Logical Design

Lecture 8

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Binary Coded Decimal (BCD).

A code used to represent each decimal digit of a number by a 4-Bit Binary Value, the following table represents a conversion of decimal number to BCD.

Decimal	Binary
0	0000
1	0001
2	0010
3	0011
4	0100
5	0101
6	0110
7	0111
8	1000
9	1001

BCD code

However, ***binary coded decimal*** is not the same as **hexadecimal**. Whereas a 4-bit hexadecimal number is valid up to F_{16} representing binary 1111_2, (decimal 15), binary coded decimal numbers stop at 9 binary 1001_2.

Example: 357_{10} = 0011 0101 0111 (BCD).

Addition of BCD code

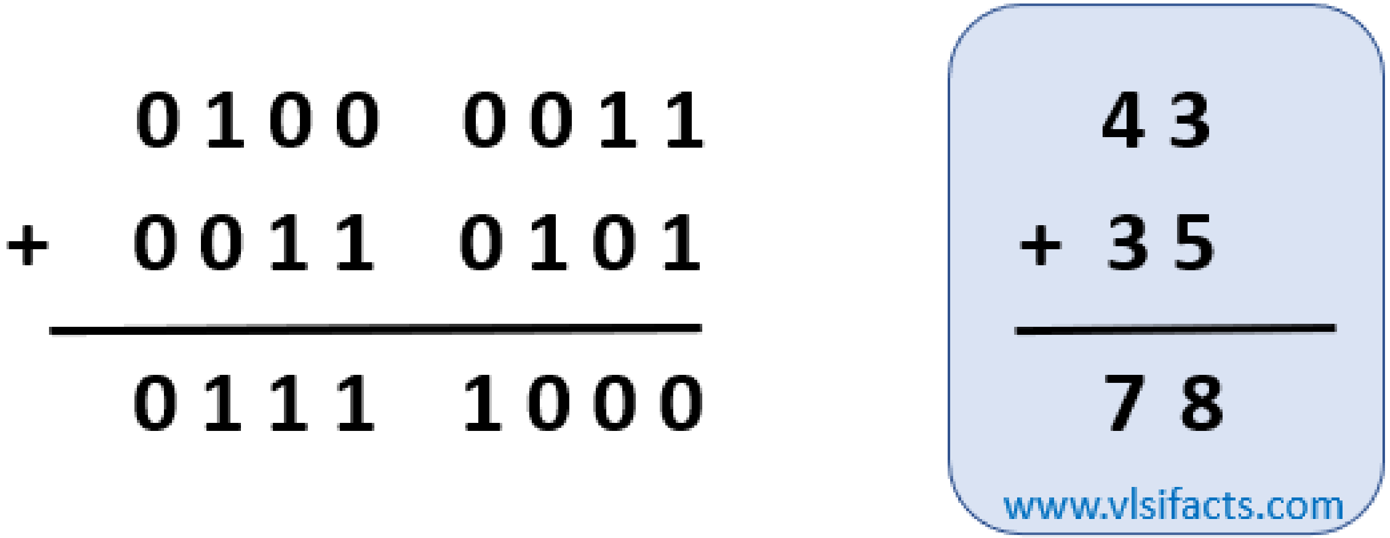
Step 1: Add the two BCD numbers, using the rules for binary addition.

Step 2: If a 4-bit sum is equal to or less than 9, it is a valid BCD number.

Step 3: If a 4-bit sum is greater than 9, or if a carry out of the 4-bit group is generated, it is an invalid result. Add 6 (0110) to the 4-bit sum in order to skip the six invalid BCD code words and return the code to 8421. If a carry results when 6 is added, simply add the carry to the next 4-bit group.

Addition of BCD code examples

Example 1: Find the sum of the BCD numbers 01000011 + 00110101



Addition of BCD code examples

Example 2: Find the sum of the BCD numbers 01110101 + 00110101

```
          0111    0101
      +   0011    0101
      ----------------
          1010    1010
        + 0110  + 0110
      ----------------
0001      0001    0000
  1         1       0
```

Both left and right BCD numbers are invalid. So we would add 6 to both the BCD numbers.

```
  75
+ 35
----
 110
```

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Addition of BCD code examples

Example:

Convert each of the following decimal numbers to BCD

A- 45 B- 2693

45 = 0100 0101

2693 = 0010 0110 1001 0011

Gray Code

The **gray code** is unweighted and is not an arithmetic code; that is, there are no specific weights assigned to the bit positions. The important feature of the Gray code is that it exhibits only a single bit change from one code number to the next. Table (2) is a listing of the four bit gray code for decimal numbers 0 through 15.

Table bellow shows the Decimal, Binary, Gray Code Numbers

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

Decimal (base 10)	Binary (base 2)	Binary-Reflected (no base)
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

Gray code pros and cons

Advantages:

1. Can be used to minimise a logic circuit.
2. It minimise error while converting analog to digital signals.
3. It is widely used in digital communications, such as digital terrestrial television and cable TV systems, to correct errors.

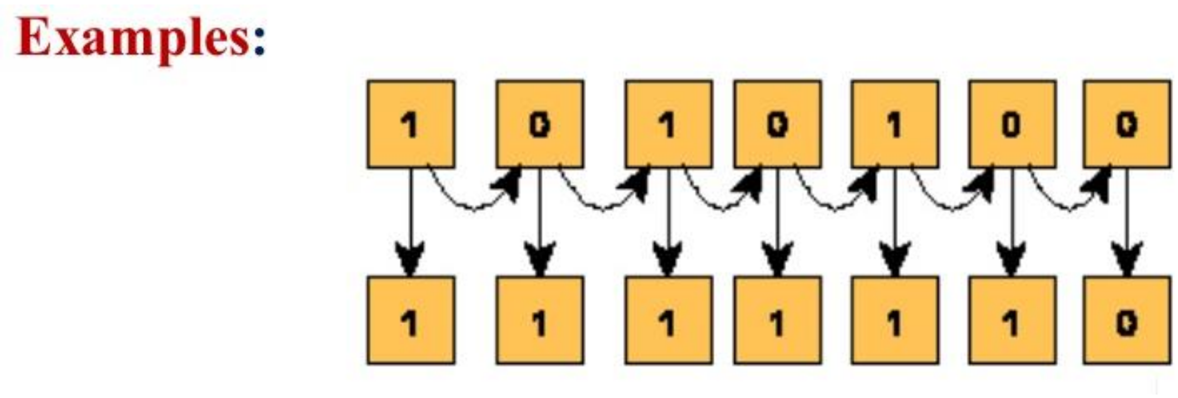
Disadvatages:

1. It is not suitable for arithmatics opertions.
2. It is limited to few practical applications.

Binary-to-Gray Conversion

1. The most significant bit (left-most) in the gray code is the same as the corresponding MSB in binary number.

2. Going from left to right, add each adjacent pair of binary code bits to get the next gray code bit. Discard carry.



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: