

EE 3755, Fall 2010

Homework #1 solutions

10 pts



1 Here the numbers  $X, Y$  are of different signs. Therefore, we have to perform the subtraction

$$(\text{magnitude of } X) - (\text{magnitude of } Y) =$$

$$(1011011)_2 - (1101001)_2 =$$

$$= (1011011) + 2's \text{ compl. of } (1101001)$$

$$= 1011011$$

$$+ 0010111$$

$$\hline 01110010$$

$\hookrightarrow c=0 \Rightarrow \text{result} < 0 \Rightarrow (\text{mag. of } X) - (\text{mag. of } Y) < 0$

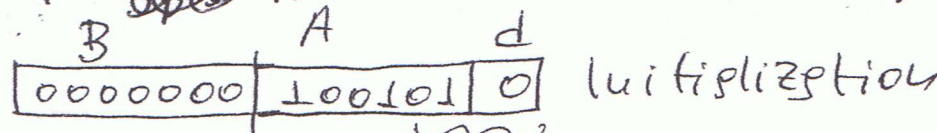
$\Rightarrow \text{mag. of } X < \text{mag. of } Y$

So sign bit of result = sign bit of  $Y = 1$

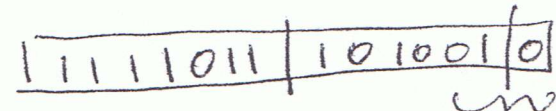
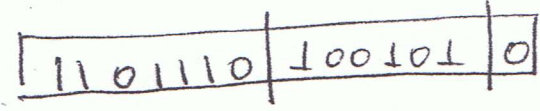
and magnitude of  $X+Y =$

$$= 2's \text{ compl. of } (1110010) = 0001110$$

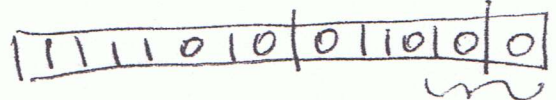
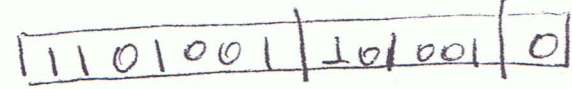
$$\text{Thus, } X+Y = (10001110)_2 = (-14)_{10}$$



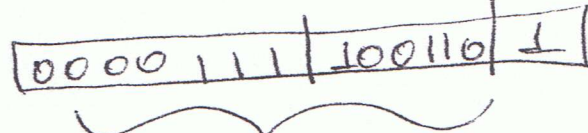
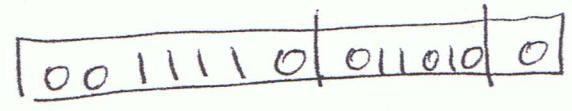
+ 1101110  $\rightarrow$  010  $\Rightarrow$  add 1x mult/carry / double right shift



+ 1101110  $\rightarrow$  010  $\Rightarrow$  add 1x mult/carry / double right shift



0100100  $\rightarrow$  100  $\Rightarrow$  add -2x mult/carry / double right shift.



$\Rightarrow$  product =  
 $(000111100110)_2 = (486)_{10}$   
 $= (-18) \times (-27)$

3 → 20 pts

C  
X  
R      Q  
01010 | 10001

Multiplication  
shift left/subtr. B

C  
1  
10101 | 0001

C  
1  
01000 | 00011

shift left/subtr. B

C  
1  
10000 | 0011

C  
1  
00011 | 00111

shift left/subtr. B

C  
0  
00110 | 0111

C  
0  
11001 | 0110

shift left/add B

C  
0  
10010 | 1110

C  
0  
01101

C  
1  
11111 | 11100

C  
1  
11111 | 1100

shift left/add B

C  
1  
01101

01100 | 11001

\* Restore is not needed

$R = (01100)_2 = 12$

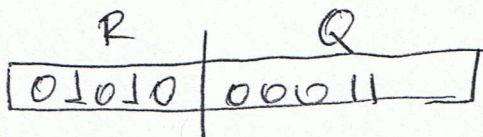
$Q = (11001)_2 = 25$

# 3755 HW#1 solution

4

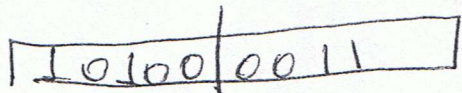
4 → 20pts

C  
X

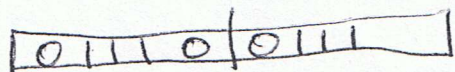
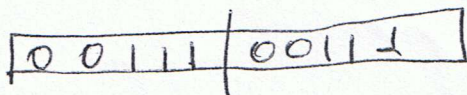


multiplication  
shift left/subtr B

C  
1



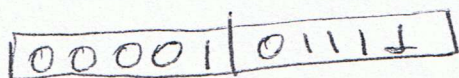
10011



shift left/subtr B

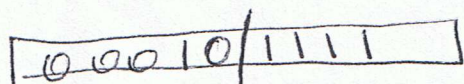
C  
1

10011

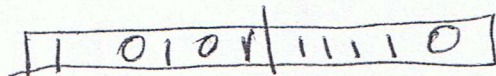


shift left/subtr B

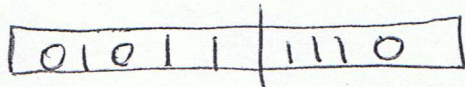
C  
0



10011

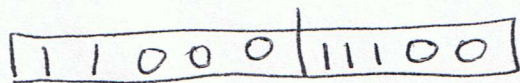


shift left/add B

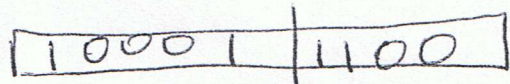


C  
0

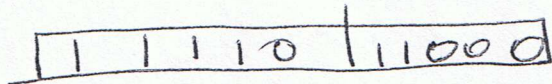
01101



shift left/add B

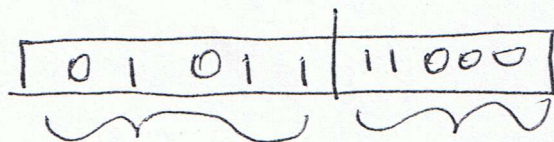


01101



restore; (ie add B)

01101



$R = (01011)_2 = 11$

$Q = (11000)_2 = 24$

5  $\rightarrow 10^4$  The range of the fraction (5) is  $0.5 \leq f \leq 1 - 2^{-48}$

The range of the exponent is

$$-2^{10} \leq e \leq 2^{10} - 1 \quad \text{or} \quad [-1024 \leq e \leq 1023]$$

So the positive dynamic range is

$$0.5 \times 2^{-1024} \leq A^+ \leq (1 - 2^{-48}) \times 2^{1023}$$

The negative dynamic range is

$$-(1 - 2^{-48}) \times 2^{1023} \leq A^- \leq -0.5 \times 2^{-1024}$$

6 <sup>→ 20pts</sup> 1. Align/adjust

$$e_1 - e_2 = e_1 + 2^3 \text{ complement of } e_2 =$$

$$= 0111$$

$$+ ) \underline{0111}$$

$$01110$$

$$\hookrightarrow c=0 \Rightarrow e_1 - e_2 < 0 \Rightarrow e_1 < e_2 \text{ and}$$

$$e_2 - e_1 = 2^3 \text{ compl. of } (1110) = (0010)_2 = (2)_{10}$$

Thus  $A_1$  becomes

$$A_1: \begin{array}{|c|c|c|} \hline s_1 & e_2 & f_1' \\ \hline 0 & 1001 & 00111100 \\ \hline \end{array}$$

2. Subtract fractions

Since  $A_1$  and  $A_2$  are of different signs and  $A_1 + A_2$  needs to be performed, a subtraction must take place.

$$f_1' - f_2 = f_1' + 2^3 \text{ complement of } f_2 =$$

$$= \cdot 00111100$$

$$+ ) \cdot \underline{01101110}$$

$$0.10101010$$

$$\hookrightarrow c=0 \Rightarrow f_1' - f_2 < 0 \Rightarrow f_1' < f_2$$



Since  $f_2$  is the larger fraction, the result  $A_3 = A_1 + A_2$  must have as a sign bit the sign bit of  $A_2$  (negative sign). The fraction of  $A_3 = A_1 + A_2$  will be the 2's compl. of  $(10101010) = 01010110$ .

Therefore

$$A_3: \boxed{1 \mid 1001 \mid 01010110}$$

### 3. Postnormalize

After postnormalization we get

$$A_3: \boxed{\overset{s_3}{1} \mid \overset{e_3}{1000} \mid \overset{f_3}{10101100}}$$

### 4. Check for exponent underflow

No exponent underflow occurred

See that  $e_3 = (1000)_2 = 8 \in [0, 15]$