Codes and Their Conversions

Computers and other digital circuits process data in binary format. Various binary codes are used to represent data which may be numeric, alphabetic or special characters, elements, etc.

Although, the information is represented in binary form, but the interpretation of the data is only possible if the code in which the data is being represented is known. For example, the binary number 1000010 represents 66 (decimal) in straight binary, 42 (decimal) in BCD, and letter B in ASCII code.

Any discrete element of information can be represented with a binary code. An n-bit bit binary code is used to represent up to 2^n combinations of elements. For example, a set of four elements can be coded with two bits, with each element assigned one of the following bit combinations: 00, 01, 10, 11.

Codes are generally classified into Weighted Binary Codes and Non-Weighted Binary Codes.

Weighted Binary Codes

Each position of a number represents a specific weight. In such coding, the **bits** are multiplied by **their corresponding weight** and then the sum of these weighted bits gives the **equivalent decimal**.

- BCD Code or 8421 Code
- 84-2-1 Code
- 2421 Code

BCD Code or 8421 Code

In Binary-Coded Decimal, four bits are required to code each decimal number. The maximum decimal digit available is $(9)_{10}$. Therefore, the binary codes 1010, 1011, 1100, 1101, 1110, 1111, representing 10, 11, 12, 13, 14, and 15 in decimal are never used in BCD code (forbidden codes).

For example, $(35)_{10}$ is represented as 0011 0101 using BCD code, rather than $(100011)_2$ in straight binary code. It is clear that it requires more number of bits to code a decimal number using BCD code than using the straight binary code.

Ex) Give the BCD equivalent for the decimal number $(589)_{10}$.

Solution.	The decimal number	5	8	9
	BCD code is	0101	1000	1001

Hence, $(589)_{10} = (010110001001)_{BCD}$

Ex) Give the BCD equivalent for the decimal number $(69.27)_{10}$.

84-2-1 Code

It is also possible to assign negative weights to decimal code. This is a self-complementary code which means that the 9's complement of the decimal number is obtained just by changing the zeros to ones and ones to zeros (1's complement). This property is useful to do arithmetic operations such as subtraction.

For example, the bit combination 0101 is interpreted as:

$0 \times 8 + 1 \times 4 + 0 \times (-2) + 1 \times (-1) = 3.$

If we change the 1s to 0s and 0s to 1s in the previous example we have 1010, which is interpreted as decimal 6. And 6 is the 9's complement of 3.

2421 Code

This is also a self-complementary code, that is, the 9's complement of the decimal number is obtained by changing the 1s to 0s and 0s to 1s. The 2421 code is the same as that in BCD from 0 to 4. However, it varies from 5 to 9 as shown in the table below:

Decimal digit	*(BCD) 8421*	*84-2-1*	*2421*
0	0000	0000	0000
1	0001	0111	0001
2	0010	0110	0010
3	0011	0101	0011
4	0100	0100	0100
5	0101	1011	1011
6	0110	1010	1100
7	0111	1001	1101
8	1000	1000	1110
9	1001	1111	1111

Non-Weighted Binary Codes

Gray code belongs to a class of code known as **minimum change code**, in which a number changes by only one bit as it proceeds from one number to the next. Gray code finds use in shaft encoders.

Decimal numbers	*Binary code*	*Gray code*
0	0000	0000
1	0001	0001
2	0010	0011
3	0011	0010
4	0100	0110
5	0101	0111
6	0110	0101
7	0111	0100
8	1000	1100
9	1001	1101
10	1010	1111
11	1011	1110
12	1100	1010
13	1101	1011
14	1110	1001
15	1111	1000

Conversion of a Binary Number into Gray Code

The conversion from binary to gray code is as follow:

(i) The MSB of the Gray code is the same as the MSB of the binary number.
(ii) Then we compare the MSB of the binary number with bit next to it. The Gray bit will be 0 if they are the same and it will be 1 for different binary bits.
(iii) Similarly, all the next lower order bits follow the same mechanism.

Ex) Convert $(101011)_2$ into Gray code.

1	0	1	0	1	1	Binary
1	1	1	1	1	0	Gray

Ex) Convert $(0110101)_2$ into Gray code.

Conversion of Gray Code into a Binary Number

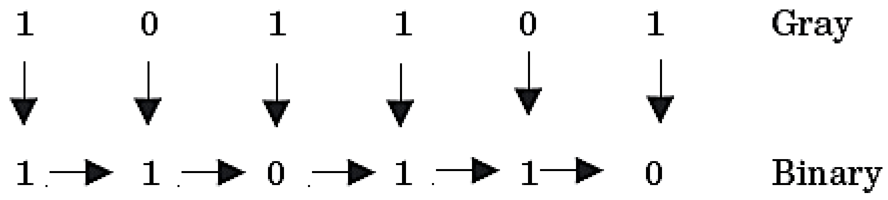
The conversion from gray to binary code is as follow:

(*i*) The MSB of the binary number is the same as the MSB of the Gray code.

(*ii*) Then we compare the MSB of the binary number with bit next to the MSB of the gray code. The binary bit will be 0 if they are the same and it will be 1 for different binary bits.

(*iii*) Similarly all the next lower order bits follow the same mechanism.

Ex) Convert the Gray code 101101 into a binary number.



Ex) Convert the Gray code 11011001 into a binary number.