CSE 331 - Project 2

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Modules:

1. xor_
2. mux_4_1
3. alu_1
4. alu_1_msb
5. alu_32_msb

1) xor_(in: a, b)(out: res) and xor_tb:

This xor module has 2 not, 2 and, 1 or gates. Total: 5 gates.

```
# time =    0, a = 0, b = 0, res=0
# time =   20, a = 0, b = 1, res=1
# time =   40, a = 1, b = 0, res=1
# time =   60, a = 1, b = 1, res=0
```

2) mux_4_1(in: [3:0]in, [1:0]sl)(out: res) and mux_4_1_tb:

This 4:1 mux module has 2 not, 4 and, 1 or gates. Total: 7 gates.

```
# time =  0, in = 0000, sl = 00, res=0
# time = 20, in = 0000, sl = 01, res=0
# time = 40, in = 0000, sl = 10, res=0
# time = 60, in = 0000, sl = 11, res=0
# time = 80, in = 0001, sl = 00, res=1
# time = 100, in = 0001, sl = 01, res=0
# time = 120, in = 0001, sl = 10, res=0
# time = 140, in = 0001, sl = 11, res=0
# time = 160, in = 0010, sl = 00, res=0
# time = 180, in = 0010, sl = 01, res=1
# time = 200, in = 0010, sl = 10, res=0
# time = 220, in = 0010, sl = 11, res=0
# time = 240, in = 0011, sl = 00, res=1
# time = 260, in = 0011, sl = 01, res=1
# time = 280, in = 0011, sl = 10, res=0
# time = 300, in = 0011, sl = 11, res=0
# time = 320, in = 0100, sl = 00, res=0
# time = 340, in = 0100, sl = 01, res=0
# time = 360, in = 0100, sl = 10, res=1
# time = 380, in = 0100, sl = 11, res=0
# time = 400, in = 0101, sl = 00, res=1
# time = 420, in = 0101, sl = 01, res=0
# time = 440, in = 0101, sl = 10, res=1
# time = 460, in = 0101, sl = 11, res=0
# time = 480, in = 0110, sl = 00, res=0
# time = 500, in = 0110, sl = 01, res=1
# time = 520, in = 0110, sl = 10, res=1
# time = 540, in = 0110, sl = 11, res=0
# time = 560, in = 0111, sl = 00, res=1
# time = 580, in = 0111, sl = 01, res=1
# time = 600, in = 0111, sl = 10, res=1
# time = 620, in = 0111, sl = 11, res=0
# time = 640, in = 1000, sl = 00, res=0
# time = 660, in = 1000, sl = 01, res=0
# time = 680, in = 1000, sl = 10, res=0
# time = 700, in = 1000, sl = 11, res=1
# time = 720, in = 1001, sl = 00, res=1
# time = 740, in = 1001, sl = 01, res=0
# time = 760, in = 1001, sl = 10, res=0
# time = 780, in = 1001, sl = 11, res=1
# time = 800, in = 1010, sl = 00, res=0
# time = 820, in = 1010, sl = 01, res=1
# time = 840, in = 1010, sl = 10, res=0
# time = 860, in = 1010, sl = 11, res=1
# time = 880, in = 1011, sl = 00, res=1
# time = 900, in = 1011, sl = 01, res=1
# time = 920, in = 1011, sl = 10, res=0
# time = 940, in = 1011, sl = 11, res=1
# time = 960, in = 1100, sl = 00, res=0
# time = 980, in = 1100, sl = 01, res=0
# time = 1000, in = 1100, sl = 10, res=1
# time = 1020, in = 1100, sl = 11, res=1
# time = 1040, in = 1101, sl = 00, res=1
# time = 1060, in = 1101, sl = 01, res=0
# time = 1080, in = 1101, sl = 10, res=1
# time = 1100, in = 1101, sl = 11, res=1
# time = 1120, in = 1110, sl = 00, res=0
# time = 1140, in = 1110, sl = 01, res=1
# time = 1160, in = 1110, sl = 10, res=1
# time = 1180, in = 1110, sl = 11, res=1
# time = 1200, in = 1111, sl = 00, res=1
# time = 1220, in = 1111, sl = 01, res=1
# time = 1240, in = 1111, sl = 10, res=1
# time = 1260, in = 1111, sl = 11, res=1
```

3) alu_1(in: a, b, cin, less, [2:0]op)(out: res, cout) and alu_1_tb:

This 1 bit alu module has 1 xor_, 1 mux_4_1 modules with 3 or, 4 and, 2 and gates. Total: 21 gates.

```
# time =   0, a = 0, b = 0, cin = 0, less = 1, op= 0, res=0, cout=0
# time =  20, a = 0, b = 0, cin = 1, less = 0, op= 0, res=0, cout=0
# time =  40, a = 0, b = 0, cin = 1, less = 1, op= 0, res=0, cout=0
# time =  60, a = 0, b = 1, cin = 0, less = 0, op= 0, res=0, cout=0
# time =  80, a = 0, b = 1, cin = 0, less = 1, op= 0, res=0, cout=0
# time = 100, a = 0, b = 1, cin = 1, less = 0, op= 0, res=0, cout=1
# time = 120, a = 0, b = 1, cin = 1, less = 1, op= 0, res=0, cout=1
# time = 140, a = 1, b = 0, cin = 0, less = 0, op= 0, res=0, cout=0
# time = 160, a = 1, b = 0, cin = 0, less = 1, op= 0, res=0, cout=0
# time = 180, a = 1, b = 0, cin = 1, less = 0, op= 0, res=0, cout=1
# time = 200, a = 1, b = 0, cin = 1, less = 1, op= 0, res=0, cout=1
# time = 220, a = 1, b = 1, cin = 0, less = 0, op= 0, res=1, cout=1
# time = 240, a = 1, b = 1, cin = 0, less = 1, op= 0, res=1, cout=1
# time = 260, a = 1, b = 1, cin = 1, less = 0, op= 0, res=1, cout=1
# time = 280, a = 1, b = 1, cin = 1, less = 1, op= 0, res=1, cout=1
# time = 300, a = 0, b = 0, cin = 0, less = 0, op= 0, res=0, cout=0
```

4) alu_1_msb(in: a, b, cin, less, [2:0]op)(out: res, cout, set):

This 1 bit msb alu module has 3 xor_, 1 mux_4_1 modules with 3 or, 4 and, 2 and gates. Total: 31 gates. This module has not any testbench modules.

5) alu_32_msb(in: [31:0]a, [31:0]b, [2:0]op)(out: [31:0]res, cout, z) and alu_32_msb_tb:

This 32 bit msb alu module has 31 alu_1, 1 alu_1_msb modules with 11 or, 1 not gates. Total: 694 gates.

```
# time =   0, a = 11101101101000001010001010101101, b = 11010110011111101101111101111110, op = 000,
          res = 11000100001000001000001000101100, cout = 1, z = 0
# time =  20, a = 11101101101000001010001010101101, b = 11010110011111101101111101111110, op = 001,
          res = 11111111111111101111111111111111, cout = 1, z = 0
# time =  40, a = 11101101101000001010001010101101, b = 11010110011111101101111101111110, op = 010,
          res = 11000100000111111000001000101011, cout = 1, z = 0
# time =  60, a = 11101101101000001010001010101101, b = 11010110011111101101111101111110, op = 110,
          res = 00010111001000011100001100101111, cout = 1, z = 0
# time =  80, a = 11101101101000001010001010101101, b = 11010110011111101101111101111110, op = 111,
          res = 00000000000000000000000000000000, cout = 1, z = 1
# time = 100, a = 00000010111001000001111010101011, b = 11010011101111001101000010101001, op = 000,
          res = 00000010101001000001000010101001, cout = 0, z = 0
# time = 120, a = 00000010111001000001111010101011, b = 11010011101111001101000010101001, op = 001,
          res = 11010011111111001101111010101011, cout = 0, z = 0
# time = 140, a = 00000010111001000001111010101011, b = 11010011101111001101000010101001, op = 010,
          res = 11010110101000001110111010101100, cout = 0, z = 0
# time = 160, a = 00000010111001000001111010101011, b = 11010011101111001101000010101001, op = 110,
          res = 00101111001001110100111000000010, cout = 0, z = 0
# time = 180, a = 00000010111001000001111010101011, b = 11010011101111001101000010101001, op = 111,
          res = 00000000000000000000000000000000, cout = 0, z = 1
# time = 200, a = 11100110111010000000110011010010, b = 00010001001011101010010011100101, op = 000,
          res = 00000000001010000000010011000000, cout = 0, z = 0
# time = 220, a = 11100110111010000000110011010010, b = 00010001001011101010010011100101, op = 001,
          res = 11110111111011101010110011110111, cout = 0, z = 0
# time = 240, a = 11100110111010000000110011010010, b = 00010001001011101010010011100101, op = 010,
          res = 11111000000101101011000110110111, cout = 0, z = 0
# time = 260, a = 11100110111010000000110011010010, b = 00010001001011101010010011100101, op = 110,
          res = 11010101101110010110011111101101, cout = 1, z = 0
# time = 280, a = 11100110111010000000110011010010, b = 00010001001011101010010011100101, op = 111,
          res = 00000000000000000000000000000001, cout = 1, z = 0
# time = 300, a = 10100100111011001100111001111101, b = 00111001010111010100110101001100, op = 000,
          res = 00100000010011000100110001001100, cout = 0, z = 0
# time = 320, a = 10100100111011001100111001111101, b = 00111001010111010100110101001100, op = 001,
          res = 10111101111111011100111101111101, cout = 0, z = 0
# time = 340, a = 10100100111011001100111001111101, b = 00111001010111010100110101001100, op = 010,
          res = 11011110010010100001101111001001, cout = 0, z = 0
# time = 360, a = 10100100111011001100111001111101, b = 00111001010111010100110101001100, op = 110,
          res = 01101011100011111000000100110001, cout = 1, z = 0
# time = 380, a = 10100100111011001100111001111101, b = 00111001010111010100110101001100, op = 111,
          res = 00000000000000000000000000000001, cout = 1, z = 0
```