The University of Texas at Dallas
Department of Computer Science
CS 4141: Digital Systems Lab

Experiment #2 – Familiarization with Multiplexers & Decoders; Construction of Circuits to Represent Given Boolean Expressions

CS 4141 Laboratory 2, PRE-LAB 2

Objective
Become familiar with the behavior of *combinational logic components*. Combinational logic components are larger integrated circuits created from the logic gates. Gates such as AND, OR, and NOT can be turned into devices such as Multiplexers, which allow the circuity to have a different result based on the input.

Turn-In Checklist

Make certain that your name, your lab section, the date, and “Pre-Lab 2” is at the top of your paper.

- Problem 1. Understanding the Multiplexer
- Problem 2. Understanding the Decoder
- Problem 3. Using a Multiplexer to represent a Boolean equation, truth table and diagram
- Problem 4. Using a Decoder to represent a Boolean Equation, truth table and diagram

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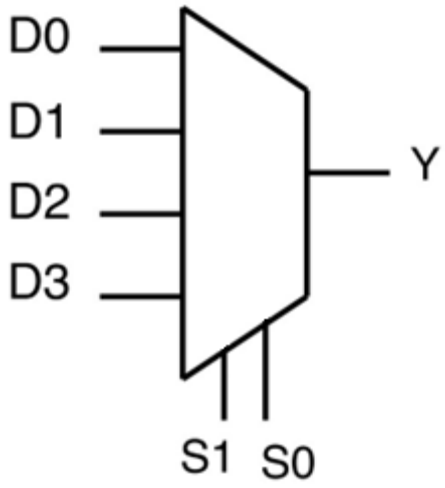
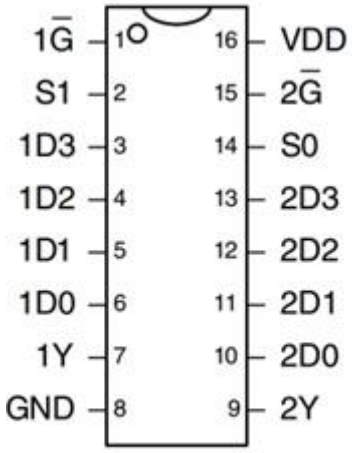
Problem 1. Understanding the Multiplexer (5 points)

Below on the left is the logic symbol for a 4:1 Multiplexer (MUX). You can copy this symbol to make logic diagram later in the post-lab report. On the right is the 4:1 MUX IC Pinout (same diagram is on second page of *ic_diagrams.pdf*).



Multiplexer Symbol for Logic Diagram



74153 4 :1 Mux

IC Pinout

Two 4:1 Multiplexers

$D_{3:0}$:	data
$S_{1:0}$:	select
Y:	output
Gb:	enable

Legend for IC Pinout

1.1 How many select bits are used for the 4:1 Mux?

1.2 Which select bit is the most significant bit?

1.3 Suppose S1 = 1, S0 = 0 and 1G = 0, then which signal will be assigned to output 1Y?

1.4 Now we still have S1 = 1, S0 = 0 but 1G = 1, then what will 1Y be?

1.5 Notice that we also have another set of inputs 2D and output 2Y. Explain how 2Y is related to 2D in one or two sentences.

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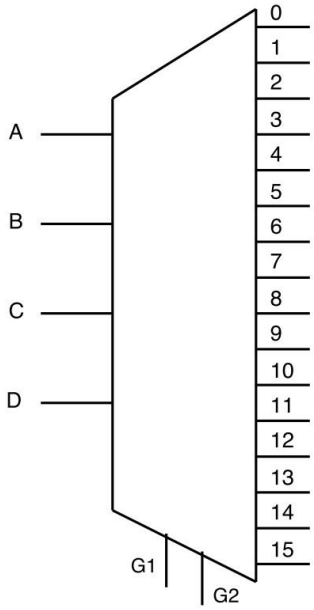
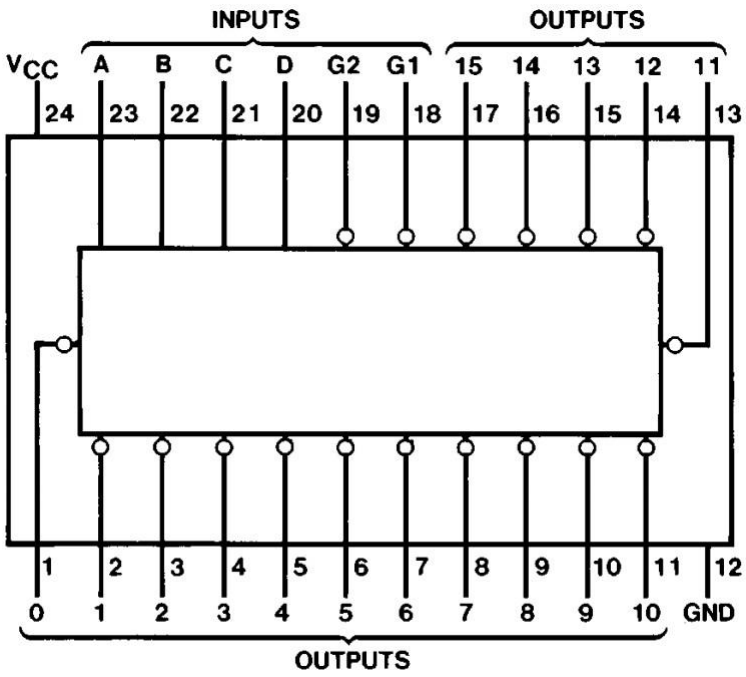
Problem 2. Understanding the Decoder (5 points)

Below on the left is the logic symbol for a 4:16 Decoder, on the right is the circuit diagram (taken from DECODER_75154.pdf)



Decoder Symbol
for Logic Diagram



IC Pinout

In ***DECODER_75154.pdf***, on the second page you will see a Function Table for the decoder IC. Note that H = High Level or logic value 1, L = Low Level or logic value 0, X = don't care.

Answer the following questions:

2.1 Given G1 and G2 are two enable pins. For the decoder to function, which logic value should we assign to G1 and G2?

2.2 In a decoder, basically we select one output (among all outputs) based on the inputs. Suppose we set the enable pins correctly, and we set A = 0, B = 1, C = 0, D = 1, which output is chosen?

2.3 The chosen output is high or low based on the IC pinout?

2.4 Given that the output number indicates the decimal value of the inputs, which input (A or B or C or D) should be considered the most significant bit?

2.5 Given that the output number indicates the decimal value of the inputs, which input (A or B or C or D) should be least significant bit?

Problem 3. Using a Multiplexer to represent a Boolean equation (5 points)

Note: Multiplication represents an AND gate. Addition represents an OR gate, and an apostrophe represents a negation. Exclusive Disjunction (⊕) represents an XOR gate.

Implement the following Boolean function using 4:1 Multiplexer.

$$Y_1=A'B'C'+A'BC+AB'C$$

Hint: http://www.asic-world.com/digital/combo6.html

Show ***the truth table*** for the equation Y_1, and then ***draw the logic diagram*** using an 4:1 Multiplexer. **A logical diagram should contain block notations (such as Full Adder, D Flip-Flop, Decoder, Multiplexer) and gate symbols (such as AND, OR, and NOT).**

Problem 4. Using a Decoder to represent a Boolean Equation (5 points)

For the following design problem, make a ***truth table that describes the problem***, then and ***draw a logic diagram of the circuit*** (you can draw the diagram by hand). The circuit should use a 4:16 Decoder with negated outputs (low) and any other logic gates: NOT, AND, OR, NAND, NOR, XOR. The logic gates in this design may have multibit inputs. **A logical diagram should contain block notations (such as Full Adder, D Flip-Flop, Decoder, Multiplexer) and gate symbols (such as AND, OR, and NOT).**

Hint 1: Which logic gate can we use to combine different outputs of the decoder into a single output?
Hint 2: Remember the logic value of an output of the decoder when it is "activated" (or "chosen"). Check the answer from Problem 2.

SOLVE: Design a logic circuit that will output HIGH when the input is an odd number less than 8, and an even number greater than or equal to 8, and all inputs are smaller than 16. The input should be a 4-bit binary number. Design the circuit using a 4:16 decoder and other gates.