## ★) Basic properties of Switching Algebra :-

1) The basic element of switching algebra is a Boolean variable.

2) A boolean variable can take two value {0, 1}.

3) Main operators in switching algebra are

$+$ , $\cdot$ , $\bar{\ }$ → also called complement.

(OR)

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

(AND)

| | | |
|---|---|---|
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

(NOT)

| | |
|---|---|
| 0 | 1 |
| 1 | 0 |

4) Basic Properties :-

a) <u>Idempotency</u> :- (checking various combinations from truth table)

$$x \cdot x = x$$

$$x + x = x$$

$x + 1 = 1$ $\quad$ $x + 0 = x$

$x \cdot 0 = 0$ $\quad$ $x \cdot 1 = x$

b) <u>Commutativity</u> :- (changing position of operand, check the value)

$$x + y = y + x$$

$$x \cdot y = y \cdot x$$

**NOTE:** Associativity is checked when there is some ambiguity.

$a + b + c \rightleftharpoons op_1 \; op^1 \; op_2 \; op^2 \; op_3$

should '$op_2$' be associated with $op^1$ or $op^2$ ?

If $op_2$ is associated with $op^1$ it is called $\boxed{\text{left associative}}$

and for $op^2$ it is called $\boxed{\text{right associative}}$.

This happens when two operators of same priority are present

c) Associativity :- (checking if left and right associative evaluation are same)

$$(x + y) + z = x + (y + z)$$

$$(x \cdot y) \cdot z = x \cdot (y \cdot z)$$

d) Complement :- (Evaluating with the complement value)

$$x + \bar{x} = 1$$

$$x \cdot \bar{x} = 0$$

e) Distributivity :-

$$x \cdot (y + z) = xy + xz$$

$$x + yz = (x + y)(x + z)$$

**NOTE:** Quick process to check the expression is

put $x = 0$ and check the L.H.S & R.H.S.

In every couple equation, $1 \rightarrow 0$, $0 \rightarrow 1$, $+ \rightarrow \cdot$, $\cdot \rightarrow +$

This property is known a ~~'duality'.~~ $\boxed{\text{'Principle of Duality'.}}$

## Switching Expressions and Simplification :-

1) Switching expression is a finite number of combinations of switching variables and constants {0, 1} by means of switching operations (+ , · , NOT)

Ex: $x + \bar{x}yz + x\bar{z}$ , $a + bc + \bar{b}d$

NOTE : Every occurence of a variable in its true or complement form is called a literal.

$x + \bar{x}yz + x\bar{z}$ has 3 variables but 6 literals.

2) Properties for simplifying switching expression :-

a) Absorption :

$\Rightarrow x + xy = x$

$\Rightarrow x + x'y = (x + x')(x + y) = x + y$ [distributivity

b) Dual :

$x(x' + y) = x.x' + x.y = 0 + xy = xy$

c) Consensus Theorem :

$xy + \bar{x}z + yz = xy + \bar{x}z$ [ $yz$ is redundant ]

A variable concatenated with another variable and its complement concatenated with a 3rd variable and again 2nd & 3rd variables are AND ed and the whole is OR ed. Then the final term is redundant.

NOTE : If the value of expression does not depend on any term then that term is called redundant.

$$\Rightarrow \quad xy + \bar{x}z + yz$$

$$= xy(1) + \bar{x}z(1) + yz(1)$$

$$= xy + \bar{x}z + (x + \bar{x})yz$$

$$= xy + \bar{x}z + xyz + \bar{x}yz.$$

$$= xy(1 + z) + \bar{x}z(1 + y)$$

$$= xy(1) + \bar{x}z(1) = xy + \bar{x}z$$ (Proved)

## SIMPLIFICATION

1. $\bar{x}\bar{y}z + yz + xz$

$$= (x + y + \bar{x}\bar{y})z$$

$$= (x + y + \overline{x + y})z$$

$$= z.$$

NOTE : In switching algebra, cancellation of variables is not allowed i.e, $a + b = a + c$ → ['a' can not be cancelled]

$$a \cdot b = a \cdot c$$

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## (*) De Morgan's Law and simplification :

1) $\overline{xy} = \bar{x} + \bar{y}$

2) $\overline{x + y} = \bar{x}\,\bar{y}$

i.e, for $f(a, b, c, 0, 1, +, \cdot)$

then complement of $f = \bar{f} = f^{\circ}(\bar{a}, \bar{b}, \bar{c}, 1, 0, \cdot$

SIMPLIFICATION

1) $(x+y)[x'(y'+z')]' + x'y' + x'z'$

$= (x+y)[x + y\cdot z] + x'y' + x'z'$

$= (x+y)(x+y)(x+z) + \overline{x+y} + \overline{x+z}$

$= (x+y)(x+z) + [(x+y)(x+z)]'$

$= 1.$ Answer

## ✱ Switching Functions :-

1) Canonical Form :-

In this form, every combination that results value of function as 1 should be present in the term.

$$f = a + bc$$

$$\Rightarrow f = \bar{a}bc + a\bar{b}\bar{c} + a\bar{b}c + ab\bar{c} + abc$$

## ✱ Canonical Sum of Products :-

→ A product term which contains each of 'n' variables as factors either in complemented or uncomplemented form is called a min term.

→ A minterm given the value '1' of exactly one combination of the variables.

→ The sum of all minterms of 'f' for which 'f' assumes '1' is called 'canonical sum of products' or 'disjunctive normal form'.

## Canonical Product of Sums :-

→ A sum term which contains each of 'n' variables as factor either in complemented or uncomplemented form is called a maxterm.

→ A maxterm gives the value of '0' for exactly one combination of the variables.

→ The product of all maxterms of 'f' for which 'f' assumes '0' is called 'canonical product of sums' or 'conjunctive normal form'.

| a | b | c | f |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |

$$f = \Pi(0, 3, 5, 7)$$

$$\Rightarrow f = (a+b+c)(a+\bar{b}+\bar{c})(\bar{a}+\bar{b}+\bar{c})(\bar{a}+\bar{b}+\bar{c})$$

## (*) Functional properties :-

→ The SOP or POS canonical form of a switching function is unique.

→ Two switching functions $f_1(x_1, \ldots x_n)$ and $f_2(x_1, \ldots x_n)$ are said to be logically equivalent if and only if both functions have same value for each and every combination of $(x_1, x_2, \ldots, x_n)$.

→ Two switching functions are equivalent if their canonical pos or sop are identical.