Logic Design

CSE 221

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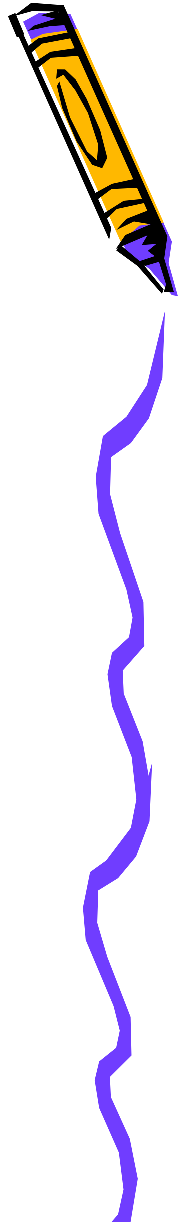
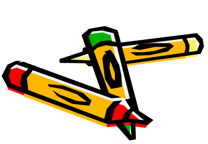
Decimal	Binary	Octal	Hexadecimal
31			
	11101		
		23	
			1A

Decimal	Binary	Octal	Hexadecimal
31	11111	37	1F
29	11101	35	1D
19	10011	23	13
26	11010	32	1A





Exercise – 2's C conversions

- What is -20 expressed as an 8-bit binary number in 2's complement notation?
  - Answer:____________

- 1100011 is a 7-bit binary number in 2's complement notation. What is the decimal value?
  - Answer:____________

Exercise – 2's C conversions

Answer

- What is -20 expressed as an 8-bit binary number in 2's complement notation?
  - Answer: 11101100
- 1100011 is a 7-bit binary number in 2's complement notation. What is the decimal value?
  - Answer: -29

One’s Complement subtraction

01010 (10)
-
00111 (7)
One’s complement for subtrahend then add
 01010
 +
 11000
____
100010
Neglect carry and add 1
 00011 (+3)

Two’s Complement subtraction
01010 (10)
-
00111 (7)
Two’s complement for subtrahend then add
 01010
 +
 11001
____
100011
Neglect carry
 00011 (+3)

One's Complement subtraction

00111 (7)
-
01010 (10)
One's complement for subtrahend then add
 00111
 +
 10101

____

11100
N0 carry and get one's complement again…put -
 -00011 (-3)

Two's Complement subtraction

00111 (7)
-
01010 (10)
Two's complement for subtrahend then add
 00111
 +
 10110

____

11101
No carry Two's complement again
 - 00011 (-3)

BCD conversion

Ex 1 : convert each of the following decimal to BCD code :

a) 35 b) 98 c) 170 d) 2469

BCD conversion

Solution

a) 35   3   5

0011   0101

Then 35 $\rightarrow$ 00110101

b) 98   9   8

1001   1000

Then 98 $\rightarrow$ 10011000

BCD conversion

c) 170   1   7   0

c) 170	1	7	0
	0001	0111	0000

Then 170 → 000101110000

d) 2469	2	4	6	9
	0010	0100	0110	1001

Then 2469 → 0010010001101001

BCD conversion

Ex2 Convert each of the following BCD code to decimal :

a) 10000110   b) 001101010001

c) 1001010001110000

Solution

a) Start from right and group each four digits

1000	0110
8	6

Then 10000110 → 86

BCD conversion

b) 001101010001

0011	0101	0001	
3	5	1	→ 351

c) 1001 0100 0111 0000

1001	0100	0111	0000
9	4	7	0

→ 9470

BCD addition

1 – use binary addition rules

2 – if the 4-bit sum is greater than 9 then it is not a BCD valid number ….add 6(0110) to the 4-bit sum.

BCD addition

Add the following BCD numbers

a) 0011 + 0100

b) 001000111 + 00010101

c) 1001 + 0100

d) 00010110 + 00010101

e) 01100111 + 01010011

BCD addition

Solutions

a) 0011 → 3

\+ 0100 → 4

0111 → 7

b) 00100011 → 2 3

\+ 00010101 → 1 5

00111000 → 38 (each number < 9)

BCD addition

Solutions

c) 1001 → 9

 + 0100 → 4

1101 → 13 → invalid BCD number > 9

+ 0110 → Add 6 (0110)

10011 → 0001 10011 → 13 in BCD

BCD addition

Solutions

d) 00010110 → 1 6

\+ 00010101 → 1 5 6+5 = 11 > 9

$0010\underline{1011}$ → 1011 > 9 then add 6(0110)

\+ 0110 → Add 6 (0110)

00110001 → 0011 00001 → 31 in BCD

BCD addition

Solutions

e) 01100111 → 6 7

\+ 01010011 → 5 3 6+5 = 11 > 9 & 7+3 > 9

1011 1010 → 1011 > 9 then add 6(0110)

\+ 0110 0110 → Add 6 (0110) & 6(0110)

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1 0010 0000 → 0001 0010 0000→ 120

Binary to Gray Code

Convert the binary number 11000110 to Gray code

Sol.

Binary	1 +	1 +	0 +	0 +	0 +	1 +	1 +	0
	↓	↓	↓	↓	↓	↓	↓	↓
Gray	1	0	1	0	0	1	0	1

Shortcut

The first number will be the same…the second number in gray = first + second in binary……… the third in gray = second + third in binary and go on …neglect carry.

Gray Code to binary

Convert the gray code number 10100101 to binary.

Sol.

Gray	1	0	1	0	0	1	0	1
	↓	↓	↓	↓	↓	↓	↓	↓
Binary	1 +0=	1 +1=	0+0=	0	0	1	1	0

Shortcut

The first number will be the same…the second number in binary = first (binary) + second (gray).. the third in binary = second (binary)+ third (gray) and go on …neglect carry.

Simplification review

OR	
1	$x+1 = 1$
2	$x+x' = 1$
3	$x+x = x$
4	$x+0 = x$
5	$(x')' = x$
6	$x+y = y+x$
7	$x+(y+z) = (x+y)+z$
8	$x.(y+z) = x.y+x.z$
9	$(x+y)' = x'.y'$
10	$x+(x.y) = x$

AND	
1	$x.1 = x$
2	$x.x' = 0$
3	$x.x = x$
4	$x.0 = 0$
5	$(x')' = x$
6	$x.y = y.x$
7	$x.(y.z) = (x.y).z$
8	$x+y.z = (x+y).(x+z)$
9	$(x.y)' = x'+y'$
10	$x.(x+y) = x$

Note

$XX' = 0$

$XX'Y = 0$

$X'XYZ'ABCD = 0$

$X + x' = 1$

$Xy + (xy)' = 1$

$Xyz + (xyz)' = 1$

EX 1

$$F = AB + A(B + C) + B(B + C)$$

EX 1

F = $AB + A(B + C) + B(B + C)$

$$AB + AB + AC + BB + BC$$

$$AB + AC + B(1 + C)$$

$$B + AB + AC$$

$$\mathrm{B}(1 + \mathrm{A}) + \mathrm{AC}$$

$$= B + AC$$

EX 2

$$F = [\,A\overline{B}\,(C + B\,D\,) + \overline{A}\,\overline{B}\,]C$$

EX 2

$$F = [A\overline{B}(C + BD) + \overline{A}\,\overline{B}]C$$

$$(A\overline{B}C + A\overline{B}BD + \overline{A}\,\overline{B})C$$

$$(A\overline{B}C + \overline{A}\,\overline{B})C$$

$$CA\overline{B}C + C\overline{A}\,\overline{B}$$

$$\overline{B}CA + \overline{B}C\overline{A}$$

$$\overline{B}C(A + \overline{A})$$

$$\overline{B}C$$

EX 3

$$F = \overline{AB} + \overline{AC} + \overline{A}\,\overline{B}\,\overline{C}$$

EX 3

$$F = \overline{AB} + \overline{AC} + \overline{A}\,\overline{B}\,\overline{C}$$

$$\overline{A} + \overline{B} + \overline{A} + \overline{C} + \overline{A}\,\overline{B}\,\overline{C}$$

$$\overline{A} + \overline{B} + \overline{C} + \overline{A}\,\overline{B}\,\overline{C}$$

$$\overline{A} + \overline{B} + \overline{C}\left(1 + \overline{A}\,\overline{B}\right)$$

$$\overline{A} + \overline{B} + \overline{C}$$

Ex 4

$$F = \overline{A\,B + A\,C} + \overline{A}\;\overline{B}\;C$$

Ex 4

$$F = \overline{A\,B + A\,C} + \overline{A}\,\overline{B}\,C$$

$$(\overline{A\,B})(\overline{A\,C}) + \overline{A}\,\overline{B}\,C$$

$$(\overline{A} + \overline{B})(\overline{A} + \overline{C}) + \overline{A}\,\overline{B}\,C$$

$$\overline{A}\,\overline{A} + \overline{A}\,\overline{C} + \overline{A}\,\overline{B} + \overline{B}\,\overline{C} + \overline{A}\,\overline{B}\,C$$

$$\overline{A}\,(1 + \overline{B} + \overline{C} + \overline{B}\,C) + \overline{B}\,\overline{C}$$

$$\overline{A} + \overline{B}\,\overline{C}$$

Ex 5

$$F = \left[AB\left(C + \overline{BD}\right) + \overline{AB}\right] CD$$

$$F = \left[AB\left(C + \overline{BD}\right) + \overline{AB}\right] CD$$

$$\left[AB \left(C + \overline{B} + \overline{D} \right) + \overline{AB} \right] CD$$

$$\left[ABC + AB\overline{B} + AB\overline{D} + \overline{AB} \right] CD$$

$$ABCCD + ABC\overline{D}D + \overline{AB}CD$$

$$ABCD + \overline{AB}CD$$

$$CD \left(AB + \overline{AB} \right)$$

$$= CD$$

ANOTHER APPRACH

$$F = \left[AB\left(C + \overline{BD}\right) + \overline{AB}\right] CD$$

$$\left[\overline{AB} + AB\left(C + \overline{B} + \overline{D}\right)\right] CD$$

$$\left[\left(\overline{AB} + AB\right)\left(\overline{AB} + \left(C + \overline{B} + \overline{D}\right)\right)\right] CD$$

$$\left[\left(\overline{AB} + \left(C + \overline{B} + \overline{D}\right)\right)\right] CD$$

$$\left[\overline{AB} + C + \overline{B} + \overline{D}\right] CD$$

$$\left[\overline{A} + \overline{B} + C + \overline{B} + \overline{D}\right] CD$$

$$\left[\overline{A}CD + \overline{B}CD + CCD + \overline{B}CD + \overline{D}\,CD\right]$$

$$CD\ (1 + A + B)$$

$$CD$$

Thank you