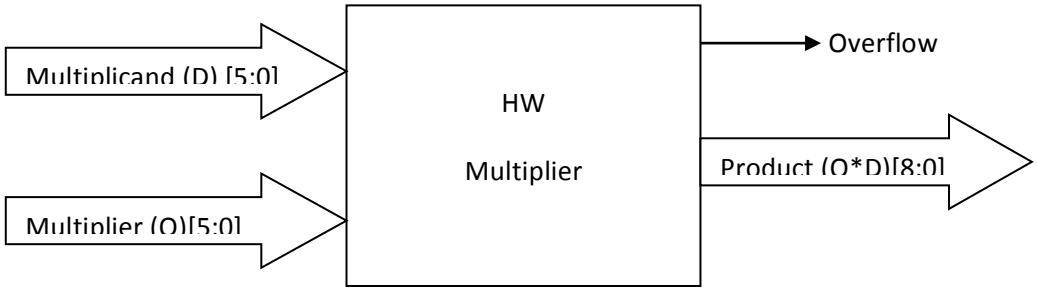
Marmara University Electrical-Electronics Eng. Dept.

CSE315.02 Digital Design Laboratory Assignment #1

The studies will be presented after 2 weeks (Lab sections). **Each group must present their own study. The group members have to work together and each member must know each step of the study.**

For this laboratory assignment, you will use Altera Quartus II software and DE-115 FPGA kit and design a hardware floating point multiplier that has the Input/output defiitions below. You should design the circuit first, then use verilog-HDL and DE-115 kit to implement your design.



All numbers in this assignment are in the IEEE 754 binary floating-point format and the inputs and output have 6 and 9 bits respectively. The FP format has three areas: the MSB represents the sign of the number (0: positive, 1: negative), the exponantial part and the mantissa.

The area lengths for the inputs:

S-1bit	E-2 bits	M-2 bits

The area lengths for the output:

S-1bit	E-3 bits	M-5 bits

The formula to convert the number from IEEE 754 format to decimal is given as:

$$\textit{For the numbers at input: } n_{input} = (-1)^{s} \cdot (1+M*2^{-2}) \cdot (2^{E-1})$$

$$\text{For the numbers at output: } n_{output} = (-1)^{s} \cdot (1+M*2^{-5}) \cdot (2^{E-3})$$

The formulas are different since area sizes are not same for input and output numbers.

Some examples:

Ex1: If the FP formatted number at **input** is: 01011 =>
The first bit is sign bit hence number is positive.

1. Exponantial area is E=10b. $2^{2-1}=2$
2. Mantissa, M=11b. $1+3*2^{-2}=1.75$
3. The number: + 2*1.75 = 3,5

Ex2: If the number at the **input** is 11101 =>
The first bit is sign bit hence number is negative.

1. Exponantial area is E=11b. $2^{3-1}=4$
2. Mantissa, M=01b. $1+1*2^{-2}=1.25$
3. The number: - 4*1.25 = -5

Ex3: If the number at the **output** is 111100011 =>
The first bit is sign bit hence number is negative.

1. Exponantial area is E=111b. $2^{7-3}=2^{4}$
2. Mantissa, M=00011b. $1+3*2^{-5}=1.09375$
3. The number: - 2^{4}*1.09375 = 17.5

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Multiplication procedure for floating point numbers:
The floating point formatted inputs Q and D will be multiplied.

Step1: Same sign bits => positive result, otherwise => negative result.

Step2: normalize the exponentials by substracting 01b, then sum them. Add 01b to the sum. $E_{result}= E_D -1 + E_Q -1$.

Step3: multiply the mantissa areas as shown in the following formula: $M_{result} = 1.M_Q * 1.M_D$. In the formula, all the numbers are binary and the mantissa areas are used as fractional parts.

Possible results:

1) M_{result} = 1x.xxxx => move the radix point one place to the left and increase the exponent by 1. After operation, M_{result} = 1.xxxxx and $E_{result}= E_D -1 + E_Q -1 +1$.
2) M_{result} = 01.xxxx => no manipulation is needed.

Step4: E_{result} should be increased by 3 and cenverted to binary, use only fractional part of M_{result} (M=xxxxx) and use sign bit at MSB position:

Multiplication result in FP format: SEEEMMMMM

Multiplication Example:
Let us multiply the numbers in Ex1 and Ex2: (Q=01011)*(D=11101) = ?

Step1: sign bits are not same => resulted sign bit: 1

Step2: E_Q=10b=2, E_D=11b=3 => E_{result}= 3+2-2=3.

Step3: M_Q=11b and M_Q=01b =>

```
  1.11
  1.01
*-------
   111
  000
 111
+-----------
 10.0011
```

M_{result}=10.0011 => the radix point should be moved to the one place left. Therefore E_{result} should be increased by one.

After Step3: E_{result}=3+1 = 4 and M_{result}=1.00011

Step4: increase E_{result} by 3 and convert it to binary: E_{result}=111. Use only fractional part for M_{result}=00011. The multiplication result in FP format: Product=111100011.

Overflows:
If the result's exponantial area exceeds 3 bits an overflow is occured. The result's Sign bit defines the type of overflow (positive or negative).

Overflow example:
11111*01111=?

Step1: result is neg., Step2: E=3-1+3-1=4,

Step3: 1.11*1.11=11.0001=> radix point should be moved to one place left and E should be increased by 1 => M=1.10001 and E=5.

Step4: E = 5+3=8=1000b and M=10001. The exponantial area has four bits=> overflow = 1, S=1, E=000 and M=10001. The result: Ov=1, Product=100010001.