ECE2277A Lab 3: Multiplexers

Laboratory Report

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Submission Date: 2020-11-17

Boolean Function

Please write your canonical Boolean function here as a sum of minterms (m_p+m_q, etc.) for reference:

$$f(a,b,c,d) = m_0 + m_1 + m_2 + m_4 + m_{10} + m_{12} + m_{13} + m_{14}$$

The truth table for this function is:

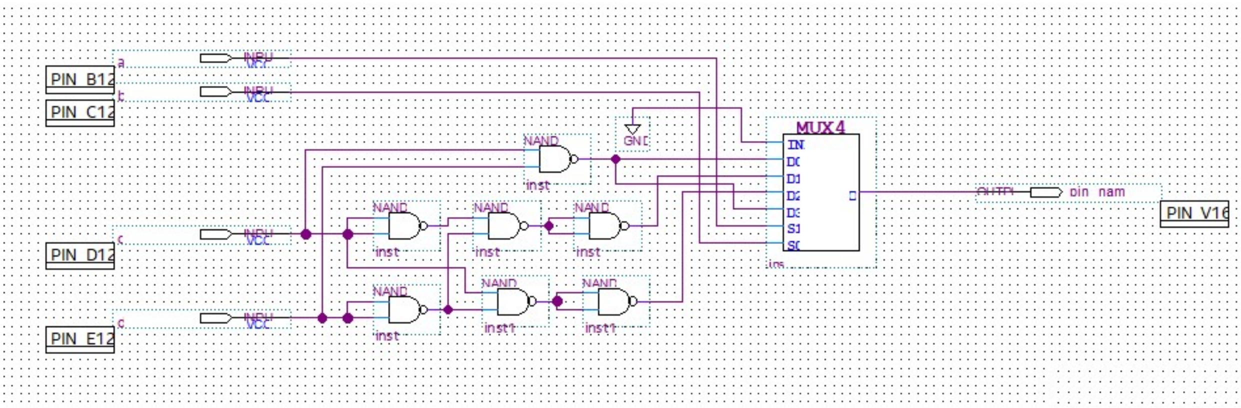
abcd	***f(a,b,c,d)***
0000	1
0001	1
0010	1
0011	0
0100	1
0101	0
0110	0
0111	0
1000	0
1001	0
1010	1
1011	0
1100	1
1101	1
1110	1
1111	0

Multiplexer Enable

The 4×1 multiplexer in Quartus is enabled by connecting `INH` to [v_{CC}/***ground***]. This is *active* [*high*/***low***] enable.

Multiplexer Circuit

Include an image of the circuit from Quartus. Add extra space if necessary.



The NAND logic function for the multiplexer inputs is:

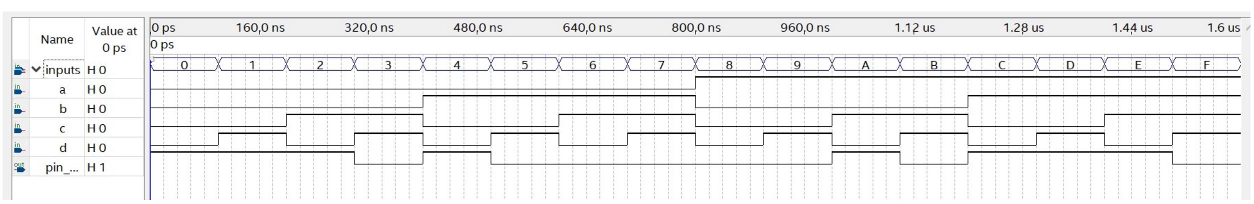
$D_0(c,d)$ = NAND(C,D)

$D_1(c,d)$ = NAND(NAND(NAND(C,C), NAND(D,D)), NAND(NAND(C,C), NAND(D,D)))

$D_2(c,d)$ = NAND(NAND(C, NAND(D,D)), NAND(C, NAND(D,D)))

$D_3(c,d)$ = NAND(C,D)

Include an image of the simulated waveforms demonstrating the correct output of the circuit. Add extra space if necessary.



Design Questions

Compare the present multiplexer circuit to your previous AND-OR-NOT circuits for the same Boolean function and answer the questions below. One or two sentences is sufficient. Add extra space if necessary.

1. **Which circuit has the lowest cost (check the gate-based implementation of the multiplexer)? Justify your answer.**

The circuit cost of the minimized standard product-of-sums was **20**, while the cost of the new implementation using multiplexers was **46**, which is more. This means that minimized standard product of sums has the lowest circuit cost. It is cheaper because it has a lower cost and simpler expressions.

2. **Which circuit has the shortest total propagation time?**

The total propagation time of the minimized standard product-of-sums was **3**, while the propagation time of the new implementation using multiplexers was **5**, which is more. This means that minimized standard product of sums has the lowest propagation time.

3. **Finally, we designed the multiplexer circuit using *a* and *b* as control variables and *c* and *d* as data variables, but really this is an arbitrary choice. Can the cost of your multiplexer circuit be reduced if this is changed (for example, use *a*, *d* for control and *b*, *c* for data)?**

There could be a scenario where a combination of cd would produce simpler circuits, in turn causing a lower circuit cost.

When calculating it for a, d being control and b,c being data – the first input equation (D0) changed to the following:

NAND(B,B) + NAND(B,C)

This shows that the circuit cost can be changed with a change in the control/data variable assignments, so finding the right one will help in optimizing it.