

Introduction to Number System

Common Number Systems

SYSTEM	BASE	SYMBOL	USED BY HUMANS?	USED BY COMPUTERS?
Decimal	10	0, 1, ... 9	YES	NO
Binary	2	0, 1	NO	YES
Octal	8	0, 1, ... 7	NO	NO
Hexadecimal	16	0, 1, ... 9, A, B, ... F	NO	NO

Quantities/Counting (1 of 3)

Decimal	Binary	Octal	Hexadecimal
0	0	0	0
1	1	1	1
2	10	2	2
3	11	3	3
4	100	4	4
5	101	5	5
6	110	6	6
7	111	7	7

Quantities/Counting (2 of 3)

Decimal	Binary	Octal	Hexadecimal
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F

Quantities/Counting (3 of 3)

Decimal	Binary	Octal	Hexadecimal
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14
21	10101	25	15
22	10110	26	16
23	10111	27	17

Conversion Among Bases

- **Binary to Decimal :**

- **Technique :**

- Multiply each bit by 2^n , where n is the “weight” of the bit .
- The weight is the position of the bit, starting from 0 on the right .
- Add the results .

Octal to Decimal

Technique

- Multiply each bit by 8^n , where n is the “weight” of the bit
- The weight is the position of the bit, starting from 0 on the right
- Add the results

Example : $724_8 \Rightarrow 4 \times 8^0 = 4$
 $2 \times 8^1 = 16$
 $7 \times 8^2 = \underline{448}$
 468_{10}

Hexadecimal to Decimal Technique

- Multiply each bit by 16^n , where n is the “weight” of the bit
- The weight is the position of the bit, starting from 0 on the right
- Add the results

Example : $ABC_{16} \Rightarrow C \times 16^0 = 12 \times 1 = 12$
 $B \times 16^1 = 11 \times 16 = 176$
 $A \times 16^2 = 10 \times 256 = \underline{2560}$
 2748_{10}

Decimal to Binary

Technique :

- Divide by two, keep track of the remainder
- First remainder is bit 0 (LSB, least-significant bit)
- Second remainder is bit 1

Octal to Binary :

Technique :

- Convert each octal digit to a 3-bit equivalent binary representation

Example : $(705)_8 = ()_2$

7	0	5
↓	↓	↓
111	000	101

$(705)_8 = (111000101)_2$

Hexadecimal to Binary

Technique :

- Convert each hexadecimal digit to a 4-bit equivalent binary representation

Example: $(10AF)_{16} = ?_2$

1	0	A	F
↓	↓	↓	↓
0001	0000	1010	1111

$10AF_{16} = 0001000010101111_2$

Decimal to Octal :

Technique:

- Divide by 8
- Keep track of the remainder

$$1234_{10} = ?_8$$

Introduction to Number System(Weighted Code)

WEIGHTED CODES

- In the weighted code, each bit is given a weightage and the decimal number is getting by adding the weight of the bits where a 1 is present. The weighted codes may be either positively weighted or negatively weighted.
- Positively weighted codes are those in which all the weights assigned to the binary digits are positive. There are only 17 positively - weighted codes. In every positively weighted code, the first weight must be 1, the second weight must be either 1 or 2, and the sum of all the weights must be equal to or greater than 9.

➤ In negatively weighted codes, some of the weight assigned to the binary digits must be negative.

- Table below shows some of the positively weighted and negatively weighted codes.

Decimal Number	8421	2421	5421	5211	64-2-3	84-2-1
0	0000	0000	0000	0000	0000	0000
1	0001	0001	0001	0001	0101	0111
2	0010	0010	0010	0011	0010	0110
3	0011	0011	0011	0101	1001	0101
4	0100	0100	0100	0111	0100	0100
5	0101	1011	1000	1000	1011	1011
6	0110	1100	1001	1010	0110	1001
7	0111	1101	1010	1100	1101	1001
8	1000	1110	1011	1110	1010	1000
9	1001	1111	1100	1111	1111	1111

UNWEIGHTED CODES

- These codes are given without any positional value for the bits.

Example: Excess three code and Gray code.

Excess - 3 CODE

- It is an unweighted code. This code derives its name from the fact that each binary code word is the corresponding 8421 code word plus 0011 (3). It is a self complementing code.

Example :

- The excess - 3 code for the decimal 7 is 1010. Its 1's complement is 0101. This 0101 is the excess - 3 code for the decimal 2. This is the 9's complement of 7.

- The excess-3 code for the decimal 9 is 1100. 1's complement is 0011. This 0011 is the excess - 3 code for the decimal 0. This is the 9's complement of 9.

GRAY CODE :

The gray code is a non weighted code, and is not suitable for arithmetic operations. It is not a BCD code.

Decimal	4 bit binary	Gray Code			
		1 bit	2 bit	3 bit	4 bit
0	0000	0	00	000	0000
1	0001	1	01	001	0001
2	0010		11	011	0011
3	0011		10	010	0010
4	0100			110	0110
5	0101			111	0111
6	0110			101	0101
7	0111			100	0100

Decimal

4 bit binary

Gray Code

1 bit

2 bit

3 bit

4 bit

8

1000

1100

9

1001

1101

10

1010

1111

11

1011

1111

12

1100

1010

13

1101

1011

14

1110

1001

15

1111

1000

BINARY TO GRAY CONVERSION

If an n bit binary number is represented by B_n, B_{n-1}, \dots, B_1 and its gray code equivalent by G_n, G_{n-1}, \dots, G_1 where B_n and G_n are the MSBs. Then the gray code is

$$G_n = B_n$$

$$G_{n-1} = B_n \oplus B_{n-1}$$

$$G_{n-2} = B_{n-1} \oplus B_{n-2}$$

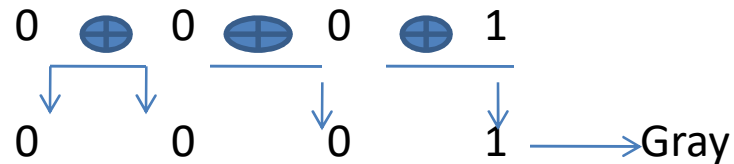
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$$G_1 = B_2 \oplus B_1$$

Example : Convert the binary 0001 to gray code.



Code :

The simple way of obtaining a gray code from a given binary number is, Add binary number with the right shifted binary number. Ignore the LSB or a right shifted binary number.

Given binary number = 0001

Adding right binary number = 000(1) ignore

Gray code 0001

GRAY TO BINARY CONVERSION :

If an n bit gray number is represented by $G_n, G_{n-1}, G_{n-2}, \dots, G_1$ and its binary equivalent by $B_n, B_{n-1}, B_{n-2}, \dots, B_1$ then the binary number from a given gray number is

$$B_n = G_n$$

$$B_{n-1} = G_{n-1} \oplus B_n$$

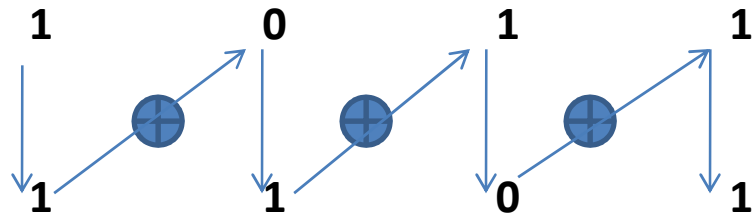
$$B_{n-2} = G_{n-2} \oplus B_{n-1}$$

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$$B_1 = G_1 \oplus B_2$$

Example : Convert (1011) Gray code to Binary.



(1011) Gray code=(1101) Binary

WEIGHTED AND UNWEIGHTED CODES

Weighted codes

- (1) The digital code. Which exhibits the specific weights assigned to bit positions is known as positions, weighted code". Code".
- (2) Each position represents a specific Weights.
- (3) Ex: 8421, 2421, and 5211 codes code.
- (4) Applications: I/O Operations in digital circuits, data manipulation during arithmetic operations to represent the decimal digits in systems like digital calculators, **Voltmeters, etc.**

Unweighted codes

- (1) The digital code which exhibits no specific weights assigned to the bit the is known as "unweighted "
- (2) Each position with in the binary num. is not assigned fixed value.
- (3) Ex: Excess - 3 code and gray
- (4) To perform certain arithmetic operations digital computers, shift position Encoders where error susceptibility increases, etc.

THANK YOU