BCD addition

Like other number system in BCD arithmetical operation may be required. BCD is a numerical code which has several rules for addition. The rules are given below in three steps with an example to make the idea of **BCD Addition** clear.

At first the given number are to be added using the rule of binary. For example,

In second step we have to judge the result of addition. Here two cases are shown to describe the rules of **BCD Addition**. In case 1 the result of addition of two binary number is greater than 9, which is not valid for BCD number. But the result of addition in case 2 is less than 9, which is valid for BCD numbers.

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1. At first the given number are to be added using the rule of binary. For example,

Case 1:

$$\begin{array}{r} 1010 \\ +\ 0101 \\ \hline 1111 \end{array}$$

Case 2:

$$\begin{array}{r} 0001 \\ +\ 0101 \\ \hline 0110 \end{array}$$

BCD Addition

2. In second step we have to judge the result of addition. Here two cases are shown to describe the rules of **BCD Addition**. In case 1 the result of addition of two binary number is greater than 9, which is not valid for BCD number. But the result of addition in case 2 is less than 9, which is valid for BCD numbers.
3. If the four bit result of addition is greater than 9 and if a carry bit is present in the result then it is invalid and we have to add 6 whose binary equivalent is $(0110)_2$ to the result of addition. Then the resultant that we would get will be a valid binary coded number. In case 1 the result was $(1111)_2$, which is greater than 9 so we have to add 6 or $(0110)_2$ to it.

$$(1111)_2 + (0110)_2 = 0001\ 0101 = 15$$

As you can see the result is valid in BCD.

But in case 2 the result was already valid BCD, so there is no need to add 6. This is how BCD Addition could be.

Now a question may arrive that why 6 is being added to the addition result in case BCD Addition instead of any other numbers. It is done to skip the six invalid states of binary coded decimal i.e from 10 to 15 and again return to the BCD codes.

Now the idea of BCD Addition can be cleared from two more examples.

Example:1

Let, 0101 is added with 0110.

$$\begin{array}{rl} & 0101 \\ + & 0110 \\ \hline & 1011 \rightarrow \text{Invalid BCD number} \\ + & 0110 \rightarrow \text{Add 6} \\ \hline 0001 & 0001 \rightarrow \text{Valid BCD number} \end{array}$$

Check your self.

Example:2

Now let 0001 0011 is added to 0010 0110.

$$\begin{array}{r} 0001\ 0001 \\ +\ 0010\ 0110 \\ \hline 0011\ 0111 \end{array} \longrightarrow \text{Valid BCD number}$$

$$(0001\ 0001)_{BCD} \rightarrow (11)_{10},\ (0010\ 0110)_{BCD} \rightarrow (26)_{10}\ and\ (0011\ 0111)_{BCD}$$
$$\rightarrow (37)_{10}(11)_{10} + (26)_{10} = (37)_{10}$$

So no need to add 6 as because both

$$(0011)_2 = (3)_{10}\ and\ (0111)_2 = (7)_{10}$$

are less than $(9)_{10}$. This is the process of BCD Addition.

BCD Subtraction

- There are several methods of **BCD Subtraction**. BCD subtraction can be done by 1's compliment method and 9's compliment method or 10's compliment method. Among all these methods 9's compliment method or 10's compliment method is the most easiest. We will clear our idea on both the methods of **BCD Subtraction**.

Method of BCD Subtraction : 1

In 1st method we will do **BCD Subtraction** by 1's compliment method. There are several steps for this method shown below. They are:-

- At first 1's compliment of the subtrahend is done.
- Then the complimented subtrahend is added to the other number from which the subtraction is to be done. This is called adder 1.
- Now in BCD Subtraction there is a term 'EAC(end-around-carry)'. If there is a carry i.e if EAC = 1 the result of the subtraction is +ve and if EAC = 0 then the result is –ve.

A table shown below gives the rules of EAC.

carry of individual groups	EAC = 1	EAC = 0
1	Transfer real result of adder 1 and add 0000 in adder 2	Transfer 1's compliment result of adder 1 and add 1010 in adder 2
0	Transfer real result of adder 1 and add 1010 in adder 2	Transfer 1's compliment result of adder 1 and add 0000 to adder 2

4. In the final result if any carry bit occurs the it will be ignored.

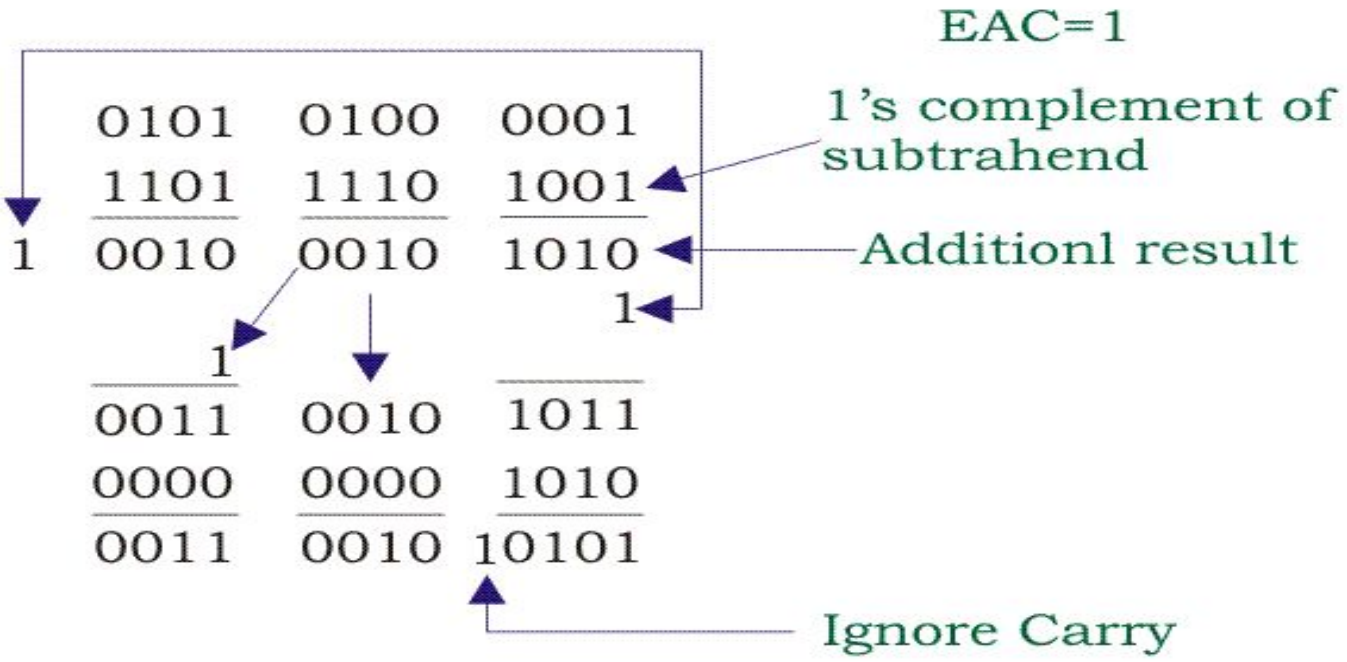
Example: – 1

In this example 0010 0001 0110 is subtracted from 0101 0100 0001.

- At first 1's compliment of the subtrahend is done, which is 1101 1110 1001 and is added to 0101 0100 0001. This step is called adder 1.
- Now after addition if any carry occurs then it will be added to the next group of numbers towards MSB. Then EAC will be examined. Here, EAC = 1. So the result of addition is positive and true result of adder 1 will be transferred to adder 2.
- Now notice from LSB. There are three groups of four bit numbers. 1010 is added 1011 which is the first group of numbers because it do not have any carry. The result of the addition is the final answer.
- Carry 1 will be ignored as it is from the rule.
- Now move to the next group of numbers. 0000 is added to 0010 and gives the result 0010. It is the final result again.
- Now again move to the next group here 0000 is also added to 0011 to give the final

result 0011.

- You may have noticed that in this two groups 0000 is added, because result of first adder do not contain any carry. Thus the results of the adder 2 is the final result of BCD Subtraction.



Therefore,

$$(0101\ 0100\ 0001) - (0010\ 0001\ 0110) = (0011\ 0010\ 0101)$$

Now you can check yourself.

$$(0101\ 0100\ 0001) = (541)_{10}$$
$$(0010\ 0001\ 0110) = 216_{10}$$
$$(0011\ 0010\ 0101) = 325_{10}$$

We know that $541 - 216 = 325$, Thus we can say that our result of **BCD Subtraction** is correct.

- **Method of BCD Subtraction: 2**
- In 2nd method we will do BCD subtraction in 9's compliment method.
- Here the method is very simple. At first the decimal equivalent of the given Binary Coded Decimal (BCD) codes are found out.
- Then the 9's compliment of the subtrahend is done and then that result is added to the number from which the subtraction is to be done.
- If there is any carry bit then the carry bit may be added to the result of the subtraction.
- Idea may be cleared from an example given below.
  Let (0101 0001) − (0010 0001) be the given subtraction.
- As we can see 51 and 21 are the decimal value of the given BCD codes. Then the 9's compliment of the subtrahend is done i.e 99 − 21 = 78.
- This complimented value is added with the 51. i.e 51 + 78 = 129.
- In this result the MSB i.e 1 is the carry. This carry will be added to 29. Therefore 29 + 1 = 30, which is the final answer of **BCD Subtraction**.
- The decimal result will be changed into **BCD** codes to get the result in BCD. Therefore from the example we can conclude the final result of BCD Subtraction i.e
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  Binary Coded Decimal Subtraction using 10's compliment is same as in case of 9's compliment, here the only difference is that instead of 9's compliment we have to do 10's compliment of the subtrahend.