

Binary Subtraction

Binary Codes

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BCD Arithmetic using 2's Complement method

- As an example, imagine we want to add

$$(+257) + (-160) = +097$$

0 2 5 7 0000 0010 0101 0111

0 1 6 0 0000 0001 0110 0000

Taking 10's complement of 0160

1001 1111 1010 0000
 + 0000 1111 1010 0000

-160 in BCD: 1001 1000 0100 0000

In BCD

0001
 0000 0010 0101 0111
 + 1001 1000 0100 0000

1010 1010 1001 0111
 0110 0110

~~001~~) 0000 0000 1001 0111

Ans = + 0 9 7

2's Compl of each digit.

Other Decimal Codes

- There are various other decimal codes that can be used:
 - BCD (8 4 2 1)
 - 2 4 2 1
 - Excess-3 code. (adds binary 0011 to the BCD code)
 - 8 4 -2 -1
 - Gray Code
 - ASCII Character Code
 - Error-Detecting Code
- Each bit has a "weight" associated with it and you can compute the decimal value by adding the weights where a 1 exists in the code-word.

Four Different Binary Codes

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

Summary Binary Codes

- Binary Codes?
 - To represent discrete information, n bits can represent 2^n quantities
 - Decimal digits codes, representing each digit separately
 - BCD, 2421, Excess-3, 84-2-1, 4321etc
- BCD Addition?
 - If the sum of two BCD number is more than 9 then add 6 to it.
- BCD Arithmetic?
 - Signed BCD : 0000 for positive, 1001 for negative number
 - Take 10's complement of negative number and add it to the other number, discard carry, if sum is more than nine add binary 6 to get BCD digits
 - Take 2's complement of each digit, leaving least significant zeros, add binary 10 to first non zero digit and add binary nine to all other digits

Gray Code

- It is sometimes convenient to use the Gray code to represent the digital data when it is converted from analog data
- The advantage of Gray code over straight binary number sequence is that only one bit in the code group changes when going from one number to the next

Gray Code

Decimal digit	Gray code
0	0000
1	0001
2	0011
3	0010
4	0110
5	0111
6	0101
7	0100

Decimal digit	Gray code
8	1100
9	1101
10	1111
11	1110
12	1010
13	1011
14	1001
15	1000

Gray Code Vs Binary Code

- Compare the number of bits changing when going from one number to the next:
 - In Gray code it is always 1 bit.

Binary Code	Bit Changes	Gray Code	Bit Changes
000	1	000	1
001	2	001	1
010	1	011	1
011	3	010	1
100	1	110	1
101	2	111	1
110	1	101	1
111	3	100	1
000		000	1

End of Lecture