Digital Logic Design

By

Dr. Sadiq Ahmad

Lecturer COMSATS University Islamabad

1-7. Binary codes

- Digital systems use signals that have two distinct values and circuit elements that have two stable states.
- Any discrete element of information that is distinct among a group of quantities can be represented with a binary code (i.e. , a pattern of 0's and 1's).
- An n-bit binary code is a group of n bits that assumes up to 2^n distinct combinations of 1's and 0's, with each combination representing one element of the set that is being coded .

BCD code

- We are more accustomed to the decimal system, and is straight binary assignment as listed in Table1-4. this is called binary coded decimal(BCD).
- 1010~1111 are not used and have no meaning in BCD code.

Ex: $(185)_{10} = (1011001)_2$
$= (0001\ 1000\ 0101)_{BCD}$

Table 1-4
Binary Coded Decimal (BCD)

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

BCD Addition

- When the binary sum is greater than or equal to 1010, the addition of 6 to the binary sum converts it to the correct digit and also produces a carry as required.

One digit addition:

1000	8
+1001	+9
10001	17
+0110	
1 0111	

two digits addition:

BCD carry	1	1			
	0001	1000	0100		184
	+0101	0111	0110		+576
Binary sum	0111	10000	1010	>9	
Add 6		0110	0110	+6	
BCD sum	0111	0110	0000		760

BCD Subtraction

Consider the addition
(+ 375) +(- 240) = + 135, done in the signed-complement system:
10’s complement of 240 is 760 while +9 represent that it is –ve

```
       0  375
      +9  760
   1|  0  135
```

(+ 3470) +(- 8750) = + 5280, done in the signed-complement system:
10’s complement of 8750 is 1250 while +9 represent that it is –ve

```
       0  3470
      +9  1250
   0|  9  4720
```

So taking again 10’s complements and put minus due to 0’s remainder
so the final answer is (-5280)

Other Decimal Codes

- The BCD,8-4-2-1, and the 2-4-2-1 codes are examples of weighted codes.
- The excess-3 codes are examples of self-complementing codes.

Ex. $(395)_{10} = (0110\ 1100\ 1000)_{excess\text{-}3}$

9's complement

self-complementing

$(604)_{10} = (1001\ 0011\ 0111)_{excess\text{-}3}$

it is obviously to know the self-complementing that the excess-3 code of 9's complement of 395 is complementing the excess-3 of 395 directly. So does the 2421 code.

Other Decimal Codes

Table1-5
Four Different Binary Codes for the Decimal Digits

Decimal Digit	BCD 8421	2421	Excess-3	8 4-2-1
0	0000	0000	0011	0 0 0 0
1	0001	0001	0100	0 1 1 1
2	0010	0010	0101	0 1 1 0
3	0011	0011	0110	0 1 0 1
4	0100	0100	0111	0 1 0 0
5	0101	1011	1000	1 0 1 1
6	0110	1100	1001	1 0 1 0
7	0111	1101	1010	1 0 0 1
8	1000	1110	1011	1 0 0 0
9	1001	1111	1100	1 1 1 1
	1010	0101	0000	0 0 0 1
Unused bit	1011	0110	0001	0 0 1 0
Combinations	1100	0111	0010	0 0 1 1
	1101	1000	1101	1 1 0 0
	1110	1001	1110	1 1 0 1
	1111	1010	1111	1 1 1 0

2 → $8 \times \boxed{0} + 4 \times \boxed{1} + (-2) \times \boxed{1} + (-1) \times \boxed{0} = 2$

weight

7 → $\boxed{2} \times \boxed{1} + \boxed{4} \times \boxed{1} + \boxed{2} \times \boxed{0} + \boxed{1} \times \boxed{1} = 7$

Gray Code

- The advantage of the Gray code over the straight binary number sequence is that only one bit in the code group changes when one number to the next.

EX: from 7 to 8

Gray code changes from

0100 to 1100.

Table 1-6
Gray Code

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

$(0\ 1\ 1\ 1)_2$

xor

$(0 1\ 0\ \ 0)_{Gray}$

xor

$(0 1\ 1\ \ 1)_2$