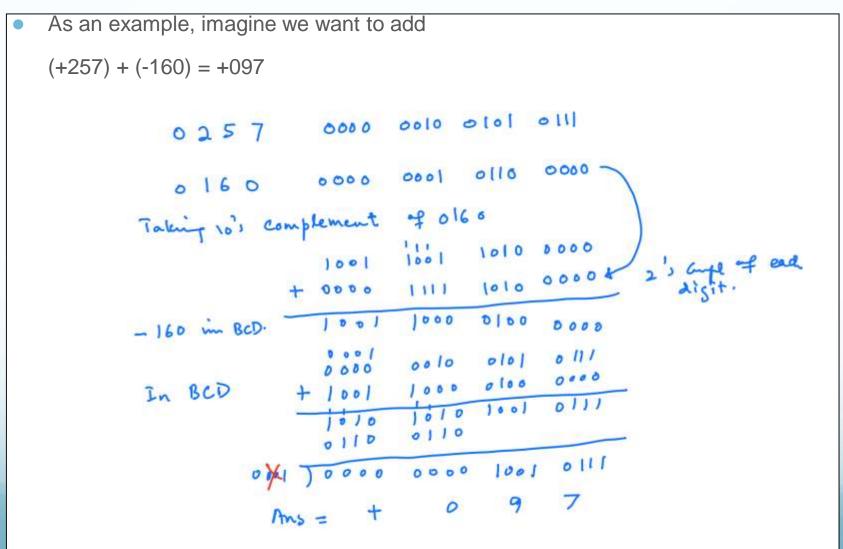
## **Binary Subtraction Binary Codes**

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# BCD Arithmetic using 2's Complement method



#### Other Decimal Codes

- There are various other decimal codes that can be used:
  - BCD (8 4 2 1)
  - 2421
  - Excess-3 code. (adds binary 0011 to the BCD code)
  - 84-2-1
  - 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<sup>n</sup> 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	Gray code
digit	
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	Bit	Gray	Bit
Code	Changes	Code	Changes
000 001 010 011 100 101 110 111 000	1 2 1 3 1 2 1 3	000 001 011 010 110 111 101 100 000	1 1 1 1 1 1 1

#### **End of Lecture**