DIGITAL CODES CONVERSION

BCD (Binary Coded Decimal) Code :

A number with k decimal digits will require 4k bits in BCD. Decimal 396 is represented in BCD with 12bits as 0011 1001 0110, with each group of 4 bits representing one decimal digit. A decimal number in BCD is the same as its equivalent binary number only when the number is between 0 and 9. A BCD number greater than 10 looks different from its equivalent binary number, even though both contain 1's and 0's. Moreover, the binary combinations1010 through 1111 are not used and have no meaning in BCD.

There are many methods or techniques which can be used to convert code from one format to another. We'll demonstrate here the following

Binary to BCD Conversion BCD to Binary Conversion BCD to Excess-3 Excess-3 to BCD

Binary to BCD Conversion

Steps
Step 1 -- Convert the binary number to decimal. **Step 2** -- Convert decimal number to BCD.

Example – convert 11101_2 to BCD.

Step 1 – Convert to Decimal

Binary Number – 11101_2

Calculating Decimal Equivalent –

Steps	**Binary Number**	**Decimal Number**
Step 1	11101_2	$((1 \times 2^4)$ + (1×2^3) + (1×2^2) + (0×2^1) + $(1 \times 2^0))_{10}$
Step 2	11101_2	<u>16 + 8 + 4 + 0 + 1</u> $_{10}$
Step 3	11101_2	29_{10}

Step 2 – Convert to BCD

Decimal Number – 29_{10}
Calculating BCD Equivalent. Convert each digit into groups of four binary digits equivalent.

Step	Decimal Number	Conversion
Step 1	29_{10}	0010_2 1001_2
Step 2	29_{10}	00101001_{BCD}

Result

$(11101)_2 = (00101001)_{BCD}$

BCD to Binary Conversion

Steps
Step 1 -- Convert the BCD number to decimal.

Step 2 -- Convert decimal to binary.

Example – convert 00101001_{BCD} to Binary.

Step 1 - Convert to BCD

BCD Number – 00101001_{BCD}

Calculating Decimal Equivalent. Convert each four digit into a group and get decimal equivalent for each group.

Step	BCD Number	Conversion
Step 1	00101001_{BCD}	0010_2 1001_2
Step 2	00101001_{BCD}	2_{10} 9_{10}
Step 3	00101001_{BCD}	29_{10}

BCD Number – 00101001_{BCD} = Decimal Number – 29_{10}

Step 2 - Convert to Binary

Used long division method for decimal to binary conversion.

Decimal Number – 29_{10}
Calculating Binary Equivalent –

Step	Operation	Result	Remainder
Step1	29/2	14	1
Step 2	14/2	7	0
Step 3	7/2	3	1
Step 4	3/2	1	1
Step 5	1/2	0	1

As mentioned in Steps 2 and 4, the remainders have to be arranged in the reverse order so that the first remainder becomes the least significant digit LSD and the last remainder becomes the most significant digit MSD.

Decimal Number – 29_{10} = Binary Number – 11101_2

Result

$(00101001)_{BCD} = (11101)_2$

BCD to Excess-3

Steps

Conversion

Step 1 -- Convert BCD to decimal.
Step 2 -- Add 3_{10} to this decimal number.
Step 3 -- Convert into binary to get excess-3 code.

Example – convert 1001_{BCD} to Excess-3.

Step 1 – Convert to decimal

$1001_{BCD} = 9_{10}$

Step 2 – Add 3 to decimal

9_{10} + $3_{10} = 12_{10}$

Step 3 – Convert to Excess-3

$12_{10} = 1100_2$

Result

$(1001)_{BCD} = (1100)_{XS-3}$

Excess-3 to BCD Conversion

Steps

Step 1 -- Subtract 0011_2 from each 4 bit of excess-3 digit to obtain the corresponding BCD code.

Example – convert 10011010_{XS-3} to BCD.

Given XS-3number = 1 0 0 1 1 0 1 0

Subtract $(0011)_2$ = 0 0 1 1 0 0 1 1

BCD = 0 1 1 0 0 1 1 1

Result

$(10011010)_{XS-3} = (01100111)_{BCD}$

Advantages of Gray Code

Better for error minimization in converting analog signals to digital signals

Reduces the occurrence of “Hamming Walls” (an undesirable state) when used in genetic algorithms

Can be used to in to minimize a logic circuit

Useful in clock domain crossing

Disadvantages of Gray Code

Not suitable for arithmetic operations

Limited practical use outside of a few specific applications

Binary Storage and Registers

■ Registers

A binary cell is a device that possesses two stable states and is capable of storing one of the two states.

A register is a group of binary cells. A register with n cells can store any discrete quantity of information that contains n bits.

•A binary cell

–two stable state

–store one bit of information

–examples: flip-flop circuits, ferrite cores, capacitor

•A register

–a group of binary cells

■ Register Transfer

a transfer of the information stored in one register to another

one of the major operations in digital system

Exercise:

1. **Consider decimal 159 and its corresponding value in BCD and binary.**
2. **Calculate 184 + 576 in BCD.**
3. **Find the equivalent gray code for the binary 11101_2.**
4. **Find the equivalent binary number for the gray code 1010.**
5. **Construct a table showing the conversion between binary code to gray code and decimal to gray code from Decimal numbers 0 to 9.**
6. **(1011001)2 = (?   ) Gray Code**
7. **Construct a Number system conversion table from 0 to 15 for Decimal Number Base-10, Binary Number Base-2, Octal Number Base-8, Hexadecimal Number Base-16**