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Subtraction of 2s complement

$\begingroup$ How can i perform binary subtraction of two numbers that are already in 2's complement? I have to subtract 01010011 from 10100110,both numbers are in 2's complement. I know that 10100110 is -90,and 01010011 is 83,so the result should be -173. So if i use 8 bits that means that there's overflow. But i don't get how can i perform the subtraction when both the numbers are in 2's complement. If i just perform the subtraction i get the same number 01010011. How do i show the result and that there's overflow? $\endgroup$ In this article, we will perform a subtraction using 2's complement. An unsigned binary number does not have a sign bit in the most significant bit (MSB) position. For example, consider 8-bit representation of 38103810 = 01001002= 0. 27 + 0. 26 + 1. 25 + 0. 24 + 0. 23 + 1. 22 + 0. 21 + 0. 20= 0 + 0 + 32 + 0 + 0 + 4 + 0 + 0= 34 + 4= 3810Now, if we take two's complement of unsigned binary number then we get signed binary representation of a number which is nothing but negative equivalent the unsigned binary number.To understand this in an easy way, consider previous example of 3810. Let us convert the number 3810 into binary.3810 = 0 0 1 0 0 1 0 0Take 1's complement of each binary digit in above number. That is, 0 becomes 1 and 1 becomes 0.= 1 1 0 1 1 0 1 1Adding 1 to the 1's complement of 3810 we get two's complement of the binary number. 1 1 1 1 0 1 1 0 1 1 + 1 _____ 1 1 0 1 1 1 0 0 The Most Significant Bit (MSB) has 1 which shows that it is a negative number. The resultant number is -3810Subtraction using 2's Complement of unsigned binary numberTwo's complement of binary number is used for subtraction between unsigned and signed binary numbers.For example,How do we subtract? -34 – (-45) = -34 + 45 = 11Step 1: Convert +34 in 2's Complement form.34 = 0 0 1 0 0 0 1 0Obtain 1's complement of 0 0 1 0 0 0 1 0 0 0 1 0 0 0 1 0 + 1 _____ 0 0 1 0 0 0 1 1 = -3410Note: The above step is only performed to obtain the -34 values. There are other methods to obtain negative signed valuesStep 2: Convert -45 into 2's complement to find +45.But we can also do it directly.450 = 0 0 1 0 1 1 0 1 = 0. 27 + 0. 26 + 1. 25 + 0. 24 + 1. 23+ 1. 22 + 0. 21 + 1. 20= 0 + 0 + 32 + 0 + 8 + 4 + 0 + 1= 32 + 8 + 4 + 1= 45Step 3: Add binary value of -34 and 45 1 1 0 1 1 1 1 0 = -34 0 0 1 0 1 1 0 1 = +45 _____ 0 0 0 0 1 0 1 1 = 1 1 1 0 Example ProblemsQ 1: Perform the subtraction with the unsigned binary numbers by taking the 2's complement of the subtrahend.Source: Computer System Architecture by Morris Manoa) 1 1 0 1 0 – 1 0 0 0 0Solution:Given 1 1 0 1 0 = + 26 1 0 0 0 0 = + 16 Take 1's complement of 1 0 0 0 0 = 0 1 1 1 1 Add +1 to get 2's complement of + 16 Add the binary value of +26 and -16 1 0 1 1 0 1 0 = +26 0 1 0 0 0 0 = -16 _____ 1 0 1 0 1 0 = +10 = 10 is the answer.b) 1 1 0 1 0 – 1 1 0 1Solution:Given 1 1 0 1 0 = +26 0 1 1 0 1 = +13 Take 1's complement of +13 = 0 1 1 0 1 = 1 0 0 1 0 Add 1 to get 2's complement of +13 1 0 0 1 0 + 1 _____ 1 0 0 1 1 Add binary values of +26 and -13 to get the result. 1 0 1 1 0 1 0 = +26 0 1 0 0 1 1 = -13 _____ 1 0 1 1 0 1 = -13 The answer is +13.c) 100 – 110000Solution: 0 0 0 0 0 1 0 0 = +4 0 0 1 1 0 0 0 0 = +48 Take 1's complement of 48 = 1 1 0 0 1 1 1 1 Add 1 to get the 2's complement of + 48 1 1 1 0 0 1 0 1 1 1 1 = +48 + 1 _____ 0 1 1 1 0 0 0 0 Add the binary values of +4 and -48 to get the correct answer. 0 0 0 0 0 1 0 0 = +04 1 1 0 1 0 0 0 0 = -48 _____ 1 1 0 1 0 1 0 0 = -44 -44 is the answer.d) 1010100 – 1010100Solution: 0 1 0 1 0 1 0 0 = 64 + 16 + 4 = +84 0 1 0 1 0 1 0 0 = 64 + 16 + 4 = +84 Take 1's complement of +84 subtrahend = 1 0 1 0 1 0 1 1 Add 1 to get the 2's complement of +84 subtrahend 1 1 0 1 0 1 0 1 1 + 1 _____ Add the binary values of +84 and -84 to get the result. 1 1 1 1 1 0 1 0 1 0 1 0 0 1 0 1 0 1 1 0 0 _____ 0 0 0 0 0 0 0 0 The answer is zero.ReferencesMano, M. Morris. 1984. Digital Design. Pearson.Shjiva, Sajjan G. 1998. Introduction to Logic Design. New York: Marcel Dekker, Inc . Arithmetic Operations on Binary Numbers Because of its widespread use, we will concentrate on addition and subtraction for Two's Complement representation. The nice feature with Two's Complement is that addition and subtraction of Two's complement numbers works without having to separate the sign bits (the sign of the operands and results is effectively built-into the addition/subtraction calculation). Remember: −2n−1 ≤ Two's Complement ≤ 2n−1 − 1 −8 ≤ x[4] ≤ +7 −128 ≤ x[8] ≤ +127 −32768 ≤ x[16] ≤ +32767 −2147483648 ≤ x[32] ≤ +2147483647 What if the result overflows the representation? If the result of an arithmetic operation is to too large (positive or negative) to fit into the resultant bit-group, then arithmetic overflow occurs. It is normally left to the programmer to decide how to deal with this situation. Two's Complement Addition Add the values and discard any carry-out bit. Examples: using 8-bit two's complement numbers. Add −8 to +3 (+3) 0000 0011 +(−8) 1111 1000 ---------- (−5) 1111 1011 Add −5 to −2 (−2) 1111 1110 +(−5) 1111 1011 ---------- (−7) 1 1111 1001 : discard carry-out Overflow Rule for addition If 2 Two's Complement numbers are added, and they both have the same sign (both positive or both negative), then overflow occurs if and only if the result has the opposite sign. Overflow never occurs when adding operands with different signs. i.e. Adding two positive numbers must give a positive result Adding two negative numbers must give a negative result Overflow occurs if (+A) + (+B) = −C (−A) + (−B) = +C Example: Using 4-bit Two's Complement numbers (−8 ≤ x ≤ +7) (−7) 1001 +(−6) 1010 ---------- (−13) 1 0011 = 3 : Overflow (largest −ve number is −8) A couple of definitions: Subtrahend: what is being subtracted Minuhend: what is being subtracted from Example: 612 - 485 = 127 485 is the subtrahend, 612 is the minuhend, 127 is the result Two's Complement Subtraction Normally accomplished by negating the subtrahend and adding it to the minuhend. Any carry-out is discarded. Example: Using 8-bit Two's Complement Numbers (−128 ≤ x ≤ +127) (+8) 0000 1000 0000 1000 −(+5) 0000 0101 -> Negate -> +1111 1011 ---------- (+3) 1 0000 0011 : discard carry-out Overflow Rule for Subtraction If 2 Two's Complement numbers are subtracted, and their signs are different, then overflow occurs if and only if the result has the same sign as the subtrahend. Overflow occurs if (+A) − (−B) = −C (−A) − (+B) = +C Example: Using 4-bit Two's Complement numbers (−8 ≤ x ≤ +7) Subtract −6 from +7 (+7) 0111 0111 −(−6) 1010 -> Negate -> +0110 ---------- ----- 13 1101 = −8 + 5 = −3 : Overflow Number Circle for 4-bit Two's Complement numbers Numbers can be added or subtracted by moving round the number circle Clockwise for addition Anti-Clockwise for subtraction (addtion of a negative number) Overflow occurs when a transition is made from +2n−1−1 to −2n−1 when adding from −2n−1 to +2n−1−1 when subtracting Two's Complement Summary Addition Add the values, discarding any carry-out bit Subtraction Negate the subtrahend and add, discarding any carry-out bit Overflow Occurs when adding two positive numbers produces a negative result, or when adding two negative numbers produces a positive result. Adding operands of unlike signs never produces an overflow Notice that discarding the carry out of the most significant bit during Two's Complement addition is a normal occurrence, and does not by itself indicate overflow As an example of overflow, consider adding (80 + 80 = 160)10, which produces a result of −9610 in 8-bit two's complement: 01010000 = 80 + 01010000 = 80 ---------- 10100000 = −96 (not 160 because the sign bit is 1.) (largest +ve number in 8 bits is 127) Multiplication and Division No problem with unsigned (always positive) numbers, just use the same standard techiques as in base 10 (remembering that x[n] × y[n] = z[2n]) Multiplication Example 11001012 × 1111012 (10110 × 6110) 1100101 10110 × 111101 × 6110 ------- 1100101 +1100101 +1100101 +1100101 +1100101 ---------- ????????????? ---------- Easier to use intermediary results: 1100101 10110 × 111101 × 6110 ---------- 1100101 +1100101 ---------- 111111001 +1100101 ---------- 10100100001 +1100101 ---------- 101101110001 +1100101 ---------- 1100000010001 = 409610 + 204810 + 1610 + 1 = 616110 ---------- Division Example: 1001012 ÷ 1012 (3710 ÷ 510) 111 result = 710 ------- 101)100101 −101 --- 1000 −101 --- 111 −101 --- 10 remainder = 210 --- Multiplication in Two's complement cannot be accomplished with the standard technique since, as far as the machine itself is concerned, for Y[n]: −Y º 0 − Y º 2n − Y since, when subtracting from zero, need to "borrow" from next column leftwards. Example: −1910 in 8-bits= (28 − 19)10 = 25610 − 1910 = 23710 = 111011012 unsigned = −27 + 26 + 25 + 23 + 22 + 20 = −128 + 64 + 32 + 8 + 4 + 1 = −128 + 109 = −1910 in Two's Complement Consider X × (−Y) Internal manipulation of −Y is as 2n − Y Therefore X × (−Y) = X × (2n − Y) = 2n × X − X × Y However the expected result should be 22n − (X × Y) since x[n] × y[n] = z[2n] Can perform multiplication by converting the Two's Complement numbers to their absolute values and then negating the result if the signs of the operands are different. Similar for Two's Complement division. Can convert the operands to their absolute values, perform the division, and then negating the result if the signs of the operands are different. Most contemporary architectures implement more sophisiticated algorithms for multiplication and division of Two's Complement numbers. Beyond the scope of this course! [Index] last updated: 21-Oct-02 Ian Harries addition and subtraction of 2s complement

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