$Maximum : \mathbf{0}\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1 = +127$

- For $-ve$ number

$Minimum : \mathbf{1}\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0\ \ 0 = -128$

$Maximum : \mathbf{1}\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1\ \ 1 = -1$

Range ==> -128 —> +127

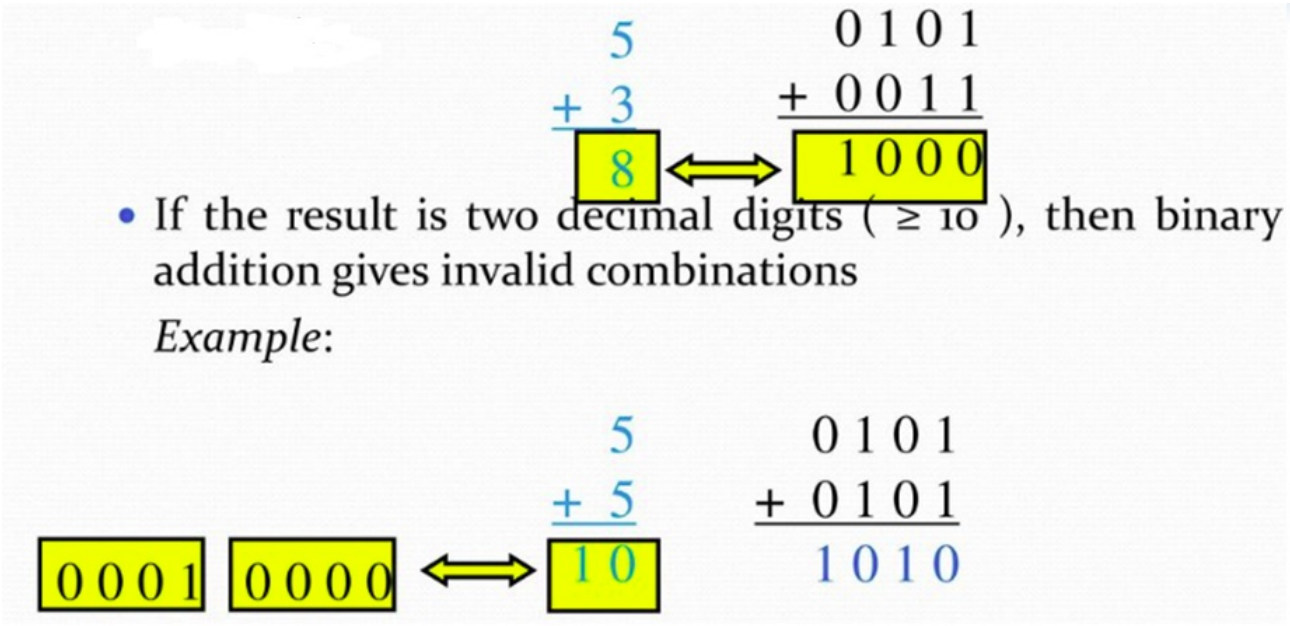
Binary Coded Decimal (BCD).

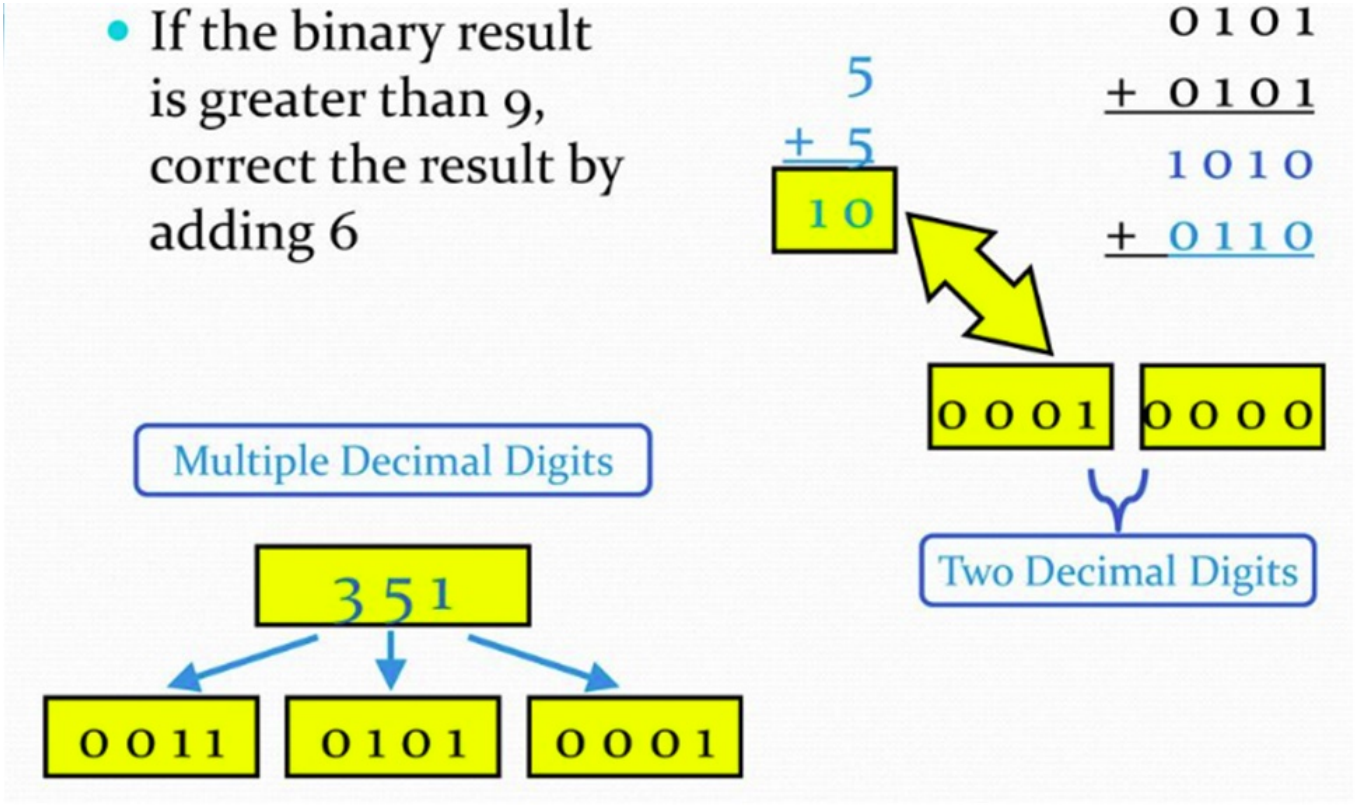
- A code used to represent each decimal digit of a number by a 4-Bit Binary Value.
- Valid Digits (combinations) for 0 to 9 are 0000 to 1001.
- Invalid Digits (combinations) (10 – 15).
- The binary codes 1010 to 1111 are invalid.
- Called an 8421 Code due to the decimal weight of each bit position.
- The following table represents a conversion of decimal number to BCD.

Decimal Digit	BCD 8 4 2 1
0	0 0 0 0
1	0 0 0 1
2	0 0 1 0
3	0 0 1 1
4	0 1 0 0
5	0 1 0 1
6	0 1 1 0
7	0 1 1 1
8	1 0 0 0
9	1 0 0 1

- One decimal digit + one decimal digit
- If the result is "1" decimal digit (<= 9), then it is a simple binary addition.

  Example:




If the binary result is greater than 9, correct the result by adding 6
5
+ 5
10
0 1 0 1
+ 0 1 0 1
1 0 1 0
+ 0 1 1 0
0 0 0 1
0 0 0 0
Two Decimal Digits
Multiple Decimal Digits
3 5 1
0 0 1 1
0 1 0 1
0 0 0 1

Example:

Convert each of the following decimal numbers to BCD

A- 45
B- 2693

A- $45 = \overbrace{0100}^{4}\ \overbrace{0101}^{5}$

B- $2693 = \overbrace{0010}^{2}\ \overbrace{0110}^{6}\ \overbrace{1001}^{9}\ \overbrace{0011}^{3}$

Gray Code.

- The Gray Code is non weighted code in which each number differs from previous number by a single bit.
- Different than Binary Code.
- Binary: $b3b2b1b0$, Gray: $g3g2g1g0$.
- Gray code bits can be defined as follows:

- g3 = b3
  g2 = b3 $\oplus$ b2
  g1 = b2 $\oplus$ b1
  g0 = b1 $\oplus$ b0

Decimal	Binary	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

- **Binary to Gray conversion.**

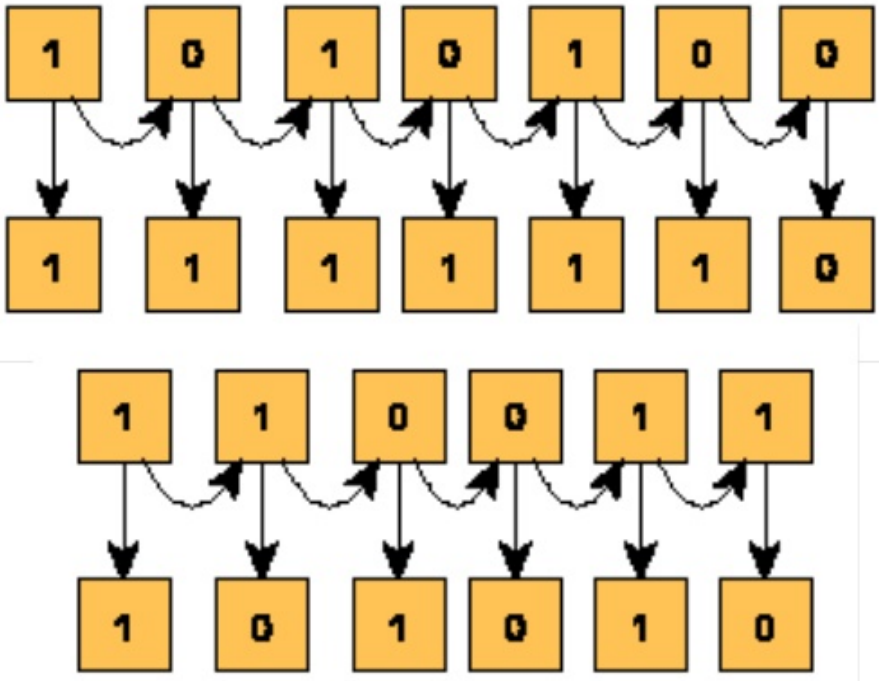
1– The MSB in the Gray code is same as the corresponding bit in the binary number.

2– Going from left to right, add each adjacent pair of binary bit to get next Gray code bit and discard carry.

11 or 00 ⟶ **0 (similar put 0)**

01 or 10 ⟶ **1 (different put 1)**

Examples:

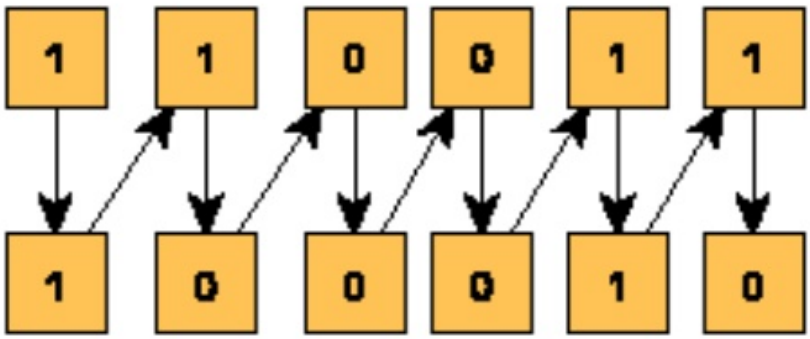


- **Gray to Binary conversion.**

1– The MSB is the binary code is same as corresponding digit in the Gray code.

2– Add each binary digit generated to the Gray digit in the next adjacent position and discard carry.

Example:



Excess code 3.

- A BCD Code formed by adding 3 (0011) to its true 4-bit binary value.
- Excess-3 is a self-complementing code:
- A negative code equivalent can be found by inverting the binary bits of the positive code.
- Inverting the bits of the Excess-3 digit yields 9's Complement of the decimal equivalent.

  Example:

- 3 = 0011 + 0011 = 0110 = 6 in E3
- 1= 0001 + 0011 = 0100 = 4 in E3
- If we complement 1= 1011 in E3, this is the code for an 8.
- 9'complement of 1 = (9-1) 8 (self-complement).