CAO HW3

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1a

The steps for multiplying -7 and 3 are found by closely following the algorithm as stated in $3.3, p. 187. First 7 is negated using two's complement. One of both of the signs is negative, hence the result must be negative. After using two's complement again on the end result after 4 iterations, the value 1110 1011 (-21) is found.

Iteration	Description	MR	MD	Product
0	Initial values	0011	1111 1001	0000 0000
	1. Convert MR and MD to positive using 2s complement	0011	0000 0111	0000 0000
1	1. Prod = Prod + MD	0011	0000 0111	0000 0111
	2. SLL MD	0011	0000 1110	0000 0111
	3. SRL MR	0001	0000 1110	0000 0111
2	1. Prod = Prod + MD	0001	0000 1110	0001 0101
	2. SLL MD	0001	0001 1100	0001 0101
	3. SRL MR	0000	0001 1100	0001 0101
3	1. NOP	0000	0001 1100	0001 0101
	2. SLL MD	0000	0011 1000	0001 0101
	3. SRL MR	0000	0011 1000	0001 0101
4	1. NOP	0000	0001 1100	0001 0101
	2. SLL MD	0000	0111 0000	0001 0101
	3. SRL MR	0000	0111 0000	0001 0101
After	Convert product to negative using 2s complement	0000	0111 0000	1110 1011

1b

This is possible because multiplication is commutative. In all cases we can begin by converting the multiplicand and multiplier to positive values, but we have to remember if either one of them was a negative value. If this is the case, the product will also be negative. We can then use two's complement on the end result to obtain a negative product.

1c

The multiplier is 8 bits, hence we need as many iterations as there are bits in the multiplier, which is 8. We need an addition and two shifts in each iteration, and the shifts of the multiplicand and multiplier are done simultaneously. We need (8 * 2) * 3u = 48u time units to perform this calculation.

1d

By using a parallel tree of ALU's we can reduce the number of iterations from 8 to $log_2(8) = 3$. The time needed is then (3 * 3u) for all layers of the tree and the shifts are then omitted. Thus we need a total of 9u time units when using a parallel tree. The price you pay is literally the extra cost of all the extra ALU's, and perhaps the extra energy needed for the calculation.

2a

C463000 represents **1100 0100 0110 0011 0000 0000 0000 0000** in binary. This is from left to right: $(2^{31} + 2^{30} + 2^{26} + 2^{22} + 2^{21} + 2^{17} + 2^{16}) = 3294822400_{10}$

2b

First the 2s complement is found by inverting all bits and adding 1 to the result.
1100 0100 0110 0011 0000 0000 0000 0000
0011 1011 1001 1100 1111 1111 1111 1111
0011 1011 1001 1101 0000 0000 0000 0000
Then we calculate the value to be -1000144896_{10}, by remembering that this is a negative value, because the sign bit in the uncomplemented value is 1.

2c

Looking at the first 6 bits, we find the opcode to be **110001** or 49 in decimal. This corresponds to the **lwc1** or Load Floating Point Single. We extract all bits in I-format:

110001 | 00011 | 00011 | 000000000000000
49 | 3 | 3 | 0
lwc1 $v1, 0($v1)

Which loads a single precision floating point number into the $v1 result register, with offset 0.

2d

Again, we partition the bits into the format as specified in the IEEE 754 standard:

1 | 10001000 | 11000110000000000000000

Sign bit is 1

Exponent is 136 - 127 = 9

Fraction is 6488064_{10}

Using the formula and expanding the fraction:

$(-1)^s \cdot (1 + \text{Fraction}) \cdot 2^E =$

$(-1)^1 \cdot (1 + [(2^{-1}) + (2^{-2}) + (2^{-6}) + (2^{-7})]) \cdot 2^9 =$

$- 908.0$