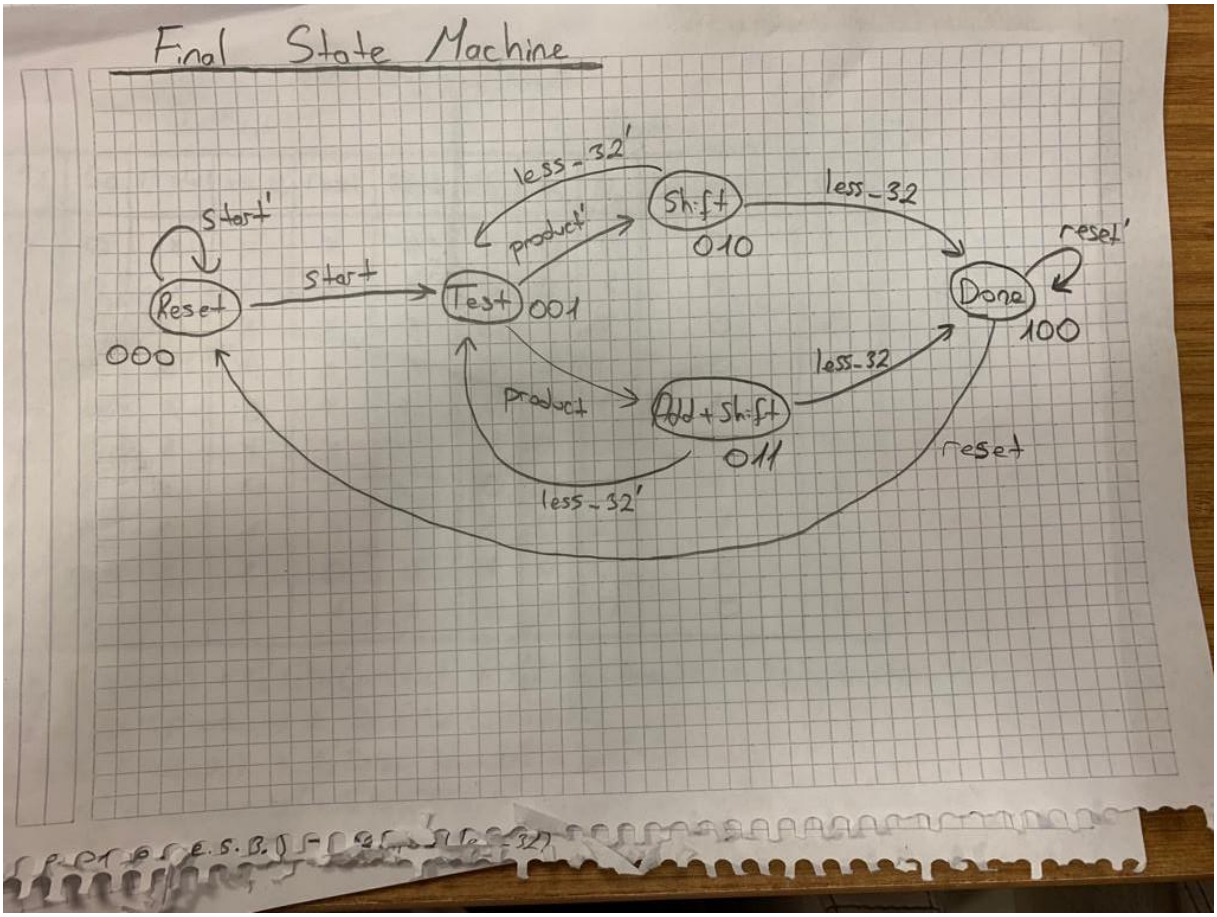
Final State Machine

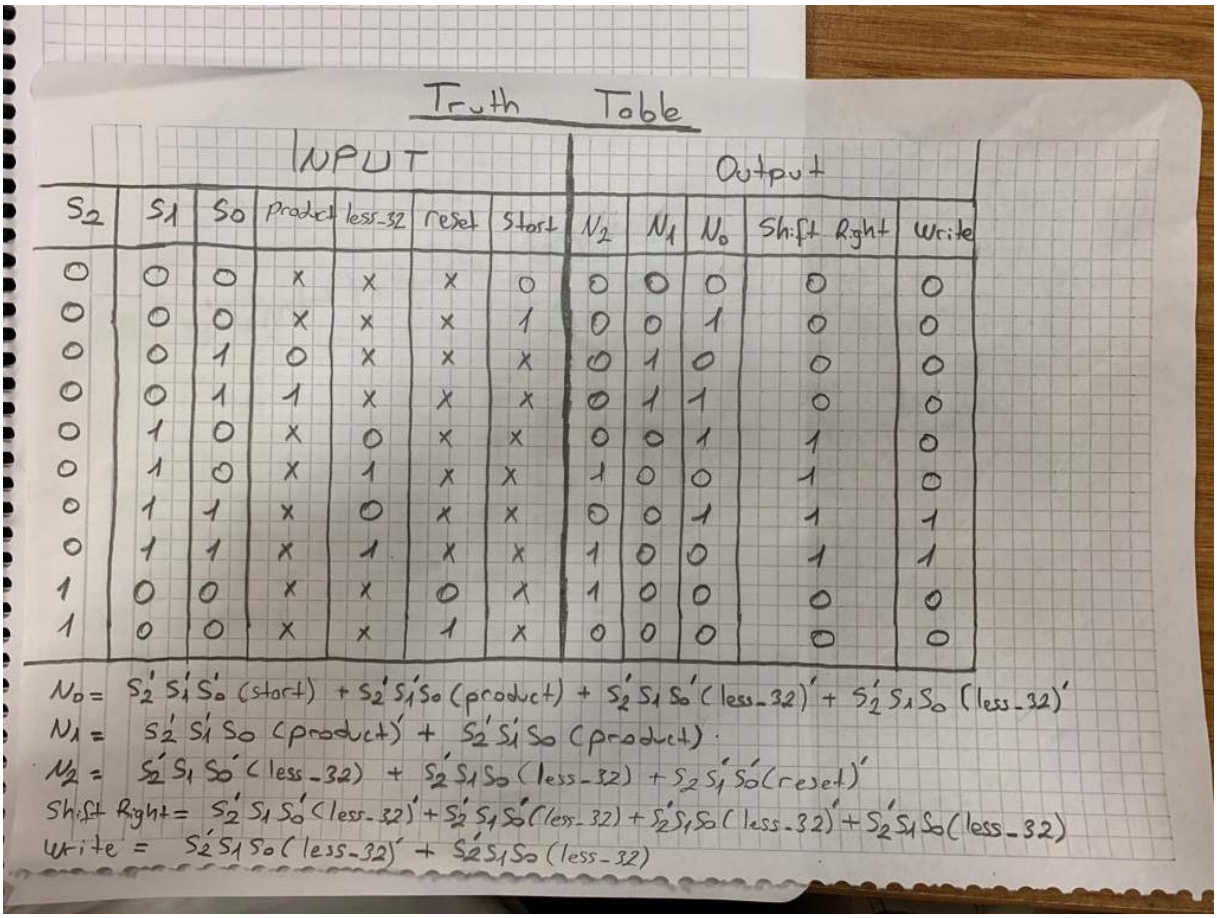


Missing Part

In the 1st part, I designed the control and datapath components. However, I couldn't make the connection. However, I done separate testbenches of control and dataPath components.

That's why there is no MULT on the ALU.

Truth Table



Truth Table

INPUT							Output				
S_2	S_1	S_0	product	less_32	reset	start	N_2	N_1	N_0	Shift Right	Write
0	0	0	x	x	x	0	0	0	0	0	0
0	0	0	x	x	x	1	0	0	1	0	0
0	0	1	0	x	x	x	0	1	0	0	0
0	0	1	1	x	x	x	0	1	1	0	0
0	1	0	x	0	x	x	0	0	1	1	0
0	1	0	x	1	x	x	1	0	0	1	0
0	1	1	x	0	x	x	0	0	1	1	1
0	1	1	x	1	x	x	1	0	0	1	1
1	0	0	x	x	0	x	1	0	0	0	0
1	0	0	x	x	1	x	0	0	0	0	0

$N_0 = S_2' S_1' S_0$ (start) $+ S_2' S_1' S_0$ (product) $+ S_2' S_1 S_0'$ (less_32)$' + S_2' S_1 S_0$ (less_32)$'$

$N_1 = S_2' S_1' S_0$ (product)$' + S_2' S_1' S_0$ (product)

$N_2 = S_2' S_1 S_0'$ (less_32) $+ S_2' S_1 S_0$ (less_32) $+ S_2 S_1' S_0'$ (reset)$'$

Shift Right $= S_2' S_1 S_0'$ (less_32)$' + S_2' S_1 S_0'$ (less_32) $+ S_2' S_1' S_0$ (less_32)$' + S_2' S_1 S_0$ (less_32)

Write $= S_2' S_1 S_0$ (less_32)$' + S_2' S_1 S_0$ (less_32)

Karnough Maps

product, less,_32, reset, start S2, S1, S0	0000	0001	0011	0010	0110	0111	0101	0100	1100	1101	1111	1110	1010	1011	1001	1000
000	0	1	1	0	0	1	1	0	0	1	1	0	0	1	1	0
001	0	0	0	0	0	0	0	0	1	1	1	1	1	1	1	1
011	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1
010	1	1	1	1	0	0	0	0	0	0	0	0	1	1	1	1
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

N0= S2’ S1’ S0’ (start) + S2’ S1’ S0 (product) + S2’ S1 (less_32)’

product, less,_32, reset, start S2, S1, S0	0000	0001	0011	0010	0110	0111	0101	0100	1100	1101	1111	1110	1010	1011	1001	1000
000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
001	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
011	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
010	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

N1 = S2’ S1’ S0

product, less,_32, reset, start S2, S1, S0	0000	0001	0011	0010	0110	0111	0101	0100	1100	1101	1111	1110	1010	1011	1001	1000
000	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
001	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
011	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
010	0	0	0	0	1	1	1	1	1	1	1	1	0	0	0	0
100	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1
101	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
111	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
110	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

N2= S2’ S1 (less_32) + S2 S1’ S0’ (reset)’

Test Benches

Half Adder (1 bit)

```
Transcript
# Loading work.half_adder_testbench
# Loading work.half_adder
add wave -position insertpoint  \
sim:/half_adder_testbench/A \
sim:/half_adder_testbench/B \
sim:/half_adder_testbench/R \
sim:/half_adder_testbench/carry_out
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlft3we6ga".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlft3we6ga
#
VSIM 6> step -current
# time =  0, A =1, B=0, Sum=1, carry Out=0
# time = 20, A =0, B=0, Sum=0, carry Out=0

VSIM 7>
```

Full Adder (1 bit)

```
Transcript
# Loading work.half_adder
add wave -position insertpoint  \
sim:/full_adder_testbench/A \
sim:/full_adder_testbench/B \
sim:/full_adder_testbench/carry_in \
sim:/full_adder_testbench/R \
sim:/full_adder_testbench/carry_out
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlft4xdhw4".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlft4xdhw4
#
VSIM 7> step -current
# time =  0, A =1, B=0, Sum=0, carry In=1, carry Out=1
# time = 20, A =1, B=1, Sum=0, carry In=0, carry Out=1

VSIM 8>
```

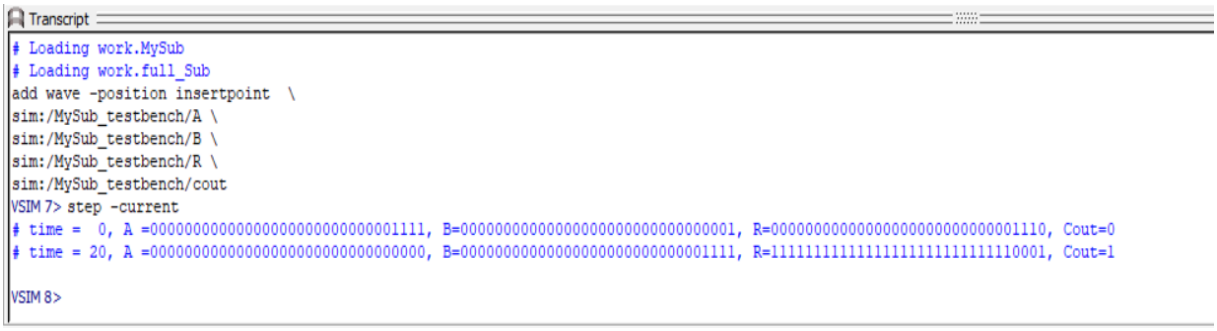
MyAdder (32 bit)

```
# Loading work.full_adder
# Loading work.half_adder
add wave -position insertpoint  \
sim:/MyAdder_testbench/A \
sim:/MyAdder_testbench/B \
sim:/MyAdder_testbench/R \
sim:/MyAdder_testbench/cout
VSIM 8> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000010000, Cout=0
# time = 20, A =11111111111111111111111110111011, B=11111111111111111111111110111011, R=11111111111111111111111101110110, Cout=1

VSIM 9>
```

Full Sub (1 bit)

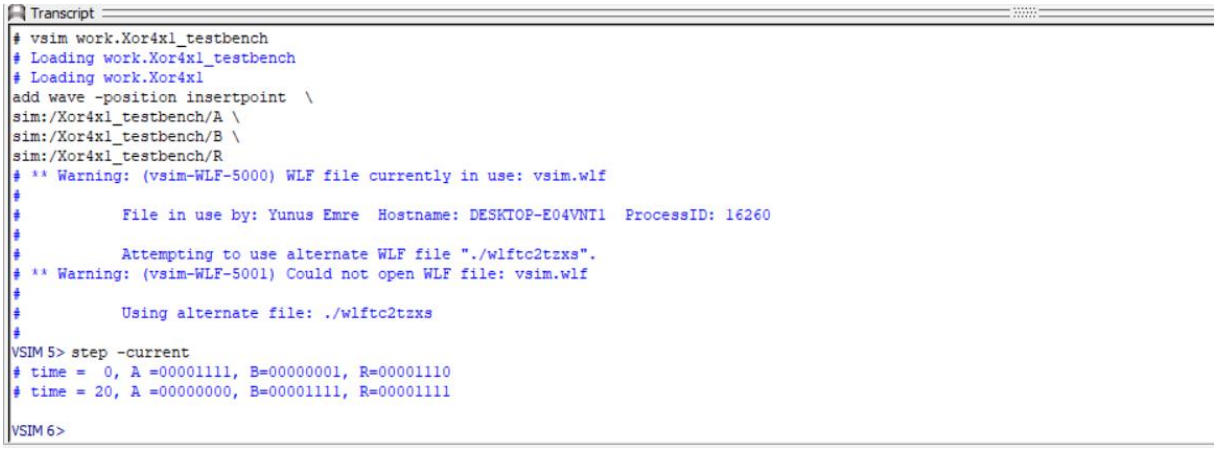
```
Transcript
# Loading work.full_Sub
add wave -position insertpoint  \
sim:/full_Sub_testbench/A \
sim:/full_Sub_testbench/B \
sim:/full_Sub_testbench/carry_in \
sim:/full_Sub_testbench/R \
sim:/full_Sub_testbench/carry_out
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlft8sht64".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlft8sht64
#
VSIM 6> step -current
# time =  0, A =1, B=0, Sum=0, carry In=1, carry Out=0
# time = 20, A =1, B=1, Sum=0, carry In=0, carry Out=0

VSIM 7>
```

MySubber (32 bit)



```
Transcript
# Loading work.MySub
# Loading work.full_Sub
add wave -position insertpoint  \
sim:/MySub_testbench/A \
sim:/MySub_testbench/B \
sim:/MySub_testbench/R \
sim:/MySub_testbench/cout
VSIM 7> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000001110, Cout=0
# time = 20, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=11111111111111111111111111110001, Cout=1

VSIM 8>
```

Xor4x1 (8 bit)



```
Transcript
# vsim work.Xor4x1_testbench
# Loading work.Xor4x1_testbench
# Loading work.Xor4x1
add wave -position insertpoint  \
sim:/Xor4x1_testbench/A \
sim:/Xor4x1_testbench/B \
sim:/Xor4x1_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlftc2tzxs".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlftc2tzxs
#
VSIM 5> step -current
# time =  0, A =00001111, B=00000001, R=00001110
# time = 20, A =00000000, B=00001111, R=00001111

VSIM 6>
```

MyXor (32 bit)

```
Transcript
# Loading work.MyXor_testbench
# Loading work.MyXor
# Loading work.Xor4x1
add wave -position insertpoint  \
sim:/MyXor_testbench/A \
sim:/MyXor_testbench/B \
sim:/MyXor_testbench/R
VSIM 7> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000001110
# time = 20, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=00000000000000000000000000001111

VSIM 8>
```

Nor4x1 (8 bit)

```
Transcript
# vsim work.Nor4x1_testbench
# Loading work.Nor4x1_testbench
# Loading work.Nor4x1
add wave -position insertpoint  \
sim:/Nor4x1_testbench/A \
sim:/Nor4x1_testbench/B \
sim:/Nor4x1_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlftj60zkg".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlftj60zkg
#
VSIM 5> step -current
# time =  0, A =00001111, B=00000001, R=11110000
# time = 20, A =00000000, B=00001111, R=11110000

VSIM 6>
```

MyNor (32 bit)

```
Transcript
# Loading work.MyNor_testbench
# Loading work.MyNor
# Loading work.Nor4x1
add wave -position insertpoint  \
sim:/MyNor_testbench/A \
sim:/MyNor_testbench/B \
sim:/MyNor_testbench/R
VSIM 7> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=11111111111111111111111111110000
# time = 20, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=11111111111111111111111111110000

VSIM 8>
```

And4x1 (8 bit)

Transcript

```
# vsim work.And4x1_testbench
# Loading work.And4x1_testbench
# Loading work.And4x1
add wave -position insertpoint  \
sim:/And4x1_testbench/A \
sim:/And4x1_testbench/B \
sim:/And4x1_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlft0ckhbf".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlft0ckhbf
#
VSIM 5> step -current
# time =  0, A =00001111, B=00000001, R=00000001
# time = 20, A =00000000, B=00001111, R=00000000

VSIM 6>
```

MyAnd (32 bit)

Transcript

```
# Loading work.MyAnd_testbench
# Loading work.MyAnd
# Loading work.And4x1
add wave -position insertpoint  \
sim:/MyAnd_testbench/A \
sim:/MyAnd_testbench/B \
sim:/MyAnd_testbench/R
VSIM 7> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000000001
# time = 20, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=00000000000000000000000000000000

VSIM 8>
```

Or4x1 (8 bit)

Transcript

```
# vsim work.Or4x1_testbench
# Loading work.Or4x1_testbench
# Loading work.Or4x1
add wave -position insertpoint  \
sim:/Or4x1_testbench/A \
sim:/Or4x1_testbench/B \
sim:/Or4x1_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlftnlv3rq".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlftnlv3rq
#
VSIM 5> step -current
# time =  0, A =00001111, B=00000001, R=00001111
# time = 20, A =00000000, B=00001111, R=00001111

VSIM 6>
```

MyOr (32 bit)

```
Transcript
# Loading work.MyOr_testbench
# Loading work.MyOr
# Loading work.Or4x1
add wave -position insertpoint  \
sim:/MyOr_testbench/A \
sim:/MyOr_testbench/B \
sim:/MyOr_testbench/R
VSIM 7> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000001111
# time = 20, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=00000000000000000000000000001111

VSIM 8>
```

Mux2x1 (1 bit)

```
Transcript
# Loading work.mux2x1_testbench
# Loading work.mux2x1
add wave -position insertpoint  \
sim:/mux2x1_testbench/A \
sim:/mux2x1_testbench/B \
sim:/mux2x1_testbench/S \
sim:/mux2x1_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlftx8y8jq".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlftx8y8jq
#
VSIM 6> step -current
# time =  0, A =1, B=0, R=1, S=0
# time = 20, A =1, B=0, R=0, S=1

VSIM 7>
```

Mux32x1 (32 bit)

```
Transcript
# Loading work.mux32bit
# Loading work.mux2x1
add wave -position insertpoint  \
sim:/mux32bit_testbench/A \
sim:/mux32bit_testbench/B \
sim:/mux32bit_testbench/S \
sim:/mux32bit_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlft363han".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlft363han
#
VSIM 7> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000000001, S=1
# time = 20, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=00000000000000000000000000000000, S=0

VSIM 8>
```

Mux8x3 (1 bit)

```
Transcript
sim:/mux8x3_testbench/R
VSIM 6> step -current
# time =  0, D0 =1, D1=0, D2=0, D3=0, D4=0, D5=0, D6=0, D7=0, S=000, R=1
# time = 20, D0 =0, D1=1, D2=0, D3=0, D4=0, D5=0, D6=0, D7=0, S=001, R=1
# time = 40, D0 =0, D1=0, D2=1, D3=0, D4=0, D5=0, D6=0, D7=0, S=010, R=1
# time = 60, D0 =0, D1=0, D2=0, D3=1, D4=0, D5=0, D6=0, D7=0, S=011, R=1
# time = 80, D0 =0, D1=0, D2=0, D3=0, D4=1, D5=0, D6=0, D7=0, S=100, R=1
# time = 100, D0 =0, D1=0, D2=0, D3=0, D4=0, D5=1, D6=0, D7=0, S=101, R=1
# time = 120, D0 =0, D1=0, D2=0, D3=0, D4=0, D5=0, D6=1, D7=0, S=110, R=1
# time = 140, D0 =0, D1=0, D2=0, D3=0, D4=0, D5=0, D6=0, D7=1, S=111, R=1

VSIM 7>
```

Mux32bit8x3 (32 bit)

```
Transcript
sim:/mux32bit_8x3_testbench/D5 \
sim:/mux32bit_8x3_testbench/D6 \
sim:/mux32bit_8x3_testbench/D7 \
sim:/mux32bit_8x3_testbench/S \
sim:/mux32bit_8x3_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#          File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#          Attempting to use alternate WLF file "./wlftf6kaq9".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#          Using alternate file: ./wlftf6kaq9
#
VSIM 5> step -current
# time =  0, D0=00000000000000000000000000001111, D1=00000000000000000000000000000001, D2=00000000000000000000000000000001, D3=00000000000000000000000000000001, D4=00000000000000000000000000000001, D5=00000000000000000000000000000001, D6=00000000000000000000000000000001, D7=00000000000000000000000000000001, S=000, R=00000000000000000000000000001111
# time = 20, D0=00000000000000000000000000001001, D1=00000000000000000000000000000101, D2=00000000000000000000000000001001, D3=00000000000000000000000000000011, D4=00000000000000000000000001000001, D5=00000000000000000000001010000001, D6=00000000000000000000000001010001, D7=00000000000000000000000010100001, S=001, R=00000000000000000000000000000101

VSIM 6>
```

ALU (32 bit)

```
Transcript
sim:/Alu_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#          File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#          Attempting to use alternate WLF file "./wlftzn0nrz".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#          Using alternate file: ./wlftzn0nrz
#
VSIM 5> step -current
# time =  0, A =00000000000000000000000000000001, B=00000000000000000000000000000011, R=00000000000000000000000000000100, Select=000
# time = 20, A =00000000000000000000000000000101, B=00000000000000000000000000001001, R=00000000000000000000000000001110, Select=000
# time = 40, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000001110, Select=001
# time = 60, A =00000000000000000000000000001111, B=00000000000000000000000000000101, R=00000000000000000000000000001010, Select=001
# time = 80, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=11111111111111111111111111110001, Select=010
# time = 100, A =00000000000000000000000000000000, B=00000000000000000000000000000110, R=11111111111111111111111111111010, Select=010
# time = 120, A =11111111111111111111111111110111011, B=11111111111111111111111111110111011, R=xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx, Select=011
# time = 140, A =11111000111111111111111110111011, B=11111111111111110000111110111011, R=xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx, Select=011
# time = 160, A =00000000000000000000000000000110, B=00000000000000000000000000001111, R=00000000000000000000000000000001, Select=100
# time = 180, A =00000000000000000000111111110110, B=00000000000000000000000011110110, R=00000000000000000000000000000000, Select=100
# time = 200, A =00000000000000000000000000001001, B=00000000000000000000000000000000, R=11111111111111111111111111110110, Select=101
# time = 220, A =00000000000000000000000000001001, B=00000000000000000000000011110000, R=11111111111111111111111111100110, Select=101
# time = 240, A =00000000000000000000000000001010, B=00000000000000000000000000001001, R=00000000000000000000000000001000, Select=110
# time = 260, A =00000000000000000000000010101010, B=00000000000000000000000000001001, R=00000000000000000000000000001000, Select=110
# time = 280, A =00000000000000000000000000000000, B=00000000000000000000000000000110, R=00000000000000000000000000000110, Select=111
# time = 300, A =00000000000000000000100111110010, B=00000000000000000000000011110110, R=00000000000000000000100111110110, Select=111

VSIM 6>
```

SetLessThan (32 bit)

```
Transcript
# Loading work.Set_less_than
# Loading work.MySub
# Loading work.full_Sub
add wave -position insertpoint  \
sim:/Set_less_than_testbench/A \
sim:/Set_less_than_testbench/B \
sim:/Set_less_than_testbench/R
# ** Warning: (vsim-WLF-5000) WLF file currently in use: vsim.wlf
#
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlft6hlt3y".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlft6hlt3y
#
VSIM 5> step -current
# time =  0, A =00000000000000000000000000001111, B=00000000000000000000000000000001, R=00000000000000000000000000000000
# time = 20, A =00000000000000000000000000000000, B=00000000000000000000000000001111, R=00000000000000000000000000000001

VSIM 6>
```

1.Part Test Benches

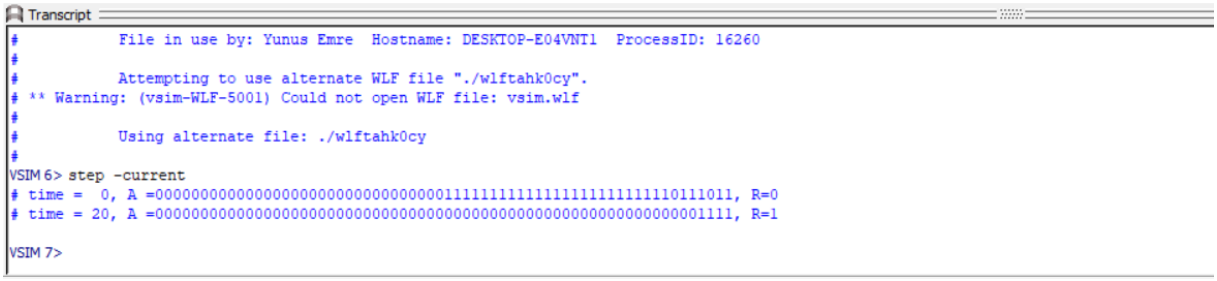
Control

```
Transcript
# time =  0, S=xxx, N=xxx, ShitfRight=x, Write=x
# time =  5, S=000, N=000, ShitfRight=0, Write=0
# time = 10, S=000, N=001, ShitfRight=0, Write=0
# time = 15, S=001, N=011, ShitfRight=0, Write=0
# time = 25, S=011, N=100, ShitfRight=1, Write=1
# time = 35, S=000, N=000, ShitfRight=0, Write=0
# ** Note: $finish    : D:/Emre/OneDrive - GTÜ/Masaüstü/ALU/control_testbench.v(44)
#    Time: 40 ps  Iteration: 0  Instance: /control_testbench
# 1
# Break in Module control_testbench at D:/Emre/OneDrive - GTÜ/Masaüstü/ALU/control_testbench.v line 44

VSIM 7>
```

Right Shift (64 bit)

```
Transcript
#           File in use by: Yunus Emre  Hostname: DESKTOP-E04VNT1  ProcessID: 16260
#
#           Attempting to use alternate WLF file "./wlft0qyldh".
# ** Warning: (vsim-WLF-5001) Could not open WLF file: vsim.wlf
#
#           Using alternate file: ./wlft0qyldh
#
VSIM 6> step -current
# time =  0, A =11111111111111111111111101110111111111111111111111111111110111011, R=01111111111111111111111101110111111111111111111111111111111011101
# time = 20, A =00000000000000000000000000000000000000000000000000000000000001111, R=00000000000000000000000000000000000000000000000000000000000000111

VSIM 7>
```

Less32Bit (check if the product less 32 bit)



Set64bit (create a product with multiplier)