EE 203

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Binary arithmetic

① addition →

0+0 = 0

0+1 = 1

1+0 = 1

1+1 = 0 & carry 1.

Eg. $(13)_{10} + (11)_{10}$

$(1101)_2 + (1011)_2$

01101
01011
11000

$(37)_{10} + (29)_{10}$

$(10101)_2 + (11101)$

10101
11101
110010

2	29	1
2	14	0
2	7	1
2	3	1
2	1	1
	1	

2	37	1
2	18	0
2	9	1
2	4	0
2	2	1

100101
011101
1000010

$(12)_{10} - (3)_{10}$

1100 − 0011

=

1100
0011
1001

$\boxed{1001}$

9

Binary sub.

0 − 0 = 0

0 − 1 = 1 and borrow 1

1 − 0 = 1

1 − 1 = 0

11101 → 29
10011 → 19
01010 → 10

multiplication →

$0 \times 0 = 0$
$0 \times 1 = 0$
$1 \times 0 = 0$
$1 \times 1 = 0$

Eg. $(12)_{10} \times (8)_{10}$

```
   1100
 × 1000
 ------
   0000
 1100××
 ------
 1100000
```

54

32+16

2^4

27

64
32
128

13
1 4 3

13×11

```
      1101
      1011
  --------
      1101
     1101×
    0000××
   1101×××
  --------
  10001111
```

128 + 8 + 4 + 2 + 1

138

143

```
  999999
  546700
  ------
  453299
```

```
  99999
  012398
  ------
  87601
```

$(1010)_2 = 10$

(0101)

5

(0101) 1's comp.

99
10

101

89

$(11)_2$

(00)

011

10

```
  99
  10
  --
  89
```

```
  999
  010
  ---
  989
```

1010

(0101)

5

Q.

$246700 \leftarrow$ 9's comp.

$\boxed{753300} \rightarrow$ 10's comp.

substraction with compliment →

$$\begin{array}{r} (13)_{10} \\ -\ (7)_{10} \\ \hline (6)_{10} \end{array}$$

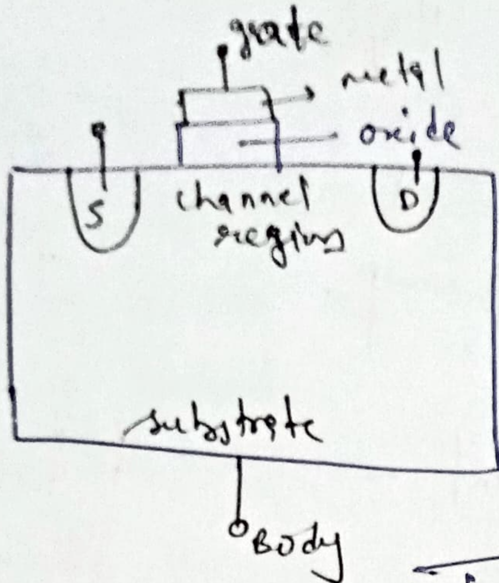
$$\begin{array}{r} 1101 \\ -\ 0111 \\ \hline 0110 \\ \hline 110 \end{array} \xrightarrow{\text{comp}} \begin{array}{r} +\ 1101 \\ 1000 \\ \hline 10101 \\ \hline 0101 \\ 1 \\ \hline 0110 \end{array} \rightarrow \boxed{6}$$

$$\begin{array}{r} 1101 \\ 1001 \\ \hline 10110 \end{array}$$

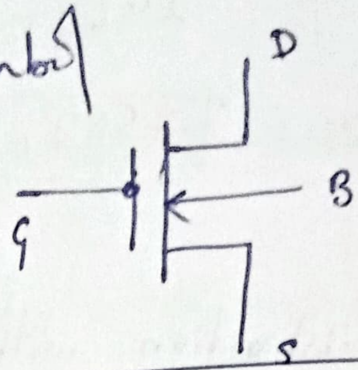
1001 → 2's comp

if we are adding in 1's compliment then MSB carry add to LSB

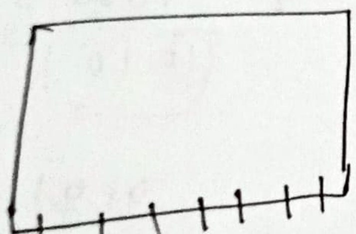
in 2's compliment just discard MSB carry.



Symbol



1000 0111 0000



6 →
−13

  1101
  0110
(1)0011

0001 0011

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Binary Codes.

476
394
(7)1610

870

0100 0111 0110
0010 01001 0000
0111 10000 (1)010
                 0110
7   (1) 0000

0100 0111 0110 0000
0011 1001 0100 ~~00111~~
0111 (1)0000
0001 0001 0001 0000 (1)0001
                    00110
0000 0110 0000 10111
     0111

K-Map :->

- modified form of truth table
- for n-variable fun" than in K-map 2^n shells will be present.
- Gray code sequence is used in k-map representation.

2-variable k-map :->

$f(x,y)$ = 4-shell. make square if it is possible.

MSB x, LSB y

$x \backslash y$	0	1
0	0	1
1	2	3

$y \backslash x$	$\bar{x}$ 0	x 1
$\bar{y} \to 0$	0	2
$y \to 1$	1	3

Gray code sequence

var.	gray code seq.
1	0,1
2	0,1,3,2
3	0,1,3,2,6,7,5,4

to minimise

- our aim to find $f(x,y) = \Sigma(a,b)$

for Ex.

x	y	$f(x,y)$
0	0	0
0	1	0
1	0	1
1	1	1

$f(x,y) = \Sigma(2,3) = \pi(0,1)$

$f(x,y)$

$x \backslash y$	$y=0$	$y=1$
$x=0$	0	0
$x=1$	1	1

$f(x,y) = \Sigma(2,3) = \pi(0,1)$

$x \backslash y$	0	1
0		
1	1	1

$\to f(x,y) = x$ (This is fully mini form).

'1' की grouping करते है और sop find करते है तो f मिलता है '0' की करते है और sop find करते है तो f' मिलता है।

'1' का pos grouping = f' , '1' का sop = f

'0' की pos grouping = f , '0' का sop = f'

x \ y	0	1
0		
1		

$f(x,y) = 0$

x \ y	0	1
0	1	1
1	1	1

$f(x,y) = 1$

x \ y	0	1
0	1	1
1	1	

$\bar{x}$

$\bar{y}$

$f(x,y) = \bar{x} + \bar{y}$

$f'(x,y) = (x)(y) = x \cdot y$

x \ y	0	1
0		
1		0

$f(x,y) = \bar{x} + \bar{y}$

$f'(x,y) = x \cdot y$

x \ y	0	1
0	1	0
1	0	1

$f(x,y) = x'y' + xy$

$= \overline{x \oplus y}$

$= x \odot y$

x \ y	0	1
0		1
1	1	

$\bar{x}y$

$x\bar{y}$

prime Implicant (P.I)

$f(x,y) = \bar{x}y + x\bar{y}$

$= x \oplus y$

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- max. no. of P.I can be possible in 2-variable k-map.

Sol max. no. of P.I $= \frac{2^n}{2}$

for $n=2$

$\boxed{P.I = 2} \rightarrow$ max. (sop based only not pos)

3 variable k-map →

$f(x,y,z)$, shells $= 2^n = 2^3 = 8$

x \ yz	00	01	11	10
0	0	1	3	2
1	4	5	7	6

or

xy \ z	0	1
00	0	1
01	2	3
11	6	7
10	4	5

Eg → $f(x,y,z) = \Sigma(3,5,6,7)$
minimize the boolean fun"

x \ yz	00	01	11	10
0			1	
1		1	1	1

$f(x,y,z) = xz + xy + yz \rightarrow$ sop

$f'(x,y,z) = (\bar{x}+\bar{z})\cdot(\bar{x}+\bar{y})\cdot(\bar{y}+\bar{z}) \rightarrow$ pos

literals (always from sop) = 6 (no. of char" repeted also counted)

less no. of leterals = less no. of logic gate required

3 variable k-map by 2 variable →

x \ yz	00	01	11	10
0	0	1	3	2
1	4	5	7	6

x \ z	0	1
0	0	1
1	4	5

$y = 0$

x \ z	0	1
0	2	3
1	6	7

$y = 1$

4 variable k-map

$f(w,x,y,z)$, cells $= 2^4 = 16$

wx \ yz	00	01	11	10
00	0	1	3	2
01	4	5	7	6
11	12	13	15	14
10	8	9	11	10

Que. minimise the boolean funⁿ

wx \ yz	00	01	11	10
00	1			
01	1	1	1	
11		1	1	
10	1	1		

$f(w,x,y,z) = \Sigma(0,4,5,7,8,9,13,15)$

→ for

Sop $f(w,x,y,z) = \cancel{xz + \bar{x}\bar{y}\bar{z}}$

$= \underbrace{xz}_{E.P.I.} + \underbrace{w\bar{x}\bar{y}}_{P.I} + \underbrace{\bar{w}\bar{y}\bar{z}}_{P.I}$

no. of literals = 8

wx \ yz	00	01	11	10
00		0	0	0
01				0
11	0			0
10			0	0

for pos