**Codes :**

 The binary number is the most natural system , but people are familiar to the decimal system . one way to solve this conflict is to convert all input decimal numbers into binary numbers and then convert the binary results back to decimal for the human user to understand . However , it is also possible for the computer to perform arithmetic operations directly with decimal numbers provided they are placed in registers in a coded form . When decimal numbers are used for internal arithmetic computations , they are converted to a binary code with four bits per digit .

It is very important to understand difference between the conversion of decimal numbers into binary and the binary coding for decimal numbers .

**BCD ( binary – coded – decimal ) :**

 These are codes that combine some of the features of both decimal and binary numbers.

There are different types of BCD codes :

**1- Excess-3 code :**

 It is an important BCD code . To encode decimal number to it’s excess-3 , we add (3) to each decimal digit before converting to binary :

|  |  |
| --- | --- |
| **ex-3****Note :** It is un weighted code .  | **Decimal** |
| 0011 | 0 |
| 0100 | 1 |
| 0101 | 2 |
| 0110 | 3 |
| 0111 | 4 |
| 1000 | 5 |
| 1001 | 6 |
| 1010 | 7 |
| 1011 | 8 |
| 1100 | 9 |
| 0100 0011 | 10 |
| 0100 0100 | 11 |

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**2- BCD 8421 code :**

 It is weighted code .

|  |  |
| --- | --- |
| **BCD 8421** | **Decimal** |
| 0000 | 0 |
| 0001 | 1 |
| 0010 | 2 |
| 0011 | 3 |
| 0100 | 4 |
| 0101 | 5 |
| 0110 | 6 |
| 0111 | 7 |
| 1000 | 8 |
| 1001 | 9 |
| 0001 0000 | 10 |
| 0001 0001 | 11 |

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**3- Other 4-bit BCD codes :**

 Many other 4-bit codes exists , such as 7421 , 6311 , 5421 ,5311 , 5211 , 2421 …..

All are weighted codes .

***EX***: (16)D  to 2421 code

  1 6

 0001 1100

 (75)D  to 5421 code

 1010 1000

 (693)D to 6311 code

 1000 1100 0100

|  |  |  |  |
| --- | --- | --- | --- |
| **7421** | **6311** | **2421** | **D** |
| 0000 | 0000 | 0000 | 0 |
| 0001 | 0001 | 0001 | 1 |
| 0010 | 0011 | 0010 | 2 |
| 0011 | 0100 | 0011 | 3 |
| 0100 | 0101 | 0100 | 4 |
| 0101 | 0111 | 1011 | 5 |
| 0110 | 1000 | 1100 | 6 |
| 1000 | 1001 | 1101 | 7 |
| 1001 | 1011 | 1110 | 8 |
| 1010 | 1100 | 1111 | 9 |

|  |  |  |
| --- | --- | --- |
| **5311** | **5421** | **Decimal** |
| 0000 | 0000 | 0 |
| 0001 | 0001 | 1 |
| 0011 | 0010 | 2 |
| 0100 | 0011 | 3 |
| 0101 | 0100 | 4 |
| 1000 | 1000 | 5 |
| 1001 | 1001 | 6 |
| 1011 | 1010 | 7 |
| 1100 | 1011 | 8 |
| 1101 | 1100 | 9 |

**Gray code :**

 It is un weighted code the main characteristic of this code is that each gray number differs from the preceding number by single bit .

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

***EX***:

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

 1 1 0 0 Binary 1 0 1 0 Gray