

## Overview

- Condition Code Flag interpretation

## ELEC2041

### Microprocessors and Interfacing

### Lecture 7: Number Systems – II Extras

<http://webct.edtec.unsw.edu.au/>

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## Review: int and unsigned int in C

- With  $N$  bits we can represent  $2^N$  different Numbers:

- $2^N$  numbers 0 to  $2^N - 1$  : Only zero and Positive numbers
- $2^N$  numbers  $-2^{N/2}$  to 0 to  $2^{N/2} - 1$ : Both Negative and positive numbers in 2's Complement

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

Is 1000 > 0110 ?

1000 > 0110 if only +ve representation used

1000 < 0110 if both +ve and -ve representation in 2's complement used

## Review: Condition Flags

Flags	Arithmetic Instruction
Negative (N='1')	Bit 31 of the result has been set Indicates a negative number in signed operations
Zero (Z='1')	Result of operation was zero
Carry (C='1')	Result was greater than 32 bits
oVerflow (V='1')	Result was greater than 31 bits Indicates a possible corruption of the sign bit in signed numbers

31	28 27	8 7 6 5 4	0
N Z C V	unused	I F T	mode

## Experimentation with Condition Flags (#1/5)

Indicate the changes in **N, Z, C, V** flags for the following arithmetic operations: (Assume 4 bit-numbers)

$$\begin{array}{r} 0010 \\ 0011 + \\ \hline 0010 \\ \hline 00101 \end{array}$$

$\neq \rightarrow$  Overflow,  $V = 0$   
 $= 0 \rightarrow$  Carry set,  $C = 0$   
 $= 0 \rightarrow$  Result +Ve  $N = 0$   
 $\rightarrow$  Result Not Zero  $Z = 0$

**Signed interpretation:**  $3 + 2 = 5$ . The number is within the range of  $-8$  to  $+7$ . No overflow ( $V$ )

**Unsigned interpretation:**  $3 + 2 = 5$ . The number is within the range of the range of  $0$  to  $+15$ . Carry NotSet, NoOverflow ( $C$ )

## Experimentation with Condition Flags (#2/5)

Indicate the changes in **N, Z, C, V** flags for the following arithmetic operations: (Assume 4 bit-numbers)

$$\begin{array}{r} 1110 \\ 1111 + \\ \hline 0010 \\ \hline 10001 \end{array}$$

**NOTE:  $V = \text{MSB Carry In (XOR) MSB Carry out}$**

$\neq \rightarrow$  No Overflow,  $V = 0$   
 $= 1 \rightarrow$  Carry set,  $C = 1$   
 $= 0 \rightarrow$  Result +Ve  $N = 0$   
 $\rightarrow$  Result Not Zero  $Z = 0$

**Signed interpretation:**  $-1 + 2 = 1$ . The number is within the range of  $-8$  to  $+7$ . No overflow ( $V$ )

**Unsigned interpretation:**  $15 + 2 = 17$ . The number is out of the range of  $0$  to  $+15$ . Carry Set, Overflow ( $C$ )

## Experimentation with Condition Flags (#3/5)

Indicate the changes in **N, Z, C, V** flags for the following arithmetic operations: (Assume 4 bit-numbers)

$$\begin{array}{r} 0110 \\ 0111 + \\ \hline 0010 \\ \hline 01001 \end{array}$$

**NOTE:  $V = \text{MSB Carry In (XOR) MSB Carry out}$**

$\neq \rightarrow$  Overflow,  $V = 1$   
 $= 0 \rightarrow$  Carry set,  $C = 0$   
 $= 1 \rightarrow$  Result -Ve  $N = 1$   
 $\rightarrow$  Result Not Zero  $Z = 0$

**Signed interpretation:**  $7 + 2 = 9$ . The number is out of the range of  $-8$  to  $+7$ . overflow ( $V$ )

**Unsigned interpretation:**  $7 + 2 = 9$ . The number is within the range of  $0$  to  $+15$ . Carry NotSet, NoOverflow ( $C$ )

## Experimentation with Condition Flags (#4/5)

Indicate the changes in **N, Z, C, V** flags for the following arithmetic operations: (Assume 4 bit-numbers)

$$\begin{array}{r} 1110 + \\ 1001 \\ \hline 10111 \end{array}$$

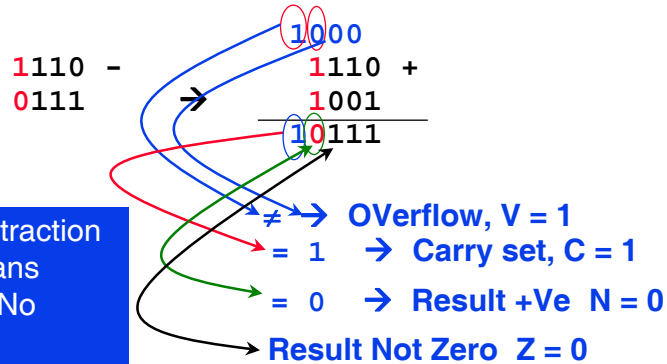
$\neq \rightarrow$  Overflow,  $V = 1$   
 $= 1 \rightarrow$  Carry set,  $C = 1$   
 $= 0 \rightarrow$  Result +Ve  $N = 0$   
 $\rightarrow$  Result Not Zero  $Z = 0$

**Signed interpretation:**  $-2 - 7 = -2 + (-7) = -9$ . The number is out of the range of  $-8$  to  $+7$ . overflow ( $V$ )

**Unsigned interpretation:**  $14 + 9 = 23$ . The number is out of the range of  $0$  to  $+15$ . Carry Set, Overflow ( $C$ )

## Experimentation with Condition Flags (#5/5)

Indicate the changes in **N, Z, C, V** flags for the following arithmetic operations: (Assume 4 bit-numbers)



Note: For Subtraction  
Carry Set means  
No Overflow (No  
Borrow)

**Signed interpretation:**  $-2 - 7 = -2 + (-7) = -9$ . The number is out of the range of  $-8$  to  $+7$ . **oV**erflow (V)

**Unsigned interpretation:**  $14 - 7 = 7$ . The number is within the range of  $0$  to  $+15$ . **Carry Set, NoO**verflow (C)

## Signed /Unsigned Overflow Summary

**Signed Arithmetic overflow Condition:**

oVerflow flag V = 0 **NO OVERFLOW**

oVerflow flag V = 1 **OVERFLOW**

**NOTE: V = MSB Carry In (XOR) MSB Carry out**

**UnSigned Arithmetic overflow Condition:**

**Addition:**

(Carry flag C = 0) **NO OVERFLOW**

(Carry flag C = 1) **OVERFLOW**

**Subtraction:**

(Carry flag C = 0) **OVERFLOW**

(Carry flag C = 1) **NO OVERFLOW**