

MECE336– Microprocessors I

Lecture 8 – Addition and Subtraction

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Compulsory Course in Mechatronics Engineering
Credits (3/2/4)

Course Webpage: <http://MECE336.cankaya.edu.tr>

Addition: Addition of Two 8bit Numbers

Half Adder Truth Table Full Adder Truth Table

Input		Output	
A	B	S	C
0	0	0	0
0	1	1	0
1	0	1	0
1	1	0	1

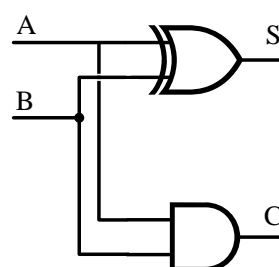
Input			Output	
A	B	Cin	S	Cout
0	0	0	0	0
0	1	0	1	0
1	0	0	1	0
1	1	0	0	1

Input			Output	
A	B	Cin	S	Cout
0	0	1	1	0
0	1	1	0	1
1	0	1	0	1
1	1	1	1	1

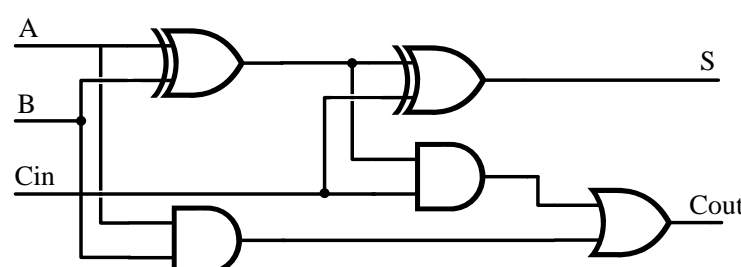
→ Without carry input

→ Addition with carry input

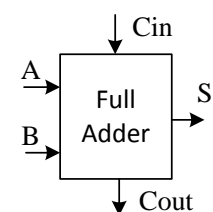
Half Adder



Full Adder



Full Adder Block

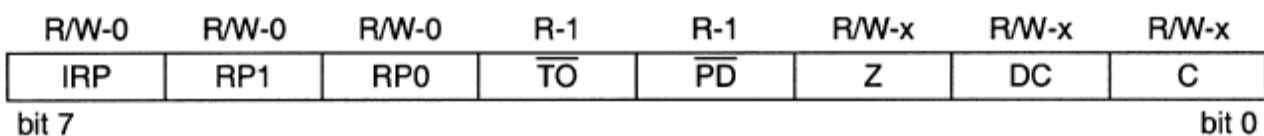


Addition: Addition of Two 8bit Numbers

Explanation

Realization

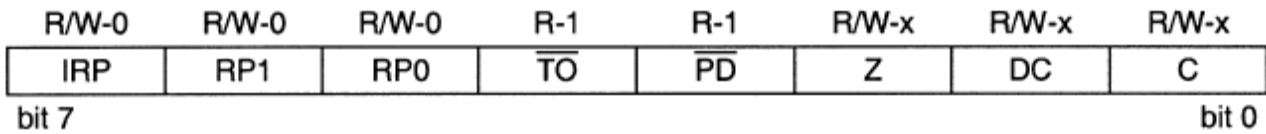
Addition: Status Register



Carry flag C (bit 0)

- C = 1: A carry out from the MSB of the result occurred
- C = 0: No carry out occurred

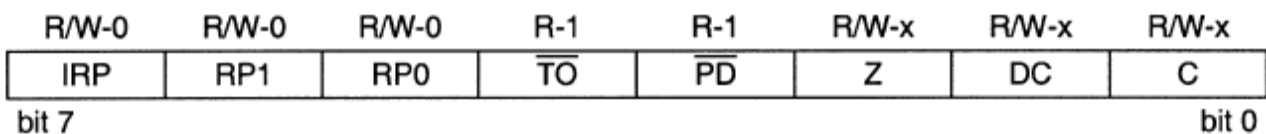
Addition: Status Register



Digital carry flag DC (bit 1)

- DC = 1: A carry out from the MSB of the low nibble of the result occurred
- DC = 0: No carry out from the low nibble occurred

Addition: Status Register



Zero flag Z (bit 2)

- Z = 1: The result of an arithmetic or logical operation is zero
- Z = 0: The result of an arithmetic or logical operation is non-zero

Addition: Instructions

Different Versions

- `addlw k`: Add the contents of the working register W and the literal k . Result is in W .
- Affects C , DC , Z
Example:

Addition: Instructions

Different Versions

- `addwf f,d`: Add the contents of the working register W and the content of file register f . Result is in
 - W if $d = 0$
 - f if $d = 1$
- Affects C , DC , Z
Example:

Addition: Example Program

Task

- Add 5 to file register 0x22 whenever button at RB0 is pressed. Clear 0x22 if content of 0x22 becomes larger than 255.

Addition: Example Program

Addition: Limitation

Addition of Large Numbers

- Largest possible result of 8-bit addition is

$$11111111_2 = 255_{10} = FF_{16}$$

- Example Computation

Addition: 16 bit Numbers

Solution

- Use 2 file registers (2 bytes) for 16 bit addition
- Carry of lower byte is used for evaluation of higher byte
- Largest possible number is $1111111111111111_2 = FFFF_{16} = 65535_{10}$
- Illustration

Addition: 16 bit Numbers

Program for 16 Bit Addition

Addition: 16 bit Numbers

Program for 16 Bit Addition

Addition: 16 bit Numbers

Program for 16 Bit Addition

Subtraction: Background

Twos-Complement

- Binary operation that can be used for subtraction
- Computation for a given binary number B
 - Take the bitwise complement of B (called ones-complement)
 - Add 1 to the result
- Examples

Subtraction: Background

Subtraction of Two Binary Numbers: $B1 - B2$

- Compute the twos-complement of $B2$
- Add $B1$ and the twos-complement of $B2$
⇒ Result is $B1 - B2$
- If the result is negative, there is "borrow" ⇒ C flag is zero
- Examples

Subtraction: Instructions

Subtract Working Register from File Register

- `subwf f, d`: Subtract the W register from the content of memory location f . Result is written in
 - Working register W if $d = 0$
 - File register f if $d = 1$
- The $C/\overline{\text{borrow}}$ flag (bit 0) in the Status register is
 - 0 if there is borrow
 - 1 if there is no borrow

Example:

Subtraction: Instructions

Subtract Working Register from Literal

- `sublw k`: Subtract the W register from a literal k . Result is written into W .
- The $C/\overline{\text{borrow}}$ flag (bit 0) in the Status register is
 - 0 if there is borrow
 - 1 if there is no borrow

Example:

Subtraction: Programming Examples

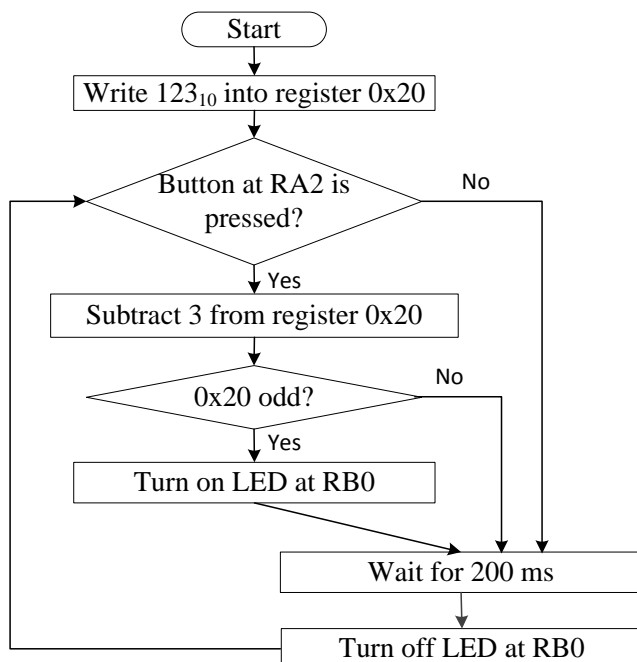
Description

- Write 250_{10} in file register $0x0C$. Repeatedly subtract 7 from file register $0x0C$ until the content is negative. If the content is negative, write the content of $0x0C$ to W .

Subtraction: Programming Examples

Subtraction: Programming Examples

Flow Chart for Program



Subtraction: Programming Examples

Program

Subtraction: Programming Examples

Program