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Computer Organization and Architecture

Data Representation part-1

ABOUT ME : MURALIKRISHNA BUKKASAMUDRAM

- MTech with 20 years of Experience in Teaching GATE and Engineering colleges
- IIT NPTEL Course topper in Theory of computation with 96 %
- IGIP Certified (Certification on International Engineering educator)
- GATE Qualified
- Trained more than 50 Thousand students across the country
- Area of Expertise : TOC,OS,COA,CN,DLD

Data Representation Part-1

Binary {0,1}

$(764)_8$

111 110100

Decimal (0 → 9)
Octal (0 - 7)
Hexa Decimal (0 - 9, A, B, C, D, E, F)

0000
0001
0010
0011
⋮
1111

( ) radix

$(79)_{10}$

BCD

12

1100

0001 0010

0 → 9

$(175)_8$

14 (1110)

00010100

Radix

000 (0)
001 (1)
010
011
100
101
110
111 (7)

$(1AB)_{16}$

0001 1010 1011

Data Representation Part-1

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Convertion from other Number system to Decimal

$8^3 \; 8^2 \; 8^1 \; 8^0$

$2^3 \; 2^2 \; 2^1 \; 2^0$

$16^2 \; 16^1 \; 16^0$

$(143)_8 = (99)_{10}$

$1\times8^2 + 4\times8^1 + 3\times8^0$

$64 + 32 + 3 = 99$

$(143.21)_8 = (\quad)_{10}$

$8^2 \; 8^1 \; 8^0 . 8^{-1} \; 8^{-2}$ --- $\left(99\frac{17}{64}\right)_{10}$

$8)\,30\,(0.375$
24
60
56
40

$(143)_8 = (99)_{10}$

$2\times8^{-1} + 1\times8^{-2}$

$\frac{2}{8} + \frac{1}{64} = \frac{16+1}{64} = \frac{17}{64}$

$(21.375)_{10}$

$(10101.0110)_2 = (\quad)_{10}$

$1\times2^4 + 1\times2^2 + 1\times2^0 + \frac{1}{4} + \frac{1}{8}$

$16 + 4 + 1$

$\frac{2+1}{8} = \frac{3}{8}$

$$\begin{array}{r} 16 \times 16 \\ \hline 256 \end{array}$$

$(12F)_{16} = (303)_{10}$

$1 \times 16^2 + 2 \times 16 + 15 \times 16^0$

$256 + 32 + 15$

$$\begin{array}{r} 256 \\ 32 \\ 15 \\ \hline 303 \end{array}$$

$(2131)_4 = (157)_{10}$

$2 \times 4^3 + 1 \times 4^2 + 3 \times 4^1 + 1 \times 4^0$

$= 128 + 16 + 12 + 1 = 157.$

$(3AF.12)_{16} = (\quad)$

$3 \times 16^2 + 10 \times 16^1 + 15 \times 16^0$

$+ \frac{1}{16} + \frac{2}{16^2}$

$r = 4$

$r = \{0, 1, 2, 3\}$

$r = 8$

$\{0, 1, 2 \ldots 7\}$

$$\begin{array}{r} 128 \\ 16 \\ 12 \\ \hline 157 \end{array}$$

Convertion from Decimal to other System

$$
\begin{array}{r|l}
2 & 143 \\
2 & 71 - 1 \\
2 & 35 - 1 \\
2 & 17 - 1 \\
2 & 8 - 1 \\
2 & 4 - 0 \\
2 & 2 - 0 \\
 & 1 - 0
\end{array}
$$

$(143)_{10} = (\quad)_2$

$= (10001111)_2$

$(143.125)_{10} = (10001111.001)_2$

$$
\begin{array}{l}
0.125 \times 2 \\
\hline
0.250 \times 2 \\
\hline
0.500 \times 2 \\
\hline
1.000
\end{array}
$$

$(25.625)_{10} = (11001.101)_2$.

$$
\begin{array}{r|l}
2 & 25 \\
2 & 12 - 1 \\
2 & 6 - 0 \\
2 & 3 - 0 \\
 & 1 - 1
\end{array}
$$

$$
\begin{array}{l}
0.625 \times 2 \\
\hline
1.250 \times 2 \\
\hline
0.500 \times 2 \\
\hline
1.000
\end{array}
$$

Hexa Decimal to Octal

$(1BFA0.123)_{16}$

$(0337640.0443)_8$

000 011 011 111 110 100 000 . 000 100 100 011

0 3 3 7 6 4 0 . 0 4 4 3

Convertion from Octal to Hexa

$(1742.301)_8 = (3E2.608)_{16}$

1 7 4 2

0011 1110 0010 . 0110 0000 1000

3E2 . 608

0000 to 1111

9 .

09

009

9

90

.1

.01

.1

.10

.100

Data Representation Part-1

1. Consider the signed binary number A = 01010110 and B = 11101100 where B is the 1's complement and MSB is the sign bit. In list-I operation is given, and in list-II resultant binary number is given.

List-I	List-II
P. A + B	1. 0100 0011
Q. B – A	2. 0110 1001
R. A – B	3. 0100 0010
S. – A – B	4. 1001 0101
	5. 1011 1100
	6. 1001 0110
	7. 1011 1101
	8. 0110 1010

The correct match is

	P	Q	R	S
A.	3	4	2	5
B.	3	6	8	7
C.	1	4	8	7
D.	1	6	2	5

Data Representation Part-1

2. A computer has the following negative numbers stored in binary form as shown. The wrongly stored number is

A. –37 as 1101 1011

B. –89 as 1010 0111

C. –48 as 1110 1000

D. –32 as 1110 0000

Data Representation Part-1

3. Consider the signed binary number A = 0100 0110 and B = 1101 0011, where B is in 2’s complement and MSB is the sign bit. In list-I operation is given and in List-II resultant binary number is given

List-I	List-II
P. A + B	1. 1 0 0 0 1 1 0 1
Q. A – B	2. 1 1 1 0 0 1 1 1
R. B – A	3. 0 1 1 1 0 0 1 1
S. – A – B	4. 1 0 0 0 1 1 1 0
	5. 0 0 0 1 1 0 1 0
	6. 0 0 0 1 1 0 0 1
	7. 0 1 0 1 1 0 1 1

Data Representation Part-1

4. In number of represented in 2’s complement from then what will be the result of addition of decimal –6 and +9 ?

   A. 0000011

   B. 1000011

   C. 1111101

   D. 0001111

Data Representation Part-1

5. P is a 16-bit signed integer. The 2's complement representation of P is $(F87B)_{16}$. The 2's complement representation of 8*P is

   A. $(C3D8)_{16}$

   B. $(187B)_{16}$

   C. $(F878)_{16}$

   D. $(987B)_{16}$

Data Representation Part-1

6. 10’s complement of $(835)_{10}$ is

A. $(164)_{10}$

B. $(165)_{10}$

C. $(999)_{10}$

D. None of these

7. The following pairs of six-bit (i.e., one sign bit and five data bits) two's complement numbers are to be added

$$\begin{array}{r} 0\ 0\ 1\ 0\ 0\ 1 \\ +\ 0\ 1\ 0\ 1\ 1\ 0 \\ \hline \end{array} \qquad \begin{array}{r} 1\ 1\ 0\ 0\ 0\ 0 \\ +\ 1\ 1\ 0\ 0\ 0\ 0 \\ \hline \end{array} \qquad \begin{array}{r} 1\ 0\ 0\ 1\ 0\ 1 \\ +\ 1\ 0\ 1\ 0\ 1\ 0 \\ \hline \end{array}$$

(I) (II) (III)

In which of the above cases there will be overflow ?

A. II and III

B. III only

C. I and II

D. I, II and III

Data Representation Part-1

8. The value of X and Y, if $(X567)_8 + (2YX5)_8 = (71YX)_8$ is

A. 4, 3

B. 3, 3

C. 4, 4

D. 4, 5

$8 \,|\, 9$

$1 - 1$

$$\begin{array}{r} X\,5\,6\,7 \\ 2\,Y\,X\,5 \\ 1 \\ \hline 7\,1\,Y\,X \\ 4 \end{array}$$

$8 \,|\, 12$

$1 - 4$

14

$X = 4$

$$\begin{array}{r} 4\,5\,6\,7 \\ 2\,Y\,4\,5 \\ 1\;\;1\;\;1 \\ \hline 7\,1\,Y\,4 \\ 3 \end{array}$$

$8 \,|\, 11$

$1 - 3$

$(13)_8$

Data Representation Part-1

9. The values of a, b, c if 47b79 is the 9's complement of caca0 are

A. 4, 3, 2

B. 5, 4, 4

C. 3, 4, 5

D. 2, 4, 5

99999
caca0

47b79

99999
caca0
(5) 2 5 (2)
47b79
4

a = 2
c = 5
b = 4

99999
52520

47479

9 − c = 4

c = 5

9 − a = 7

a = 2

10. Which of the following signed number of divisible by –5. 2's complement notification is used.

is

A. 1111 1111 1001

B. 1111 1111 0111

C. 1111 1111 0111

D. 1111 1111 0001

−5

1 000 0000 1001

1 000 0000 0110
1
000 0000 0111

−7

1 000 0000 1000
1
000 0000 1001

(−9)

1 000 0000 1110
1
0000 0000 1111

−15

Data Representation Part-1

11. Which of the following pattern is having identical value in signed magnitude and 2’s complement notification ?

A. 1000 0000

B. 1110 0000

C. 1100 0000

D. No such no is possible

1 000 0000

1 111 1111

1 0000 0000

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Data Representation Part-1

12. Determine the value of M and N respectively if, $(M776)_8 + (31N4)_8 = (512N)_8$

A. 1, 2

B. 2, 2

C. 2, 1

D. 1, 1

$8 \,\underline{|\, 9}$
$\;\; 1 - 1$

$$\begin{array}{r} M776 \\ 31N4 \\ \hline 512N \end{array}$$

$8 \,\underline{|\, 10}$
$\;\; 1 - 2$

M = 1

N = 2

$$\begin{array}{r} 1776 \\ 3124 \\ \hline 5122 \end{array}$$

$8 \,\underline{|\, 10}$
$\;\; 1 - 2$

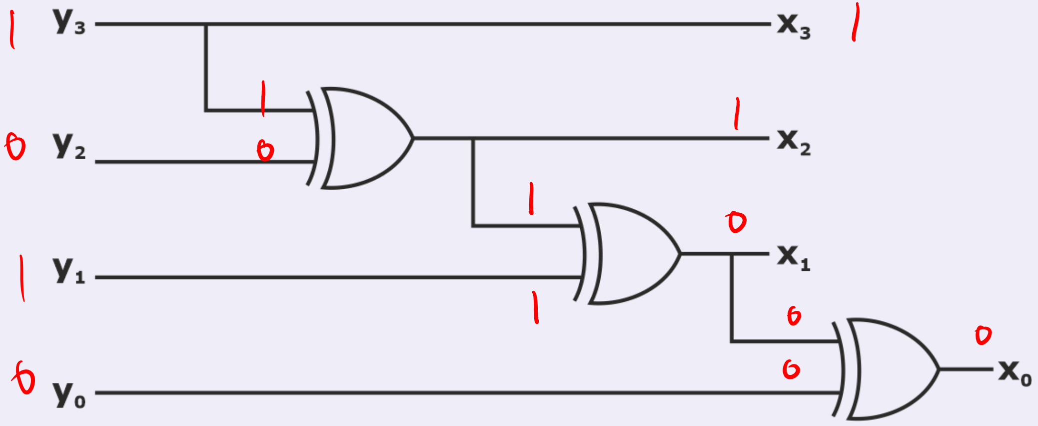
7+2+1

10

$Y_3\ Y_2\ Y_1\ Y_0$

$X_3\ X_2\ X_1\ X_0$

13. Consider the given circuit :



The given logic circuit convert a

A. A binary code into gray code

B. A gray code into binary code

C. A binary code into BCD code

D. A Excess-3 code into BCD code

1100

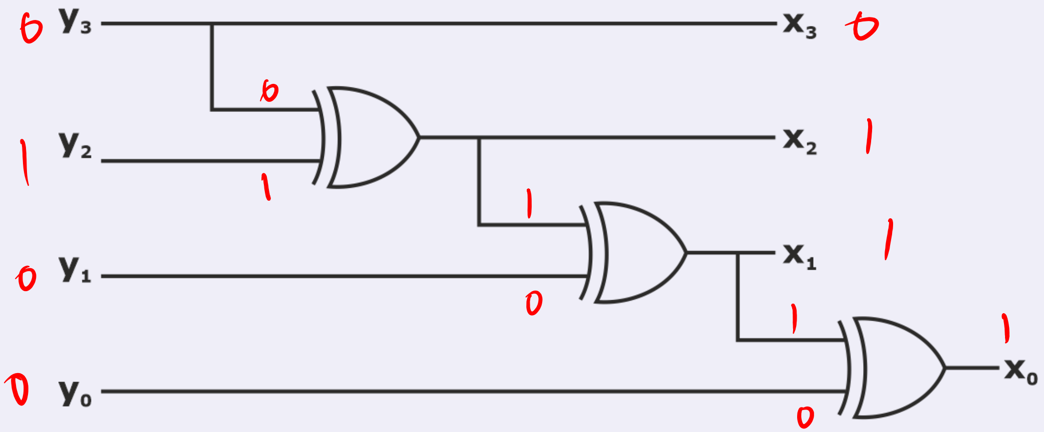
1010

1100

Gray to Binary

Reflected code

14. If $y_3y_2y_1y_0$ is 0100 what will be $x_3x_2x_1x_0$?



A. 0110

B. 0111

C. 0100

D. 0001

0100

0111

The r's Complement

Given a positive number N in base r with an integer part of n digits, the r's complement of N is defined as $r^n - N$ for $N \neq 0$ and 0 for $N = 0$. The following numerical example will help clarify the definition.

The 10's complement of $(52520)_{10}$ is $10^5 - 52520 = 47480$.

The number of digits in the number is $n = 5$.

The 10's complement of $(0.3267)_{10}$ is $1 - 0.3267 = 0.6733$.

No integer part, so $10^n = 100 = 1$.

The 10's complement of $(25.639)_{10}$ is $10^2 - 25.639 = 74.361$.

The 2's complement of $(101100)_2$ is $(2^6)_{10} - (101100)_2 = (1000000 - 101100)_2 = 010100$.

The 2's complement of $(0.0110)_2$ is $(1 - 0.0110)_2 = 0.1010$.

Data Representation Part-1

The (r – 1)'s Complement

Given a positive number N in base r with an integer part of n digits and a fraction part of m digits, the (r – 1)'s complement of N is defined as $r^n - r^{-m} - N$. Some numerical examples follow :

The 9's complement of $(52520)_{10}$ is $(10^5 - 1 - 52520)$ = 9999 – 52520 = 47479.

No fraction part, so $10^{-m} = 10^0 = 1$.

The 9's complement of $(0.3267)_{10}$ is $(1 - 10^{-4} - 0.3267)$ = 0.9999 – 0.3267 = 0.6732.

No integer part, so $10^n = 10^0 = 1$.

The 9's complement of $(25.639)_{10}$ is $(10^2 - 10^{-3} - 25.639)$ = 99.999 – 25.639 = 74.360.

The 1's complement of $(101100)_2$ is $(2^6 - 1) - (101100) = (111111 = 101100)_2$ = 010011.

The 1's complement of $(0.0110)_2$ is $(1 - 2^{-4})_{10} - (0.0110)_2 = (0.1111 - 0.0110)_2$ = 0.1001.

Data Representation Part-1

Convertion from Binary to gray code

0 1 1 1 – Binary

0 1 0 0 – Gray

1 0 1 0 (Binary)

1 1 1 1

Convertion from Gray to Binary code

1 1 1 1 – Gray

1 0 1 0 (Binary)

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Data Representation Part-1

Integer Representation

$(182)_8$ ✗

D {0, 1 - - - 9} ✓

B {0, 1} ✓

$(123)_8$

O (0 - 7) ✓

H (0 - 9, A, B, C, D, E, F)

(1) Signed integers

(2) Unsigned integers.

+10, −20, +70

5 9 20 70

8-bits

0 0001010

MSB

8421

16+4

4-bits

0101

8-bits

0000 0101

−20 ✓

1 0010100

−20

16-bits

10

0000000000001010

2^4 2^3 2^2 2^1 2^0

0 0 0 0

0 0 0 1

0 0 1 0

8421

0000

0001

0110

4

1010

Data Representation Part-1

0101

1010
1

1011

(15)
0000
to
1111

$\boxed{8421}$

$2^3\ 2^2\ 2^1\ 2^0$

$\boxed{0110}$

Base-2
r = 2 (2's / 1's)

$\boxed{6}$ 4+2
0000

(12)
8+4
1100

10
1010

Binary Representation

sign + Magnitude
" 1st complement
" 2's "

+ve 0
−ve − 1

−5	1 0101 ①
	1 1010 ②
	1 1011 ③

Integer Representation

(1) Signed Magnitude
(2) Signed 1's Complement
(3) Signed 2's Complement.

For a Base-r System, We have
r's complement
(r−1)'s "

Complements in a Number System

$r=2$

$N = \boxed{1010}$

$(r-1)$'s

$\boxed{(2^4-1)-N}$

$15 -$

$$\begin{array}{r} 1111 \\ 1010 \\ \hline \boxed{0101} \end{array}$$

$(r-1)$'s Complement

Let N be a given number

$(r^n-1)-N$ [where n is the no. of digits in given N]

r's Complement

$(r^n - N)$

$10^4 - N$

$N = (5047)_{10}$

$$\begin{array}{r} 10000 \\ 5047 \\ \hline 4953 \end{array}$$

(4953)

1243

8757

$$\begin{array}{r} 9999 \\ 4952 \end{array}$$

$r=10$ $\boxed{5047}$

$\boxed{(4952)}_{10}$

$(10^4-1)-N$

$A = 5432$

$B = 1243$

$A - B$

$A + 10\text{'s}(B)$

$$\begin{array}{r} 5432 \\ +\,8757 \\ \hline 1\;\boxed{4189} \end{array}$$

Data Representation Part-1

$(r-1)$

r

$n = 3$ bits

$$\begin{array}{r} 9\,9\,9\,10 \\ 5\,0\,4\,7 \\ \hline \boxed{4\,9\,5\,3} \end{array}$$

5047

Subtract LSP from 10
Remaining all sub from 9

1's complement range

$-(2^{n-1}-1)$ to $(2^{n-1}-1)$

$-(2^{3-1}-1)$ to $\boxed{2^{3-1}-1}$

$-(4-1)$

-3 (3)

1 11 $\quad$ 011

2's complement range

(-2^{n-1}) to $(2^{n-1}-1)$

-2^{3-1} to $2^{3-1}-1$

-4 to 3