Paper 7, TDC Part-3
Chapter– 4, Combinational Logic Design
Lecture - 4

By:

Mayank Mausam

Assistant Professor (Guest Faculty)

Department of Electronics

L.S. College, BRA Bihar University,

Muzaffarpur, Bihar

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Karnaugh Map Representation of Logic Functions.

As we know that before implementing any logical function (boolean expression) using logic gates, it is required to simply the boolean expression. Sometimes it is difficult to simplify the boolean expression using Boolean algebraic theorems. Karnaugh map is another graphical technique which provides a systematic method for simplifying Boolean expressions.

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In this method, the information contained in a truth table or available in POS or SOP form is represented on a Map called Karnaugh Map (K-Map).

K-Map contain 'N' no. of cells where 'N' depends on the number of variable present in the Boolean Expression.

If no. of variables in the expression is 'n' then $N = 2^n$

For example a boolean expression with 3 variable will have $2^3 = 8 = N$ (number

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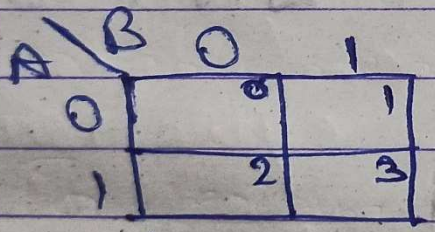
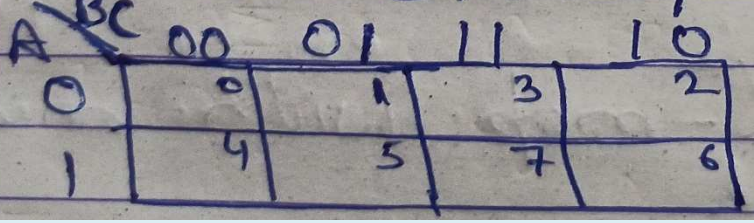
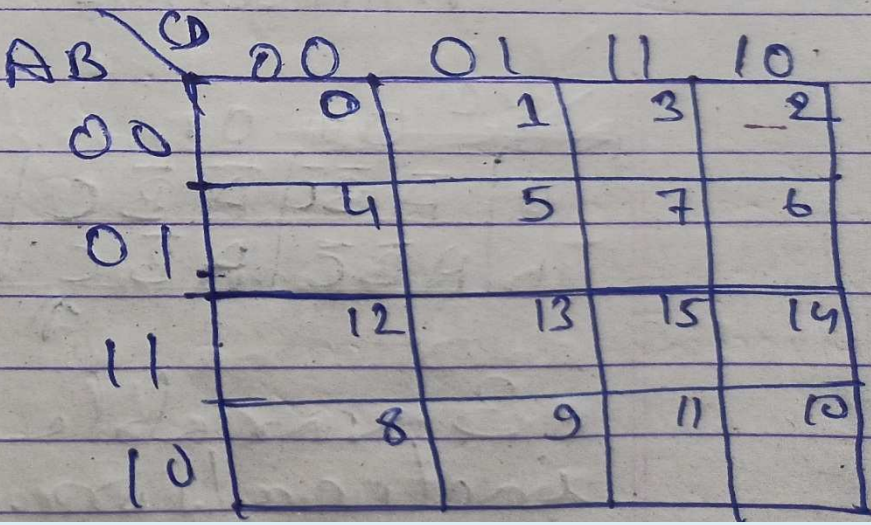
of cell). The technique of K-Map may be used for any number of variables. In general it is used upto 6 variables, beyond this it becomes very cumbersome.

Figure below shows the K-Map for 2, 3 & 4 variables.



2-Variable K-Map





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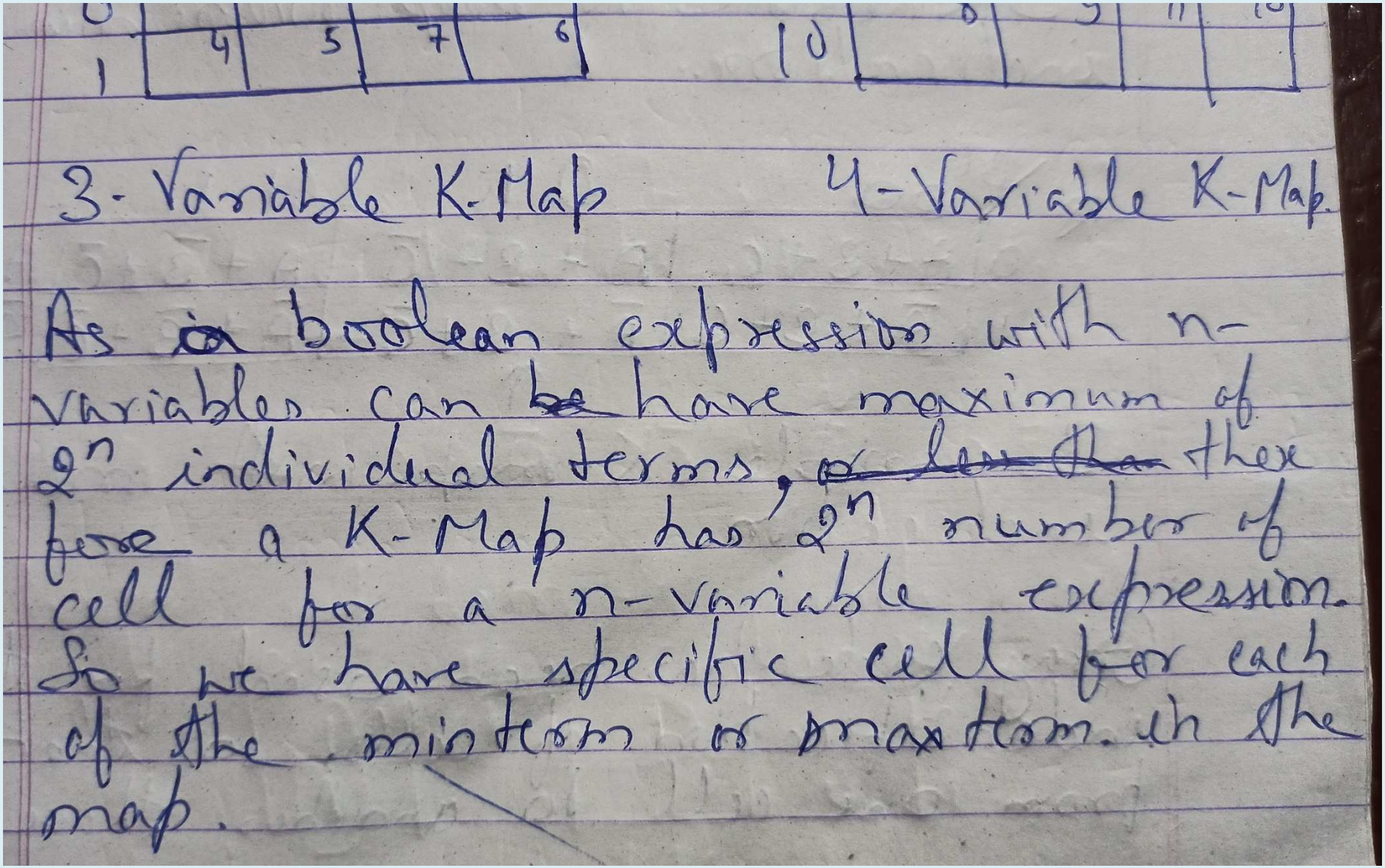

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Figure below shows the minterm / maxterm corresponding to each cell.

A \ B	0	1
0	$\bar{A}\bar{B}$ 0	$\bar{A}B$ 1
1	$A\bar{B}$ 2	AB 3

2-variable K-map with minterms

A \ B	0	1
0	$A+B$	$\bar{A}+\bar{B}$
1	$\bar{A}+B$	$\bar{A}+\bar{B}$

2-Variable K-map with maxterms

A \ BC	00	01	11	10
0	$\bar{A}\bar{B}\bar{C}$	$\bar{A}\bar{B}C$	$\bar{A}BC$	$\bar{A}B\bar{C}$
1	$A\bar{B}\bar{C}$	$A\bar{B}C$	ABC	$AB\bar{C}$

3 variable K-map with minterms indication.

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A \ BC	00	01	11	10
0	$A+B+C$	$A+B+\bar{C}$	$A+\bar{B}+\bar{C}$	$A+\bar{B}+C$
1	$\bar{A}+B+C$	$\bar{A}+B+\bar{C}$	$\bar{A}+\bar{B}+\bar{C}$	$\bar{A}+\bar{B}+C$

3 variable K-map with maxterms indication.

3-variable K-map with minterms indication.

Gray code has been used for the identification of cells, so that moving from one cell to another there should

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be change of only one variable.

Hardy we can also write K-Map entry for 4-variables.

Representation of Truth Table on K-Map.

Let us take example of 3-variable logic function (Y) as below

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Truth table of Function Y.

A	B	C	Y
0	0	0	0
0	0	1	1
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

So we can express the logic function Y in equation from the table

$$Y = \bar{A}\bar{B}C + \bar{A}B\bar{C} + \bar{A}BC + AB\bar{C}$$

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Simplify

Let us reduce the expression.

$$Y = \bar{A}\bar{B}C + \bar{A}BC + \bar{A}B\bar{C} + AB\bar{C}$$

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

$$Y = \bar{A}C + B\bar{C} \quad \text{(i)}$$

Looking into the truth table of function Y, we will now map the function Y into the K-map and then simplify the equation.

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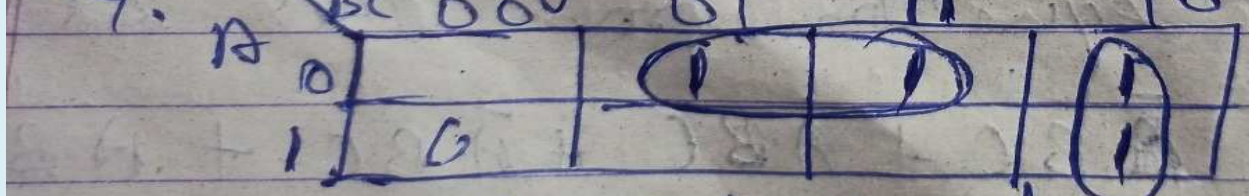
To map a logical function in SOP form into the K-map we enter '1' in each cell for which the function is true, i.e. 1.

So from the truth table we can see that the function Y is true for following minterms :-

$\bar{A}\bar{B}C$, $\bar{A}B\bar{C}$, $\bar{A}BC$ & $AB\bar{C}$

Now drawing K-map for logical function Y.



K-Map for logical function Y.

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To solve (simplify) the logical function using K-Map, grouping of '1' is done in case of SOP form.

The grouping of '1' is done by taking 2, 4, 8, 16 ---- and so on numbers of "1" i.e. dual, quad, octet --- and so on. This has been discussed later.

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So after simplifying using K-Map, the logical function Y can be written as,

$$Y = \bar{A}C + B\bar{C} \quad \text{——— (ii)}$$

So (i) & (ii) are equivalent.

Here we observe that K-map has simplified our function easily.

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Refer book- Modern Digital Electronics by RP Jain.

Thank You