Daniel Donato

Cse 341 Project 2

Add
10 output: 0000000000000010 <> A:0000000000000000 <> B: 0000000000000001
20 output: 0000000000000011 <> A:0000000000000001 <> B: 0000000000000001
30 output: 0000000000000100 <> A:0000000000000010 <> B: 0000000000000001
40 output: 0000000000000101 <> A:0000000000000011 <> B: 0000000000000001
50 output: 0000000000000110 <> A:0000000000000100 <> B: 0000000000000001
60 output: 0000000000000111 <> A:0000000000000101 <> B: 0000000000000001
70 output: 0000000000001000 <> A:0000000000000110 <> B: 0000000000000001
80 output: 0000000000001001 <> A:0000000000000111 <> B: 0000000000000001
90 output: 0000000000001010 <> A:0000000000001000 <> B: 0000000000000001
100 output: 0000000000001011 <> A:0000000000001001 <> B: 0000000000000001
Add
10 output: 0000000000000001 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000100 <> A:0000000000000001 <> B: 0000000000000010
30 output: 0000000000000111 <> A:0000000000000010 <> B: 0000000000000100
40 output: 0000000000001010 <> A:0000000000000011 <> B: 0000000000000110
50 output: 0000000000001101 <> A:0000000000000100 <> B: 0000000000001000
60 output: 0000000000010000 <> A:0000000000000101 <> B: 0000000000001010
70 output: 0000000000010011 <> A:0000000000000110 <> B: 0000000000001100
80 output: 0000000000010110 <> A:0000000000000111 <> B: 0000000000001110
90 output: 0000000000011001 <> A:0000000000001000 <> B: 0000000000010000
100 output: 0000000000011100 <> A:0000000000001001 <> B: 0000000000010010
Add
10 output: 0000000000000001 <> A:0000000000000000 <> B: 0000000000000000

20 output: 0000000000000100 <> A:0000000000000010 <> B: 0000000000000001
30 output: 0000000000000111 <> A:0000000000000100 <> B: 0000000000000010
40 output: 0000000000001010 <> A:0000000000000110 <> B: 0000000000000011
50 output: 0000000000001101 <> A:0000000000001000 <> B: 0000000000000100
60 output: 0000000000010000 <> A:0000000000001010 <> B: 0000000000000101
70 output: 0000000000010011 <> A:0000000000001100 <> B: 0000000000000110
80 output: 0000000000010110 <> A:0000000000001110 <> B: 0000000000000111
90 output: 0000000000011001 <> A:0000000000010000 <> B: 0000000000001000
100 output: 0000000000011100 <> A:0000000000010010 <> B: 0000000000001001
Add
10 output: 0000001001010001 <> A:0000000100101110 <> B: 0000000100100010
20 output: 0000001001100101 <> A:0000000100111000 <> B: 0000000100101100
30 output: 0000001001111001 <> A:0000000101000010 <> B: 0000000100110110
40 output: 0000001010001101 <> A:0000000101001100 <> B: 0000000101000000
50 output: 0000001010100001 <> A:0000000101010110 <> B: 0000000101001010
60 output: 0000001010110101 <> A:0000000101100000 <> B: 0000000101010100
70 output: 0000001011001001 <> A:0000000101101010 <> B: 0000000101011110
80 output: 0000001011011101 <> A:0000000101110100 <> B: 0000000101101000
90 output: 0000001011110001 <> A:0000000101111110 <> B: 0000000101110010
100 output: 0000001100000101 <> A:0000000110001000 <> B: 0000000101111100

sub
10 output: 0000111111111111 <> A:0000000000000000 <> B: 0000000000000001
20 output: 0000000000000000 <> A:0000000000000001 <> B: 0000000000000001
30 output: 0000000000000001 <> A:0000000000000010 <> B: 0000000000000001
40 output: 0000000000000010 <> A:0000000000000011 <> B: 0000000000000001
50 output: 0000000000000011 <> A:0000000000000100 <> B: 0000000000000001
60 output: 0000000000000100 <> A:0000000000000101 <> B: 0000000000000001
70 output: 0000000000000101 <> A:0000000000000110 <> B: 0000000000000001
80 output: 0000000000000110 <> A:0000000000000111 <> B: 0000000000000001

90 output: 0000000000000111 <> A:0000000000001000 <> B: 0000000000000001
100 output: 0000000000001000 <> A:0000000000001001 <> B: 0000000000000001
sub
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000111111111111 <> A:0000000000000001 <> B: 0000000000000010
30 output: 0000111111111110 <> A:0000000000000010 <> B: 0000000000000100
40 output: 0000111111111101 <> A:0000000000000011 <> B: 0000000000000110
50 output: 0000111111111100 <> A:0000000000000100 <> B: 0000000000001000
60 output: 0000111111111011 <> A:0000000000000101 <> B: 0000000000001010
70 output: 0000111111111010 <> A:0000000000000110 <> B: 0000000000001100
80 output: 0000111111111001 <> A:0000000000000111 <> B: 0000000000001110
90 output: 0000111111111000 <> A:0000000000001000 <> B: 0000000000010000
100 output: 0000111111110111 <> A:0000000000001001 <> B: 0000000000010010
sub
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000001 <> A:0000000000000010 <> B: 0000000000000001
30 output: 0000000000000010 <> A:0000000000000100 <> B: 0000000000000010
40 output: 0000000000000011 <> A:0000000000000110 <> B: 0000000000000011
50 output: 0000000000000100 <> A:0000000000001000 <> B: 0000000000000100
60 output: 0000000000000101 <> A:0000000000001010 <> B: 0000000000000101
70 output: 0000000000000110 <> A:0000000000001100 <> B: 0000000000000110
80 output: 0000000000000111 <> A:0000000000001110 <> B: 0000000000000111
90 output: 0000000000001000 <> A:0000000000010000 <> B: 0000000000001000
100 output: 0000000000001001 <> A:0000000000010010 <> B: 0000000000001001
sub
10 output: 0000000000001100 <> A:0000000100101110 <> B: 0000000100100010
20 output: 0000000000001100 <> A:0000000100111000 <> B: 0000000100101100
30 output: 0000000000001100 <> A:0000000101000010 <> B: 0000000100110110
40 output: 0000000000001100 <> A:0000000101001100 <> B: 0000000101000000
50 output: 0000000000001100 <> A:0000000101010110 <> B: 0000000101001010

60 output: 0000000000001100 <> A:0000000101100000 <> B: 0000000101010100
70 output: 0000000000001100 <> A:0000000101101010 <> B: 0000000101011110
80 output: 0000000000001100 <> A:0000000101110100 <> B: 0000000101101000
90 output: 0000000000001100 <> A:0000000101111110 <> B: 0000000101110010
100 output: 0000000000001100 <> A:0000000110001000 <> B: 0000000101111100
and
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000001
20 output: 0000000000000001 <> A:0000000000000001 <> B: 0000000000000001
30 output: 0000000000000000 <> A:0000000000000010 <> B: 0000000000000001
40 output: 0000000000000001 <> A:0000000000000011 <> B: 0000000000000001
50 output: 0000000000000000 <> A:0000000000000100 <> B: 0000000000000001
60 output: 0000000000000001 <> A:0000000000000101 <> B: 0000000000000001
70 output: 0000000000000000 <> A:0000000000000110 <> B: 0000000000000001
80 output: 0000000000000001 <> A:0000000000000111 <> B: 0000000000000001
90 output: 0000000000000000 <> A:0000000000001000 <> B: 0000000000000001
100 output: 0000000000000001 <> A:0000000000001001 <> B: 0000000000000001
and
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000000 <> A:0000000000000001 <> B: 0000000000000010
30 output: 0000000000000000 <> A:0000000000000010 <> B: 0000000000000100
40 output: 0000000000000010 <> A:0000000000000011 <> B: 0000000000000110
50 output: 0000000000000000 <> A:0000000000000100 <> B: 0000000000001000
60 output: 0000000000000000 <> A:0000000000000101 <> B: 0000000000001010
70 output: 0000000000000100 <> A:0000000000000110 <> B: 0000000000001100
80 output: 0000000000000110 <> A:0000000000000111 <> B: 0000000000001110
90 output: 0000000000000000 <> A:0000000000001000 <> B: 0000000000010000
100 output: 0000000000000000 <> A:0000000000001001 <> B: 0000000000010010
and
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000000 <> A:0000000000000010 <> B: 0000000000000001
30 output: 0000000000000000 <> A:0000000000000100 <> B: 0000000000000010

40 output: 0000000000000010 <> A:0000000000000110 <> B: 0000000000000011
50 output: 0000000000000000 <> A:0000000000001000 <> B: 0000000000000100
60 output: 0000000000000000 <> A:0000000000001010 <> B: 0000000000000101
70 output: 0000000000000100 <> A:0000000000001100 <> B: 0000000000000110
80 output: 0000000000000110 <> A:0000000000001110 <> B: 0000000000000111
90 output: 0000000000000000 <> A:0000000000010000 <> B: 0000000000001000
100 output: 0000000000000000 <> A:0000000000010010 <> B: 0000000000001001
and
10 output: 0000000100100010 <> A:0000000100101110 <> B: 0000000100100010
20 output: 0000000100101000 <> A:0000000100111000 <> B: 0000000100101100
30 output: 0000000100000010 <> A:0000000101000010 <> B: 0000000100110110
40 output: 0000000101000000 <> A:0000000101001100 <> B: 0000000101000000
50 output: 0000000101000010 <> A:0000000101010110 <> B: 0000000101001010
60 output: 0000000101000000 <> A:0000000101100000 <> B: 0000000101010100
70 output: 0000000101001010 <> A:0000000101101010 <> B: 0000000101011110
80 output: 0000000101100000 <> A:0000000101110100 <> B: 0000000101101000
90 output: 0000000101110010 <> A:0000000101111110 <> B: 0000000101110010
100 output: 0000000100001000 <> A:0000000110001000 <> B: 0000000101111100
or
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000001
20 output: 0000000000000001 <> A:0000000000000001 <> B: 0000000000000001
30 output: 0000000000000000 <> A:0000000000000010 <> B: 0000000000000001
40 output: 0000000000000001 <> A:0000000000000011 <> B: 0000000000000001
50 output: 0000000000000000 <> A:0000000000000100 <> B: 0000000000000001
60 output: 0000000000000001 <> A:0000000000000101 <> B: 0000000000000001
70 output: 0000000000000000 <> A:0000000000000110 <> B: 0000000000000001
80 output: 0000000000000001 <> A:0000000000000111 <> B: 0000000000000001
90 output: 0000000000000000 <> A:0000000000001000 <> B: 0000000000000001
100 output: 0000000000000001 <> A:0000000000001001 <> B: 0000000000000001
or
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000

20 output: 0000000000000011 <> A:0000000000000001 <> B: 0000000000000010
30 output: 0000000000000110 <> A:0000000000000010 <> B: 0000000000000100
40 output: 0000000000000111 <> A:0000000000000011 <> B: 0000000000000110
50 output: 0000000000001100 <> A:0000000000000100 <> B: 0000000000001000
60 output: 0000000000001111 <> A:0000000000000101 <> B: 0000000000001010
70 output: 0000000000001110 <> A:0000000000000110 <> B: 0000000000001100
80 output: 0000000000001111 <> A:0000000000000111 <> B: 0000000000001110
90 output: 0000000000011000 <> A:0000000000001000 <> B: 0000000000010000
100 output: 0000000000011011 <> A:0000000000001001 <> B: 0000000000010010
or
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000011 <> A:0000000000000010 <> B: 0000000000000001
30 output: 0000000000000110 <> A:0000000000000100 <> B: 0000000000000010
40 output: 0000000000000111 <> A:0000000000000110 <> B: 0000000000000011
50 output: 0000000000001100 <> A:0000000000001000 <> B: 0000000000000100
60 output: 0000000000001111 <> A:0000000000001010 <> B: 0000000000000101
70 output: 0000000000001110 <> A:0000000000001100 <> B: 0000000000000110
80 output: 0000000000001111 <> A:0000000000001110 <> B: 0000000000000111
90 output: 0000000000011000 <> A:0000000000010000 <> B: 0000000000001000
100 output: 0000000000011011 <> A:0000000000010010 <> B: 0000000000001001
or
10 output: 0000000100101110 <> A:0000000100101110 <> B: 0000000100100010
20 output: 0000000100111100 <> A:0000000100111000 <> B: 0000000100101100
30 output: 0000000101110110 <> A:0000000101000010 <> B: 0000000100110110
40 output: 0000000101001100 <> A:0000000101001100 <> B: 0000000101000000
50 output: 0000000101011110 <> A:0000000101010110 <> B: 0000000101001010
60 output: 0000000101110100 <> A:0000000101100000 <> B: 0000000101010100
70 output: 0000000101111110 <> A:0000000101101010 <> B: 0000000101011110
80 output: 0000000101111100 <> A:0000000101110100 <> B: 0000000101101000
90 output: 0000000101111110 <> A:0000000101111110 <> B: 0000000101110010
100 output: 0000000111111100 <> A:0000000110001000 <> B: 0000000101111100

slt
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000001 <> A:0000000000000001 <> B: 0000000000000010
30 output: 0000000000000001 <> A:0000000000000010 <> B: 0000000000000100
40 output: 0000000000000001 <> A:0000000000000011 <> B: 0000000000000110
50 output: 0000000000000001 <> A:0000000000000100 <> B: 0000000000001000
60 output: 0000000000000001 <> A:0000000000000101 <> B: 0000000000001010
70 output: 0000000000000001 <> A:0000000000000110 <> B: 0000000000001100
80 output: 0000000000000001 <> A:0000000000000111 <> B: 0000000000001110
90 output: 0000000000000001 <> A:0000000000001000 <> B: 0000000000010000
100 output: 0000000000000001 <> A:0000000000001001 <> B: 0000000000010010
slt
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000000 <> A:0000000000000010 <> B: 0000000000000001
30 output: 0000000000000000 <> A:0000000000000100 <> B: 0000000000000010
40 output: 0000000000000000 <> A:0000000000000110 <> B: 0000000000000011
50 output: 0000000000000000 <> A:0000000000001000 <> B: 0000000000000100
60 output: 0000000000000000 <> A:0000000000001010 <> B: 0000000000000101
70 output: 0000000000000000 <> A:0000000000001100 <> B: 0000000000000110
80 output: 0000000000000000 <> A:0000000000001110 <> B: 0000000000000111
90 output: 0000000000000000 <> A:0000000000010000 <> B: 0000000000001000
100 output: 0000000000000000 <> A:0000000000010010 <> B: 0000000000001001
slt
10 output: 0000000000000000 <> A:0000000100101110 <> B: 0000000100100010
20 output: 0000000000000000 <> A:0000000100111000 <> B: 0000000100101100
30 output: 0000000000000000 <> A:0000000101000010 <> B: 0000000100110110
40 output: 0000000000000000 <> A:0000000101001100 <> B: 0000000101000000
50 output: 0000000000000000 <> A:0000000101010110 <> B: 0000000101001010
60 output: 0000000000000000 <> A:0000000101100000 <> B: 0000000101010100
70 output: 0000000000000000 <> A:0000000101101010 <> B: 0000000101011110
80 output: 0000000000000000 <> A:0000000101110100 <> B: 0000000101101000

90 output: 0000000000000000 <> A:0000000101111110 <> B: 0000000101110010
100 output: 0000000000000000 <> A:0000000110001000 <> B: 0000000101111100

Critical Path: Because of the carryout/in ripple the critical path is on operations using the Adder **(addition, subtraction, SLT)**

Gate Cost: total – 174

And gates: 80 **Or** gates: 46 **Xo**r gates: 48

Average Delay for 1000 inputs:

Addition 5.966010733

Subtraction 2.855694693

And 2.855694693

Or 2.6460177

Set Less Than 26.154047

Time delay compared on Addition operation:

The result of addition operates fluctuate under a time delay waiting for the carry in to ripple from the adder.

0 output: 0000000000000000
7 output: 0000000000000001
8 output: 0000000000000011
10 output: 0000000000000111
12 output: 0000000000001111
14 output: 0000000000011110
15 output: 0000000000011100
16 output: 0000000000111100
17 output: 0000000000111000
18 output: 0000000001111000
19 output: 0000000001110000
20 output: 0000000011110000
21 output: 0000000011100000
22 output: 0000000111100000
23 output: 0000000111000000
24 output: 0000001111000011
25 output: 0000001110000001
26 output: 0000011110000001
27 output: 0000011100000001
28 output: 0000111100000001
29 output: 0000111000000001
30 output: 0000111000000001

10 output: 0000000000000111
20 output: 0000000011110000
30 output: 0000111000000001

Time delay compared on Subtraction operation:

Similar to addition the result of subtraction operates fluctuate under a time delay waiting for the carry in to ripple from the adder.

10 output: 0000001001010001
14 output: 0000001001001001
15 output: 0000001001101101
17 output: 0000001001100101
20 output: 0000001001100101
24 output: 0000001000000101
25 output: 0000001010010001
27 output: 0000001010111001
29 output: 0000001011111001
30 output: 0000001011111001

10 output: 0000001001010001
20 output: 0000001001100101
30 output: 0000001001111001

Time delay compared on AND and OR operation:

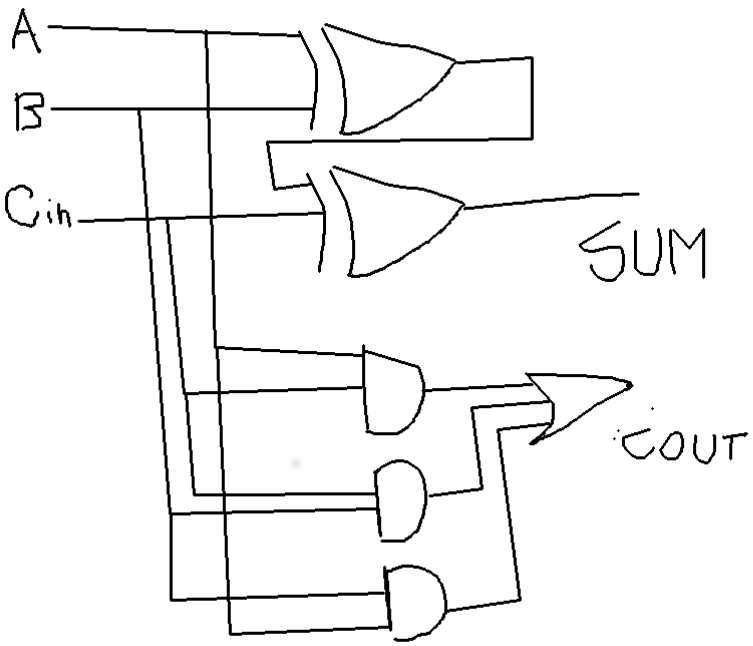
The paths for And and Or do not use the adder and pass through far fewer gates resulting in less interference between cycles to the output

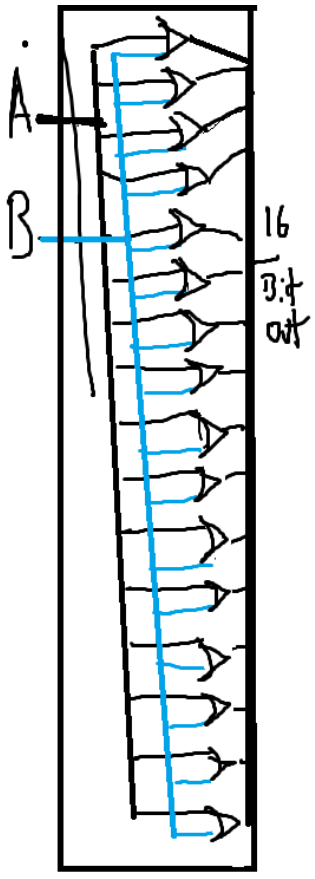
0 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000001
3 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000001
10 output: 0000000000000000 <> A:0000000000000001 <> B: 0000000000000010
20 output: 0000000000000000 <> A:0000000000000010 <> B: 0000000000000011
23 output: 0000000000000010 <> A:0000000000000010 <> B: 0000000000000011
30 output: 0000000000000010 <> A:0000000000000011 <> B: 0000000000000100
33 output: 0000000000000000 <> A:0000000000000011 <> B: 0000000000000100
40 output: 0000000000000000 <> A:0000000000000100 <> B: 0000000000000101
43 output: 0000000000000100 <> A:0000000000000100 <> B: 0000000000000101
50 output: 0000000000000100 <> A:0000000000000101 <> B: 0000000000000110
60 output: 0000000000000100 <> A:0000000000000110 <> B: 0000000000000111
63 output: 0000000000000110 <> A:0000000000000110 <> B: 0000000000000111
70 output: 0000000000000110 <> A:0000000000000111 <> B: 0000000000001000
73 output: 0000000000000000 <> A:0000000000000111 <> B: 0000000000001000
80 output: 0000000000000000 <> A:0000000000001000 <> B: 0000000000001001
83 output: 0000000000001000 <> A:0000000000001000 <> B: 0000000000001001
90 output: 0000000000001000 <> A:0000000000001001 <> B: 0000000000001010
100 output: 0000000000001000 <> A:0000000000001010 <> B: 0000000000001011
103 output: 0000000000001010 <> A:0000000000001010 <> B: 0000000000001011

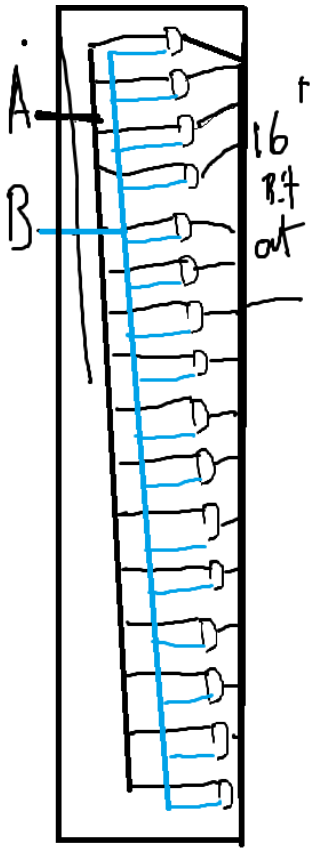
and
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000000 <> A:0000000000000001 <> B: 0000000000000010
30 output: 0000000000000000 <> A:0000000000000010 <> B: 0000000000000100
40 output: 0000000000000010 <> A:0000000000000011 <> B: 0000000000000110
50 output: 0000000000000000 <> A:0000000000000100 <> B: 0000000000001000
60 output: 0000000000000000 <> A:0000000000000101 <> B: 0000000000001010
70 output: 0000000000000100 <> A:0000000000000110 <> B: 0000000000001100
80 output: 0000000000000110 <> A:0000000000000111 <> B: 0000000000001110
90 output: 0000000000000000 <> A:0000000000001000 <> B: 0000000000010000
100 output: 0000000000000000 <> A:0000000000001001 <> B: 0000000000010010

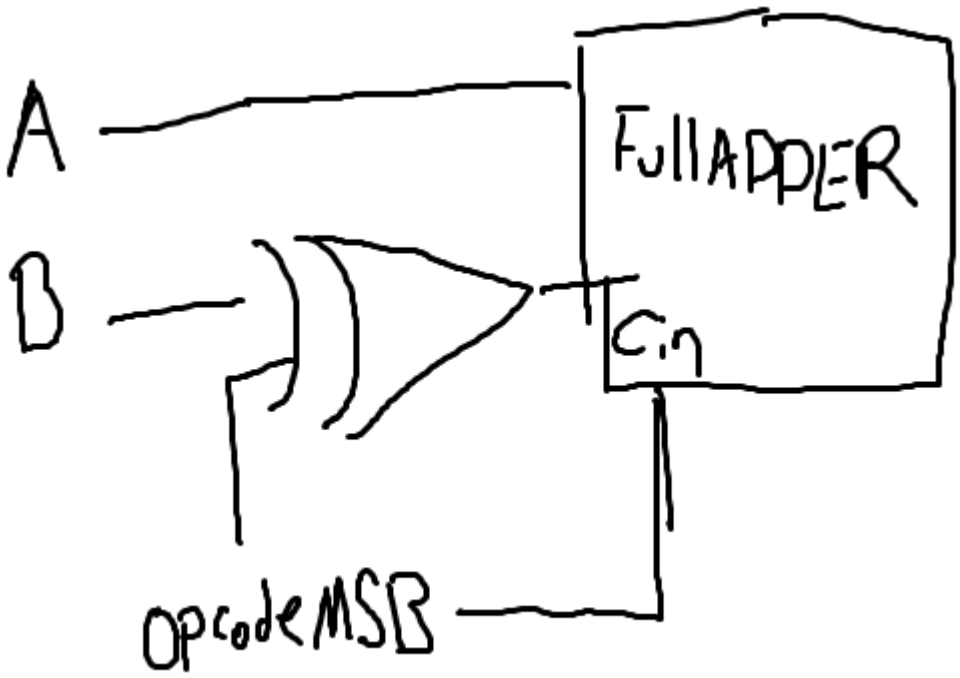
0 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000001
3 output: 0000000000000001 <> A:0000000000000000 <> B: 0000000000000001
10 output: 0000000000000001 <> A:0000000000000001 <> B: 0000000000000010
13 output: 0000000000000011 <> A:0000000000000001 <> B: 0000000000000010
20 output: 0000000000000011 <> A:0000000000000010 <> B: 0000000000000011
30 output: 0000000000000011 <> A:0000000000000011 <> B: 0000000000000100
33 output: 0000000000000111 <> A:0000000000000011 <> B: 0000000000000100
40 output: 0000000000000111 <> A:0000000000000100 <> B: 0000000000000101
43 output: 0000000000000101 <> A:0000000000000100 <> B: 0000000000000101
50 output: 0000000000000101 <> A:0000000000000101 <> B: 0000000000000110
53 output: 0000000000000111 <> A:0000000000000101 <> B: 0000000000000110
60 output: 0000000000000111 <> A:0000000000000110 <> B: 0000000000000111
70 output: 0000000000000111 <> A:0000000000000111 <> B: 0000000000001000
80 output: 0000000000001111 <> A:0000000000001000 <> B: 0000000000001001
83 output: 0000000000001001 <> A:0000000000001000 <> B: 0000000000001001
90 output: 0000000000001001 <> A:0000000000001001 <> B: 0000000000001010
93 output: 0000000000001011 <> A:0000000000001001 <> B: 0000000000001010
100 output: 0000000000001011 <> A:0000000000001010 <> B: 0000000000001011

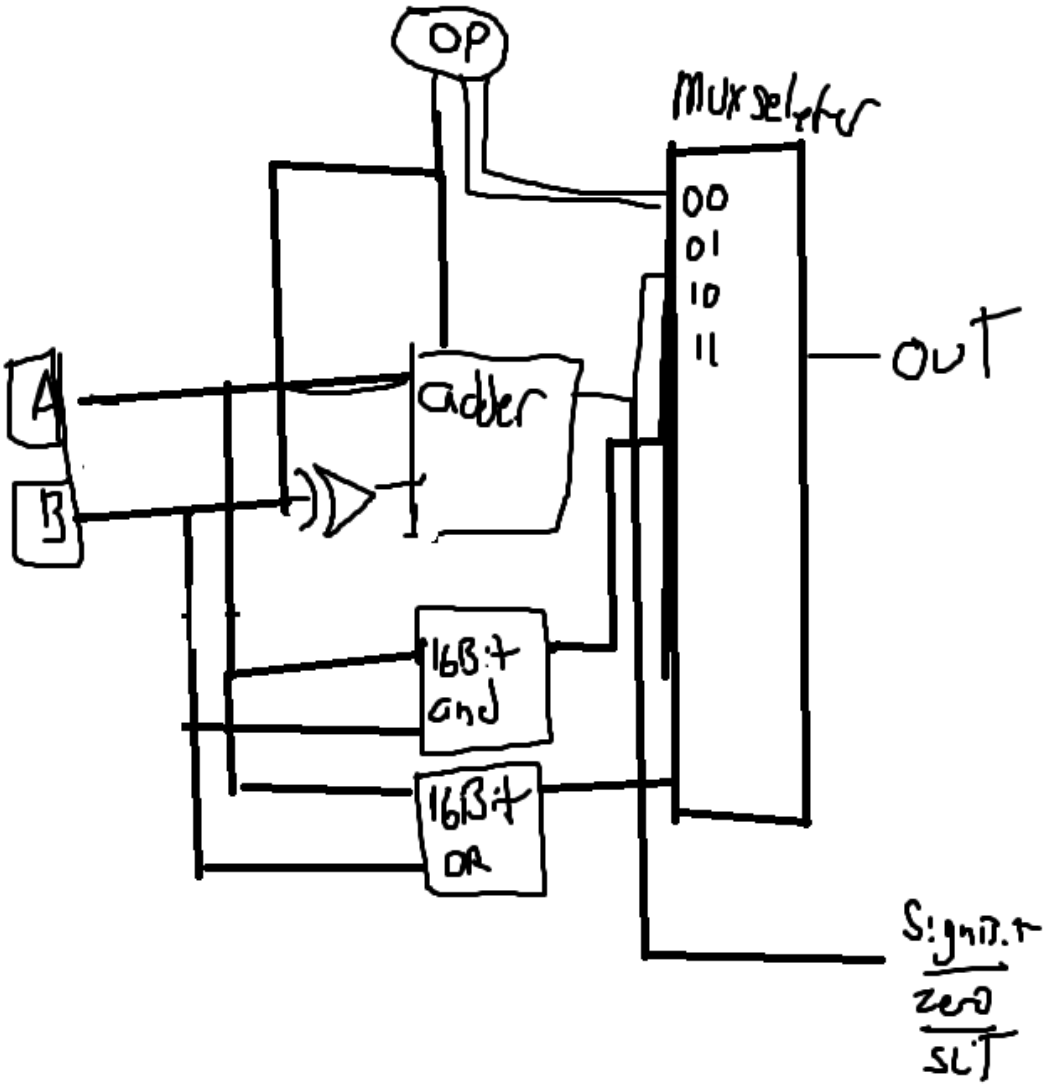
or
10 output: 0000000000000000 <> A:0000000000000000 <> B: 0000000000000000
20 output: 0000000000000011 <> A:0000000000000001 <> B: 0000000000000010
30 output: 0000000000000110 <> A:0000000000000010 <> B: 0000000000000100
40 output: 0000000000000111 <> A:0000000000000011 <> B: 0000000000000110
50 output: 0000000000001100 <> A:0000000000000100 <> B: 0000000000001000
60 output: 0000000000001111 <> A:0000000000000101 <> B: 0000000000001010
70 output: 0000000000001110 <> A:0000000000000110 <> B: 0000000000001100
80 output: 0000000000001111 <> A:0000000000000111 <> B: 0000000000001110
90 output: 0000000000011000 <> A:0000000000001000 <> B: 0000000000010000
100 output: 0000000000011011 <> A:0000000000001001 <> B: 0000000000010010


A
B
Cin
SUM
COUT


A
B
16
Bit
out


A
B
16
Bit
out


A
B
FullAdder
Cin
opcodeMSB


OP
Mux selector
00
01
10
11
OUT
A
B
adder
16Bit
and
16Bit
OR
Signal
zero
slt