LAB 4 ALU

LAB4

Design a circuit with the following.

- Four 8-bit registers
- One 8-bit input port
- One 8-bit output port
- extra 1-bit sign output
- One 8-bit unidirectional tribus
- One arithmetic logic unit with two 8-bit input ports and one 8-bit output port. That makes operations on next slide.
- Necessary MUX components in order to make a generic purpose datapath with ALU.

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Following operations are supported (X,Y,Z are three registers):

- input X,inputvalue: Input value is transferred to X from the input port.
- output X: Content of X is transferred to the output port in signed format with sign bit.
- outputu X: Content of X is transferred to the output port in unsigned format.

- ALU OPERATIONS
- add Z, X, Y: Contents of X and Y are added and the result is transferred to Z.
- mul Z, X, Y: Contents of X and Y are multiplied and the result is transferred to Z.
- sub Z, X, Y : Content of Y is subtracted from content of X and the result is transferred to Z.
- div Z, X, Y : Content of Y is divided from content of X and the result is transferred to Z.
- shl Z, X: Content of **X** is shifted 1 bit left and the result is transferred to Z.
- shr Z, X: Content of **X** is shifted 1 bit right and the result is transferred to Z.
- and Z, X, Y: Contents of X and Y are bitwise-anded and the result is transferred to Z.
- or Z, X, Y: Contents of X and Y are bitwise-ored and the result is transferred to Z.

Two's complement

Three-bit signed integers

Decimal value	Binary (two's-complement representation)	Two's complement $(2^3 - n)_2$
0	000	000
1	001	111
2	010	110
3	011	101
-4	100	100
-3	101	011
-2	110	010
-1	111	001

Eight-bit signed integers

Decimal value	Binary (two's-complement representation)	Two's complement $(2^8 - n)_2$
0	0000 0000	0000 0000
1	0000 0001	1111 1111
2	0000 0010	1111 1110
126	0111 1110	1000 0010
127	0111 1111	1000 0001
−128	1000 0000	1000 0000
−127	1000 0001	0111 1111
−126	1000 0010	0111 1110
−2	1111 1110	0000 0010
−1	1111 1111	0000 0001

Adding Unsigned Numbers

Decimal	Unsigned Binary
1 (carry) 06 +07 13	*110* (carry) 0110 +0111 1101

Decimal	Unsigned Binary
0 (carry) 13 +05 18	*1101* (carry) 1101 +0101 10010

Adding Signed Numbers

Decimal	Signed Binary
	1110 (carry) 1110
-2	+0011
+3	0001
1	

Decimal	Signed Binary
	011 (carry) 1011
-5	+0011
+3	1110
-2	

Decimal	Signed Binary
	1100 (carry) 1100
-4	+1101
-3	1001
-7	

Decimal	Signed Binary
	110 (carry) 0110
6	+0011
+3	1001
9	

Decimal	Signed Binary
	1001 (carry) 1001
-7	+1101
-3	0110
-10	

Subtract Signed Numbers

Decimal	Signed Binary
5 - 3 2	0101 + 1101 10010

Decimal	Signed Binary
3 - 5 - 2	0011 + 1011 1110

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Example 1

```
input r1,74
input r2,42
sub r3,r1,r2
out r3
input r4,-45
add r4,r4,r3
out r4
outu r4
```

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Example 2

```
input r3,116
input r2,12
div r4,r3,r2
out r4
input r1,-7
mul r1,r1,r4
out r1
outu r1
```

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Example 3

```
input r1,34
input r2,110
and r3,r1,r2
out r3
input r4,-45
or r4,r4,r3
out r4
outu r4
```

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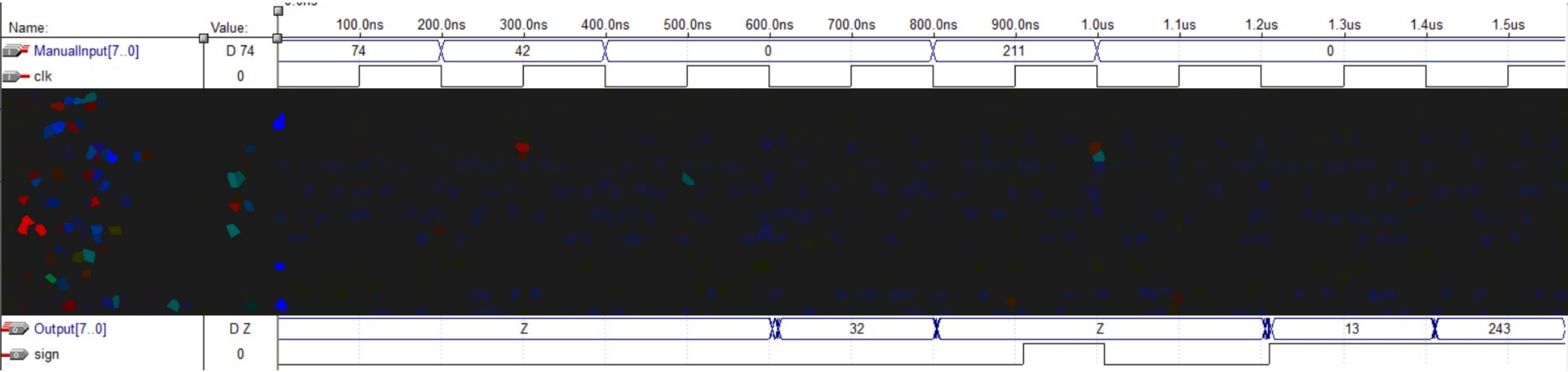
Example 4

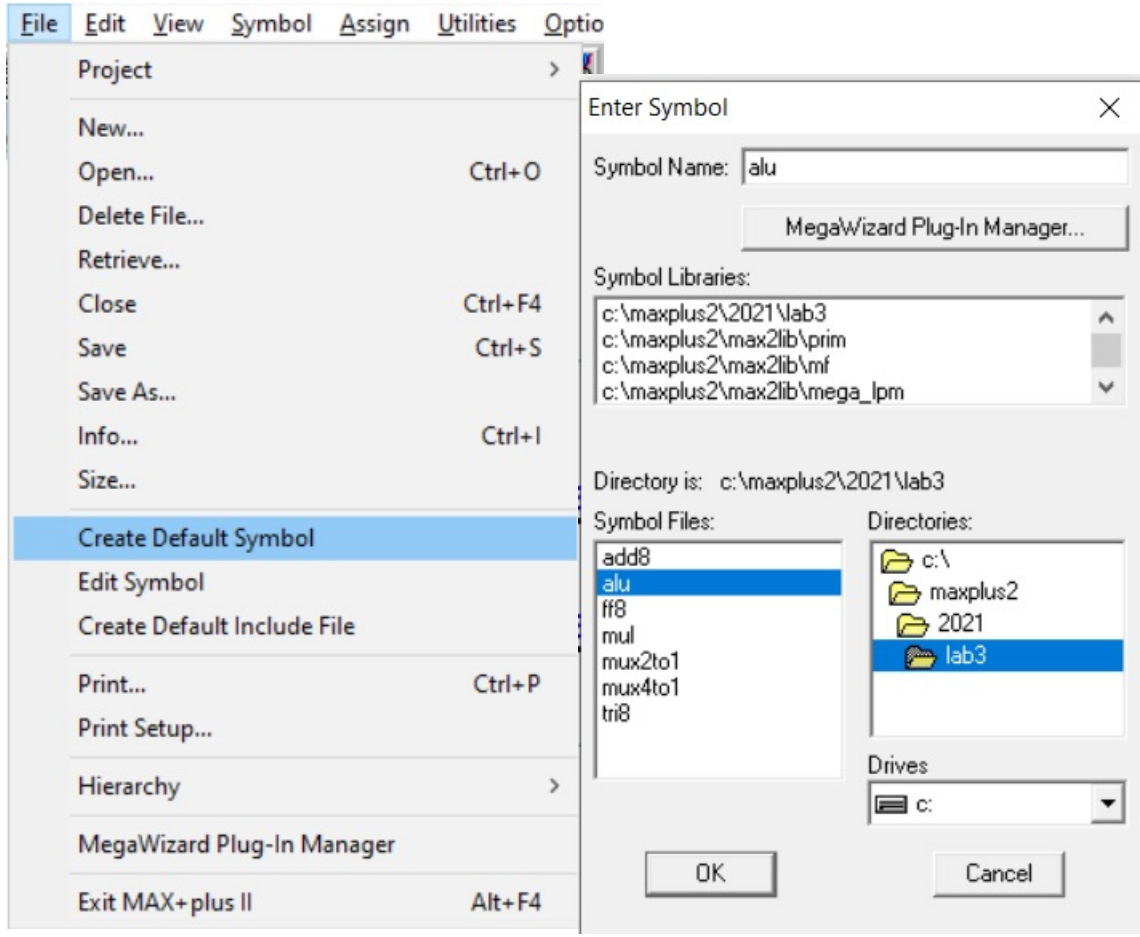
```
input r3,26
input r2,120
shr r2,r2
shl r1,r1
out r1
input r3,-7
add r4,r1,r2
sub r3,r3,r4
out r3
outu r3
```

Sample scf file for Example 1



Hint 1

You can create your ALU as a symbol file and include it to your main project with: File-> Create Default Symbol.
After than you can add it with Right Click to Plane -> Enter Symbol -> your Component



*Note:If you change your symbol file you have to recreate default symbol and delete previous component to get changes.