EE 2504

Data Representation

Data Types

- Numbers used in arithmetic computations.
- Letters of the Alphabet used in data processing.
- Other discrete symbols used for specific purposes such as graphics.

Information Representation in Digital Computers.

- Digital computers store and process information in binary form, that is in strings of 1’s and 0’s.
- Computers use data and control information that specifies how the data is to be processed.

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Number Systems

A number system of **base** or **radix r**:

- Is a number representation system that uses distinct symbols to represent **r** digits.
- Each number is represented by a unique string of the **r** digits.
- Each digit has a weight which is an integer power of the base **r**.

Decimal System

Radix = 10

Symbols: 0,1,2,3,4,5,6,7,8,9

Example:

$39.5 = 3 \times 10^{1} + 9 \times 10^{0} + 5 \times 10^{-1}$

Binary system

Radix = 2

Symbols: 0,1

Example:

$10011 = 1 \times 2^4 + 0 \times 2^3 + 0 \times 2^2 + 1 \times 2^1 + 1 \times 2^0$

Octal system

Radix = 8

Symbols: 0,1,2,3,4,5,6,7

Example:

$731 = 7 \times 8^2 + 3 \times 8^1 + 1 \times 8^0$

Hexadecimal system

Radix = 16

Symbols: 0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

Example:

$D32 = D \times 16^2 + 3 \times 16^1 + 2 \times 16^0$

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Conversion from radix r to decimal

To convert a number in radix **r** to decimal:

- Multiply each digit by the Nth power of r where N is the position of the digit in the string (starting with 0 and using negative numbers for positions to the left of the fraction point)

Examples:

Binary to decimal

$(101101)_2 = (45)_{10}$

Octal to Decimal

$(736.4)_8 = (478.5)_{10}$

Hex to Decimal

$(F1)_{16} = (241)_{10}$

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Conversion from decimal to radix r.

To convert a decimal number to a radix r number:

- Separate the number into integer and fraction part.
- Convert the integer part by performing successive divisions by r and accumulating the remainders until the integer quotient is less than r.
- The converted integer part is obtained from the remainders with the first remainder being the low order bit of the new number.
- Convert the fraction part by performing successive multiplication's by r and accumulating the resulting integer digits until the fraction part becomes zero or the desired accuracy is achieved.
- The converted fraction part is obtained from the integer digits with the first obtained digit being the digit nearest the fractional point.

Examples

Decimal to Binary:

$(41.6875)_{10} = (101001.1011)_{2}$

Decimal to Octal:

$(41.6875)_{10} = (51.54)_{8}$

Decimal to Hex:

$(41.6875)_{10} = (29.B)_{16}$

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Binary-Coded Octal Numbers

Octal Number	Binary-Coded Octal	Decimal Equivalent
0	000	0
1	001	1
2	010	2
3	011	3
4	100	4
5	101	5
6	110	6
7	111	7
10	001 000	8
11	001 001	9
12	001 010	10
24	010 100	20
62	110 010	50

Binary-Coded Hexadecimal Numbers

Hexadecimal Number	Binary-Coded Hexadecimal	Decimal Equivalent
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
A	1010	10
B	1011	11
C	1100	12
D	1101	13
E	1110	14
F	1111	15
14	0001 0100	20
32	0011 0010	50
63	0110 0011	99
F8	1111 1000	248

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American Standard Code for Inforamtion Interchange (ASCII)

Character	Binary Code
A	0100 0001
B	0100 0010
C	0100 0011
D	0100 0100
E	0100 0101
F	0100 0110
G	0100 0111
H	0100 1000
I	0100 1001
J	0100 1010
0	0011 0000
1	0011 0001
2	0011 0010
3	0011 0011
4	0011 0100

Binary-Coded Decimal Numbers

Decimal Number	Binary-Coded Decimal
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001
10	0001 0000
20	0010 0000
50	0101 0000
99	1001 1001
248	0010 0100 1000