Number with different Bases

Decimal base 10	Binary base 2	Octal base 8	Hexadecimal base 16
00	0000	00	0
01	0001	01	1
02	0010	02	2
03	0011	03	3
04	0100	04	4
05	0101	05	5
06	0110	06	6
07	0111	07	7
08	1000	10	8
09	1001	11	9
10	1010	12	10 – A
11	1011	13	11 – B
12	1100	14	12 – C
13	1101	15	13 – D
14	1110	16	14 – E
15	1111	17	15 – F

Base (or) radix

In general a number expressed in base r system has co-efficients multiplied by powers of r:

$$a_n r^n + a_{n-1} r^{n-1} + \dots + a_2 r^2 + a_1 r^1 + a_0 r^0 + a_{-1} r^{-1} + a_{-2} r^{-2} + \dots + a_{-n} r^{-n}$$

The coefficients of range in value from 0 to r-1.

Ex. decimal $(30)_{10}$ binary $(1011)_2$ octal $(23)_8$

Hexadecimal $(5A)_{16}$ base 5 $(4021)_5$

① Convert 41 into binary & octal & Hexadecimal

$$
\begin{array}{r|l}
2 & 41 \\
2 & 20 - 1 \\
2 & 10 - 0 \\
2 & 5 - 0 \\
2 & 2 - 1 \\
 & 1 - 0
\end{array}
$$

$(41)_{10} = (101001)_2$

$= \underline{101}\ \underline{001}$

$= 5\ \ 1 = (51)_8$

$$
\begin{array}{r|l}
8 & 41 \\
 & 5 - 1
\end{array}
$$

$= (51)_8$

$= \underline{10}\ \underline{1001} = (29)_H$

$$
\begin{array}{r|l}
16 & 41 \\
 & 2 - 9
\end{array}
$$

$= (29)_{16} = 29_H$

② Convert $(0.6875)_{10}$ to binary

$0.6875 \times 2 = 1.3750 = 1$

$0.3750 \times 2 = 0.7500 = 0$

$0.75 \times 2 = 1.50 = 1$

$0.50 \times 2 = 1.00 = 1$

$(0.6875)_{10} = (\cancel{a}1011)_2 = (0.1011)_2$

③ Convert $(0.513)_{10}$ to octal

$0.513 \times 8 = 4.104$

$0.104 \times 8 = 0.832$

$0.832 \times 8 = 6.656$

$0.656 \times 8 = 5.248$

$0.248 \times 8 = 1.984$

$0.984 \times 8 = 7.872$

$(0.513)_{10} = (0.406517)_8$

④ $(41.6875)_{10}$ — fractional seperate.

decimal separate +

$(41.6875)_{10} = (101001.1011)_2$

⑤ $(101001.1011)_2$ convert to decimal

101001

$1 \times 2^0 = 1 \times 1 = 1$

$0 \times 2^1 = 0 \times 2 = 0$

$0 \times 2^2 = 0 \times 4 = 0$

$1 \times 2^3 = 1 \times 8 = 8$

$0 \times 2^4 = 0 \times 16 = 0$

$1 \times 2^5 = 1 \times 32 = 32$

41

0.1011

$1 \times 2^{-1} = 1 \times 0.5 = 0.5$

$0 \times 2^{-2} = 0 \times 0.25 = 0.0$

$1 \times 2^{-3} = 1 \times 0.125 = 0.125$

$1 \times 2^{-4} = 1 \times 0.0625 = 0.0625$

$= 0.6875$

Binary Arithmetil

A	B	Sum	Carry
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

① Add 28 & 15 in binary

$$
\begin{array}{r|l}
2 & 28 \\
2 & 14 - 0 \\
2 & 7 - 0 \\
2 & 3 - 1 \\
 & 1 - 1
\end{array}
\qquad
\begin{array}{r|l}
2 & 15 \\
2 & 7 - 1 \\
2 & 3 - 1 \\
 & 1 - 1
\end{array}
$$

$(28)_{10} = 11100$

$(15)_{10} = 1111$

$$
\begin{array}{r}
1\;\;\;\; \\
11100 \\
1111 \\
\hline
101011
\end{array}
$$

② Binary Subtraction

Rules

A	B	Diff	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

subtract $(0101)_2$ from $(1011)_2$

$$
\begin{array}{rl}
1011 & \text{— Decimal } 11 \\
-\;0101 & \text{— Decial } 5 \\
\hline
0110 & \text{— Decimal } 6
\end{array}
$$

Binary Multiplication

Rules :

0x0 = 0

0x1 = 0

1x0 = 0

1x1 = 01

Ex. 011 X 110

$$
\begin{array}{r}
000 \\
011\;\; \\
011\;\;\;\; \\
\hline
10010
\end{array}
$$

Ex:2 1110 X1010

= 10001100

Binary division

Rules

$0 \div 1 = 0$

$1 \div 1 = 1.$

Ex. 1 ⇒ Divide $(11011011)_2$ by $(110)_2$

```
        100100
     ┌──────────
 110 │ 11011011
       110
     ──────────
       000110
          110
       ────────
          00011
       ──────
```

Ex 2: Divide (110101101) by $(101)_2$

```
         1010101
     ┌───────────
 101 │ 110101101
       101
     ─────────
       0110
        101
      ────────
         0111
          101
        ────────
          01001
             101
          ────────
             100
          ─────────
```

Signed Binary numbers

Unsigned numbers represent only magnitude

Signed numbers :→ MSB represents the sign

MSB = 0 ⇒ +ve number & MSB = 1 ⇒ -ve number

For 8 bit number

MSB ← → LSB

D7	B6	B5	B4	B3	B2	B1	B0

$\underbrace{\text{D7}}_{\text{sign}}\ \underbrace{\text{B6 B5 B4 B3 B2 B1 B0}}_{\text{magnitude}}$

	sign				magnitude			
+6 =	0	0	0	0	0	0	1	0
-14 =	1	0	0	0	1	1	1	0
+24 =	0	0	0	1	1	0	0	0
-64 =	1	1	0	0	0	0	0	0

8 bit binary numbers decimal range 0 to 255

Incase signed 8 bits binary " " +127 to -128

Maximum positive number = +127 = 0111 1111

Maximum negative number = -128 = 11111111

$\boxed{\text{-128 represented as } 10000000}$ ⊛

1's complement representation

change all 1's to zero & All 0's to 1.

① Find 1's complement of $(1101)_2 \Rightarrow (0010)_2$

② $(10111001)_2 \Rightarrow (01000110)_2$

2's Complement Representation

2's complement = 1's Complement +1

2's complement form is used to represent -ve no

① Find 2's Complement of. $(1001)_2$.

1's complement 0110
$+\ 1$

0111 2's complement

② Find 2's complement of $(1010\ 0011)_2$.

1010 0011 number

0101 1100 1's complement
$+\ \ \ \ \ 1$

0101 1101 ⇒ 2's Complement

1's complement subtraction

(i) Subtraction of smaller Number from larger number

Method

1. Determine the 1's complement of smallest no.
2. Add the 1's complement to the larger no
3. Remove the carry & add it to the result

This is called end-around carry

EX ① subtract 001011_2 from 111001_2

~~111001~~
~~01 10~~

111001 (+)
1's comp 010100
end around carry ← (1)001101
$+\ 1$
001110 - Final answer

Subtraction of Larger Number from Small number

1. Determine the 1's Complement of Larger number.
2. Add the 1's complement ~~of~~ to the smaller number.
3. Answer in 1's complement Form. To get the answer in true form take the 1's complement & assign negative sign to the answer.

Ex Subtract 111001_2 from 101011_2 using 1's Complement method:

```
                    101011
1's complementofno: 000110
                    ------
                    110001  ← Answer in 1's
                              comp form
                    ------
                  - 001110  ← true Ans (After 1's comp)
                    ------
```

Advantages of 1's complement subtraction

- This is accomplished with an binary adder ∴ This is Useful in arithmetic Logic circuits
- 1's complement of a number is easily obtained by inverting each bit in the number.

2's Complement subtraction

① Subtraction of smaller Number from Larger Number

Method 1. Determine the 2's complement of a smaller number

2. Add the 2's complement to the larger number

3. Discard the carry.

Ex subtract $(101011)_2$ from $(111001)_2$ using 2's Complement method.

no : 111001

2's comp : 010101

Discard (1) 001110

001110 – Final answer.

010100
1 +
010101

Subtraction of larger Number from smaller Number

Method :

1. Determine the 2's comp of larger no
2. Add the 2's comp to the smaller no
3. Answer in 2's comp form. To get the answer in the true form take the 2's complement & assign negative sign to the answer.

Ex subtract $(111001)_2$ from $(101011)_2$ using 2's Complement method.

no : 101011

2's comp : 000111

110010 – Ans 2's comp form

000110
1 +
000111

110010
1 (–)
110001

1's comp 001110

∴ – 001110

Answer

Gate level minimization

Binary Codes

The digital data is represented, stored & transmitted as groups of binary digits (bits). The group of bits, also known as binary code represented as both numbers & letters of the alphabets as well as many special characters & control functions.

Classification of Binary codes

① weighted codes:

Each digit position of the number represented a specific weight

Ex :- 567 ⇒ weight of 5 is 100 & 6 is 10 & 7 is 1.

8421, 2421, 5211 are weighted codes.

② Non weighted codes

- are not assigned with any weight to each digit position.

Ex: Excess-3 & gray codes are non weighted code

③ Reflective codes

A code is said to be reflective when the code for 9's complement must be found. (Reflecting) 2421, 5211 & excess 3 codes are reflective 8421 is not

④ Sequential codes:

- succeeding code is one binary number greater than its preceding code.

8421 & excess 3 are sequential.

⑤ Alphanumeric codes

Codes which contain both numbers & alphabetic characters are called alphanumeric codes.

Most commonly used codes are:

ASCII - American standard code for Information Interchange

EBCDIC - Extended Binary coded decimal Interchange code

Hollerith code.

⑥ Error detecting & correcting codes

When the digital information in the binary form is transmitted from one circuit or system to another circuit or system an error may occur. This means a signal corresponding to 0 may change 1 or vice versa due to presence of noise. To maintain the data Integrity between transmitter & Receiver extra bit or more than one bit are added in the data. These extra bits allow the detection & some times correction of error in the data. The data along with the extra bit/bits forms the code.

- codes which allow only error detection are called error detecting codes & codes which allow error detection & correction are called error detecting & correcting code.

Binary coded decimal (BCD) (8421)

- most common code 8421 BCD (4-bit)
- Called 8421 BCD because the weights associated with 4 bits are 8421 from Left to right.

Decimal digit	BCD code 8421	2421	7421
0	0000	0000	0000
1	0001	0001	0001
2	0010	0010	0010
3	0011	0011	0011
4	0100	0100	0100
5	0101	1011	0101
6	0110	1100	0110
7	0111	1101	1000
8	1000	1110	1001
9	1001	1111	1010

Excess-3 code

- Excess 3 code modified form of BCD number.
- The Excess 3 code can be derived from the natural BCD code by adding 3 to each coded number

Decimal degit	Excess 3		
0	0011	6	1001
1	0100	7	1010
2	0101	8	1011
3	0110	9	1100
4	0111		
5	1000		

In excess 3 code we get 9's complement of a number by just complementing each bit. Due to this excess 3 code is called <u>self complementing</u> code.

Gray code

- Gray code is a special case of unit distance code.
- In unit distance code bit patterns for two consecutive numbers differ in only one bit position. These codes are also called cyclic codes.

Decimal code	Gray code
0	0000
1	0001
2	0011
3	0010
4	0110
5	0111
6	0101
7	0100
8	1100
9	1101
10	1111
11	1110
12	1010
13	1011
14	1001
15	1000

Gray code any two adjacent code groups differ only in one bit position. The gray code is also called reflected code.

Binary to gray conversion

Ex: Convert 10111011 in binary to equivalent graycode

Binary 1→0→1→1→1→0→1→1

Gray 1 1 1 0 0 1 1 0

Gray to binary

convert gray code 101011 into its binary equivalant.

Gray code : 1 0 1 0 1 1

Binary : 1 1 0 0 1 0

Gate Level minimization:

Usually literals (Boolean variables) & terms are arranged in one of the two standard forms of equations (i) Sum of product form (SOP)

(ii) Product of sum form (POS)

Sum of product :- (SOP)

(i) $ABC + A\bar{B}\bar{C}$

(ii) $\bar{P}Q + Q\bar{R} + PQR$

Product of sum : (POS)

(i) $(A+B)(B+\bar{C})$

(ii) $(X+Y)(Y+\bar{Z})(Z+X)$

Canonical Logic Forms

- Sum of Products is Canonical (standard) sum of products if every product term involves every literal or its complement.

$SOP = AB + BC + ABC$

Canonical (standard) $SOP = AB\bar{C} + ABC + A\bar{B}C + \bar{A}BC$

" $POS = (A+B+C)(A+\bar{B}+C)$

Example: convert the given expression in canonical SOP.

$Y = AC + AB + BC$

$= AC(B+\bar{B}) + AB(C+\bar{C}) + BC(A+\bar{A})$

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

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

(2) Convert the given expression in canonical SOP form.

$Y = A + AB + ABC$

$= A(B+\bar{B})(C+\bar{C}) + AB(C+\bar{C}) + ABC$

$= (AB + A\bar{B})(C+\bar{C}) + ABC + AB\bar{C} + ABC$

$= ABC + AB\bar{C} + A\bar{B}C + A\bar{B}\bar{C} + ABC + ABC$

$= ABC + AB\bar{C} + A\bar{B}C + A\bar{B}\bar{C}$

(3) Convert the given Expression in Canonical POS form

$Y = (A+B)(B+C)(A+C)$

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

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

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

④ $Y = A(A+B)(A+B+C)$

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

$= \cancel{(A+B)(A+\bar{B}) + C.\bar{C}}$

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

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

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

Minterms & Max terms:

Each individual term in canonical SOP form is called minterm & Each individual term in canonical POS form is called maxterm.

For n variable logical function there are 2^n minterms & equal number of maxterms. For 3 variables/literals minterm = maxterm = $2^3 = 8$.

Variables			Minterms	Maxterms
A	B	C	m_i	M_i
0	0	0	$\bar{A}\bar{B}\bar{C} = m_0$	$A+B+C = M_0$
0	0	1	$\bar{A}\bar{B}C = m_1$	$A+B+\bar{C} = M_1$
0	1	0	$\bar{A}B\bar{C} = m_2$	$A+\bar{B}+C = M_2$
0	1	1	$\bar{A}BC = m_3$	$A+\bar{B}+\bar{C} = M_3$
1	0	0	$A\bar{B}\bar{C} = m_4$	$\bar{A}+B+C = M_4$
1	0	1	$A\bar{B}C = m_5$	$\bar{A}+B+\bar{C} = M_5$
1	1	0	$AB\bar{C} = m_6$	$\bar{A}+\bar{B}+C = M_6$
1	1	1	$ABC = m_7$	$\bar{A}+\bar{B}+\bar{C} = M_7$

With these shorthand notations logical function can be represented as

1. $Y = \bar{A}\bar{B}\bar{C} + \bar{A}\bar{B}C + \bar{A}BC + AB\bar{C}$

$= m_0 + m_1 + m_3 + m_6 = \Sigma m(0,1,3,6)$ → denotes sum of product

2. $Y = (A+B+\bar{C})(A+\bar{B}+\bar{C})(\bar{A}+\bar{B}+C)$

$= M_1 + M_3 + M_6 = \Pi M(1,3,6)$ → Product of sum.

Karnaugh Map Simplification

- For simplification of boolean expressions by boolean algebra we need better understanding of boolean laws, rules & theorems.
- Time consuming process
- map method gives us a systematic approach for simplifying a Boolean expression. The map method first proposed by Veitch and modified by Karnaugh hence it is known as the Veitch diagram or Karnaugh map. [Kmap]

2 Variables (4 cells)

A \ B	0	1
0	m_0	m_1
1	m_2	m_3

3 Variables (8 cells)

A \ BC	00	01	11	10
0	m_0	m_1	m_3	m_2
1	m_4	m_5	m_7	m_6

4 Variables (16 cells)

AB \ CD	00	01	11	10
00	m_0	m_1	m_3	m_2
01	m_4	m_5	m_7	m_6
11	m_{12}	m_{13}	m_{15}	m_{14}
10	m_8	m_9	m_{11}	m_{10}

2 variable K MAP

$f = \Sigma m(0,2,3)$ $\xrightarrow{SOP}$

(1)

A \ B	0	1
0	$\bar{A}\bar{B}_0$	$\bar{A}B_1$
1	$A\bar{B}_2$	AB_3

A \ B	0	1
0	1_0	0
1	1_2	1_3

$= f = \bar{B} + A = A + \bar{B}$

(2)

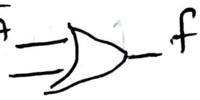
$f = \bar{A}\bar{B} + \bar{A}B + AB$ using mapping.

$\quad\;\; 00 \qquad 01 \qquad 11$

$f = m_0 + m_1 + m_3 = \Sigma m(0,1,3)$

A \ B	0	1
0	1	1
1	0	1

$f = \bar{A} + B.$

$= \bar{A}$, B  f

(3)

Mapping POS form.

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

$f = \pi(0,2,3)$

A \ B	0	1
0	0_0	01_1
1	0_2	0_3

$\bar{f} = \bar{B} + A \Rightarrow \bar{A} \cdot B$

$f = \overline{A + \bar{B}}.$

$= \bar{A} \cdot \bar{\bar{B}}$

$= \bar{A} \cdot B$

$\bar{A}$, B 

Reduce the following expression $f = (A+B)(A+\bar{B})(\bar{A}+\bar{B})$

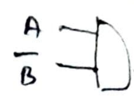
$= \pi M(0, 1, 3)$

A \ B	0	1
0	0	0
1	1	0

$\Rightarrow \bar{A}+\bar{B}$

$\Rightarrow \bar{f} = \bar{A} + B$

$f = A\bar{B}$



Three Variable K Map

Sum of products

(4) Map the expression $f = \bar{A}\bar{B}C + A\bar{B}C + \bar{A}B\bar{C} + \dots$

001 m_1, 101 m_5, 010 m_2

A \ BC	00	01	11	10
0	0	1	0	1
1	0	1	1	1

$f = \bar{B}C + AC + B\bar{C}$

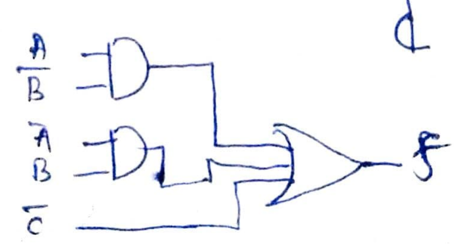
(5) Reduce the expression $f = \Sigma m(0,2,3,4,5,6)$ using map & Implement it in AOI Logic.

$f = \Sigma m(0, 2, 3, 4, 5, 6)$

A \ BC	00	01	11	10
0	1	0	1	1
1	1	1	0	1

$f_{min} = \mathrm{I} + \mathrm{II} + \mathrm{III}$

$\Rightarrow \bar{C} + \bar{A}B + A\bar{B}$



5 Variables POS

Ex.

$F = \prod M(2,3,7,8,9,10,11,12,16,17,18,19,20,21,23,26,27)$

A = 0

BC \ DE	00	01	11	10
00			0	0
01			0	
11	0			
10	0	0	0	0

A = 1

BC \ DE	00	01	11	10
00	0	0	0	0
01	0	0	0	
11				
10			0	0

$m_{2,3,19,18,11,10,26,27} \rightarrow \bar{C}D = (C+\bar{D})$

$16,17,20,21 \rightarrow A\bar{B}\bar{D} = (\bar{A}+B+D)$

$8,9,11,10 \rightarrow \bar{A}B\bar{C} = (A+\bar{B}+C)$

$3,7,19,23 \rightarrow \cancel{ABDE} = \cancel{(\bar{A}+\bar{B}+\bar{E})}\ \bar{B}DE = (B+\bar{D}+\bar{E})$

$8,12 \rightarrow \bar{A}B\bar{D}\bar{E} = (A+\bar{B}+D+E)$

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

Logic diagram

Ex. ① minimize the expression using Kmap.

3/26/19

$Y = A\bar{B}C + \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}\bar{C} + \bar{A}\bar{B}\bar{C}$

101 001 100 011 000

step ① : plot the K map according to the given expression.

A \ BC	00	01	11	10
0	1 (0)	1 (1)	1 (3)	0 (2)
1	1 (4)	1 (5)	0 (7)	0 (6)

I, II

1. octet 1's
2. quad 1's
3. pair of 1's
4. isolated 1's

step ② no octet & group quad 1's

step ③ Group pair of 1's

step ④ no Isolated one's

step ⑤ All 1's grouped

step ⑥ Final Expression

$Y = I + II$

$= \bar{B} + \bar{A}C$

$\boxed{\therefore Y = \bar{B} + \bar{A}C}$

EX: 2 minimize the expression

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

0100 0101 1100 1101 1001 0010

① Plot the Kmap

② quad 1's grouped

③ pair 1's grouped

④ Isolated 1's grouped

AB \ CD	00	01	11	10
00	0 (0)	0 (1)	0 (3)	1 (2)
01	1 (4)	1 (5)	0 (7)	0 (6)
11	1 (12)	1 (13)	0 (15)	0 (14)
10	0 (8)	1 (9)	0 (11)	0 (10)

I, II, III

$Y = I + II + III$

$\boxed{Y = B\bar{C} + A\bar{C}D + \bar{A}\bar{B}C\bar{D}}$

(3) Reduce the following function using Karnaugh map technique & Implement using basic gates.

$$f(A,B,C,D) = \bar{A}\bar{B}D + AB\bar{C}\bar{D} + \bar{A}BD + AB\ldots$$

Note: The given function is not in the standard SOP form. So It's converted into SOP form.

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

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

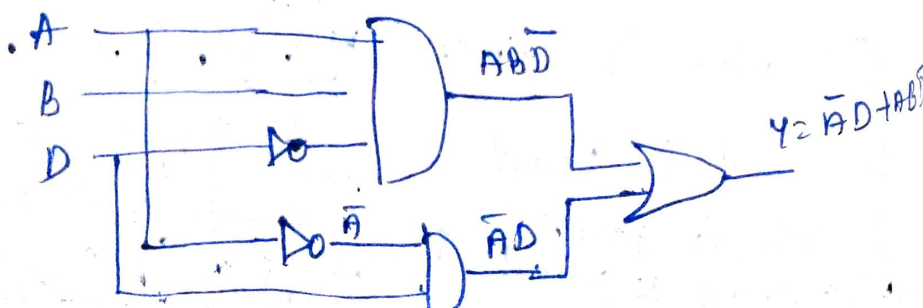
(2) plot the K map

AB \ CD	00	01	11	10
00	0	1	1	0
01	0	1	1	0
11	1	0	0	1
10	0	0	0	0

$$Y = \mathrm{I} + \mathrm{II}$$

$$= \bar{A}D + AB\bar{D}$$

Implementation



Reduce the following function using K-map technique

$f(A,B,C,D) = \sum m(0,1,4,8,9,10)$

① plot the kmap

AB \ CD	00	01	11	10
00	1 (0)	1 (1)	0 (3)	0 (2)
01	1 (4)	0 (5)	0 (7)	0 (6)
11	(12)	(13)	(15)	(14)
10	1 (8)	1 (9)	(11)	1 (10)

$Y = \mathrm{I} + \mathrm{II} + \mathrm{III}$

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

Don't care conditions

$f(A,B,C,D) = \sum m(1,3,7,11,15) + \sum d(0,2,4)$

AB \ CD	00	01	11	10
00	X	1	1	X
01	X		1	
11			1	
10			1	

AB \ CD	00	01	11	10
00	1	1	1	1
01			1	
11			1	
10			1	

$Y = \bar{A}\bar{B} + CD$

(b) $f(A,B,C) = \sum m(0,1,3,7) + \sum d(2,5)$

A \ BC	00	01	11	10
0	1	1	1	X
1	0	X	1	0

=

A \ BC	00	01	11	10
0	1	1	1	1
1	0	1	1	0

(1)

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

(2) Find the reduced SOP form of following function.

$F(w,x,y,z) = \sum m(0,7,8,9,10,12) + \sum d(2,5,13)$

wx (AB) \ yz (CD)	00	01	11	10
00	1	0	0	X
01	0	X	1	0
11	1	X	0	0
10	1	1	0	1

III

I

II

(2)

$Y = I + II + III$

$= \bar{B}\bar{D} + A\bar{C} + \bar{A}BD = \bar{x}\bar{z} + w\bar{y} + \bar{w}xz$

(2)

Introduction

Simplification of Product of Sums (POS) Expressions

① $Y = (A+B+\bar{C})(A+\bar{B}+\bar{C})(\bar{A}+\bar{B}+\bar{C})(\bar{A}+B+C)(A+B+C)$

$M_1 \quad M_3 \quad M_7 \quad M_4 \quad M_0$

(i) Plot the K-map

(ii) Group the 0's

A \ BC	00	01	11	10
0	0	0	0	
1	0		0	

I, II, III

$\bar{Y} = I + II + III$

$= \bar{B}\bar{C} + BC + \bar{A}C$

$Y = \overline{\bar{B}\bar{C} + BC + \bar{A}C}$

Demorgan's law $Y = (\overline{\bar{B}\bar{C}}).(\overline{BC}).(\overline{\bar{A}C})$

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

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

② $f(A,B,C,D) = \pi M(0,2,3,8,9,12,13,15)$

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

② $f(A,B,C,D) = \pi M(0,3,4,7,8,10,12,14) + \Sigma d(2,6)$

AB \ CD	00	01	11	10
00	0		0	X
01	0		0	X
11	0			0
10	0			0

$\bar{f} \Rightarrow \overline{\bar{D} + \bar{A}C}$

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

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