Homework 7

ECE2504 CRN:82729

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October 12, 2017

Question 1: (8 pts) Find the 1's and 2's complement of the following unsigned binary numbers.

a)

$$\begin{aligned} Original &: 11001 \\ 1's\ Compliment &: 00110 \\ 2's\ Compliment &: 00111 \end{aligned}$$

b)

$$\begin{aligned} Original &: 110 \\ 1's\ Compliment &: 001 \\ 2's\ Compliment &: 010 \end{aligned}$$

c)

$$\begin{aligned} Original &: 1100101 \\ 1's\ Compliment &: 0011010 \\ 2's\ Compliment &: 0011011 \end{aligned}$$

d)

$$\begin{aligned} Original &: 1011 \\ 1's\ Compliment &: 0100 \\ 2's\ Compliment &: 0101 \end{aligned}$$

Question 2: (12 pts) Perform the indicated subtraction with the following unsigned binary numbers by taking the 2's complement of the subtrahend. Use zero-fill to equalize the length of the operands.

a) 11001 – 10101

$$\begin{aligned} &= 011001 - 010101 \\ &= 011001 + 101010 + 1 \\ &= 011001 + 101011 \\ &= 000100 \end{aligned}$$

b) 110110 – 1011

$$\begin{aligned} &= 0110110 - 0001011 \\ &= 0110110 + 1110100 + 1 \\ &= 0110110 + 1110101 \\ &= 0001011 \end{aligned}$$

c) 1011001 – 1011001

$$\begin{aligned} &= 01011001 - 01011001 \\ &= 01011001 + 10100110 + 1 \\ &= 01011001 + 10100111 \\ &= 00000000 \end{aligned}$$

d) 101101 – 100000

$$\begin{aligned} &= 0101101 - 0100000 \\ &= 0101101 + 1011111 + 1 \\ &= 0101101 + 1100000 \\ &= 0001101 \end{aligned}$$

e) 101010 – 1110

$$\begin{aligned} &= 0101010 - 0001110 \\ &= 0101010 + 1110001 + 1 \\ &= 0101010 + 1110010 \\ &= 0011100 \end{aligned}$$

f) 11001 – 01100

$$\begin{aligned} &= 011001 - 001100 \\ &= 011001 + 110011 + 1 \\ &= 011001 + 110100 \\ &= 001101 \end{aligned}$$

Question 3: (8 pts) Perform the addition of the following 8-bit (signed) 2's complement numbers:

a) 10011011 + 00101011

$$\begin{aligned}&=10011011 + 00101011\\&=11000110\end{aligned}$$

b) 00110111 + 00100110

$$\begin{aligned}&=00110111 + 00100110\\&=01011001\end{aligned}$$

c) 01011010 + 10110010

$$\begin{aligned}&=01011010 + 10110010\\&=00001100\end{aligned}$$

d) 11011010 + 11111110

$$\begin{aligned}&=11011010 + 11111110\\&=11011000\end{aligned}$$

Question 4: (4 pts) Convert each result from the previous problem to signed decimal.

a) 10011011 + 00101011

$$\begin{aligned}&=11000110\\&=11000101\\&=00111010\\&=-(32+16+8+2)\\&=-58\end{aligned}$$

b) 00110111 + 00100110

$$\begin{aligned}&=01011001\\&=64+16+8+1\\&=91\end{aligned}$$

c) 01011010 + 10110010

$$\begin{aligned}&=00001100\\&=8+4\\&=12\end{aligned}$$

d) 11011010 + 11111110

$$\begin{aligned}&=11011000\\&=11010111\\&=00101000\\&=-(32+8)\\&=-40\end{aligned}$$

Question 5: (18 pts) Repeat Problem 2, assuming the numbers are 2s complement numbers. Use sign extension to equalize the length of the operands. (Note: 2cm numbers have a sign bit, so they must be signed numbers.)

- Indicate whether overflow occurs during the complement operation for any of the given subtrahends.
- Indicate whether overflow occurs overall for any of the given subtractions.

a) 11001 – 10101

$$
\begin{aligned}
&=011001 - 10101 \\
&=011001 + 01010 + 1 \\
&=011001 + 01011 \\
&=011001 + 001011 \\
&=100100 \\
&\quad Integer\ Overflow
\end{aligned}
$$

b) 110110 – 1011

$$
\begin{aligned}
&=0110110 - 1011 \\
&=0110110 + 0100 + 1 \\
&=0110110 + 0101 \\
&=0110110 + 0000101 \\
&=0111011
\end{aligned}
$$

c) 1011001 – 1011001

$$
\begin{aligned}
&=01011001 - 1011001 \\
&=01011001 + 0100110 + 1 \\
&=01011001 + 0100111 \\
&=01011001 + 00100111 \\
&=10000000 \\
&\quad Integer\ Overflow
\end{aligned}
$$

d) 101101 – 100000

$$
\begin{aligned}
&=0101101 - 100000 \\
&=0101101 + 011111 + 1 \\
&=0101101 + 100000 \\
&\quad Integer\ Overflow \\
&=0101101 + 1100000 \\
&=0001101
\end{aligned}
$$

e) 101010 – 1110

$$
\begin{aligned}
&=0101010 - 1110 \\
&=0101010 + 0001 + 1 \\
&=0101010 + 0010 \\
&=0101010 + 0000010 \\
&=0101100
\end{aligned}
$$

f) 11001 – 01100

$$
\begin{aligned}
&=011001 - 01100 \\
&=011001 + 10011 + 1 \\
&=011001 + 10100 \\
&\quad Integer\ Overflow \\
&=011001 + 110100 \\
&=001101
\end{aligned}
$$

Question 6: (6 pts) Convert each result from the previous problem to signed decimal.

a) 11001 – 10101

$$\begin{aligned}&=011001-10101\\&=100100\end{aligned}$$

b) 110110 – 1011

$$\begin{aligned}&=0110110-1011\\&=0111011\\&=32+16+8+2+1\\&=59\end{aligned}$$

c) 1011001 – 1011001

$$\begin{aligned}&=01011001-1011001\\&=10000000\\&=10000000-1\\&=01111111\\&=10000000\\&=-128\end{aligned}$$

d) 101101 – 100000

$$\begin{aligned}&=0101101-100000\\&=0001101\\&=8+4+1\\&=13\end{aligned}$$

e) 101010 – 1110

$$\begin{aligned}&=0101010-1110\\&=0101100\\&=32+8+4\\&=44\end{aligned}$$

f) 11001 – 01100

$$\begin{aligned}&=011001-01100\\&=001101\\&=8+4+1\\&=13\end{aligned}$$

Question 7: (4 pts) What are the maximum positive and negative numbers that can be represented in 12-bit 2's complement form? Find the smallest positive value expressed in this form that when added to itself, the sum causes an overflow to occur.

$$\begin{aligned}Max\ Positive &=011111111111\\&=2^{11}-1\\&=2047\end{aligned}$$

$$\begin{aligned}Max\ Negative &=100000000000\\&=011111111111\\&=100000000000\\&=-2^{11}\\&=-2048\end{aligned}$$

$$\begin{aligned}Min\ to\ Overflow &=2^{10}\\&=1024\end{aligned}$$

GRADING SCALE

Total: 60 pts

Pts	0	7	15	22	30	37	45	52
Letter Grade	D-	D	C-	C	B-	B	A-	A