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Canonical form of Boolean Expression (Standard form)

•In standard SOP and POS each term of Boolean expression must contain all the literals (with and without bar) that has been used in Boolean expression.
•If the above condition is satisfied by the Boolean expression, that expression is called Canonical form of Boolean expression.
•In Boolean expression AB+AC, the literal C is not in the 1st term AB and B is not in 2nd term AC. That is why AB+AC is not a Canonical SOP.

e.g. Convert AB+AC in Canonical SOP (Standard SOP).

Sol. AB + AC
=AB(C+C’) + AC(B+B’)
=ABC+ABC’+ABC+AB’C
=ABC+ABC’+AB’C

Minterm & Maxterm:

•Each term of Canonical Sum of Products (SOP) is called Minterm. In otherwords minterm is a product of all the literals (with or without bar) within the Boolean expression.
•‘1’ means the variable is “Not Complemented” and ‘0’ means the variable is “Complemented”.
•Each term of Canonical Products of Sum (POS) is called Maxterm. In otherwords maxterm is a sum of all the literals (with or without bar) within the Boolean expression.
•‘0’ means the variable is “Not Complemented” and ‘1’ means the variable is “Complemented”.

Minterms & Maxterms for 2 variables (Derivation of Boolean function from Truth Table)

x	y	Index	Minterm	Maxterm
0	0	0	$m_0 = x' y'$	$M_0 = x + y$
0	1	1	$m_1 = x' y$	$M_1 = x + y'$
1	0	2	$m_2 = x y'$	$M_2 = x' + y$
1	1	3	$m_3 = x y$	$M_3 = x' + y'$

- The minterm m_i should evaluate to 1 for each combination of x and y.
- The maxterm is the complement of the minterm

Karnaugh map (K – map)

Boolean functions can be simplified using the Boolean theorems but This method of simplification is not used in practice due to reduced expression is not minimal & unique. For that reason Karnaugh map (K – map) method is used most frequently.

- It is used when output is 0,1 & x(don't care).
- In K-Map gray code representation is used.
- K-maps are graphical representations of Boolean functions.
- It's similar to truth table; instead of being organized (i/p & o/p) into columns and rows, the K-map is an array of cells in which each cell represents a binary value of the input variables.
- K-maps can be used for expressions with 2, 3, 4, and 5 variables.

Two-Variable Map

x_1 \ x_2	0	1
0	0 m_0	1 m_1
1	2 m_2	3 m_3

OR

x_2 \ x_1	0	1
0	0 m_0	2 m_2
1	1 m_1	3 m_3

- ordering of variables is IMPORTANT for $f(x_1,x_2)$..
- Cell 0 represents $x_1'x_2'$; Cell 1 represents $x_1'x_2$; etc. If a minterm is present in the function, then a 1 is placed in the corresponding cell.

2-Variable Map -- Example

- $f(x_1,x_2) = x_1'x_2' + x_1'x_2 + x_1x_2'$

  $= m_0 + m_1 + m_2$

  $= x_1' + x_2'$

- 1s placed in K-map for specified minterms m_0, m_1, m_2
- Grouping of 1s allows simplification
- What (simpler) function is represented by each dashed rectangle?
  - $x_1' = m_0 + m_1$
  - $x_2' = m_0 + m_2$
- Here m_0 covered twice