

Paper 7, TDC Part-3
Chapter– 4, Combinational Logic Design
Lecture - 24

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Combinational Logic Design

* 6-Variable K-Maps --

To simplify any logical function with 6-variables we need 6-variable K-Map. A 6-variable K-Map will have provision for entries of 64 terms i.e. from (0-63). So to having 64 blocks we will draw 4 four variable K-Maps. As each four variable K-Map has 16 boxes so 4 four variable K-Map will have $16 \times 4 = 64$ boxes as shown below.

A \ B		$0 \rightarrow \bar{B}$				$1 \rightarrow B$					
		CD \ EF	00	01	11	10	CD \ EF	00	01	11	10
A	1	00	0	1	3	2	00	16	17	19	18
	0	01	4	5	7	6	01	20	21	23	22
	1	11	12	13	15	14	11	28	29	31	30
	0	10	8	9	11	10	10	24	25	27	26

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K-Map 1 (Left)					K-Map 2 (Right)				
CD \ EF					CD \ EF				
CD	EF 00	EF 01	EF 11	EF 10	CD	EF 00	EF 01	EF 11	EF 10
11	12	13	15	14	11	28	29	31	30
10	8	9	11	10	10	24	25	27	26
00	32	33	35	34	00	48	49	51	50
01	36	37	39	38	01	52	53	55	54
11	44	45	47	46	11	60	61	63	62
10	40	41	43	42	10	56	57	59	58

After plotting the K-Map for 6 variable we can do the entries in the K-Map as per the given logical function.

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Let us see one example for SOP function of 6-variables.

(Example-1) Simplify the 6-variable logic function using K-Map technique.

$$f(U, V, W, X, Y, Z) = \sum m(0, 2, 4, 8, 10, 13, 15, 16, 18, 20, 23, 24, 26, 32, 34, 40, 41, 42, 45, 47, 48, 50, 56, 57, 58, 60, 61)$$

Solution Let us draw the K-Map as below,

		UW				UW			
		00	01	11	10	00	01	11	10
YZ	00	0	0	0	0	0	0	0	0
	01	0	1	0	0	0	1	0	0
11	00	0	0	0	0	0	0	0	0
	01	0	0	0	0	0	0	0	0

Note: The handwritten K-map shows a large red circle around the entire map and a smaller red circle around the cell (UW=00, YZ=01). The numbers 1, 2, 3, 4 are written in the cells corresponding to the minterms listed in the problem.

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Solution Let us draw the K-Map as below,

0

WX \ YZ	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

WX \ YZ	00	01	11	10
00	16	17	19	18
01	20	21	23	22
11	28	29	31	30
10	24	25	27	26

1

WX \ YZ	00	01	11	10
00	32	33	35	34
01	36	37	39	38
11	44	45	47	46
10	40	41	43	42

WX \ YZ	00	01	11	10
00	48	49	51	50
01	52	53	55	54
11	60	61	63	62
10	56	57	59	58

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UVWZ

UVWZ

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Blue coloured pair group is group of 16 ones and so the corresponding term is \overline{XZ}

Pink coloured group marked '1' will form group of 4 ones and the corresponding term is $\overline{U}\overline{W}\overline{Y}Z$

Pink coloured group marked '2' will form group of 4 ones and the corresponding term is $\overline{V}WXZ$

Pink coloured group marked '3' will form group of 4 ones and the corresponding term is $UW\overline{Y}Z$

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Black coloured group is a 1 single one and can't be grouped with any ones the term is $\bar{U}\bar{V}\bar{W}X\bar{Y}Z$

pink coloured group marked '4' will form group of 4 ones and the corresponding term is $UVW\bar{Y}$.

So, the reduced/simplified logic expression is given as

$$f(U, V, W, X, Y, Z) = \bar{X}\bar{Z} + \bar{U}\bar{W}\bar{Y}\bar{Z} + \bar{V}WXZ + UVW\bar{Y} + \bar{U}\bar{V}\bar{W}XYZ$$

The above logic function can be implemented using basic gates and also we can use NAND two level implementation.

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Example 2: Simplify the 6 variable logic expression using K-Map technique in POS form.

$$f(A, B, C, D, E, F) = \prod M(0, 5, 7, 8, 9, 12, 13, 23, 24, 25, 28, 29, 37, 40, 42, 44, 46, 55, 56, 57, 60, 61)$$

Solution \rightarrow let us draw the six variable K-map

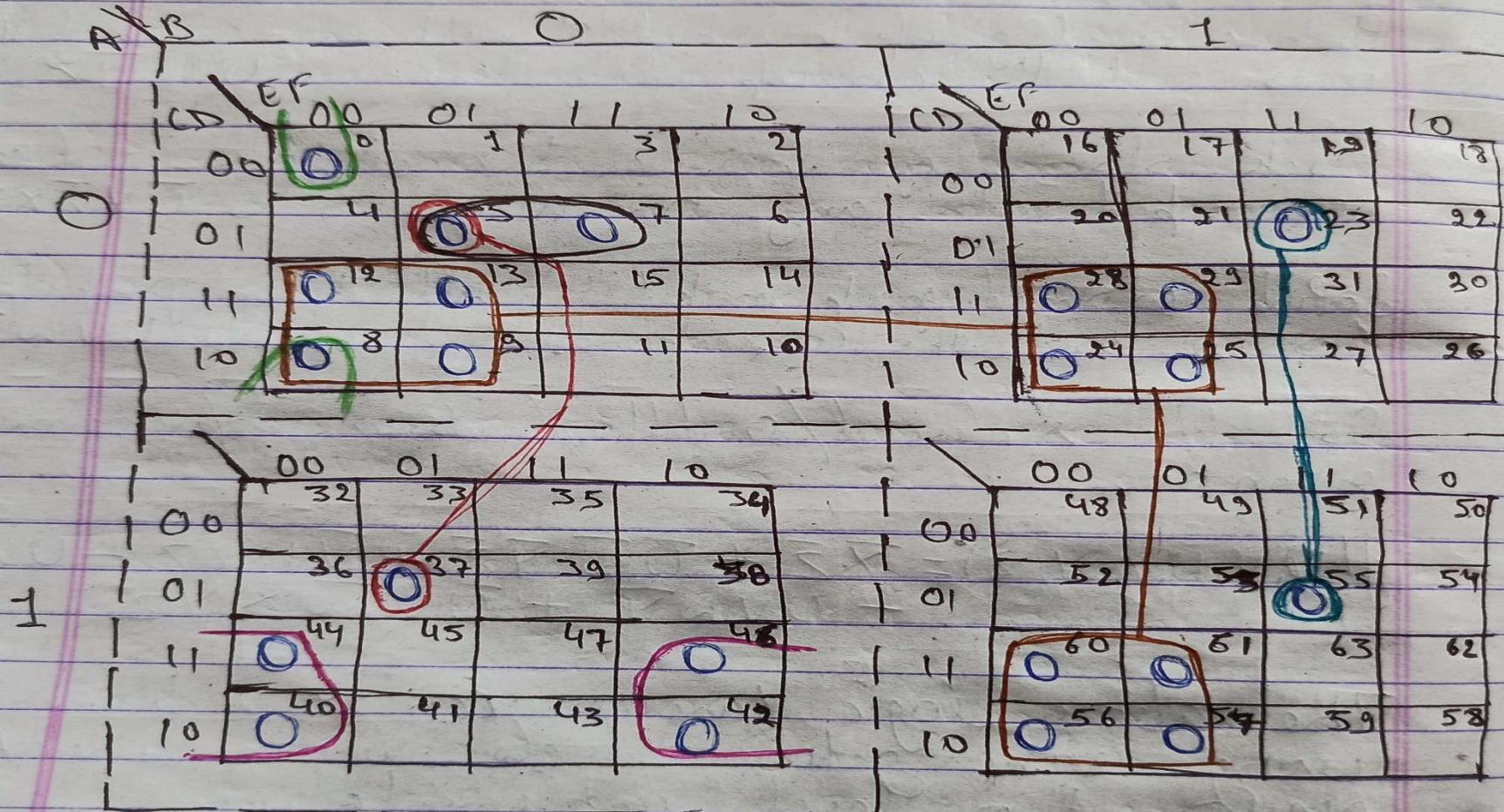
A \ B		0				1			
		00	01	11	10	00	01	11	10
C \ D	00	0	1	3	2	16	17	19	18
	01	4	5	7	6	20	21	23	22
	11	12	13	15	14	28	29	31	30
	10	8	9	11	10	24	25	27	26

The K-map shows the following groupings:

- Group 1 (Green circle): Cell (00, 00) = 0.
- Group 2 (Red oval): Cells (01, 01) = 5 and (11, 01) = 7.
- Group 3 (Red oval): Cells (00, 12) = 12 and (00, 13) = 13.
- Group 4 (Red oval): Cells (01, 23) = 23 and (11, 23) = 31.
- Group 5 (Blue oval): Cell (11, 23) = 31.
- Group 6 (Blue oval): Cells (10, 24) = 24 and (10, 25) = 25.
- Group 7 (Blue oval): Cell (10, 24) = 24.
- Group 8 (Blue oval): Cell (10, 25) = 25.

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Solution → let us draw the six variable K-map



Grouping of zeros have been done as follows

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There are 2 groups of 8 zeros and shown by orange colour.

12, 13, 8, 9, 24, 25, 28 & 29 form group of 8 zeros, and given by term $(A + \bar{C} + E)$

Similarly 24, 25, 28, 29, 56, 57, 60 & 61 form group of 8 zeros and given by term $(\bar{B} + \bar{C} + E)$

There is only ^{one} group of 4 zeros and shown by pink colour i.e. (40, 42, 44, & 46) and given by term $(\bar{A} + B + \bar{C} + \bar{F})$

Remaining zeros form group of 2 zeros and there are 4 such a 2 zeros.

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Remaining zeros form group^{of} 2 zeros and these are 4 group of 2 zeros.

Group of 2 zeros are $(0 \& 8) \rightarrow (A+B+D+E+F)$

" " " " " $(5 \& 7) \rightarrow (B+C+\bar{D}+\bar{F}+A)$

$(5 \& 37) \rightarrow (B+C+\bar{D}+E+\bar{F})$

$(23 \& 55) \rightarrow (\bar{B}+C+\bar{D}+\bar{E}+\bar{F})$

So the function can be written in POS form as,

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

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2.) Recognition of prime-implicant that may form part of the simplified function on the ability of the human user making it difficult to be sure whether the best selection has been made.

The above disadvantages of K-Map is satisfied by the Quine-McCluskey minimisation technique. This technique is capable of handling large nos of variables. However the discussion of Quine-McCluskey technique is beyond the scope of our syllabus.

End of Chapter - (Combinational Logic Design).

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Refer book- Modern Digital Electronics by RP Jain.

Thank You