ECEN 2350 Spring 2017 Homework 4
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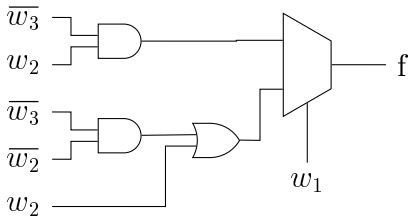
1. *Book Problems: 4.3, 4.21*

(4.3) *Consider* $f = \overline{w_1}\,\overline{w_3} + w_2\overline{w_3} + \overline{w_1}w_2$. *Use the truth table to derive a circuit for* f *that uses a 2-to-1 multiplexer.*
Note that the truth table for the above can be found as:

w_1	w_2	w_3	f
0	0	0	1
0	0	1	0
0	1	0	1
0	1	1	1
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	0

Which is equvilent to the below circuit, using w_1 as the select in a muliplexer.



(4.21) *Write Verilog code for an 8-to-3 binary encoder.*

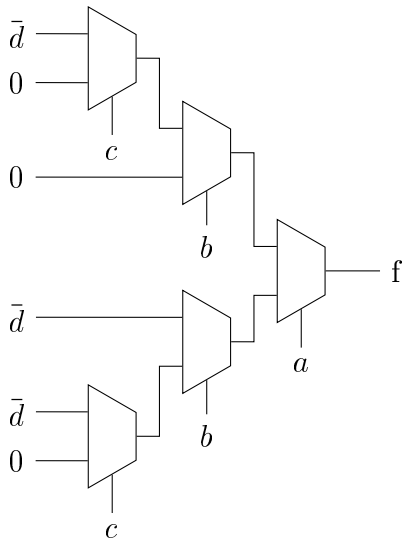
```
module Encode (b, f);
    input [7:0] b;
    output reg [2:0] f;
    always@(*)
    begin
                    case(b)
                    8'b00000001: f = 3'b000;
                    8'b00000010: f = 3'b001;
                    8'b00000100: f = 3'b010;
                    8'b00001000: f = 3'b011;
                    8'b00010000: f = 3'b100;
                    8'b00100000: f = 3'b101;
                    8'b01000000: f = 3'b110;
                    8'b10000000: f = 3'b111;
                    endcase
    end
endmodule
```

2. *Implement the following circuits using only 2-to-1 mulitplexers.*

(a) $f = \sum m(2, 5, 6, 14)$

Note that the truth table, and circuit visually derived from it, are as shown below:

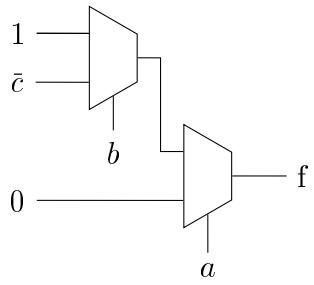
a	b	c	d	f
0	0	0	0	0
0	0	0	1	0
0	0	1	0	1
0	0	1	1	0
0	1	0	0	1
0	1	0	1	0
0	1	1	0	1
0	1	1	1	0
1	0	0	0	0
1	0	0	1	0
1	0	1	0	0
1	0	1	1	0
1	1	0	0	0
1	1	0	1	0
1	1	1	0	1
1	1	1	1	0



(b) $f = \prod M(3, 4, 5, 6, 7)$

Note that the truth table, and circuit derived from it, are as shown below:

a	b	c	f
0	0	0	1
0	0	1	1
0	1	0	1
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	0
1	1	1	0



3. *Convert the following decimal numbers to 32-bit floating point format.*

   (a) *33554430*

First, note that $(\frac{33554430}{2^{24}})_{10} = 1.99...$ and that

$$\begin{aligned} 33554430 &= 2^{24} + 2^{23} + 2^{22} + ... + 2^3 + 2^2 \\ &= (11111111111111111111110)_2 \\ &= (1.11111111111111111111111)_2 * 2^{24} \end{aligned}$$

Which implies that $Expontent = 24 \implies E = 24 - 127 = 151 = (10010111)_2$ for the floating point form below.

$$S, E, E, E, E, E, E, E, E, 23bitsM$$
$$(0\ 10010111\ 11111111111111111111111)_2$$

   (b) *33554431*

First, note that $(\frac{33554431}{2^{24}})_{10} = 1.99...$ and that

$$\begin{aligned} 33554430 &= 2^{24} + 2^{23} + 2^{22} + ... + 2^3 + 2^2 + 2^1 \\ &= (11111111111111111111111)_2 \\ &= (1.11111111111111111111111)_2 * 2^{24} \end{aligned}$$

Which implies that $Expontent = 24 \implies E = 24 - 127 = 151 = (10010111)_2$ for the floating point form below.

$$S, E, E, E, E, E, E, E, E, 23bitsM$$
$$(0\ 10010111\ 11111111111111111111111)_2$$

However, there needs to be 24 bits in the Mantissa to accurately represent 33554431. Therefor, there is no way to accuratly represent the given number without double precision or rounding.

4. *Convert the following decimal numbers to fixed point unsigned binary with at least 8-bits of binary precision*

   (a) *12.45897*
   Note that $(12)_{10} = (1100)_2$, and $(.45897)_{10} \approx \frac{1}{4} + \frac{1}{8} + \frac{1}{16} = (.0111)_2$, which implies that $(12.45897)_{10} \approx \boxed{(1100.0111)_2}$

   (b) *0.333333*
   Note that $.333333 \approx \frac{1}{4} + \frac{1}{16} + \frac{1}{64} + \frac{1}{256} = \boxed{(.01010101)_2}$

5. *For 32-bit Precision Floating point numbers,* `E=0x00` *and* `E=0xFF` *are used for special numbers (like* 0 *and* ∞*). What are the decimal values of the floating point numbers (32-bit) of smallest (non-zero) and largest (non-infinity) magnitude*

   The smallest number would have `E=0x1` and `M=0x1`, which results in a number of value $(1 + 2^{-24}) * 2^{1-127} \approx \boxed{1.1754945 * 10^{-38}}$

   Similarly, the largest number would have `E=0xFE` and `M=b111...111`, which results in $(1 + 2^{-2} + 2^{-4} + .. + 2^{-24}) * 2^{127} \approx \boxed{3.4028235 * 10^{38}}$