Technician's Guide To Programmable Controllers

Chapter 5. Numbering System

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Chapter 5. Numbering System

1. **When information is stored using 1s and 0s, it is called a Binary system**.

Answer:

A binary system means a numbering system with only two numbers 0 and 1. Its base is 2. i.e. its values will be calculated based on numeral 2. Any number or any character can be represented by this binary system. Most of the data in communication systems as well as storage systems will be stored in binary systems.

2. **A bit is an acronym for binary digit**.

Answer:

Binary numbers 0 and 1 are the digits of the binary numbering system. In order to represent binary numbers in the description, a name was assigned which is nothing but a bit. A bit may be either 1 or 0, but it will represent a binary number.

3. **The decimal numbering system uses 10 digits or a base of 10. List the base for each of the following numbering systems.**

Answer:

a. Binary base: 2

b. Hexadecimal base: 16

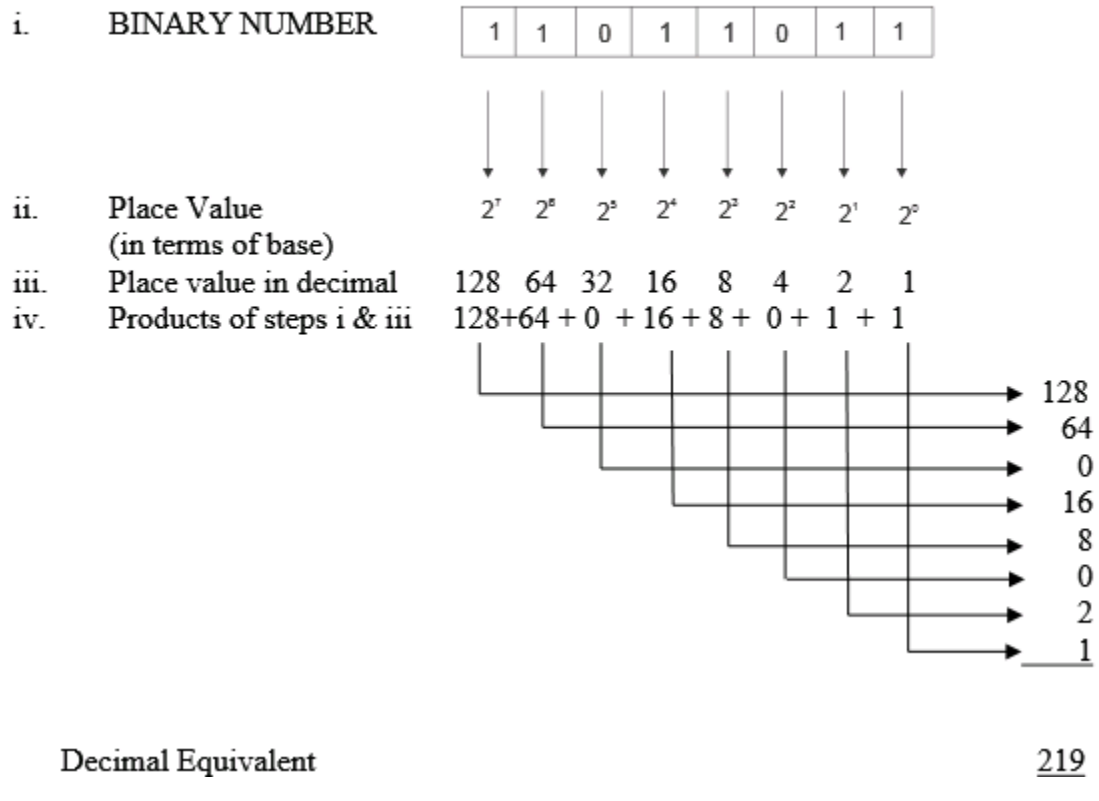
c. Octal base: 8

Binary System as it contains only two numbers 0 and 1, so its base is 2
The hexadecimal system base is 16. It utilizes numeric values from 0-9, 10 is represented by A, 11 by B, etc. And up to 15 or F
Likewise, octal numbering consists of a base as 8.

4. **Convert the binary number 11011011 to a decimal number**.

Answer:

The given binary number is 11011011, the procedure to find the decimal equivalent to the given binary number



Decimal Equivalent 219

5. **Convert decimal number 359 to a binary number.**

Answer:

The steps to follow while converting a decimal number into binary number are

i. Divide the given number by 2, keep the reminder and quotient

ii. Divide the quotient in the step (i) with 2, keep the reminder and quotient

iii. Continue this division of quotient with 2 until it the quotient becomes 0

iv. Consider the reminders from the reminder of the last step to the reminder of the first step writing them in the order of left to right.

Let's apply the procedure to the given number 359

Decimal Number 359_{10} = 1 0 1 1 0 0 1 1 1_2

i. 359/2 = 179 reminder 1

ii. 179/2 = 89 reminder 1

iii. 89/2 = 44 reminder 1

iv. 44/2 = 22 reminder 0

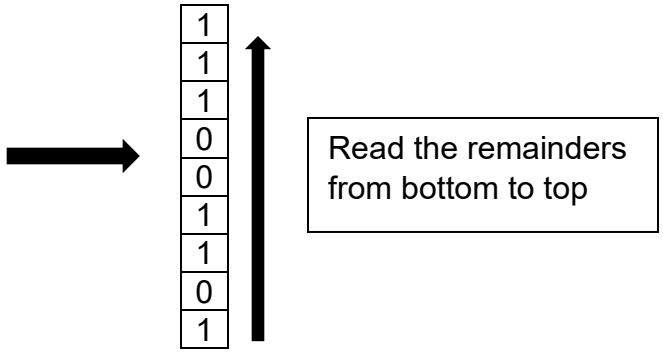
v. 22/2 = 11 reminder 0 Them

vi. 11/2 = 5 reminder 1

vii. 5/2 = 2 reminder 1

viii. 2/2 1 reminder 0

ix. 1/2 = 0 reminder 1



6. **Convert hexadecimal number 14CD to a decimal number.**

Answer:

The given hexadecimal number is 14CD; the procedure to convert to decimal is like the conversion of a Binary to a Decimal number. This will be as follows

Before proceeding to the conversion procedure, remember the decimal equivalents of the hexadecimal numbers

A = 10, B = 11, C = 12, D = 13, E = 14, F = 15

14CD

- Given Hexadecimal Number
  14CD

- The Hexadecimal values will be 163 162 161 160
- Decimal Equivalent values 4096 256 16 1
- Take the product of steps 1 & 3 4096 +(4X256) +(12X16)+(13X1)

  Then, Add them together
- The equivalent decimal number is 5325.

  Hence $14CD_{16} = 5325_{10}$

7. **Convert the decimal number 3247 to a hexadecimal number.**

Answer:

The given decimal number 3247 is to be converted into a hexadecimal number. This is similar to the decimal to binary conversion, but here in conversion to hexadecimal, the decimal number will be divided by 16. The procedure will continue till the quotient becomes 0, and then all the reminders will be considered from Down to Top in Left to Right arrangement, which yields the equivalent hexadecimal number. The decimal equivalents of hexadecimal numbers are given below. From 0 – 9, it is the same, but from 10 onwards, the numbering will be like this

10 – A,

11 – B,

12 – C,

13 – D,

14 – E,

15 – F

- Now the given decimal number is 3247
- Divide 3247 by 16 3247/16 = 202 reminder is 15
- Divide the quotient 202 again by 16 202/16 = 12 Reminder is 10
- Divide quotient 12 by 16 12/16 = 0 Reminder is 12

Read bottom to top

12 10 15

C	A	F

Hence, the given decimal number 3247_{10} is equivalent to CAF_{16}

8. **Convert the decimal number 232 to an octal number**.

Answer:

The given decimal number 232 is to be converted into an octal number. This is similar to the decimal to binary conversion, but here in conversion to octal, the decimal number will be divided by 8. The procedure will continue till the quotient becomes 0, and then all the reminders will be considered from Down to Top in the Left to Right arrangement, which yields the equivalent octal number. The numbers in the octal system are from 0 - 7

- Now the given decimal number is 232
- Divide 232 by 8 232/8 = 29 reminder is 0
- Divide the quotient 29 again by 8 29/8 = 3 Reminder is 5
- Divide quotient 3 by 8 3/8 = 0 Reminder is 3

From bottom to top

3 5 0

3	5	0

Hence, the given decimal number 232_{10} is equivalent to 350_8

9. **How do we prevent binary numbers 10 and 11 from being confused as decimal numbers?**

Answer:

Any numbering system is differentiated by subscripting its base at the number. Suppose the number is binary, it will be subscripted with 2. If the number is decimal, it will be subscripted with 10, if the number is Hexadecimal, the number will be subscripted with 16, and the octal number with 8. Here the binary numbers 10 and 11, are mentioned without base, and there may be confusion of whether they are binary or decimal. Hence the binary numbers 10 and 11 are represented by $(10)_2$ and $(11)_2$.

10. **Convert the following binary values to decimal.**

    a. 10011000

    b. 01100101

    c. 10011001

    d. 00010101

Answer:

The given binary values are to be converted into decimals.

i. 10011000 = $2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$ = 128+0+0+16+8+0+0+0 = 152_{10}

ii. 01100101 = $2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$ = 0 + 64 +32+0+0+4+0+1 = 101_{10}

iii. 10011001 = $2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$ = 128+0+0+16+8+0+0+1 = 153_{10}

iv. 00010101 = $2^7 + 2^6 + 2^5 + 2^4 + 2^3 + 2^2 + 2^1 + 2^0$ = 0+0+0+16+0+4+0+1 = 21_{10}

11. **Convert the following BCD values to decimal.**

    a. 1001 1000

    b. 0110 0101

    c. 1001 1001

    d. 0001 0101

Answer:

Binary coded decimal (BCD) is different to binary system. In order to avoid complex calculations while performing operations on large decimal numbers, it is devised. In this system four binary digits would represent a decimal value. So to convert a BCD to decimal, need to divide the given binary numbers in four number of digits from left to right. BCD representation will be subscripted with BCD at the right most position of the number.

a.

i. Given BCD is 1001 1000

1	0	0	1
1	0	0	0

ii. Convert the above 4 digits into equivalent decimal values

8+ 0+0+1= 9 8+0+0+0 = 8

iii. Hence the equivalent decimal number is 98_{10}

b.

i. Given BCD is 0110 0101

0	1	1	0
0	1	0	1

ii. Convert the above 4 digits into equivalent decimal values

0+4+2+0 = 6 0+4+0+1 = 5

iii. Hence the equivalent decimal number is 65_{10}

c. Given BCD number is 1001 1001

The equivalent decimal number is 99_{10}

d. Given BCD number is 0001 0101

The equivalent decimal number is 15_{10}

12. **The BCD value 1001 0011 0101 is not**

    a. 935 decimal

    b. 0011 1010 0111 binary

    c. 647 octal

    d. 3A7 hexadecimal

Answer:

Given BCD value is 1001 0011 0101, when converted to decimal value yields 935_{10}. This decimal value 935_{10} if converted to binary will be equal to 001110100111_2. If it is converted to hexadecimal number, it will be equal to $3A7_{16}$. If the same number is converted to octal number, it will be equal to 1647_8. Hence from the given options, it can be said that all the answers are correct except answer regarding octal system.

Correct Answer is **C**

13. **The hexadecimal value 2CB is not**

    a. 715 decimal

    b. 1313 octal

    c. 0010 1100 1011 binary

    d. 0111 0001 0011 BCD

Answer:

Given Hexadecimal number is 2CB, when converted to decimal yields 715_{10}.

But when converted to binary number $2CB_{16} = 001011001011$

When converted to octal number $2CB_{16} = 1313_8$

But when converted to BCD, $2CB_{16}$ can be converted as follows

$2CB_{16} = 0010\ 1100\ 1011_{BCD}$

But the given answer is 0111 0001 0011 which differs from the correct answer, hence the correct answer for the question is D

14. **Express the following signed decimal numbers in 2s complement. Use 8-bit words. Show all work.**

    a. (−)7

    b. (−)4

    c. (−)3

Answer:

To represent negative numbers, 2's complement is the best method. In this method, one bit represents the sign of the number. That bit usually will be the MSB (most significant bit) of the given number.

The procedure to represent signed decimal numbers using 2's complement is given below.

i. Take the equivalent binary value of the given decimal number

ii. Complement binary number

iii. Add 1 to the 1's complement, which is obtained in step no.2

iv. The result is called 2's complement, and it represents the signed decimal number. If the most significant bit (MSB) is 1 i.e., it is a negative number, otherwise it is a positive number.

a. Here, the given number is (-)7

i. Take the binary equivalent of positive decimal value i.e. for 7, considering 8 bit word

0 0 0 0 0 1 1 1

ii. complement the above number i.e. take 1's complement

1 1 1 1 1 0 0 0

iii. Add 1 to the above number to get 2's complement

1 1 1 1 1 0 0 0

+ 1

_____

1 1 1 1 1 0 0 1

iv. 2's complement

1 1 1 1 1 0 0 1

Which represents (-)7. The 1 in the MSB shows that the number is negative.

Likewise for others can be found

b. Given number is (-)4

i. Finding binary equivalent of positive decimal of the given number

It will be

0 0 0 0 0 1 0 0

Find 1's complement – Complement the above number 1 1 1 1 1 0 1 1

Add 1 to the 1's complement + 1

2's complement 1 1 1 1 1 1 0 0

So (-)4 is equal to 1 1 1 1 1 1 0 0

c. Given number is (-)3

i. Finding binary equivalent of positive decimal of the given number

It will be

0 0 0 0 0 0 1 1

Find 1's complement – Complement the above number 1 1 1 1 1 1 0 0

Add 1 to the 1's complement + 1

2's complement 1 1 1 1 1 1 0 1

So (-)3 is equal to 1 1 1 1 1 1 0 1

15. **Convert the following decimal numbers to 2s complement and add. Use 8-bit words. Show all work.**

    a. (+)4
    (-)7

    b. (-)10
    (+)22

    c. (+)22
    (+)33

Answer:

- The following work involves finding 2's complement and addition of the binary numbers. The procedure will be as follows, using 8 bit words

  (a)

  Add the following (+)4

  (-) 7

  The first step is to find the equivalent binary number of the both numbers

  (+)4 – 0000 0100

  (-)7 – for the negative numbers, 2's complement of the positive quantity should be considered.

2's complement of (-)7 can be as follows

Binary equivalent of (+)7 0000 0111

Complement it 1111 1000

Add 1 to the above number 1

1111 1001

The binary equivalent for (-)7 is 1111 1001

- Next step is performing addition on the both binary numbers

(+)4 0000 0100

(-)7 1111 1001

(-)3 1111 1101

If you want to check the answer whether it is correct or not, proceed to the following steps

Check the Most significant bit (MSB) of the answer, if it is 1 it represents negative number, if it is 0, it represents positive number. Here in our answer MSB is 1 i.e. the result is negative decimal value and hence need to go for 2's complement again.

Consider the resultant binary number 1111 1101

Complement it 0000 0010

Add 1 to the complemented value 0000 0011

Put (-) to the decimal equivalent of number in step (c), which yields (-) 3.

- (b)

Add the following (-)10

(+)22

The first step is to find the equivalent binary number of the both numbers

(+)22 – 0001 0110

(-)10 – for the negative numbers, 2's complement of the positive quantity should be considered.

2's complement of (-)10 can be as follows

Binary equivalent of (+)10 0000 1010

Complement it 1111 0101

Add 1 to the above number 1

1111 0110

The binary equivalent for (-)10 is 1111 0110

Next step is performing addition on the both binary numbers

(-)10 1111 0110

(+)22 0001 0110

(+)12 10000 1100

If you want to check the answer whether it is correct or not, proceed to the following steps

Check the Most significant bit (MSB) of the answer, if it is 1 it represents negative number, if it is 0, it represents positive number. Here in our answer MSB is 0 i.e. the result is positive decimal value and hence need not to go for 2's complement again.

Hence the decimal equivalent is (+)12 which is the correct answer.

- (c) Add the following (+)22 (+)33

The first step is to find the equivalent binary number of the both numbers

(+)22 – 0001 0110

(+)33 – 0010 0001

As both numbers are positive numbers, they can be added directly.

Next step is performing addition on the both binary numbers

(+)22 0001 0110

(+)33 0010 0001

(+)55 0011 0111

If you want to check the answer whether it is correct or not, proceed to the following steps

Check the Most significant bit (MSB) of the answer, if it is 1 it represents negative number, if it is 0, it represents positive number. Here in our answer MSB is 0 i.e. the result is positive decimal value and hence need not to go for 2's complement again.

Hence the decimal equivalent of the added value in step (ii) is (+)55 which is the correct answer.