Variable Entered Mapping (VEM)

- Modified form of K-map (extended upto 8 var's in which we have few isolated var's in addition to more frequently used var's)
- Modification of map method (K-map)

\# $f = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}B\bar{C} + \bar{A}BC + \underbrace{AB\bar{C}D}_{\text{isolated variable 'D'}}$

$f \rightarrow$ 4-var

So, it can be converted into a 3-var problem.

$$\therefore \boxed{f = m_0 + m_1 + m_2 + m_3 + m_6 \cdot D}$$

A \ BC	00	01	11	10
0	1_0	1_1	1_3	1_2
1	$_4$	$_5$	$_7$	D_6

AB \ CD	00	01	11	10
00	1_0	1_1	1_3	1_2
01	1_4	1_5	1_7	1_6
11	$_{12}$	1_{13}	$_{15}$	$_{14}$
10	$_8$	$_9$	$_{11}$	$_{10}$

$f = \bar{A} + B\bar{C}D$ Ans

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

$= (m_0, m_1) + (m_2, m_3) + (m_4, m_5) + (m_6, m_7) + m_{13}$

$\therefore f = \bar{A} + B\bar{C}D$ Ans

Same answer
[But simplification (reduction) of expression is very easy using VEM].

A \ BC	00	01	11	10
0	$(D+\bar{D})_0$	$(D+\bar{D})_1$	$(D+\bar{D})_3$	$(D+\bar{D})_2$
1	$_4$	$_5$	$_7$	D_6

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

$f = \bar{A} + B\bar{C}D$ Ans

Objective $\Rightarrow$ Cover all minterms / maxterms and variables atleast once.

VEM method $\Rightarrow$ It has 5 values in Kmap cell.
ie. 0, 1, X, var, complemented var.
(Minterm, Maxterm, Don't cares, A, $\bar{A}$)

For K-maps, only 3 var's $\Rightarrow$ 0, 1, X.

Reduce by mapping :-

$f = \bar{A}\bar{B}CD + \bar{A}\bar{B}C\bar{D} + AB\bar{C}D + AB\bar{C}\bar{D} + ABC\bar{D} + ABCD$
$+ A\bar{B}C\bar{D} + \bar{A}BCD + \bar{A}B\bar{C}\bar{D} + A\bar{B}\bar{C}D$

$f = m_3 + m_2 + m_{13} + m_{12} + m_{14} + m_{15} + m_{10} + m_7 + m_4 + m_9$

$f = \Sigma m(2, 3, 4, 7, 9, 10, 12, 13, 14, 15)$ for 4-var

$f = m_1 D + m_1\bar{D} + m_6 D + m_6\bar{D} + m_7\bar{D} + m_7 D + m_5\bar{D}$
$+ m_3 D + m_2\bar{D} + m_4 \cdot D$

$= m_1(D+\bar{D}) + m_2\bar{D} + m_3 D + m_4 D + m_5\bar{D} + m_6(D+\bar{D})$
$+ m_7(D+\bar{D})$

A \ BC	00	01	11	10
0	(0)	$D+\bar{D}$ (1)	D (3)	$\bar{D}$ (2)
1	D (4)	$\bar{D}$ (5)	$D+\bar{D}$ (7)	$D+\bar{D}$ (6)

⇒

A \ BC	00	01	11	10
0	(0)	$\bar{D}+D$ (1)	D (3)	$\bar{D}$ (2)
1	D (4)	$\bar{D}$ (5)	$\bar{D}+D$ (7)	$\bar{D}+D$ (6)

Fully covered minterms ⇒ when any one of variable & its complement is covered (atleast)

$\therefore f = (m_1, m_3) + (m_1, m_5) + (m_4, m_6) + (m_2, m_6) + (m_6, m_7)$
$= \bar{A}CD + \bar{B}C\bar{D} + A\bar{C}D + B\bar{C}\bar{D} + AB(D+\bar{D})$

$f = \bar{A}CD + A\bar{C}D + \bar{B}C\bar{D} + B\bar{C}\bar{D} + AB$. Ans

$f = \bar{A}\bar{B}\bar{C}E + \bar{A}\bar{B}C + \bar{A}BCF + \bar{A}B\bar{C} + A\bar{B}CD + AB\bar{C}\bar{F}$

⇒ Reduced to 3 var.

$f = m_0 E + m_1 + m_3 F + m_2 + m_5 \cdot D + m_6 \cdot \bar{F}$

$f = (m_2, m_3) + (m_2, m_6) +$
$(m_0, m_1) + (m_1, m_5)$

A \ BC	00	01	11	10
0	E (0)	1 (1)	F (3)	1 (2)
1	(4)	D (5)	(7)	$\bar{F}$ (6)

$f = (m_0, m_1) + (m_2, m_3) + (m_2, m_6) + (m_1, m_5) + m_1$

$= \bar{A}\bar{B}E + \bar{A}BF + ABC\bar{F} \ldots$

$= \bar{A}\bar{B}E + \bar{A}BF + AB\bar{C}\bar{F} + \bar{B}CD + \bar{A}\bar{B}C$.

$m_0 \rightarrow E$ is covered (Fully covered)

$m_1 \rightarrow$ Only 'D' & 'E' are covered (Partially)

$m_2 \rightarrow F$ & $\bar{F}$ are covered (Fully)

$m_3 \rightarrow F$ is covered (Fully)

$m_5 \rightarrow D$ is covered (Fully)

$m_6 \rightarrow \bar{F}$ is covered (Fully)

$f = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}CD + \bar{A}BC\bar{E} + \bar{A}B\bar{C}E + A\bar{B}C + ABC + AB\bar{C}\bar{D}$

It is a 5-var problem. Reduced to 3-var.

$= m_0 + m_1 D + m_3 \bar{E} + m_2 E + m_5 + m_7 + m_6 \bar{D}$

A \ BC	00	01	11	10
0	1 (0)	D (1)	$\bar{E}$ (3)	E (2)
1	(4)	1 (5)	1 (7)	$\bar{D}$ (6)

$f = (m_0, m_1) + (m_0, m_2) + (m_6, m_7) + (m_5, m_7) + (m_3, m_7) + m_0$

$f = AC + AB\bar{D} + BC\bar{E} + \bar{A}\bar{B}D + \bar{A}\bar{C}E + \bar{A}\bar{B}\bar{C}$

Incompletely specified fns: (With don't cares)

If value in a cell is '1' $\Rightarrow A+\bar{A}$ or $B+\bar{B}$ or ...

" " " " " " 'X' (don't care) $\Rightarrow XA+X\bar{A}$ or $XB+X\bar{B}$ or ...

$\Rightarrow$ Don't cares may or may not be covered.

$\Rightarrow$ Cells with minterms have to be fully covered.

$\Rightarrow$ Cells with don't cares may be fully/partially covered.

Reduce by mapping:

$$f = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}CD + \bar{A}B\bar{C}\bar{D} + A\bar{B}\bar{C}D + ABCE + ABC\bar{E}$$
$$+ d(A\bar{B}CD + AB\bar{C}E)$$

fn is 5-var $\Rightarrow$ can be converted to 3-var.

$$\therefore f = m_0 + m_1 D + m_2\bar{D} + m_4 D + m_7 E + m_7\bar{E} + d(m_5 D + m_6 E)$$

A \ BC	00	01	11	10
0	1 (0)	D (1)	(3)	$\bar{D}$ (2)
1	D (4)	XD (5)	$E+\bar{E}$ (7)	XE (6)

Pair $(m_2, m_0) \Rightarrow \bar{A}\bar{C}\bar{D}$

Island (as it has no adjacent cells) $(m_7) \Rightarrow ABC$

Quad (m_0, m_1, m_4, m_5) $(\bar{B}D)$

$$\therefore \boxed{f = \bar{B}D + ABC + \bar{A}\bar{C}\bar{D}}$$

cell 1 → fully covered

cell 7 → " "

$f = m_0 + m_1 F + m_2 + m_4 E + m_6(E+\bar{E}) + m_7 F + m_{10} E + m_{12} + m_{15} F + d(m_5 F + m_9 + m_{11}\bar{E} + m_8 E)$

fn is 6-var $\Rightarrow$ but it is given in 4-var minterm form

AB \ CD	00	01	11	10
00	1 (0)	F (1)	(3)	1 (2)
01	E (4)	XF (5)	F (7)	$E+\bar{E}$ (6)
11	1 (12)	(13)	F (15)	(14)
10	XE (8)	X (9)	$X\bar{E}$ (11)	E (10)

① Quad (m_0, m_2, m_8, m_{10})

② Pair (m_7, m_{15})

③ Quad (m_0, m_2, m_4, m_6)

④ Pair (m_2, m_6) as only 'E' part was covered in quad ③

⑤ Island (m_{12})

⑥ Pair (m_1, m_5)

⑦ Pair (m_0, m_2)

option ⑤ or another quad (m_0, m_4, m_8, m_{12})

(0, 4, 8, 12)
(0, 2, 8, 10)
(7, 15)
(1, 5)
(0, 2)
(2, 6)
(12)

Status → $m_0 \cdot 1$ ✓
$m_1 \cdot F$ ✓
$m_2 \cdot 1$ ✓
$m_4 \cdot E$ ✓
$m_6 (E + \overline{E})$ ✓
$m_7 \cdot F$ ✓
$m_{10} \cdot E$ ✓
$m_{12} \cdot 1$ Island.
$m_{15} \cdot F$ ✓
× $m_5 \cdot F$ ✓
× $m_9 \cdot 1$
× $m_{11} \cdot \overline{E}$
× $m_8 \cdot E$ ✓