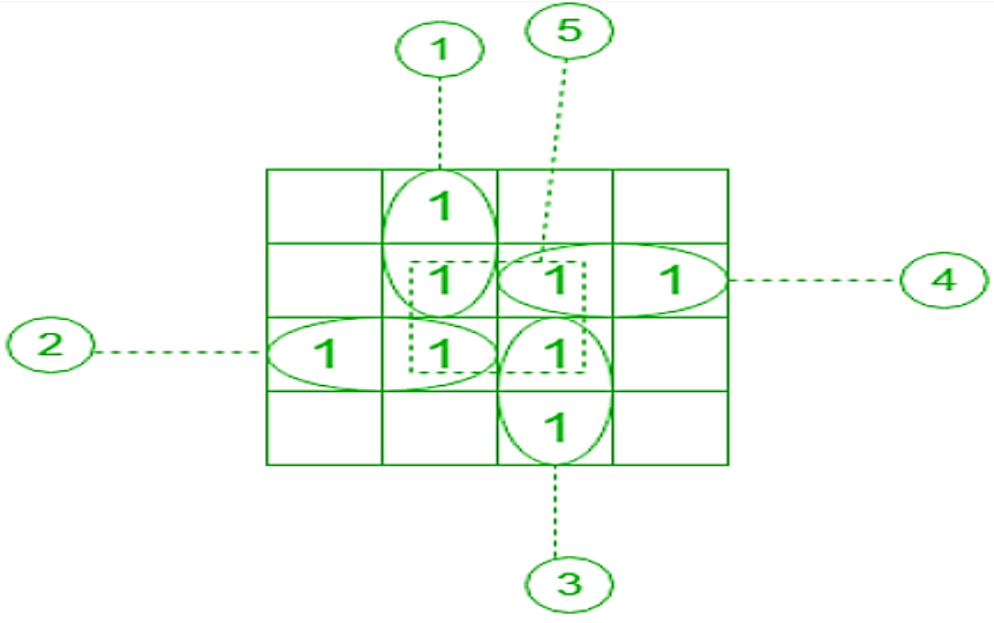
1.c $Y(A, B, C, D) = \Sigma m\,(2, 3, 4, 5) + \Sigma\, d(10, 11, 12, 13, 14, 15)$



$Y(A, B, C, D) = BC' + B'C = B \oplus C$

Solution 2

$F(P,Q,R,S) = \Sigma m(1,5,6,7,11,12,13,15)$



a) No. of prime implicants = 5 (1,2,3,4,5) = (P'R'S , PQR' , PRS , P'QR , QS)

b) No. of essential prime implicants = 4 (1,2,3,4) = (P'R'S, PQR', PRS, P'QR)

Solution 3

a)

F=abc'+b'

=abc'+b'(a+a')(c+c')

=abc'+(ab'+a'b')(c+c')

=abc'+ab'c+a'b'c+ab'c'+a'b'c'

$=\Sigma(0,1,4,5,6)$

b)One approach is to find out F' and do the same as above.
Alternative, simply minterm of F' is same as maxterm of F. So, minterm of F' is $\Sigma(2,3,7)$

Solution 4

Truth table for the given expression (F) is

A	B	C	D	BxC	A+(BxC)	(A+(BxC))/D
0	0	0	0	0	0	**0**
0	0	0	1	0	0	**0**
0	0	1	0	0	0	**0**
0	0	1	1	0	0	**0**
0	1	0	0	0	0	**0**
0	1	0	1	0	0	**0**
0	1	1	0	1	1	**X**
0	1	1	1	1	1	**1**
1	0	0	0	0	1	**X**
1	0	0	1	0	1	**1**
1	0	1	0	0	1	**X**
1	0	1	1	0	1	**1**
1	1	0	0	0	1	**X**
1	1	0	1	0	1	**1**
1	1	1	0	1	1	**X**
1	1	1	1	1	1	**1**

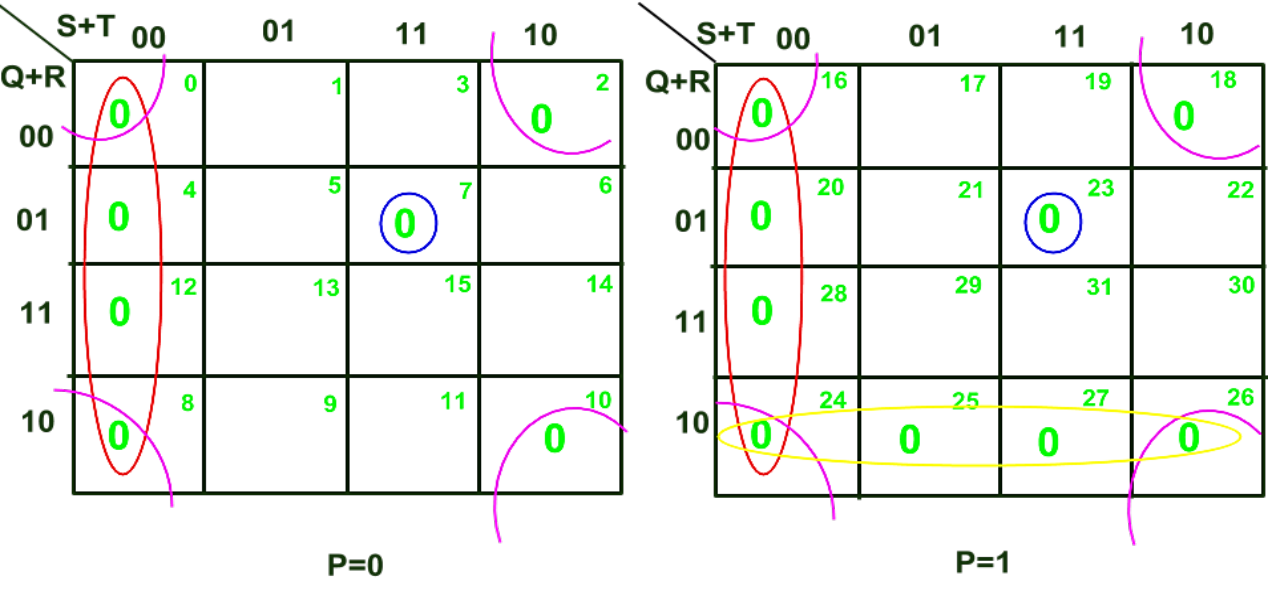
K-map minimization of minterms devised from Truth table

	C'D'	C'D	CD	CD'
A'B'				
A'B			1	X
AB	X	1	1	X
AB'	X	1	1	X

Hence, final answer is,
F = A + BC

Solution 5

5 variable POS function: $f(P,Q,R,S,T) = \prod M(0, 2, 4, 7, 8, 10, 12, 16, 18, 20, 23, 24, 25, 26, 27, 28$



In this K-Map we have 4 sub-cubes:

Subcube 1: The one marked in red comprises of cells (0, 4, 8, 12, 16, 20, 24, 28) = ***S+T***

Subcube 2: The one marked in blue comprises of cells (7, 23) = ***Q+R'+S'+T'***

Subcube 3: The one marked in pink comprises of cells (0, 2, 8, 10, 16, 18, 24, 26) = ***R+T***

Subcube 4: The one marked in yellow comprises of cells (24, 25, 26, 27) = ***P'+Q'+R***

Therefore the minimal expression of the given Boolean Function can be expressed as follows :

$$f(P,Q,R,S,T) = (S+T) \cdot (Q+R'+S'+T') \cdot (R+T) \cdot (P'+Q'+R)$$