

## **UNIT-II**

# **Combinational Logic System**

Lecture 15

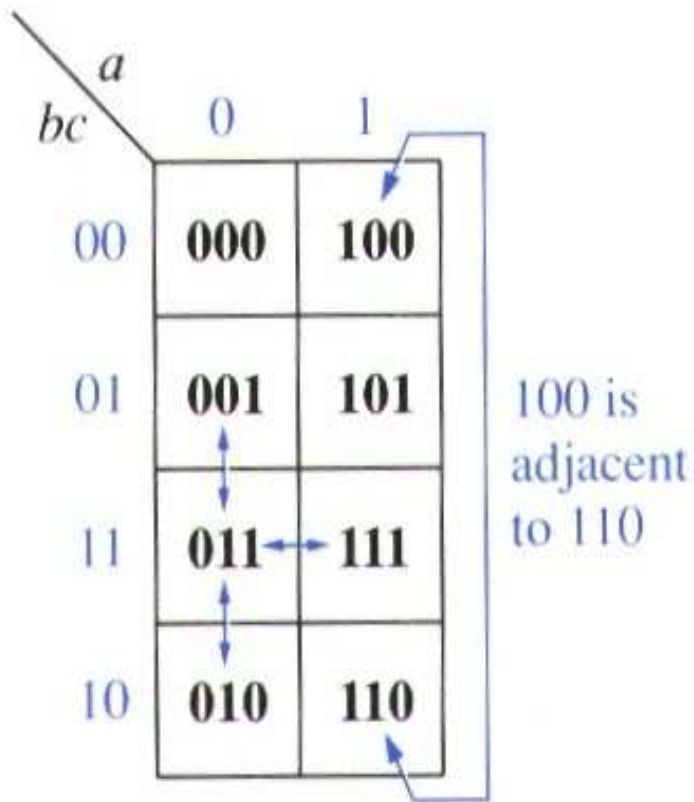
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# Location of Minterms

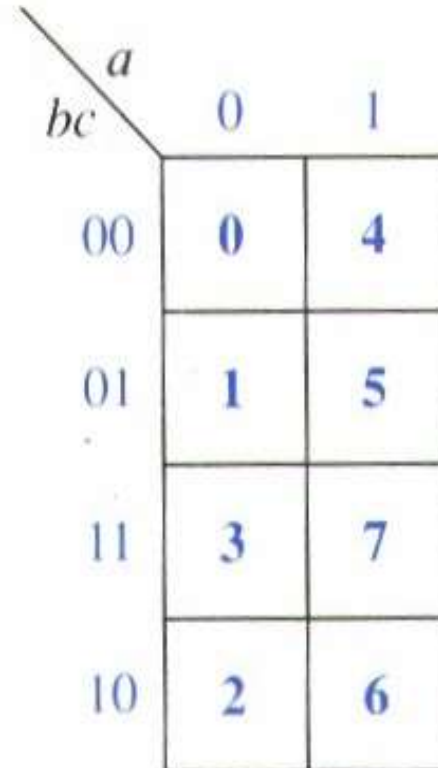
- Adjacent terms in 3-variable K map.



A 3-variable Karnaugh map in binary notation. The vertical axis is labeled 'bc' with values 00, 01, 11, 10. The horizontal axis is labeled 'a' with values 0 and 1. The cells contain the following minterms: (0,00)=000, (1,00)=100, (0,01)=001, (1,01)=101, (0,11)=011, (1,11)=111, (0,10)=010, (1,10)=110. Blue arrows indicate adjacencies: a vertical arrow between 001 and 011, a vertical arrow between 011 and 010, a horizontal arrow between 011 and 111, a vertical arrow between 100 and 110, and a wrap-around arrow from 100 to 110. A text label '100 is adjacent to 110' points to the wrap-around arrow.

$bc \backslash a$	0	1
00	000	100
01	001	101
11	011	111
10	010	110

(a) Binary notation



A 3-variable Karnaugh map in decimal notation. The vertical axis is labeled 'bc' with values 00, 01, 11, 10. The horizontal axis is labeled 'a' with values 0 and 1. The cells contain the following decimal values: (0,00)=0, (1,00)=4, (0,01)=1, (1,01)=5, (0,11)=3, (1,11)=7, (0,10)=2, (1,10)=6.

$bc \backslash a$	0	1
00	0	4
01	1	5
11	3	7
10	2	6

(b) Decimal notation

# Three Variable Maps

- A three variable Karnaugh Map is shown below:

	yz=00	yz=01	yz=11	yz=10
x=0	m <sub>0</sub>	m <sub>1</sub>	m <sub>3</sub>	m <sub>2</sub>
x=1	m <sub>4</sub>	m <sub>5</sub>	m <sub>7</sub>	m <sub>6</sub>

- Where each minterm corresponds to the product terms below:

	yz=00	yz=01	yz=11	yz=10
x=0	$\bar{x} \bar{y} \bar{z}$	$\bar{x} \bar{y} z$	$\bar{x} y z$	$\bar{x} y \bar{z}$
x=1	$x \bar{y} \bar{z}$	$x \bar{y} z$	$x y z$	$x y \bar{z}$

- Note that if the binary value for an index differs in one bit position, the minterms are adjacent on the Karnaugh Map

# Combining Squares Example

- **Example:** Let  $F = \sum m(2,3,6,7)$

<b>F</b>	<b>yz=00</b>	<b>yz=01</b>	<b>yz=11</b>	<b>yz=10</b>
<b>x=0</b>			<b>1</b>	<b>1</b>
<b>x=1</b>			<b>1</b>	<b>1</b>

- **Applying the Minimization Theorem three times:**

$$\begin{aligned} F(x, y, z) &= \bar{x} \bar{y} z + x \bar{y} z + \bar{x} y \bar{z} + x y \bar{z} \\ &= yz + yz \\ &= y \end{aligned}$$

- **Thus the four terms that form a  $2 \times 2$  square correspond to the term "y".**

# K Map Example

$$\text{K-map of } F(a,b,c) = \sum m(1,3,5) = \prod M(0,2,4,6,7)$$

$a \backslash bc$		$a$	
		0	1
$bc$	00	0 <sub>0</sub>	0 <sub>4</sub>
	01	1 <sub>1</sub>	1 <sub>5</sub>
	11	1 <sub>3</sub>	0 <sub>7</sub>
	10	0 <sub>2</sub>	0 <sub>6</sub>

Karnaugh Map of  
 $F(a, b, c) = \sum m(1, 3, 5) = \prod M(0, 2, 4, 6, 7)$

# More Than Two Minimum Solutions

- $F = \sum m(0,1,2,5,6,7)$

		<i>a</i>	
		0	1
<i>bc</i>	00	1	
	01	1	1
	11		1
	10	1	1

$$F = a'b' + bc' + ac$$

		<i>a</i>	
		0	1
<i>bc</i>	00	1	
	01	1	1
	11		1
	10	1	1

$$F = a'c' + b'c + ab$$

# 4-Variable K Map

- Each minterm is adjacent to 4 terms with which it can combine.
  - 0, 8 are adjacent squares
  - 0, 2 are adjacent squares, etc.
  - 1, 4, 13, 7 are adjacent to 5.

<i>AB</i>		<i>CD</i>			
		00	01	11	10
<i>CD</i>	00	0	4	12	8
	01	1	5	13	9
	11	3	7	15	11
	10	2	6	14	10

$$f(A, B, C, D) = \sum m(0, 1, 3, 4, 5, 7, 12, 13, 15)$$

		C D			
A B		00	01	11	10
00	1	1	1	0	
01	1	1	1	0	
11	1	1	1	0	
10	0	0	0	0	

$$\overline{A}\overline{C} + \overline{A}D + B\overline{C} + BD$$



$$f(A, B, C, D) = \prod M(2, 6, 8, 9, 10, 11, 14)$$

		C D			
		0 0	0 1	1 1	1 0
A \ B	0 0	1	1	1	0
	0 1	1	1	1	0
	1 1	1	1	1	0
	1 0	0	0	0	0

$$f(A, B, C, D) = (\bar{A} + B)(\bar{C} + D)$$

# Kmap with Don't Care

In a Kmap, a don't care condition is identified by an  $X$  in the cell of the minterm(s)

In simplification, we are free to include or ignore the  $X$ 's when creating our groups.

WX \ YZ	YZ			
	00	01	11	10
00	X	1	1	X
01		X	1	
11	X		1	
10			1	

# Simplification with Don't Care

- Don't care "x" is covered if it helps. Otherwise leave it along.

<i>ab</i>		00	01	11	10
<i>cd</i>	00			<b>x</b>	
	01	<b>1</b>	<b>1</b>	<b>x</b>	<b>1</b>
	11	<b>1</b>	<b>1</b>		
	10		<b>x</b>		

$$f = \Sigma m(1, 3, 5, 7, 9) + \Sigma d(6, 12, 13) \\ = a'd + c'd$$

$$F(A, B, C, D) = m(1, 2, 6, 7, 8, 13, 14, 15) + d(0, 3, 5, 12)$$

		CD			
AB		00	01	11	10
00	X	1	X	1	
01		X	1	1	
11	X	1	1	1	
10	1				