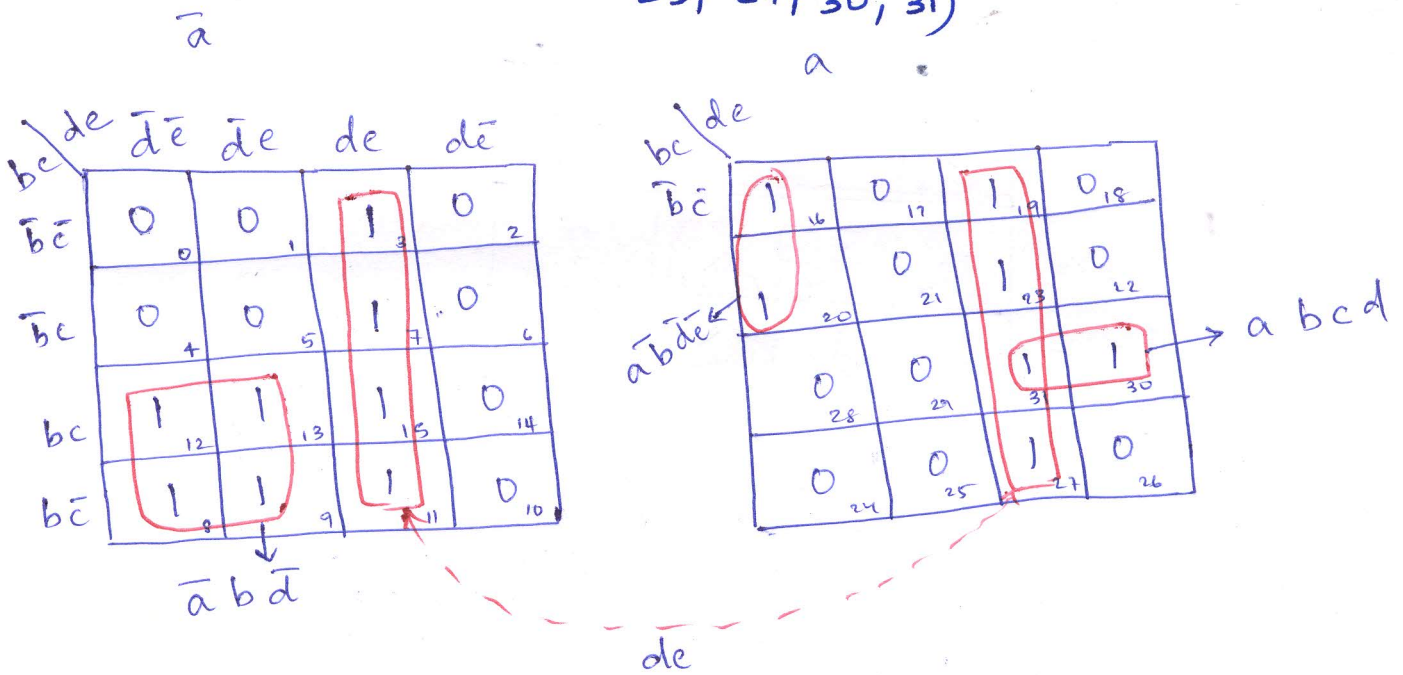


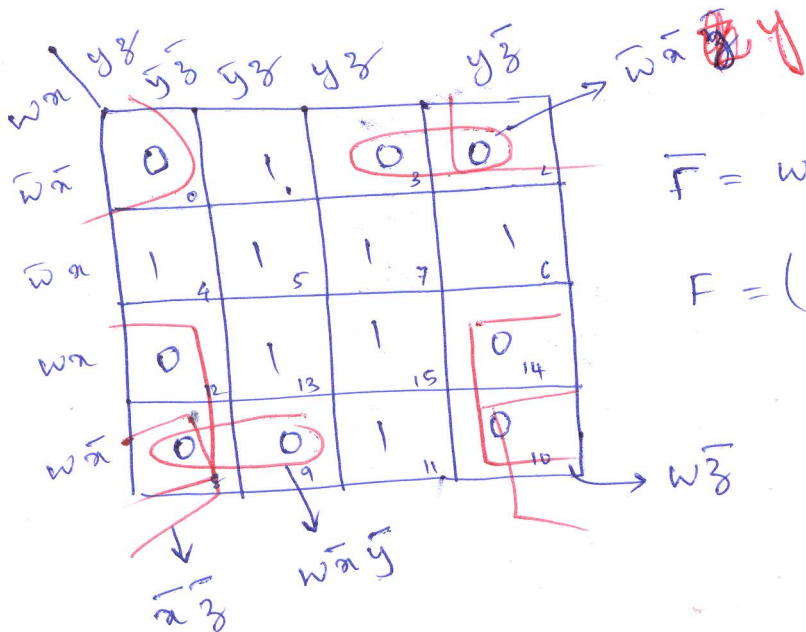
4) K-map simplification

a) $F(a, b, c, d, e) = \sum m(3, 7, 8, 9, 11, 12, 13, 15, 16, 19, 20, 23, 27, 30, 31)$



$$F = de + \bar{a}b\bar{d} + \underline{\underline{a\bar{b}\bar{d}e + abcd}}$$

b) $F(w, x, y, z) = \prod M(0, 2, 3, 8, 9, 10, 12, 14)$



$$\bar{F} = w\bar{z} + \bar{x}\bar{z} + w\bar{x}y + w\bar{x}\bar{y}$$

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

c) $F(w, x, y, z) = \sum m(6, 7, 9, 10, 13) + \sum d(1, 4, 5, 11, 15)$

| | | | | |
|--------------------|------------------|------------|------------|------|
| $wx \backslash yz$ | $\bar{y}\bar{z}$ | $\bar{y}z$ | $y\bar{z}$ | yz |
| $\bar{w}\bar{x}$ | 0 | X | 0 | 0 |
| $\bar{w}x$ | X | X | 1 | 1 |
| $w\bar{x}$ | 0 | 1 | X | 0 |
| wx | 0 | 1 | X | 1 |

OR

$F = \bar{w}x + wz + w\bar{x}y$

| | | | | |
|--------------------|------------------|------------|------------|------|
| $wx \backslash yz$ | $\bar{y}\bar{z}$ | $\bar{y}z$ | $y\bar{z}$ | yz |
| $\bar{w}\bar{x}$ | 0 | X | 0 | 0 |
| $\bar{w}x$ | X | X | 1 | 1 |
| $w\bar{x}$ | 0 | 1 | X | 0 |
| wx | 0 | 1 | X | 1 |

$F = \bar{w}x + \bar{y}z + w\bar{x}y$

OR

4) a) $F(a, b, c, d, e) = \sum m(1, 3, 4, 5, 11, 14, 15, 16, 17, 19, 20, 24, 26, 28, 30)$

| | | | | |
|--------------------|------------------|------------|------------|------|
| $bc \backslash de$ | $\bar{d}\bar{e}$ | $\bar{d}e$ | $d\bar{e}$ | de |
| $\bar{b}\bar{c}$ | | 1 | 1 | |
| $\bar{b}c$ | 1 | 1 | | |
| bc | | 1 | 1 | |
| $b\bar{c}$ | | 1 | | |

| | | | | |
|--------------------|------------------|------------|------------|------|
| $bc \backslash de$ | $\bar{d}\bar{e}$ | $\bar{d}e$ | $d\bar{e}$ | de |
| $\bar{b}\bar{c}$ | 1 | 1 | 1 | |
| $\bar{b}c$ | 1 | | | |
| bc | 1 | | | 1 |
| $b\bar{c}$ | 1 | | | |

$$F = \bar{b}\bar{c}e + \bar{a}\bar{b}c\bar{d} + a\bar{d}\bar{e} + \bar{a}deb + \bar{a}bcd + a\bar{d}\bar{e}b$$

b) $F(w, x, y, z) = \sum m(1, 4, 5, 6, 7, 11, 13, 15)$

| | | | | | |
|------------|-----------------|------------------|-----------------|-----------------|-------------------|
| | $y\bar{z}$ | $\bar{y}\bar{z}$ | $\bar{y}z$ | $y\bar{z}$ | |
| $w\bar{x}$ | 0 ₀ | 1 ₁ | 0 ₃ | 0 ₂ | $\bar{w}\bar{y}z$ |
| $\bar{w}x$ | 1 ₄ | 1 ₅ | 1 ₇ | 1 ₆ | $\bar{w}x$ |
| wx | 0 ₁₂ | 1 ₁₃ | 1 ₁₅ | 0 ₁₄ | xz |
| $w\bar{x}$ | 0 ₈ | 0 ₉ | 1 ₁₁ | 0 ₁₀ | wyz |

$$F = xz + wyz + \bar{w}x + \bar{w}\bar{y}z$$

c) $F(w, x, y, z) = \prod M(0, 3, 4, 11, 13) + d(2, 6, 8, 9, 10)$

| | | | | |
|------------|-----------------|------------------|-----------------|-----------------|
| | $y\bar{z}$ | $\bar{y}\bar{z}$ | $\bar{y}z$ | $y\bar{z}$ |
| $w\bar{x}$ | 0 ₀ | 1 ₁ | 0 ₃ | X ₂ |
| $\bar{w}x$ | 0 ₄ | 1 ₅ | 1 ₇ | X ₆ |
| wx | 1 ₁₂ | 0 ₁₃ | 1 ₁₅ | 1 ₁₄ |
| $w\bar{x}$ | X ₈ | X ₉ | 0 ₁₁ | X ₁₀ |

$$\bar{F} = \bar{w}\bar{z} + \bar{a}y + w\bar{y}z$$

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

Q.5. Simplify the expression using Quine-McCluskey Method

$$F(a,b,c,d) = \sum m(2,3,4,5,13,15) + \sum d(8,9,10,11)$$

| | a | b | c | d | | a | b | c | d | | a | b | c | d |
|-------------------------------|---|---|---|---|----------------------|---|---|---|---|-----------------|---|---|---|---|
| G ₁ 2 | 0 | 0 | 1 | 0 | (2,3) | 0 | 0 | 1 | - | (2,3,10*,11*) | - | 0 | 1 | - |
| 4 | 0 | 1 | 0 | 0 | (2,10*) | - | 0 | 1 | 0 | (2,10*,3,11*) | - | 0 | 1 | - |
| 8* | 1 | 0 | 0 | 0 | (4,5) | 0 | 1 | 0 | - | (8*,9*,10*,11*) | 1 | 0 | - | - |
| | | | | | (8*,9*) | 1 | 0 | 0 | - | (8*,10*,9*,11*) | 1 | 0 | - | - |
| G ₂ 3 | 0 | 0 | 1 | 1 | (8*,10*) | 1 | 0 | - | 0 | | | | | |
| 5 | 0 | 1 | 0 | 1 | (3,11*) | - | 0 | 1 | 1 | (9*,11*,13,15) | 1 | - | - | 1 |
| 9* | 1 | 0 | 0 | 1 | (5,13) | - | 1 | 0 | 1 | (9*,13,11*,15) | 1 | - | - | 1 |
| 10* | 1 | 0 | 1 | 0 | (9*,11*) | 1 | 0 | - | 1 | | | | | |
| G ₃ 11* | 1 | 0 | 1 | 1 | (9*,13) | 1 | - | 0 | 1 | | | | | |
| 13 | 1 | 1 | 0 | 1 | (10*,11*) | 1 | 0 | 1 | - | | | | | |
| | | | | | (11*,15) | 1 | - | 1 | 1 | | | | | |
| G ₄ 15 | 1 | 1 | 1 | 1 | (13,15) | 1 | 1 | - | 1 | | | | | |

* All terms are don't care.

$$f(a,b,c,d) = \bar{b}c + \overbrace{a\bar{b}}^{\text{Not required}} + ad + \bar{a}b\bar{c} + b\bar{c}d$$

| | 2 | 3 | 4 | 5 | 13 | 15 | 8* | 9* | 10* | 11* |
|----------------------------|-----|-----|-----|---|----|-----|----------------------------|-----|-----|-----|
| (2,3,10*,11*) - $\bar{b}c$ | (x) | (x) | | | | | | | (x) | x |
| (9*,11*,13,15) - ad | | | | | x | (x) | | (x) | | x |
| (4,5) - $\bar{a}b\bar{c}$ | | | (x) | x | | | | | | |
| (5,13) - $b\bar{c}d$ | | | | x | x | | | | | |
| | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | Not required as don't care | ✓ | ✓ | ✓ |

$$\therefore f(a,b,c,d) = \bar{b}c + ad + \bar{a}b\bar{c}$$

$$F(p, q, r, s) = \sum m(1, 5, 7, 9, 13, 15) + \sum d(8, 10, 11, 14)$$

| | p | q | r | s | | p | q | r | s | | p | q | r | s | |
|----------------|----------------|---|---|---|---|-----------------------|---|---|---|---|---------------------|---|---|---|---|
| G ₁ | 1 | 0 | 0 | 0 | 1 | (1, 5) | 0 | - | 0 | 1 | (1, 5, 9, 13) | - | - | 0 | 1 |
| | 8* | 1 | 0 | 0 | 0 | (1, 9) | - | 0 | 0 | 1 | (1, 9, 5, 13) | - | - | 0 | 1 |
| G ₂ | | | | | | (8*, 9) | 1 | 0 | 0 | - | (8*, 9, 10*, 11*) | 1 | 0 | - | - |
| | 5 | 0 | 1 | 0 | 1 | (8*, 10*) | 1 | 0 | - | 0 | (8*, 10*, 9, 11*) | 1 | 0 | - | - |
| | 9 | 1 | 0 | 0 | 1 | (5, 7) | 0 | 1 | - | 1 | (5, 7, 13, 15) | - | 1 | - | 1 |
| | 10* | 1 | 0 | 1 | 0 | (5, 13) | - | 1 | 0 | 1 | (5, 13, 7, 15) | - | 1 | - | 1 |
| G ₃ | 7 | 0 | 1 | 1 | 1 | (9, 11*) | 1 | 0 | - | 1 | (9, 11*, 13, 15) | 1 | - | - | 1 |
| | 11* | 1 | 0 | 1 | 1 | (9, 13) | 1 | - | 0 | 1 | (9, 13, 11*, 15) | 1 | - | - | 1 |
| | 13 | 1 | 1 | 0 | 1 | (10*, 11*) | 1 | 0 | 1 | - | (10*, 11*, 14*, 15) | 1 | - | 1 | - |
| | 14* | 1 | 1 | 1 | 0 | (10*, 14*) | 1 | - | 1 | 0 | (10*, 14*, 11*, 15) | 1 | - | 1 | - |
| G ₄ | | | | | | (7, 15) | - | 1 | 1 | 1 | | | | | |
| | 15 | 1 | 1 | 1 | 1 | (11*, 15) | 1 | - | 1 | 1 | | | | | |
| | | | | | | (13, 15) | 1 | 1 | - | 1 | | | | | |
| | | | | | | (14*, 15) | 1 | 1 | 1 | - | | | | | |

PI :- $\bar{r}s$ (1, 5, 9, 13)
 $p\bar{q}$ (8*, 9, 10*, 11*)
 qs (5, 7, 13, 15)
 ps (9, 11*, 13, 15)
 $p\bar{r}$ (10*, 11*, 14*, 15)

$$f(p, q, r, s) = \bar{r}s + p\bar{q} + qs + ps + p\bar{r}$$

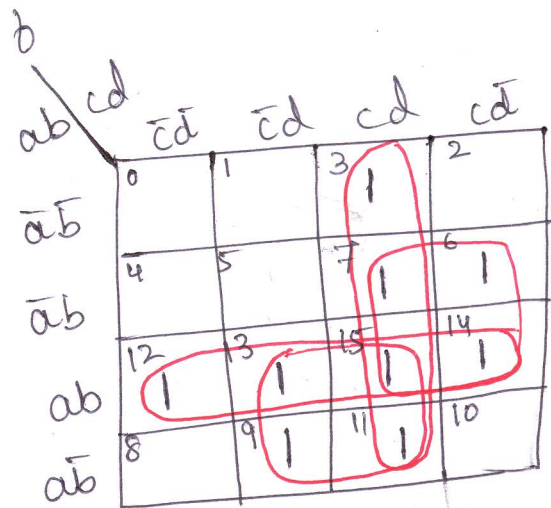
| | 1 | 5 | 7 | 9 | 13 | 15 | 8* | 10* | 11* | 14* |
|--------------------------------|--------------|---|--------------|---|----|----|--------------|-----|-----|--------------|
| (1, 5, 9, 13) $\bar{r}s$ | x | x | | x | x | | | | | |
| (8*, 9, 10*, 11*) $p\bar{q}$ | | | | x | | | x | x | x | |
| (5, 7, 13, 15) qs | | x | x | | x | x | | | | |
| (9, 11*, 13, 15) ps | | | | x | x | x | | | x | |
| (10*, 11*, 14*, 15) $p\bar{r}$ | | | | | | x | | x | x | x |
| | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ | ✓ |

$$\therefore f(p, q, r, s) = \bar{r}s + p\bar{q} + qs + p\bar{r}$$

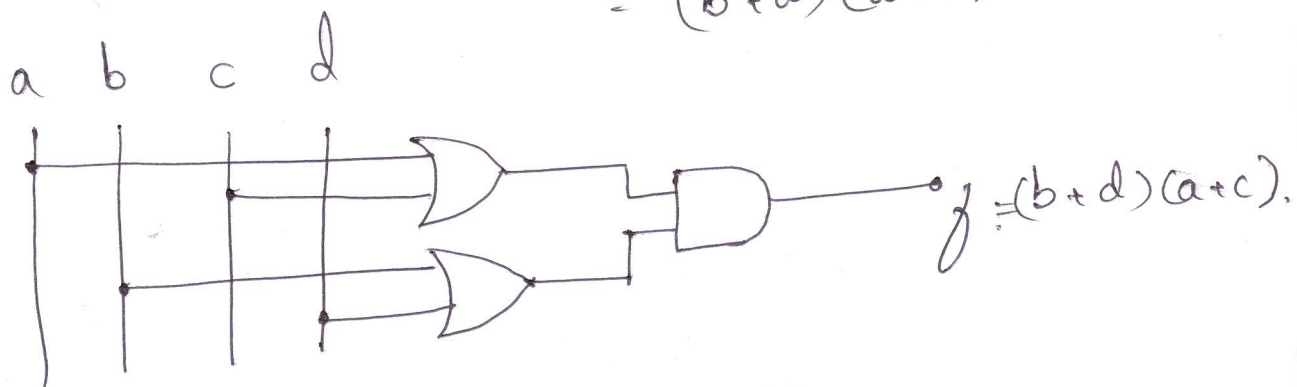
27 Design a simple logic ckt using suitable gates for a system with four i/ps a, b, c, d, that will produce a logic 1 o/p whenever two adjacent i/ps are high. a and d are also considered as adjacent i/ps in this problem.

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

$$\therefore f = \sum m(3, 6, 7, 9, 11, 12, 13, 14, 15)$$



$$\begin{aligned}
 f &= ab + cd + bc + ad \\
 &= a(b+d) + c(b+d) \\
 &= (b+d)(a+c)
 \end{aligned}$$



27 Design a combination logic circuit whose o/p is logic 1 when a non BCD code is entered.

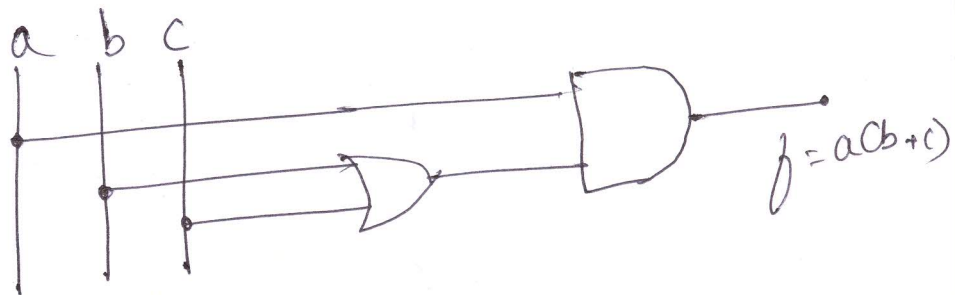
| a | b | c | d | f |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 1 | 0 |
| 0 | 1 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1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

non BCD

$$f = \sum m(10, 11, 12, 13, 14, 15)$$

| | | cd | | | |
|----|------------------|------------------|------------|------------|------|
| | | $\bar{c}\bar{d}$ | $\bar{c}d$ | $c\bar{d}$ | cd |
| b | ab | 0 | 1 | 3 | 2 |
| | $\bar{a}\bar{b}$ | 4 | 5 | 7 | 6 |
| ab | ab | 2 | 3 | 15 | 14 |
| | $\bar{a}\bar{b}$ | 8 | 9 | 11 | 10 |

$$f = ab + ac = a(b+c)$$



$$3(a) (a+\bar{b})(a+c+d)(\bar{a}+\bar{b}+\bar{d})(a+\bar{c}+d)$$

$$3(a) \bar{a}d + bc + \bar{b}d + b\bar{c}\bar{d}$$

$$\bar{a}d = \bar{a}(b+\bar{b})(c+\bar{c})d = \bar{a}[bc + b\bar{c} + \bar{b}c + \bar{b}\bar{c}]d$$

$$bc = (a+\bar{a})bc(d+\bar{d}) = \bar{a}bcd + \bar{a}b\bar{c}d + \bar{a}\bar{b}cd + \bar{a}\bar{b}\bar{c}d$$

$$= (abc + \bar{a}bc)(d+\bar{d}) = 0111 + 0101 + 0011 + 0001$$

$$= \boxed{m(7, 5, 3, 1)}$$

$$= abcd + abc\bar{d} + \bar{a}bcd + \bar{a}b\bar{c}d$$

$$= 1111 + 1110 + 0111 + 0110 = \boxed{m(15, 14, 7, 6)}$$

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

$$= (a\bar{b} + \bar{a}\bar{b})(cd + \bar{c}d)$$

$$= a\bar{b}cd + a\bar{b}\bar{c}d + \bar{a}\bar{b}cd + \bar{a}\bar{b}\bar{c}d$$

$$= 1011 + 1001 + 0011 + 0001$$

$$= \boxed{m(11, 9, 3, 1)}$$

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

$$= ab\bar{c}\bar{d} + \bar{a}b\bar{c}\bar{d}$$

$$= 1100 + 0100$$

$$= \boxed{m(12, 4)}$$

$$f(a,b,c,d) = \sum m(1, 3, 4, 5, 6, 7, 9, 11, 12, 14, 15)$$

3(a)

$$A (a+\bar{b})(a+c+d)(\bar{a}+\bar{b}+\bar{d})(a+\bar{c}+d)$$

$$(c+\bar{b}+\bar{c}\bar{c})(a+b\bar{b}+c+d)(\bar{a}+\bar{b}+c\bar{c}+d)(a+b\bar{b}+c+d)$$

$$(a+\bar{b}+c)(a+\bar{b}+\bar{c})(\underset{0}{a}+\underset{0}{b}+\underset{0}{c}+\underset{0}{d})(\underset{0}{a}+\underset{1}{b}+\underset{0}{c}+\underset{0}{d})(\underset{1}{\bar{a}}+\underset{1}{\bar{b}}+\underset{0}{c}+\underset{1}{\bar{d}})$$

$$(\underset{1}{\bar{a}}+\underset{1}{\bar{b}}+\underset{1}{\bar{c}}+\underset{1}{\bar{d}})(\underset{0}{a}+\underset{0}{b}+\underset{1}{\bar{c}}+\underset{0}{d})(\underset{0}{a}+\underset{1}{\bar{b}}+\underset{1}{\bar{c}}+\underset{0}{d})$$

$$(a+\bar{b}+c+d\bar{d})(a+\bar{b}+c+d\bar{d})$$

$$(\underset{0}{a}+\underset{1}{\bar{b}}+\underset{0}{c}+\underset{0}{d})(\underset{0}{a}+\underset{1}{\bar{b}}+\underset{0}{c}+\underset{1}{\bar{d}})(\underset{0}{a}+\underset{1}{\bar{b}}+\underset{1}{\bar{c}}+\underset{0}{d})(\underset{0}{a}+\underset{1}{\bar{b}}+\underset{1}{\bar{c}}+\underset{1}{\bar{d}})$$

$$0 \quad 1 \quad 0 \quad 0 \quad 0 \quad 1 \quad 0 \quad 1 \quad 0 \quad 1 \quad 1 \quad 0 \quad 0 \quad 1 \quad 1 \quad 1$$

$$f(a,b,c,d) = \prod M(0, 4, 13; 15, 2, 6, 4, 5, 6, 7)$$

$$\boxed{f(a,b,c,d) = \prod M(0, 2, 4, 5, 6, 7, 13, 15)}$$