Addition/Subtraction Unit

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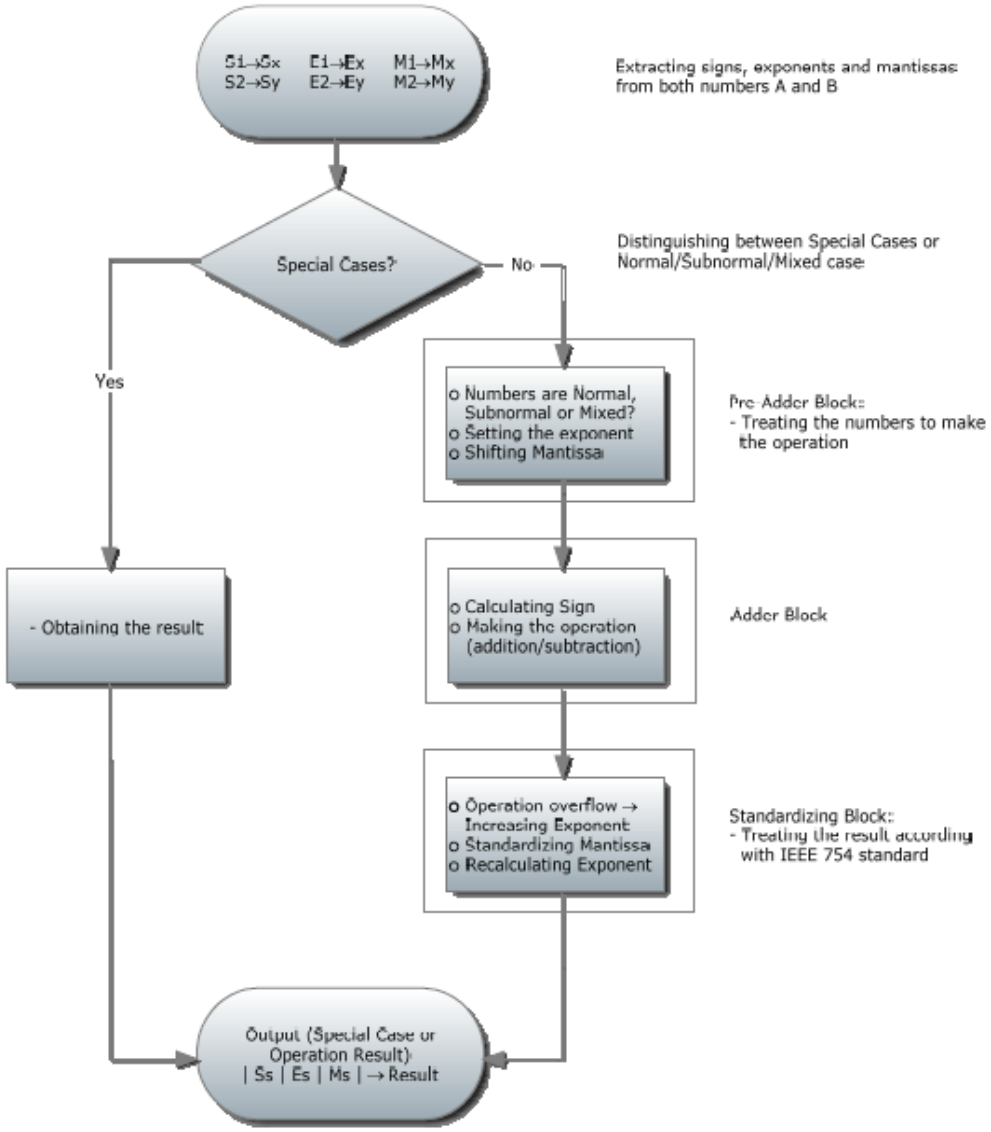
General Overview

In the next flow chart , a first approximation of the design has been done:



Block Diagrams

A division of the project in three parts will be done, a complete description of each step will be performed.

These three parts are as follows:

- Pre-Adder Block
- Adder Block
- · Standardizing Block

Pre-Adder Block

The first subblock is the Pre-Adder. The goals are:

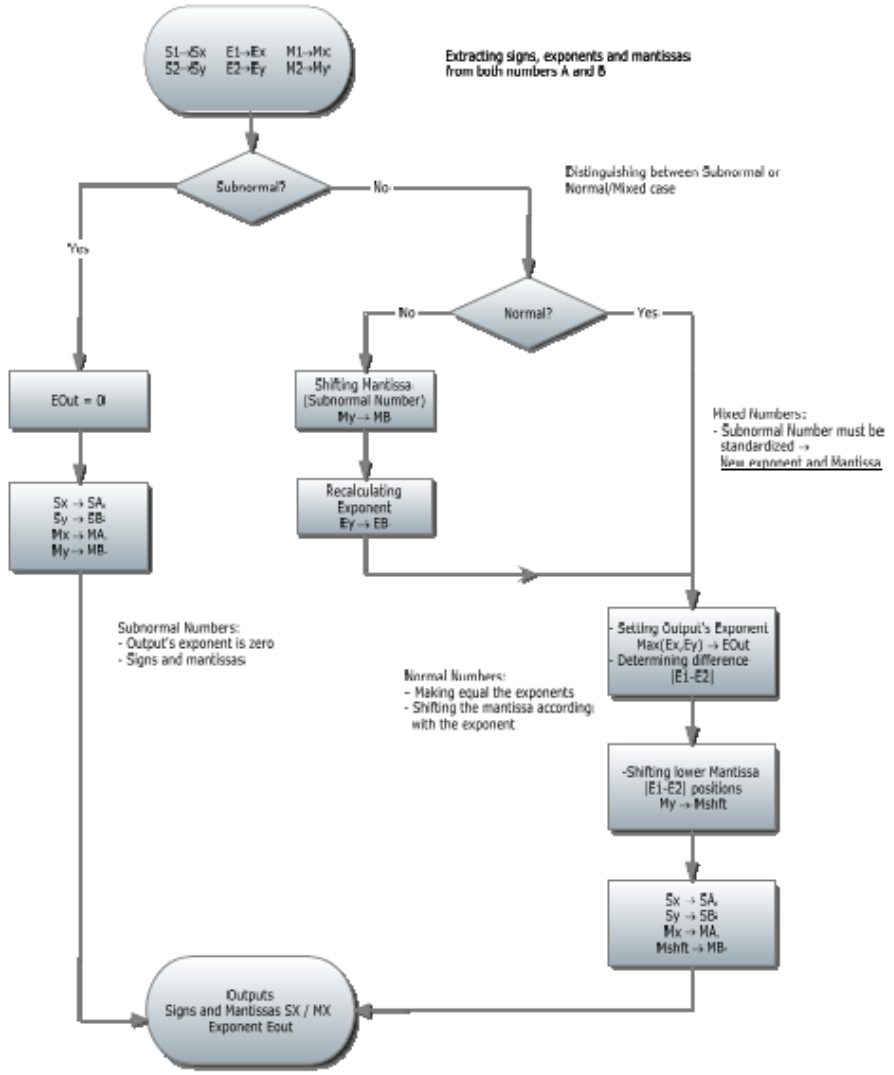
1. Distinguishing between normal, subnormal or mixed (normal-subnormal combination) numbers.

2. Treating the numbers in order to be added (or subtracted) in the adder block.

- Setting the Output's exponent
- Shifting the mantissa
- Standardizing the subnormal number in mixed numbers case to be treated as a normal case

Pre-Adder Block

The block diagram which display this behavior is shown here.



Pre-Adder Block

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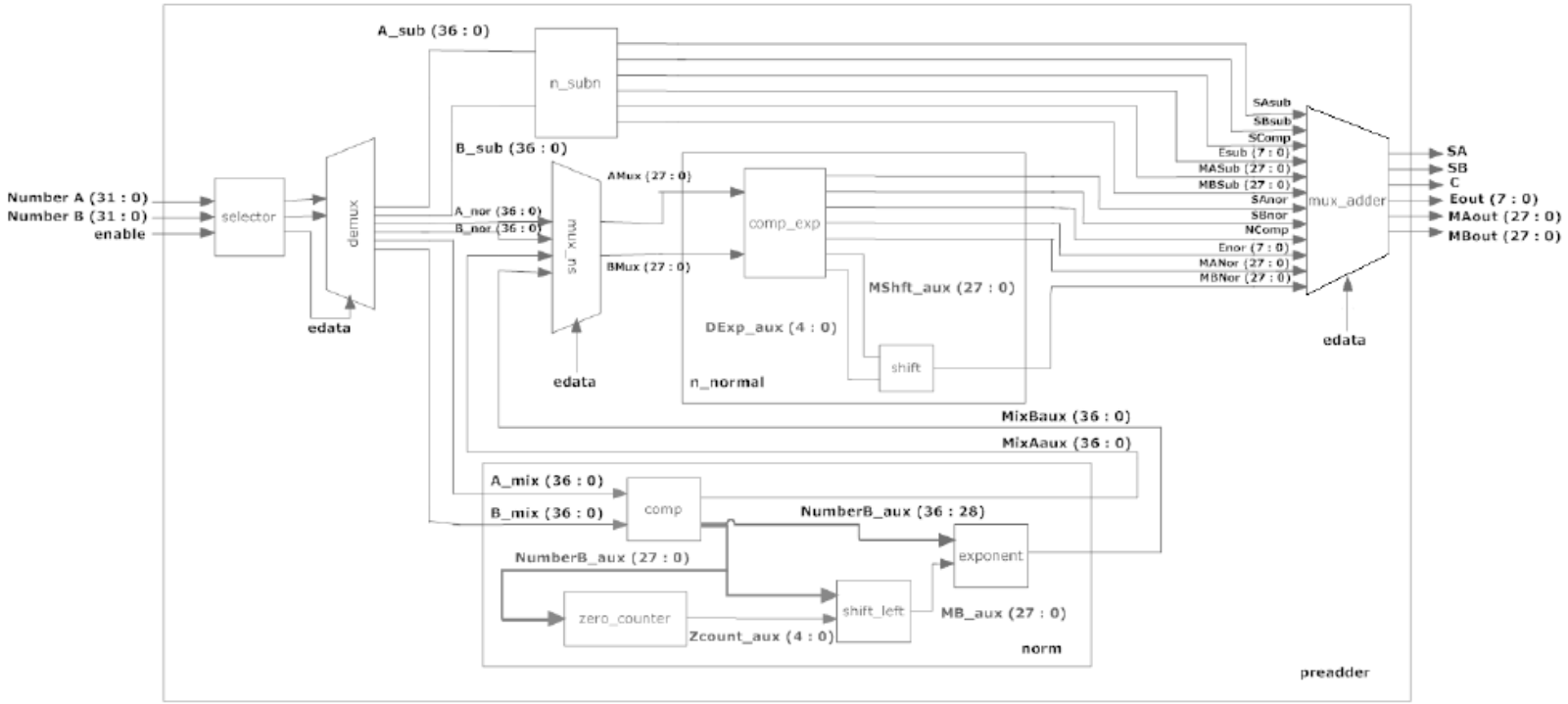


Adder Block

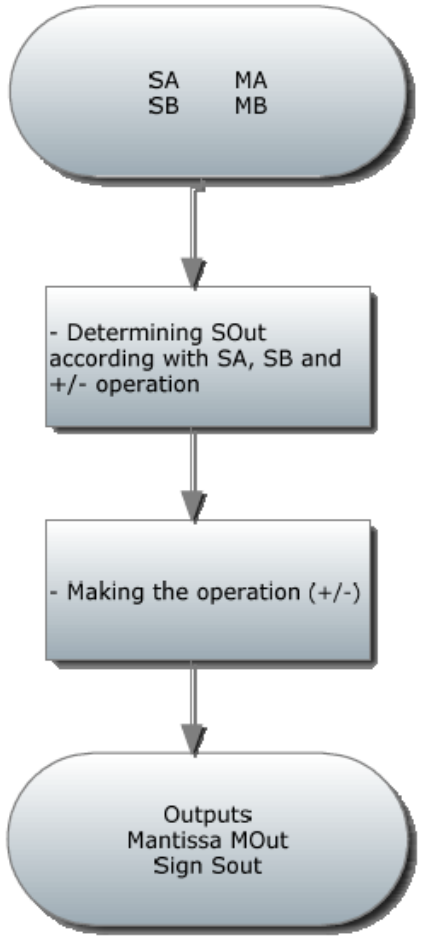
Adder is the easiest part of the blocks. This block only implements the operation (addition or subtraction). It can be said the adder block is the ALU (Arithmetic Logic Unit) of the project because it is in charge of the arithmetic operations.

Two functions are implemented in this part of the code:

1. Obtaining the output's sign
2. Implementing the desired operation

Adder Block

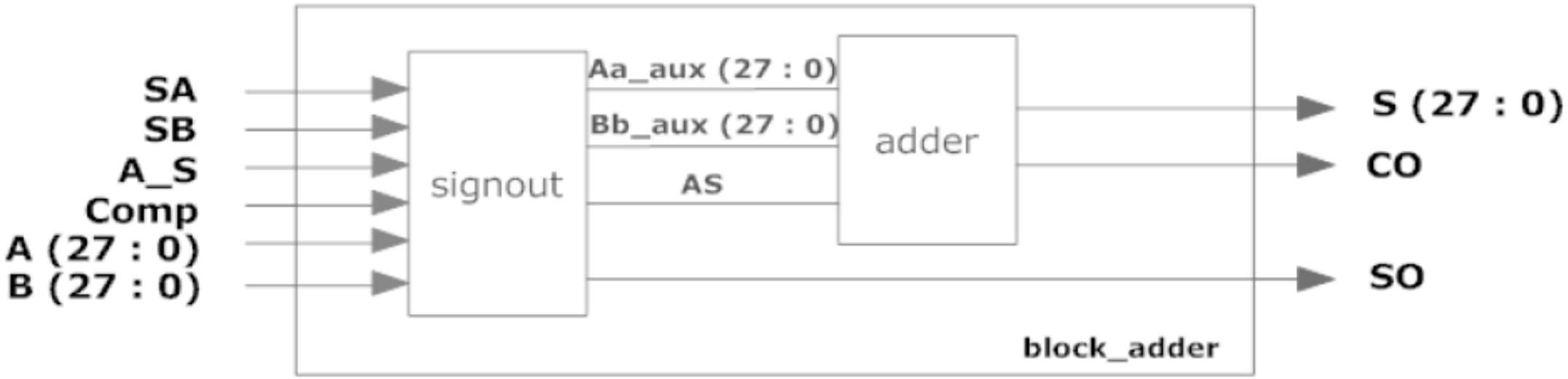
The block diagram which display this behavior is shown here.



Output's Sign:
- Knowing which number is higher and what is the operation to do (+/-) the Sout could be determined

Result:
- Implementation of the Adder (CLA)

Adder Block


SA
SB
A_S
Comp
A (27 : 0)
B (27 : 0)
signout
Aa_aux (27 : 0)
Bb_aux (27 : 0)
AS
adder
S (27 : 0)
CO
SO
block_adder

Standardizing Block

Finally the Standardizing Block takes the result of the addition/subtraction and gives it an IEEE 754 format.

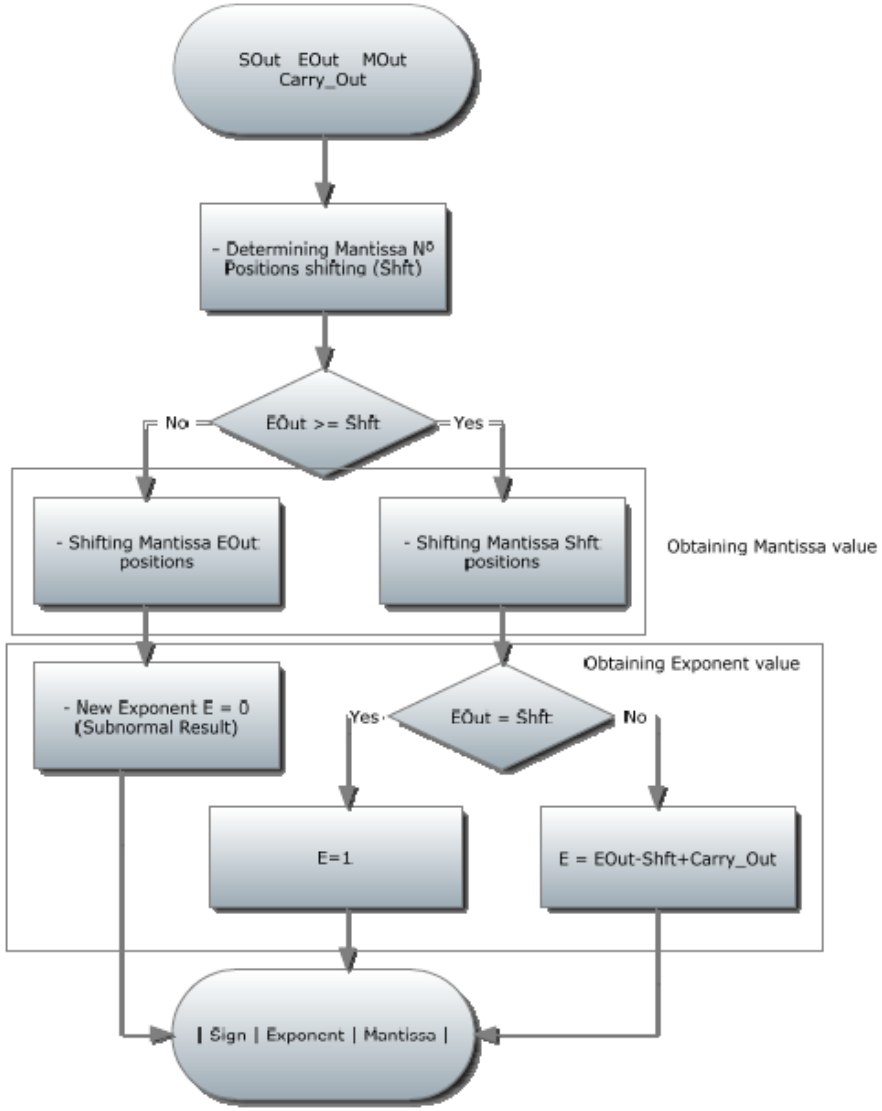
The procedure is as follows:

1. Shifting the mantissa to standardize the result

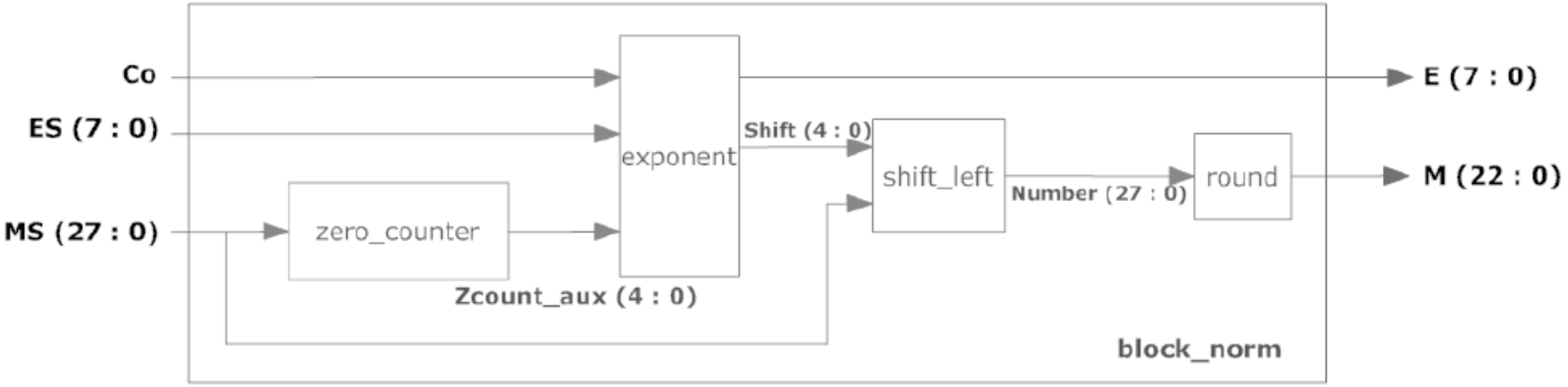
2.Calculating the new exponent according with the addition/subtraction overflow (carry out bit) and the displacement of the mantissa.

Standardizing Block

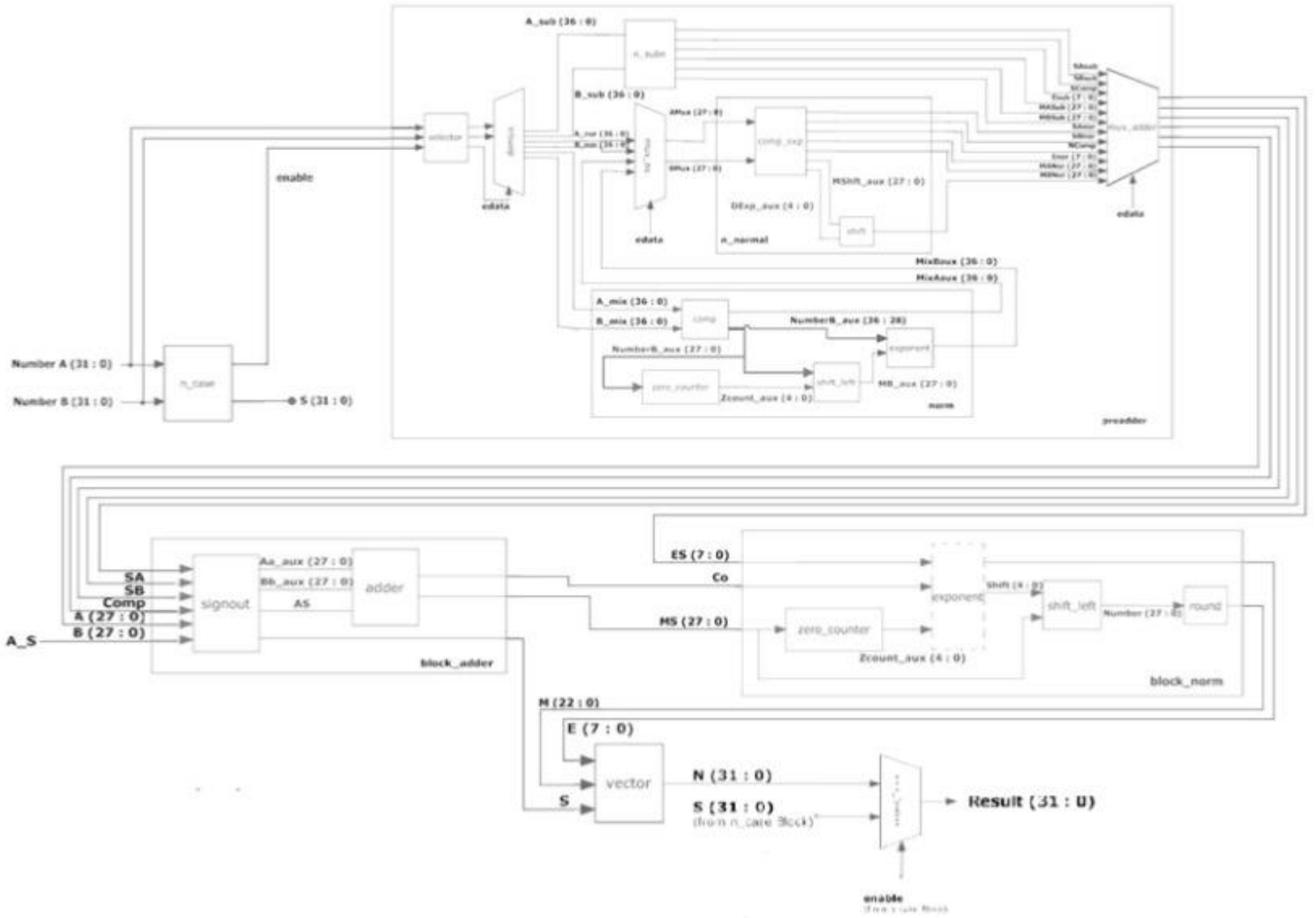
The block diagram which display this behavior is shown here.



Standardizing Block



Final Block


A_sub (36 : 0)
B_sub (36 : 0)
enable
edata
Number A (31 : 0)
Number B (31 : 0)
S (31 : 0)
MixBaux (36 : 0)
MixAaux (36 : 0)
A_mix (36 : 0)
B_mix (36 : 0)
NumberB_aux (36 : 28)
NumberB_aux (27 : 0)
MS_aux (27 : 0)
Zcount_aux (4 : 0)
norm
preadder
SA
SB
Comp
A (27 : 0)
B (27 : 0)
A_S
signout
Aa_aux (27 : 0)
Bb_aux (27 : 0)
AS
adder
block_adder
ES (7 : 0)
Co
MS (27 : 0)
exponent
zero_counter
Zcount_aux (4 : 0)
shift_left
round
Number (27 : 0)
block_norm
M (22 : 0)
E (7 : 0)
S
vector
N (31 : 0)
S (31 : 0)
(from n_calc Block)
Result (31 : 0)
enable

Simulations

We'll go through four testbenches:

1. Testbench to test Special Cases
2. Testbench to test Subnormal Numbers
3. Testbench to test Normal Numbers
4. Testbench to test Mixed Numbers (Normal and Subnormal)

Special Cases

SA	EA	MA	$A_{(10}$	SB	EB	MB	$B_{(10}$
0	00000000	00000000000000000000000	0	0	11111101	10101010101010101010101	+1.4178431616998 94e+038
0	11111110	10101010101010101010101	+1.4178431616998 94e+038	1	11111111	00000000000000000000000	-∞
1	11111111	00000000000000000000000	-∞	1	11111111	00000000000000000000000	-∞
1	11111111	00000000000000000000000	-∞	0	11111111	00000000000000000000000	+∞
1	11111111	00000000000000000000000	-∞	0	11111111	10101010101010101010001	NaN

SS	ES	MS	$S_{(10}$	$A_{(10} \pm B_{(10}$
0	11111101	10101010101010101010101	+1.4178431616998 94e+038	---
1	11111111	00000000000000000000000	-∞	---
1	11111111	00000000000000000000000	-∞	---
1	11111111	00000000000000000000001	NaN	---
1	11111111	00000000000000000000001	NaN	---

Subnormal Cases

SA	EA	MA	$A_{(10}$	AS	SB	EB	MB	$B_{(10}$
0	00000000	10101010101010101010001	+7.836622933188571e-039	+	0	00000000	10101010101010101010101	+7.836628538382429e-039
0	00000000	11111111111111111111111	+1.175494210692441e-038	+	1	00000000	01010100101010110101010	-3.887821313958274e-039
0	00000000	01010100101010110101010	3.887821313958274e-039	+	1	00000000	11111111111111111111111	-1.175494210692441e-038
1	00000000	10111011101110111011101	-8.620290691571439e-039	-	1	00000000	00111011101110111011101	-2.742818537460002e-039
1	00000000	10111001101110011011100	-8.528095061708117e-039	-	0	00000000	10111011101110111011101	8.620290691571439e-039

SS	ES	MS	$S_{(10}$	$A_{(10} \pm B_{(10}$
0	00000001	01010101010101010100110	+1.567325147157100e-038	+1.567325147157100e-038
0	00000000	10101011010101001010101	+7.867120792966137e-039	+7.867120792966137e-039
1	00000000	10101011010101001010101	-7.867120792966137e-039	-7.867120792966137e-039
1	00000000	10000000000000000000000	-5.877471754111438e-039	-5.877471754111438e-039
1	00000001	01110101011101010111001	-1.714838575327956e-038	-1.714838575327956e-038

Normal Cases

SA	EA	MA	$A_{(10}$	AS	SB	EB	MB	$B_{(10}$
0	11111101	10101010101010101010101	+1.417843161699894e+038	-	0	11111101	10101010101010101010001	+1.41784275605170 2e+038
0	11110101	01010100101010110101010	+4.422139697774293e+035	-	0	11110101	10101010101010101010101	+5.538449850390212e+035
1	11111010	10011001100110011001100	-1.701411733192544e+037	+	0	11111010	01010100101010110101010	+1.415084703287774e+037
1	11110000	10111011101110111011101	-1.799996137003937e+034	+	1	11110000	10111001101110011011100	-1.791851358103467e+034
0	11111001	10111011101110111011101	+9.215980221460157e+036	-	1	11110111	10111001101110011011100	-2.293569738372437e+036

SS	ES	MS	$S_{(10}$	$A_{(10} \pm B_{(10}$
0	11101000	00000000000000000000000	+4.056481920730334e+031	+4.056481920730334e+031
1	11110011	01010111111111010101100	-1.116310152615919e+035	-1.116310152615919e+035
1	11111000	00010011101110010001000	-2.863270299048707e+036	-2.863270299048707e+036
1	11110001	01110101011101010111001	-3.029857503386945e+034	-3.591847495107403e+034
0	11111001	11110010111100101111001	+1.036276540755903e+037	+1.150954995983259e+037

Mixed Cases

SA	EA	MA	$A_{(10}$	AS	SB	EB	MB	$B_{(10}$
0	00000100	10101010101010101010001	+1.567325315312916e-037	+	0	00000000	10101010101010101010101	+7.836628538382429e-039
1	00001000	10101010101010101010101	-2.507721221965479e-036	-	0	00000000	10101010101010101010101	+7.836628538382429e-039
0	00001010	01010100101010110101010	+8.009095588956748e-036	-	1	00000000	11111111111111111111111	-1.175494210692441e-038
1	00000000	10101010101010101010101	-7.836628538382429e-039	-	1	00000101	00111011101110111011101	-2.319641991309260e-037
1	00000000	10101010101010101010101	-7.836628538382429e-039	+	0	00001111	01010101010101010101010	+2.567906439457154e-034

SS	ES	MS	$S_{(10}$	$A_{(10} \pm B_{(10}$
0	00000100	10110101010101010100110	+1.606508422972366e-037	+1.645691600696740e-037
1	00001000	10101011010101010101010	-2.511639476679485e-036	-2.515557850503861e-036
0	00001010	01010100111010110101010	+8.014973060710860e-036	+7.997340646849824e-036
1	00000101	00110110011001100110010	-2.280458771545933e-037	-2.398008276693085e-037
0	00001111	01010101010100111111111	+2.567867179782547e-034	+2.567828073171770e-034

Thank You