

**Department of
Electronics, Computer, and Information
Technology**

ECT 213 Digital Electronics

Lecture 8: Chapter 7
Binary Arithmetic
(Sub, Mult, Div)
2's Complement
Hex Arithmetic
BCD addition

Subtraction of Binary

$0 - 0 = \underline{0}$ borrow <u>0</u>	10_2	$\overset{0}{\cancel{1}}0_2$	11_2	11_2
$0 - 1 = \underline{1}$ borrow <u>1</u>	$- 0_2$	$- 1_2$	$- 0_2$	$- 1_2$
$1 - 0 = \underline{1}$ borrow <u>0</u>	$\hline 10$	$\hline 1$	$\hline 11$	$\hline 10$
$1 - 1 = \underline{0}$ borrow <u>0</u>				

A_0	B_0	R_0	B_{out0}
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

A_1	B_1	B_{in1}	R_1	B_{out1}
0	0	0	0	0
0	0	1	1	1
0	1	0	1	1
0	1	1	0	1
1	0	0	1	0
1	0	1	0	0
1	1	0	0	0
1	1	1	1	1

$$\begin{array}{r}
 B_{in2} \quad B_{in1} \quad A_0 \\
 - \quad A_1 \quad B_0 \\
 \hline
 R_2 \quad R_1 \quad R_0 \\
 + \quad + \\
 B_{out1} \quad B_{out0}
 \end{array}$$

$$\begin{array}{r}
 100_2 \quad 100_2 \quad 100_2 \quad 100_2 \quad 110_2 \quad 110_2 \quad 110_2 \quad 110_2 \\
 - 00_2 \quad -01_2 \quad - 10_2 \quad - 11_2 \quad - 00_2 \quad - 01_2 \quad - 10_2 \quad - 11_2 \\
 \hline
 \end{array}$$

Example 1 - 2:

$$\begin{array}{r}
 8 \\
 - 5 \Rightarrow \\
 \hline
 3
 \end{array}$$

$$\begin{array}{r}
 1 1 \\
 \cancel{1} 0 1 0 \\
 1 \cancel{0} 0 0_2 \\
 - 1 0 1_2 \\
 \hline
 1 1_2
 \end{array}$$

$$\begin{array}{r}
 3 \\
 4 \\
 - 21 \Rightarrow \\
 \hline
 19
 \end{array}$$

$$\begin{array}{r}
 1 0 1 \\
 0 0 0 0 \\
 \cancel{1} 0 \cancel{1} 0 0 0_2 \\
 - 1 0 1 0 1_2 \\
 \hline
 1 0 0 1 1_2 \\
 16 \ 6 \ 4 \ 2 \ 1
 \end{array}$$

Two's Complement:

- Most used method for representing binary numbers and in performing binary arithmetic .

D₇D₆D₅D₄D₃D₂D₁D₀

- For an 8-bit binary value, D₇, called the

Sign bit, indicates if the value is
a $D_7 = 0$ positive or $D_7 = 1$ negative number.

Converting from Decimal to 2's Complement

1. Convert the positive decimal value to binary
 - a. Make use the proper number of binary digits are use.
 - b. Insure that at the sign bit is zero.

2. If decimal value is negative,
 - a. Complement each binary digit (one's complement)
 - b. Add 1 to the one's complement

Example 9: Convert 60 to an 8-bit two's complement value.

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	1	1	1	1	0	0

2

Example 10: Convert -60 to an 8-bit two's complement value.

1's comp	1	1	0	0	0	0	1	1
							+	1
= - 60								

Converting 2's complement value to decimal.

1. If sign bit equals 0, due regular binary-to-decimal conversion

2. If sign bit equals 1 (Negative number),
 - a. Complement the 2's complement value
 - b. Add 1 to complemented value
 - c. Due regular binary-to-decimal conversion

Example 11: Convert the following 2's complement value, $\underline{0}1110011_2$, to decimal.

128	64	32	16	8	4	2	1
0	1	1	1	0	0	1	1

$$64 + 32 + 16 + 2 + 1 = 115$$

Example 12: Convert the following 2's complement value, $\underline{1}1110011_2 = -13$ to decimal.

$$\begin{array}{r}
 00001100 \\
 +1 \\
 \hline
 00001101_2 = 13 \\
 8421
 \end{array}$$

2's complement Arithmetic

Note: assume 8-bit

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	0	1	0	0	0
0	0	0	0	0	1	0	1

8
5

Example 13:

$$\begin{array}{r}
 8 \\
 + 5 \\
 \hline
 \end{array}$$

$$\begin{array}{r}
 00001000 \\
 + 00000101 \\
 \hline
 00001101
 \end{array}$$

Example 14:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0	
128	64	32	16	8	4	2	1	
0	0	1	1	0	0	1	0	50
0	1	0	0	0	0	1	0	66

$$\begin{array}{r}
 50 \\
 - 66 \\
 \hline
 -16
 \end{array}$$

$$\begin{array}{r}
 1011101 \\
 + 1 \\
 \hline
 1011110 = -66
 \end{array}$$

CK

$$\begin{array}{r}
 1111 \\
 00001111 \\
 + 1 \\
 \hline
 00010000_2 = 16 \\
 16 \ 8 \ 4 \ 2 \ 1
 \end{array}$$

$$\begin{array}{r}
 111111 \\
 00110010 \\
 + 10111110 \\
 \hline
 11110000_2 = -16
 \end{array}$$

Example 15:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0
128	64	32	16	8	4	2	1
0	0	0	1	0	0	1	1
0	0	0	1	0	1	0	0

19
20

$$\begin{array}{r}
 - 19 \\
 20 \\
 \hline
 1
 \end{array}$$

$$\begin{array}{r}
 11101100 \\
 + 1 \\
 \hline
 11101101 = 19
 \end{array}$$

$$\begin{array}{r}
 11101101 \\
 00010100 \\
 \hline
 00000001 = 1
 \end{array}$$

Example 16:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

- 80

- 40

Example 17:

2^7	2^6	2^5	2^4	2^3	2^2	2^1	2^0

- 75

- 75
