Binary and Hexadecimal Data Representation

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Number Systems

Decimal	4-Bit Binary	Hexadecimal
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
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

Powers of 2

Power of 2	Decimal Value
2^0	1
2^1	2
2^2	4
2^3	8
2^4	16
2^5	32
2^6	64
2^7	128
2^8	256
:	:

Example 1

Convert 11110001 to decimal:

- $1*2^7+1*2^6+1*2^5+1*2^4+0*2^3+0*2^2+0*2^1+1*2^0$
- 128+ 64 + 32 + 16 + 0 + 0 + 0 + 1
- 241

Example 2

Convert $2AB9_{16}$ to decimal

$2AB9_{16} = 2*16^3+A*16^2+B*16^1+9*16^0$

$= 2*16^3+10*16^2+11*16^1+9*16^0$

$= 10937$

Converting To Binary
Subtraction Remainder Method

Suppose we want to convert 190 to binary:

- The largest power of 2 that can be subtracted is $2^7=128$.
- Subtract 128 from 190, giving 62.
- The next power of 2, $2^6 = 64$ is too large, so we assign a placeholder of zero.
- The next power of 2, $2^5 = 32$. We'll need one of these, so subtract 32 and write down the result.
- The next power of 2, $2^4 = 16$. We can subtract one of these too.
- The next power of 2, $2^3 = 8$.
- Continue, until all powers of 2 are represented including place holders.

$$190 = 1X2^7+0X2^6+1X2^5+1X2^4+1X2^3+1X2^2+1X\ 2^1+0X\ 2^0$$

$$\begin{array}{l} 190 \\ -128 = 1 \text{ X } 2^7 \\ \hline 62 \\ -\ 0 = 0 \text{ X } 2^6 \\ \hline 62 \\ -\ 32 = 1 \text{ X } 2^5 \\ \hline 30 \\ -\ 16 = 1 \text{ X } 2^4 \\ \hline 14 \\ -\ 8 = 1 \text{ X } 2^3 \\ \hline 6 \\ -\ 4 = 1 \text{ X } 2^2 \\ \hline 2 \\ -\ 2 = 1 \text{ X } 2^1 \\ \hline 0 \\ -\ 0 = 0 \text{ X } 2^0 \\ \hline 0 \end{array}$$

Convert 190 to Binary - Continued

$$190 = 1X2^7 + 0X2^6 + 1X2^5 + 1X2^4 + 1X2^3 + 1X2^2 + 1X2^1 + 0X2^0$$

Note: The bit corresponding to exponent 0 is on the right ***(least significant bit)*** and the bit corresponding to largest exponent is the ***most significant bit*** *(on the left)*.

$$190 = 10111110_2$$

Converting To Binary
Division Method

Converting 190 to binary...

- First we take the number that we wish to convert and carry out subsequent divisions by 2.
- At each step, record the quotient and the remainder.
- Read remainders from ***bottom to top*** and record them ***from most significant to least significant bit***.
- $190_{10} = 10111110_2$

2	190	
2	95	0
2	47	1
2	23	1
2	11	1
2	5	1
2	2	1
2	1	0
0		1

Example 3

Convert 147_{10} to binary using subtraction method:

147	
-128	2^7
19	
-16	2^4
3	
-2	2^1
1	
-1	2^0
0	

$147_{10} = 1*2^7+0*2^6+0*2^5+1*2^4+0*2^3+0*2^2+1*2^1+1*2^0$

$= 10010011$ (binary)

$= 93_{16}$ (hex)

Example 4

Convert 147_{10} to binary.

$2 \lfloor \underline{147}$	1	2 divides 147 73 times with a remainder of 1
$2 \lfloor \underline{73}$	1	2 divides 73 36 times with a remainder of 1
$2 \lfloor \underline{36}$	0	2 divides 36 18 times with a remainder of 0
$2 \lfloor \underline{18}$	0	2 divides 18 9 times with a remainder of 0
$2 \lfloor \underline{9}$	1	2 divides 9 4 times with a remainder of 1
$2 \lfloor \underline{4}$	0	2 divides 4 2 times with a remainder of 0
$2 \lfloor \underline{2}$	0	2 divides 2 1 time with a remainder of 0
$2 \lfloor \underline{1}$	1	2 divides 1 0 times with a remainder of 1
0		

Reading the remainders from bottom to top, we have: $147_{10} = 10010011_2$.

Example 5

Convert 1011110001110001 to hexadecimal:

1011110001110001

= $178F1_{16}$ (hex)

Example 6

Convert $2AB9_{16}$ to binary

$2AB9_{16}$ = 0010101010111001

= 1010101010111001

Note: 0 digits to the left of Binary or hex numbers have no value. Same as decimal.

Example 7

Convert 299_{10} to hex

16|299 **B** divides 18 times (16x18=288) with remainder of 11 (B)

16|18 **2** divides 1 times with a remainder of 2

16|1 **1** divides 0 times with a remainder of 1

0

Read remainders from ***bottom to top***

Answer: $12B_{16}$