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


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# Combinational Logic Design

Ex-(1) Convert into canonical SOP form :-

$$Y = AC + AB + \bar{C}$$

Soln. As it can be seen that function Y has three literals A, B & C but all the individual terms AC, AB & $\bar{C}$ have not all the literals present in it. So to convert Y it into canonical SOP form, we will follow below procedure.

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

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We ANDed the individual terms with ORed of missing literals and its complement. Because. ~~[illegible]~~ ORing of a literal with its complement results in '1'.

$$Y = ACB + AC\bar{B} + ABC + AB\bar{C} + AB\bar{C} + A\bar{B}\bar{C} + \bar{A}B\bar{C} + \bar{A}\bar{B}\bar{C}$$

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

$$A$$

So now, in the function Y, each individual term has each of the three literals. So the function Y is in the canonical SOP Form

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Ex 5.3) Convert into canonical POS form.

$Y = (A+\bar{C})(\bar{D})$

Soln. As it can be seen that function Y has 3 literals $A, \bar{C}$ & $\bar{D}$ but each individual term have not all the literals present in it. So to convert it into canonical POS form we will OR each individual terms with ~~not~~ ANDing of missing literals and its complement as below.

$$Y = (A+\bar{C}+D\bar{D})(\bar{D}+A\bar{A}+C\bar{C})$$

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

$$=(A+\bar{C}+D)(A+\bar{C}+\underline{\bar{D}})(A+\bar{D}+C)(\bar{A}+\bar{D}+C)(A+\bar{C}+\underline{\bar{D}})$$

$$(\bar{A}+\bar{C}+\bar{D})$$

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

B

So, the above form, has now all the literals present in each individual term in either uncomplemented form $(A, C, D)$ or in complemented form $(\bar{A}, \bar{C}, \bar{D})$.

Similarly in this way we can convert any function into its canonical form.

Individual terms of a function in SOP form is known as "minterm" while individual

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terms of a function in POS form is known as "maxterm".

Table below gives the minterms and maxterms for a 4 variable logical function where the number of minterms as well as maxterm is $2^4 = 16$. So for a n-variable logical function there are $2^n$ minterms and same number of maxterms.

| Variable | | | | Minterm | Maxterm |
|---|---|---|---|---|---|
| A | B | C | D | $m_i$ | $M_i$ |
| 0 | 0 | 0 | 0 | $\bar{A}\bar{B}\bar{C}\bar{D} = m_0$ | $A+B+C+D = M_0$ |
| 0 | 0 | 0 | 1 | $\bar{A}\bar{B}\bar{C}D = m_1$ | $A+B+C+\bar{D} = M_1$ |

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| | | | | | |
|---|---|---|---|---|---|
| 0 | 0 | 1 | 0 | $\bar{A}\bar{B}C\bar{D} = m_2$ | $A+B+\bar{C}+D = M_2$ |
| 0 | 0 | 1 | 1 | $\bar{A}\bar{B}CD = m_3$ | $A+B+\bar{C}+\bar{D} = M_3$ |
| 0 | 1 | 0 | 0 | $\bar{A}B\bar{C}\bar{D} = m_4$ | $A+\bar{B}+C+D = M_4$ |
| 0 | 1 | 0 | 1 | $\bar{A}B\bar{C}D = m_5$ | $A+\bar{B}+C+\bar{D} = M_5$ |
| 0 | 1 | 1 | 0 | $\bar{A}BC\bar{D} = m_6$ | $A+\bar{B}+\bar{C}+D = M_6$ |
| 0 | 1 | 1 | 1 | $\bar{A}CBD = m_7$ | $A+\bar{B}+\bar{C}+\bar{D} = M_7$ |
| 1 | 0 | 0 | 0 | $A\bar{B}\bar{C}\bar{D} = m_8$ | $\bar{A}+B+C+D = M_8$ |
| 1 | 0 | 0 | 1 | $A\bar{B}\bar{C}D = m_9$ | $\bar{A}+B+C+\bar{D} = M_9$ |
| 1 | 0 | 1 | 0 | $A\bar{B}C\bar{D} = m_{10}$ | $\bar{A}+B+\bar{C}+D = M_{10}$ |
| 1 | 0 | 1 | 1 | $A\bar{B}CD = m_{11}$ | $\bar{A}+B+\bar{C}+\bar{D} = M_{11}$ |
| 1 | 1 | 0 | 0 | $AB\bar{C}\bar{D} = m_{12}$ | $\bar{A}+\bar{B}+C+D = M_{12}$ |
| 1 | 1 | 0 | 1 | $AB\bar{C}D = m_{13}$ | $\bar{A}+\bar{B}+C+\bar{D} = M_{13}$ |
| 1 | 1 | 1 | 0 | $ABC\bar{D} = m_{14}$ | $\bar{A}+\bar{B}+\bar{C}+D = M_{14}$ |
| 1 | 1 | 1 | 1 | $ABCD = m_{15}$ | $\bar{A}+\bar{B}+\bar{C}+\bar{D} = M_{15}$ |

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In minterms each uncomplemented variables taken as 1's and complemented variables taken as 0's.

While in maxterms each uncomplemented variable taken as 0's and complemented variables taken as 1's.

The subscript 'i' in minterm ($m_i$) and maxterm ($M_i$) is the decimal equivalent of the natural binary number.

Using these notation the canonical SOP form of equ A i.e



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

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

can be written as

$$Y = m_0 + m_2 + m_4 + m_5 + m_6 + m_7$$

or

$$Y = \Sigma m(0, 2, 4, 5, 6, 7)$$

Where $m_0 = \bar{A}\bar{B}\bar{C}$ ; $m_2 = \bar{A}B\bar{C}$ ; $m_4 = A\bar{B}\bar{C}$

$m_5 = A\bar{B}C$ ; $m_6 = AB\bar{C}$ ; $m_7 = ABC$

Similarly canonical POS (Eq B) i.e.

$$Y = (A+C+\bar{D})(A+\bar{C}+D)(A+\bar{C}+\bar{D})(\bar{A}+C+\bar{D})(\bar{A}+\bar{C}+$$

$$= M_1 \cdot M_2 \cdot M_3 \cdot M_5 \cdot M_7$$

$$= \cancel{\Pi M(} = \Pi M(1, 2, 3, 5, 7)$$

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where, $M_1 = A + C + \bar{D}$ ; $M_2 = A + \bar{C} + D$

$M_3 = \bar{A} + \bar{C} + \bar{D}$ ; $M_5 = \bar{A} + C + \bar{D}$

$M_7 = \bar{A} + \bar{C} + \bar{D}$

A logic function can be expressed in its minterm as well as maxterm. When a logic function is specified in terms of minterm/maxterm, its maxterm/minterm representation can be determined by using the complementary property.

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For example, for a 3-variable function Y.

$Y = \Sigma m(0, 3, 7)$ is a minterm representation of logical function Y.

The same function Y can be represented in maxterm as

$$Y = \Pi M(1, 2, 4, 5)$$

So we can see that the ~~the~~ logical function Y in maxterm representation is complement of the minterm representation.

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Refer book- Modern Digital Electronics by RP Jain.

***Thank You***