# Homework 2 Solution

**6.** The 'ADD 3' block takes a 3-bit I/P & gives a 3-bit O/P. The value at the O/P is greater than I/P by 3. If O/P is too big to be represented, then all the O/P bits are set to 1. (14)


a) Construct the truth table
b) Simplify $b_0$, $b_1$, $b_2$ using K-Map.
c) Draw the ckt diagram using AND, OR, NOT gates

ANS:

a) TRUTH TABLE :

| a2 | a1 | a0 | b2 | b1 | b0 |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 1 | 1 |
| 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 1 | 1 | 0 |
| 1 | 0 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 1 | 1 | 1 |
| 1 | 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 | 1 |

b) K-Maps :

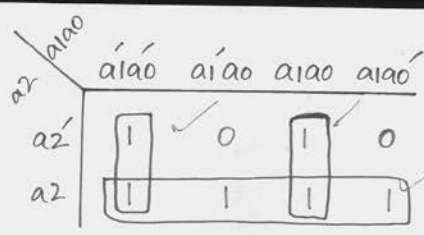
$b_0$ :

| a2 \ a1a0 | $a_1'a_0'$ | $a_1'a_0$ | $a_1a_0$ | $a_1a_0'$ |
|---|---|---|---|---|
| $a_2'$ | 1 | 0 | 0 | 1 |
| $a_2$ | 1 | 1 | 1 | 1 |

$\Rightarrow b_0 = a_0' + a_2$

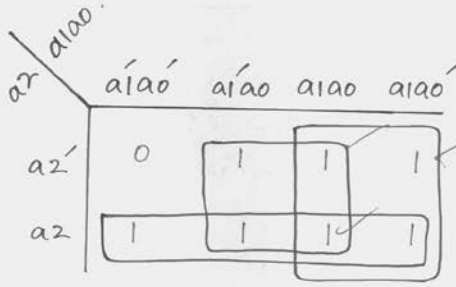
(27)

b1 :



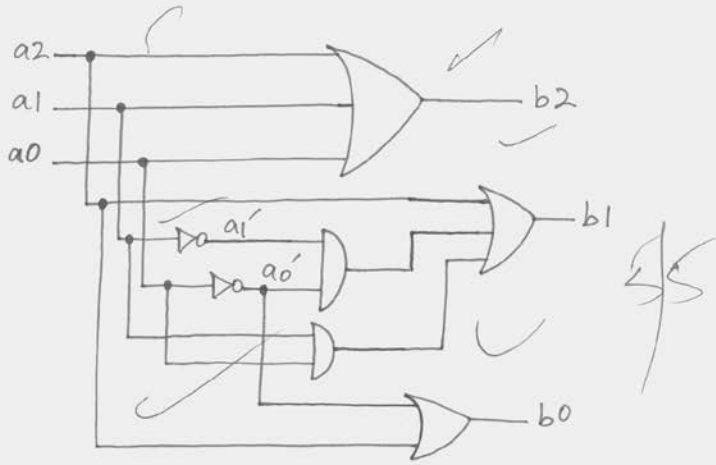

$\Rightarrow b1 = a_2 + a1'a0' + a1a0$

b2 :




$\Rightarrow b2 = a2 + a0 + a1$

c) CIRCUIT DIAGRAM :

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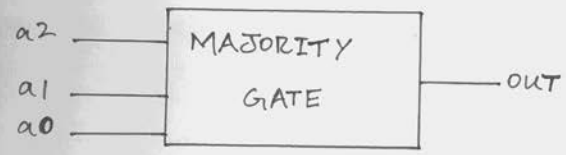
(15)

7. The 'MAJORITY GATE' block takes a 3-bit I/P & produces a 1-bit O/P. O/P is 1 if majority of the I/P's are 1's. The O/P is 0 otherwise.




a) Build the truth table
b) Simplify out using K-Map
c) Draw the ckt diagram using NAND Gates only.

ANS:

a) TRUTH TABLE:

| a2 | a1 | a0 | OUT |
|---|---|---|---|
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |

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b) K-Map:

| a2 \ a1a0 | a1'a0' | a1'a0 | a1a0 | a1a0' |
|---|---|---|---|---|
| a2' | 0 | 0 | 1 | 0 |
| a2 | 0 | 1 | 1 | 1 |

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$\Rightarrow OUT = a_2a_0 + a_1a_0 + a_2a_1$

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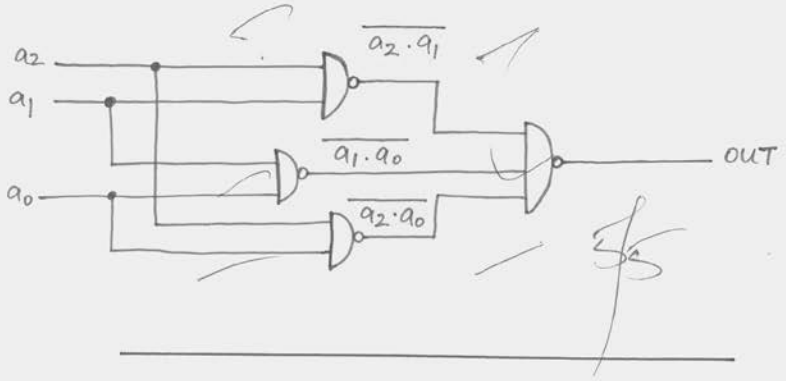
c) CIRCUIT DIAGRAM:
(USING NAND GATES)



8. There is a committee with 3 people. Each person votes either YES or NO for a proposal. If at least 2 people vote YES, the proposal is passed. Design a ckt → that determines whether a proposal passes. (16)

ANS:

Let In Voting, YES → 1
NO → 0

& for proposal, PASSED → 1
NOT PASSED → 0

TRUTH TABLE:

| People | | | Proposal |
|---|---|---|---|
| A | B | C | F(A,B,C) |
| 0 | 0 | 0 | 0 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 1 |

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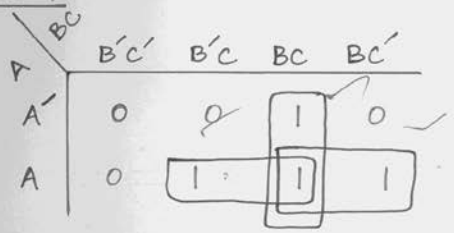
K-MAP:

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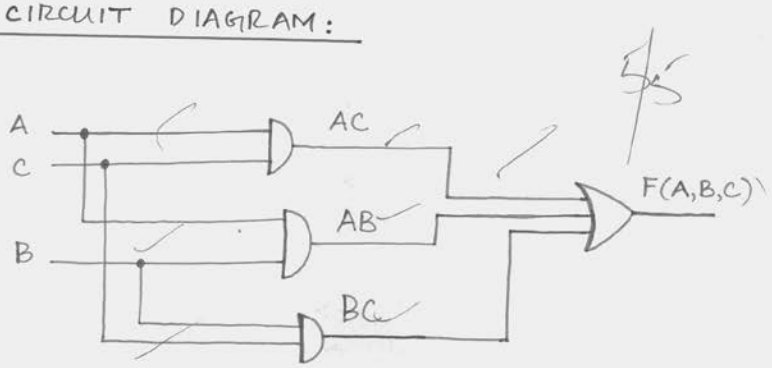
⇒ F(A,B,C) = AC + AB + BC

(21)

CIRCUIT DIAGRAM:




**9.** Sometimes lights are controlled by more than one switch, like in stairs. The downstairs switch is 'x' & upstairs switch is 'y'. The lights should get ON when both 'x' and 'y' are ON or both are OFF. Draw the logic circuit of Light(x,y).

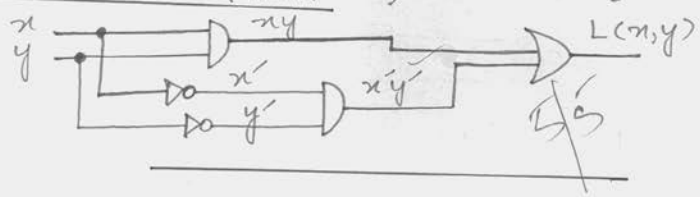
ANS: Let for switches, ON → 1
OFF → 0
& for Light, ON → 1
OFF → 0

TRUTH TABLE:

| SWITCHES | | LIGHT |
|---|---|---|
| x | y | L(x,y) |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

$\Rightarrow L(x,y) = x'y' + xy$

CIRCUIT DIAGRAM:



**10.** Design a logic ckt that accepts a 3-bit No. & generates an o/p binary No. equal to the square of I/P No.

ANS:

TRUTH TABLE :

| S. No: | $a_0$ | $a_1$ | $a_2$ | $b_0$ | $b_1$ | $b_2$ | $b_3$ | $b_4$ | $b_5$ |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 2 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 3 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| 4 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| 5 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 1 |
| 6 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 7 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |

$b_0$ : $\Rightarrow b_0 = a_0a_1a_2' + a_0a_1a_2 \Rightarrow b_0 = a_0a_1$

$b_1$ : $\Rightarrow b_1 = a_0a_1'a_2' + a_0a_1'a_2 + a_0a_1a_2$

$= a_0(a_1'a_2' + a_1'a_2 + a_1a_2)$

$= a_0(a_1'(a_2'+a_2) + a_2(a_1'+a_1))$

$= a_0(a_1' + a_2) \Rightarrow b_1 = a_0a_1' + a_0a_2$

$b_2$ : $\Rightarrow b_2 = a_0'a_1a_2 + a_0a_1'a_2$

$b_3$ : $\Rightarrow b_3 = a_0'a_1a_2' + a_0a_1a_2' \Rightarrow b_3 = a_1a_2'$

$b_4$ : $\Rightarrow b_4 = 0$

$b_5$ :

| $a_0$ \ $a_1a_2$ | $a_1'a_2'$ | $a_1'a_2$ | $a_1a_2$ | $a_1a_2'$ |
|---|---|---|---|---|
| $a_0'$ | 0 | 1 | 1 | 0 |
| $a_0$ | 0 | 1 | 1 | 0 |

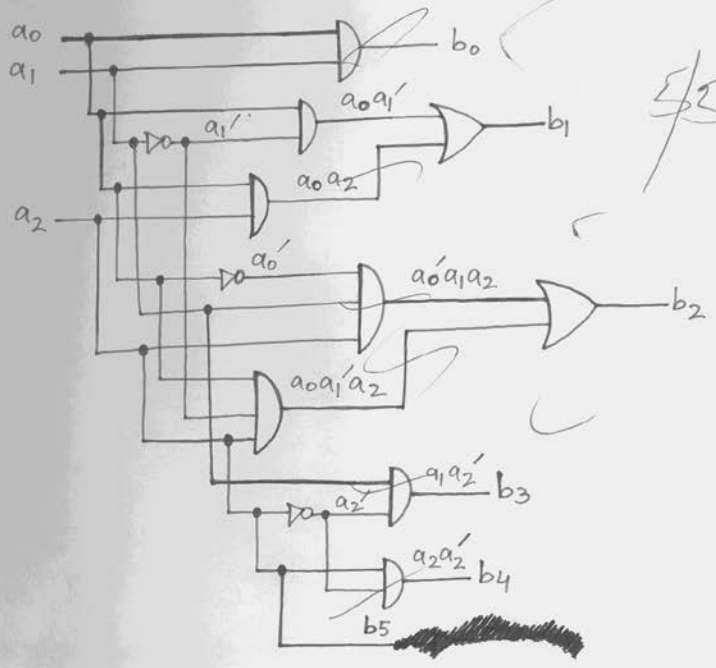
$\Rightarrow b_5 = a_2$



(Remaining part on page – 18)
(Sorry Please)

(Remaining part of Q-10)

CIRUIT DIAGRAM :




QUESTION – 11

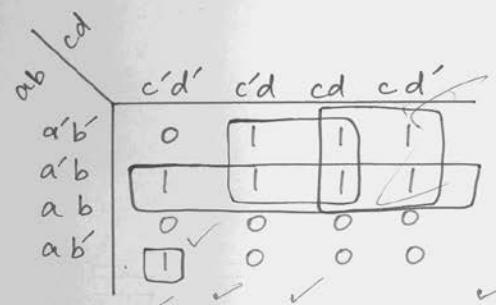
12. Design a combinational circuit whose I/P is a 4-bit No. and whose O/P is the 2's complement of I/P No.

ANS:

TRUTH TABLE :

| a | b | c | d | $F_1$ | $F_2$ | $F_3$ | $F_4$ |
|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 |
| 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 |
| 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 |
| 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 1 | 1 | 1 |
| 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 |
| 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |

$F_1 \Rightarrow$

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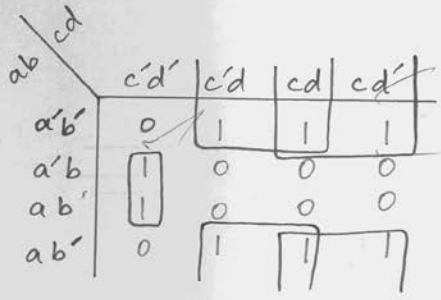
$\Rightarrow F_1 = a'd + a'c + a'b + ab'c'd'$

$F_2 \Rightarrow$

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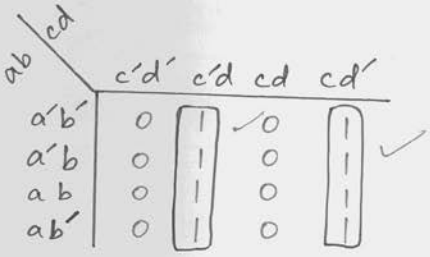
$\Rightarrow F_2 = b'd + b'c + bc'd'$

$F_3 \Rightarrow$

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$\Rightarrow F_3 = c'd + cd'$

$F_4 \Rightarrow$ $F_4 = d$ (from the truth table)

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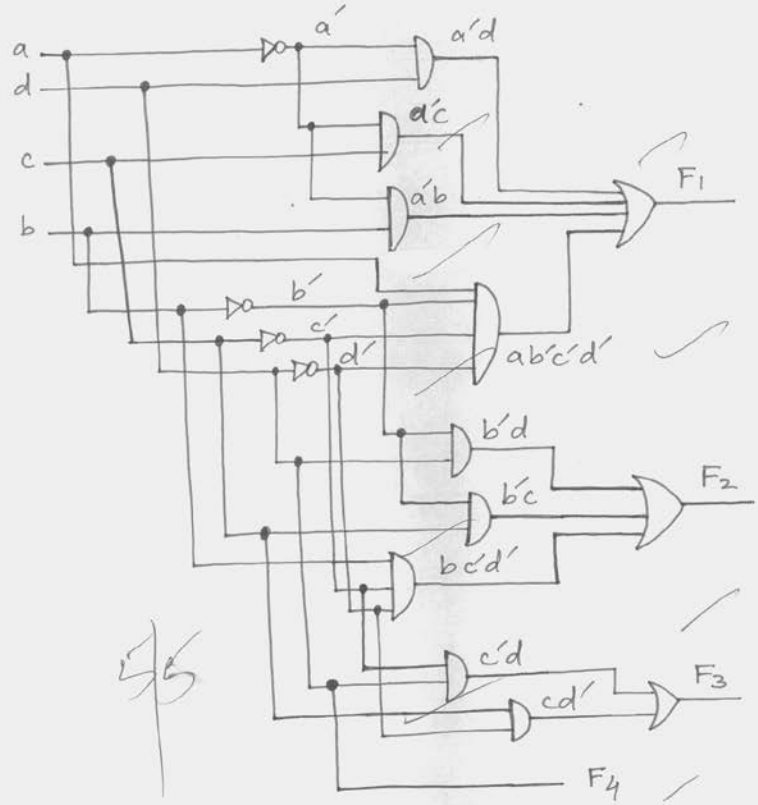
CIRCUIT DIAGRAM :



(20)

13. You as a System Engineer is given a project to construct a security system for a sensitive military zone. The conditions are as follows:

a) If it is night and door is opened or laser light is disturbed, alarm should go on.

b) In day time military is on duty, so there is no risk.

Develope the logic circuit to meet the above requirements.

ANS:

Let

Time (T) → Night → 0
Day → 1

Door (D) → Closed → 1
Open → 0

Laser (L) → Disturbed → 0
Not Disturbed → 1

& Alarm (A) → ON → 1
OFF → 0

TRUTH TABLE:

| T | D | L | A |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 1 |
| 0 | 1 | 0 | 1 |
| 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 |
| 1 | 1 | 0 | 0 |
| 1 | 1 | 1 | 0 |

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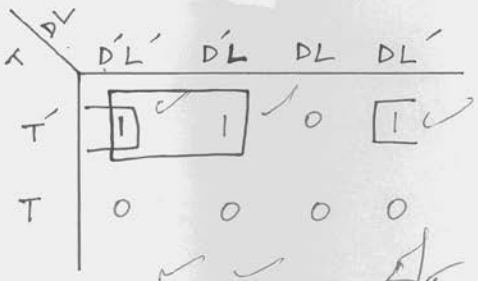
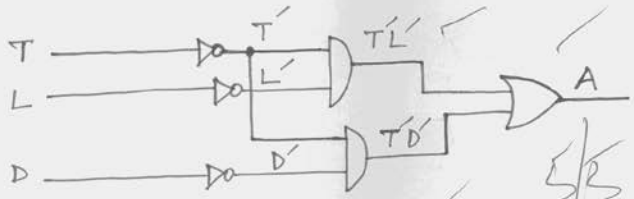
(10)

$\Rightarrow A = T'D'L' + T'D'L + T'DL'$




$\Rightarrow A = T'L' + T'D'$

CIRCUIT DIAGRAM:



**14.** Design a logic circuit to produce a HIGH o/p, only if the I/p, represented by a 4-bit binary No. is greater than 12 or less than 3. First develop the truth table & draw the logic diagram.

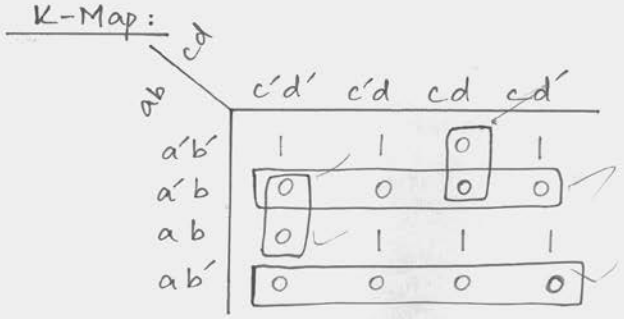
ANS:

Let High o/p → 1
Low o/p → 0
} F(a,b,c,d)

TRUTH TABLE:

| S.No. | a | b | c | d | F(a,b,c,d) |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 1 | 1 |
| 2 | 0 | 0 | 1 | 0 | 1 |
| 3 | 0 | 0 | 1 | 1 | 0 |
| 4 | 0 | 1 | 0 | 0 | 0 |
| 5 | 0 | 1 | 0 | 1 | 0 |
| 6 | 0 | 1 | 1 | 0 | 0 |
| 7 | 0 | 1 | 1 | 1 | 0 |
| 8 | 1 | 0 | 0 | 0 | 0 |
| 9 | 1 | 0 | 0 | 1 | 0 |
| 10 | 1 | 0 | 1 | 0 | 0 |
| 11 | 1 | 0 | 1 | 1 | 0 |
| 12 | 1 | 1 | 0 | 0 | 0 |
| 13 | 1 | 1 | 0 | 1 | 1 |
| 14 | 1 | 1 | 1 | 0 | 1 |
| 15 | 1 | 1 | 1 | 1 | 1 |

K-Map:

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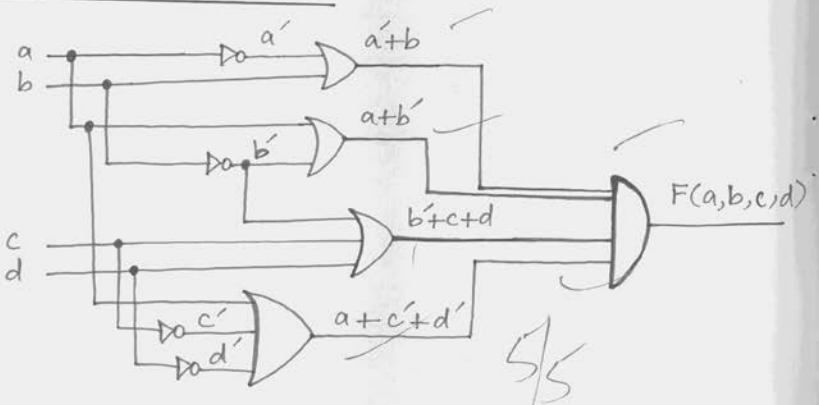
$\Rightarrow F' = ab' + a'b + bc'd' + a'cd$

$\Rightarrow F = (a'+b)(a+b')(b'+c+d)(a+c'+d')$

CIRCUIT DIAGRAM:

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**15.** Construct a logic ckt to meet the following requirements:

A battery-powered lamp in a room is to be operated from 2 switches, one at the back & one at the front door. The lamp is ON if front switch is ON & back switch is OFF, or if the front is OFF and the back is ON. The lamp is OFF if both switches are OFF or both are ON. Let a high O/P represents the ON & low represents the OFF condition.

**ANS:**

Let for

Back door S/W ⇒ B → ON → 1 ✓
OFF → 0 ✓

Front door S/W ⇒ F → ON → 1 ✓
OFF → 0 ✓

Lamp ⇒ L → ON → 1 ✓
OFF → 0 ✓

TRUTH TABLE:

| B | F | L (B,F) |
|---|---|---|
| 0 | 0 ✓ | 0 ✓ |
| 0 | 1 | 1 |
| 1 | 0 ✓ | 1 ✓ |
| 1 | 1 ✓ | 0 ✓ |

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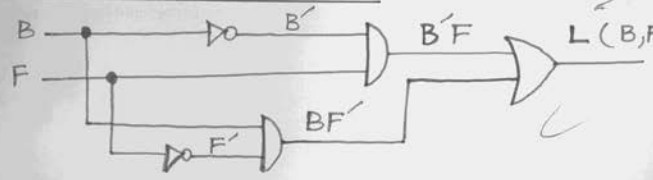
⇒ $L(B,F) = B'F + BF'$ ✓

CIRCUIT DIAGRAM:

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16. Design a logic circuit that produces '1' only when the No. of 1's in a set of 3 I/P variables A, B, C is even. (Even Parity checker)

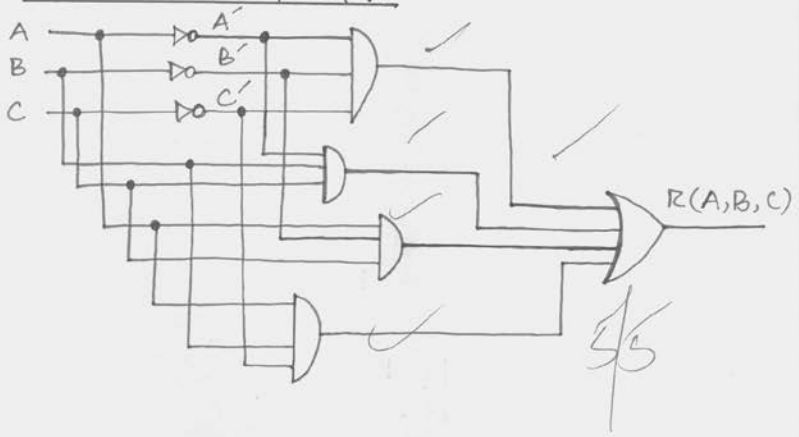
ANS:

TRUTH TABLE:

| A | B | C | R(A,B,C) |
|---|---|---|---|
| 0 | 0 | 0 | 1 |
| 0 | 0 | 1 | 0 |
| 0 | 1 | 0 | 0 |
| 0 | 1 | 1 | 1 |
| 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 1 |
| 1 | 1 | 0 | 1 |
| 1 | 1 | 1 | 0 |

$\Rightarrow R(A,B,C) = A'B'C' + A'BC + AB'C + ABC'$

CIRCUIT DIAGRAM:




(15)

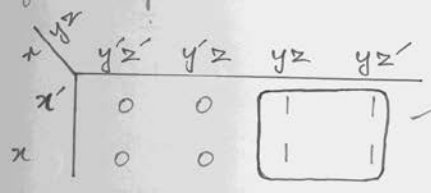
**17.** Obtain the simplified expressions in SOP :

(a). $F(x, y, z) = \Sigma m(2,3,6,7)$

Let $F = m2 + m3 + m6 + m7$

$\Rightarrow F = x'yz' + x'yz + xyz' + xyz$

Using K-Map:

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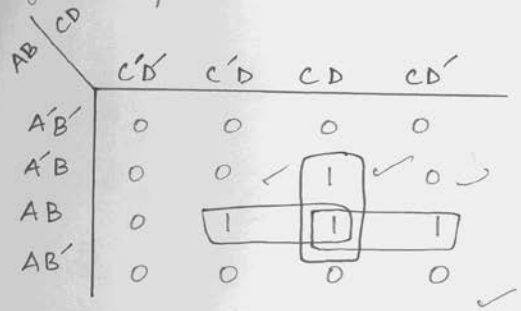
$\Rightarrow F(x, y, z) = y$

(b). $F(A, B, C, D) = \Sigma m(7,13,14,15)$

Let $F = m7 + m13 + m14 + m15$

$\Rightarrow F = A'BCD + ABC'D + ABCD' + ABCD$

Using K-Map :

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$\Rightarrow F(A, B, C, D) = ABD + ABC + BCD$

(c). $F(A, B, C, D) = \Sigma m(4,6,7,15)$

Let $F = m4 + m6 + m7 + m15$

$\Rightarrow F = A'BC'D + A'BCD' + A'BCD + ABCD$

Using K-Map :

| AB \ CD | C'D' | C'D | CD | CD' |
|---|---|---|---|---|
| A'B' | 0 | 0 | 0 | 0 |
| A'B | 1 | 0 | 1 | 1 |
| AB | 0 | 0 | 1 | 0 |
| AB' | 0 | 0 | 0 | 0 |

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$\Rightarrow F(A,B,C,D) = A'BD' + BCD$

(d). $F(w,x,y,z) = \Sigma m(2,3,12,13,14,15)$

Let $F = m_2 + m_3 + m_{12} + m_{13} + m_{14} + m_{15}$

$\Rightarrow F = w'x'yz' + w'x'yz + wxy'z' + wxy'z + wxyz' + wxyz$

Using K-Map:

| wx \ yz | y'z' | y'z | yz | yz' |
|---|---|---|---|---|
| w'x' | 0 | 0 | 1 | 1 |
| w'x | 0 | 0 | 0 | 0 |
| wx | 1 | 1 | 1 | 1 |
| wx' | 0 | 0 | 0 | 0 |

5/5

$\Rightarrow F(w,x,y,z) = wx + w'x'y$

(e). $F(x,y,z) = xy + x'y'z' + x'yz'$

Let $F = xyz + xyz' + x'y'z' + x'yz'$

Using K-Map:

| x \ yz | y'z' | y'z | yz | yz' |
|---|---|---|---|---|
| x' | 1 | 0 | 0 | 1 |
| x | 0 | 0 | 1 | 1 |

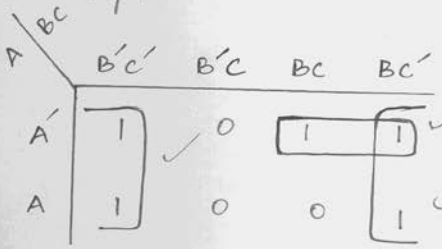
5/5

$\Rightarrow F(x,y,z) = x'z' + xy$

(f) $F(A,B,C) = A'B + BC' + B'C'$

Let $F = A'BC + A'BC' + ABC' + A'BC' + AB'C' + A'B'C'$

Using K-Map:

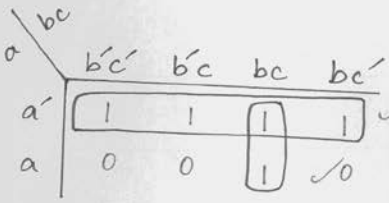



$\Rightarrow F(A,B,C) = C' + A'B$

(g). $F(a,b,c) = a'b' + bc + a'bc'$

Let $F = a'b'c + a'b'c' + abc + a'bc + a'bc'$

Using K-Map:

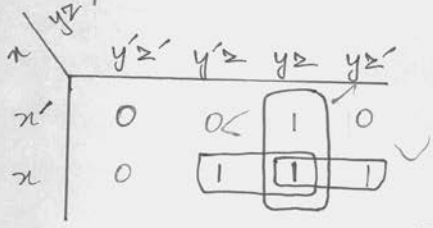



$\Rightarrow F(a,b,c) = a' + bc$

(h). $F(x,y,z) = xy'z + xyz' + x'yz + xyz$

Let $F = xy'z + xyz' + x'yz + xyz$

Using K-Map:





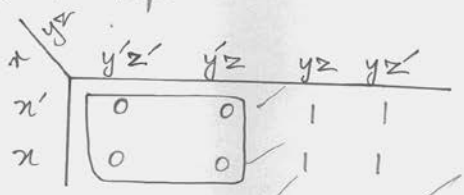

$\Rightarrow F(x,y,z) = yz + xy + xz$

18. Obtain the simplified expressions in POS:

a). $F(x,y,z) = \pi M(0,1,4,5)$

Let $F = M_0 M_1 M_4 M_5$

Using, K-Map:

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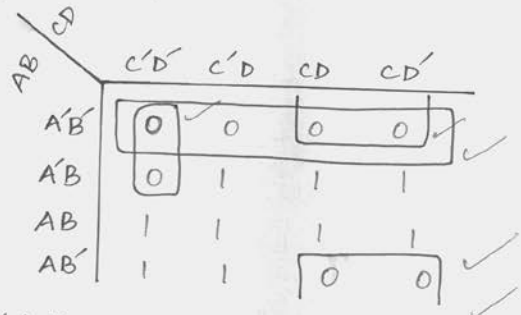
$\Rightarrow F'(x,y,z) = y' \Rightarrow F(x,y,z) = y$

b). $F(A,B,C,D) = \pi M(0,1,2,3,4,10,11)$

Let $F = M_0 M_1 M_2 M_3 M_4 M_{10} M_{11}$

Using K-Map:




5/5

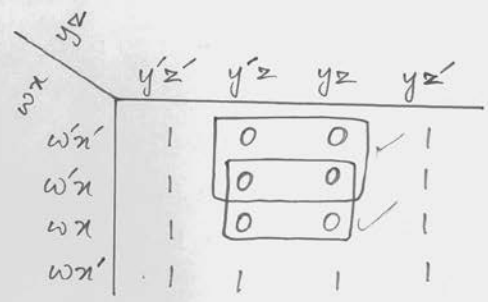
$\Rightarrow F'(A,B,C,D) = A'C'D' + A'B' + B'C$

So, $\Rightarrow F(A,B,C,D) = (A+C+D)(A+B)(B+C')$

c). $F(w,x,y,z) = \pi M(1,3,5,7,13,15)$

Let $F = M_1 M_3 M_5 M_7 M_{13} M_{15}$

Now, using K-Map:




$\Rightarrow F'(w,x,y,z) = w'z + xz$

$\therefore F(w,x,y,z) = (w+z')(x'+z')$

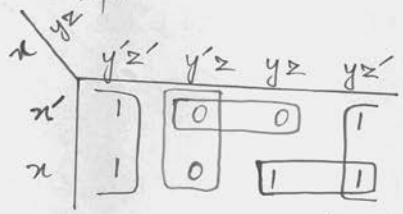
---

**19.** Obtain the simplified expressions in (1) SOP, (2) POS

a). $F(x,y,z) = x'z' + y'z' + yz' + xyz$

Let $F = x'yz' + x'y'z' + xy'z' + x'y'z' + xyz' + x'yz' + xyz$

Using K-Map:




(1) $\Rightarrow F = z' + xy$ --- SOP

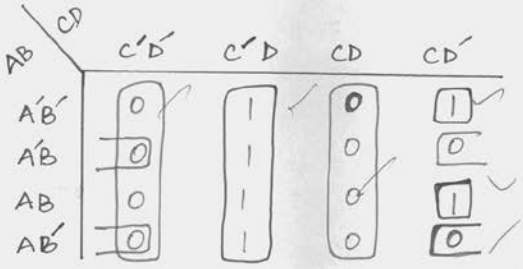
(2) $\Rightarrow F' = y'z + x'z$

$\Rightarrow F = (y+z')(x+z')$ --- POS

b). $F(A,B,C,D) = (A+B'+D)(A'+B+D)(C+D)(C+D')$

Let $F = (A+B'+C+D)(A+B'+C'+D)(A'+B+C+D)$
$(A'+B+C'+D)(A+B+C+D)(A'+B+C+D)$
$(A+B'+C+D)(A'+B'+C+D)(A+B+C'+D')$
$(A'+B+C'+D')(A+B'+C'+D')(A'+B'+C'+D')$

Using K-Map:




(1) $\Rightarrow F = C'D + A'B'CD' + ABCD$ --- SOP

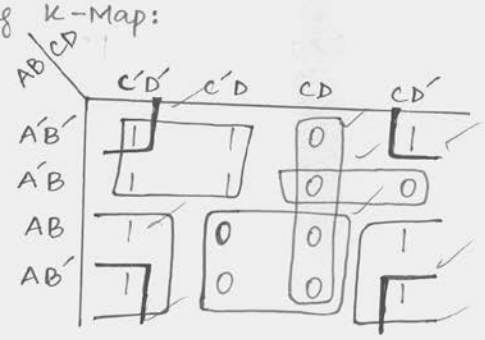
(2) $\Rightarrow F' = C'D' + CD + A'BD' + AB'D'$

$\Rightarrow F = (C+D)(C'+D')(A+B'+D)(A'+B+D)$ --- POS

c). $F(A,B,C,D) = (A'+B'+D')(A+B'+C')$
$(A'+B+D')(B+C'+D')$

Let $F = (A'+B'+C+D')(A'+B'+C'+D')$
$(A+B'+C'+D)(A+B'+C'+D')$
$(A'+B+C+D')(A'+B+C'+D')$
$(A+B+C'+D')(A'+B+C'+D')$

Using K-Map:




(51)

(1) $\Rightarrow F = B'D' + A'C' + AD'$ ✓ --- SOP 5/5

(2) $\Rightarrow F' = CD + AD + A'BC$ ✓

$\Rightarrow F = (C'+D')(A'+D')(A+B'+C')$ --- POS 5/5

d). $F(A,B,C,D) = (A'+B'+D)(A'+D')(A+B+D')$
$(A+B'+C+D)$

Let $F = (A'+B'+C+D)(A'+B'+C'+D)$
$(A'+B+C+D')(A'+B+C'+D')$
$(A'+B'+C+D')(A'+B'+C'+D)$
$(A+B+C+D')(A+B+C'+D')$
$(A+B'+C+D)$

Using K-Map:

| AB \ CD | C'D' | C'D | CD | CD' |
|---|---|---|---|---|
| A'B' | 1 | 0 | 0 | 1 |
| A'B | 0 | 1 | 1 | 1 |
| AB | 0 | 0 | 0 | 0 |
| AB' | 1 | 0 | 0 | 1 |

5/5

(1) $\Rightarrow F = B'D' + A'BC + A'BD$ --- SOP

(2) $\Rightarrow F' = BC'D' + AB + B'D$ ✓ 5/5

$\Rightarrow F = (B'+C+D)(A'+B')(B+D')$ --- POS

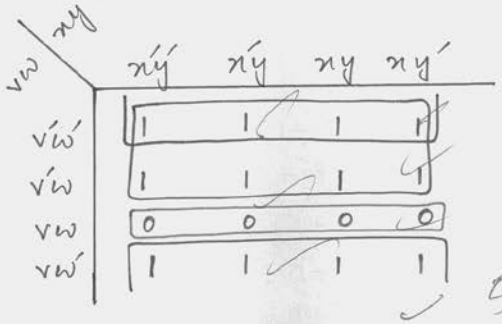
e). $F(v,w,x,y) = w'y + vw' + vw'x + v'w + vw'y'$

Let $F = vw'y + v'w'y + vw'x + vw'x'$
$+ vw'xy + vw'xy' + v'wx + v'wx'$
$+ v'w'xy + v'w'xy'$

$\Rightarrow F = vw'xy + vw'x'y + v'w'xy + v'w'x'y$
$+ vw'xy + vw'xy' + vw'x'y + vw'x'y'$
$+ vw'xy + vw'xy' + v'wxy + v'wxy'$
$+ v'wx'y + v'wx'y' + v'w'xy' + v'w'x'y'$

(52)

Using K-Map:




5/5

(1) ⇒ F = w' + v' --- SOP

(2) ⇒ F' = vw ✓ 5/5

So, ⇒ F = v' + w' --- POS

---

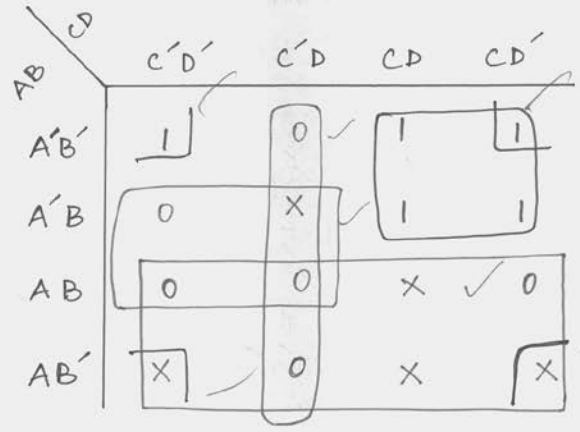
**20.** Simplify the following functions using the don't care conditions 'd' in (1) SOP (2) POS

a). $F(A,B,C,D) = A'B'D' + A'CD + A'BC$

$d = A'BC'D + ACD + AB'D'$

Let $F = A'B'CD' + A'B'C'D' + A'BCD + A'B'CD + A'BCD + A'BCD'$

& $d = A'BC'D + ABCD + AB'CD + AB'CD' + ABC'D'$



(1) $\Rightarrow F = A'C + B'D'$ --- SOP

(2) $\Rightarrow F' = C'D + BC' + A$

so, $\Rightarrow F = (C+D')(B'+C)A'$ --- POS

b). $F(w,x,y,z) = w'(x'y + x'y' + xyz) + x'z'(y+w)$

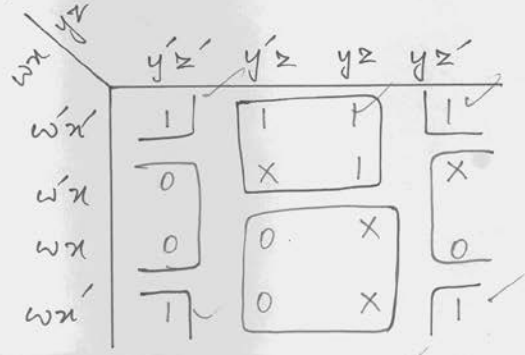
$d = w'x(y'z + yz') + wyz$

Let $F = w'x'y + w'x'y' + w'xyz + x'yz' + x'wz'$

$\Rightarrow F = w'x'yz + w'x'yz' + w'x'y'z + w'x'y'z'$
$+ w'xyz + wx'yz' + w'x'yz' + wx'yz' + wx'y'z'$

eq $d = w'xy'z + w'xyz' + wxyz + wx'yz$

using K-Map:




(1) $\Rightarrow F = x'z' + w'z$ --- SOP

(2) $\Rightarrow F' = xz' + wz$

so, $\Rightarrow F = (x'+z)(w'+z')$ --- POS

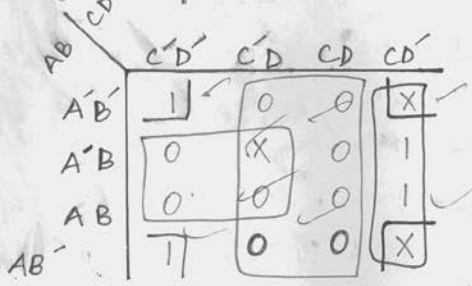
c). $F(A,B,C,D) = B'C'D' + BCD + ABCD'$

$d = B'CD' + A'BC'D$

Let $F = AB'C'D' + A'B'C'D' + ABCD' + A'BCD$
$+ ABCD'$

eq $d = AB'CD' + A'B'CD' + A'BC'D$

Using K-Map:




(1) ⇒ F = B'D' + CD' ___ SOP

(2) ⇒ F' = BC' + D

So, ⇒ F = D'(B'+C) ___ POS

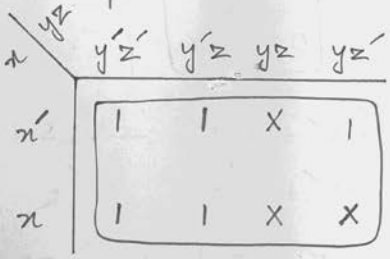
d). F(x,y,z) = y' + x'z' , d = yz + xy

Let F = xy' + x'z'y + x'z'y' + x'y'

⇒ F = xy'z + xy'z' + x'yz' + x'y'z'
+ x'y'z + x'yz'

& d = xyz + x'yz + xyz + xyz'

using K-Map:




(1) ⇒ F = 1 ___ SOP

(2) ⇒ F' = 0

⇒ F = 1 ___ POS