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

1. Introduction: In the previous laboratory exercises, we became familiar with logic gates which represented the Boolean functions: AND, OR, NOT, NAND, NOR, XOR. In this laboratory session we will become familiar with other logic gates which can be helpful in solving various problems in industry more efficiently, we will use them and solve the same Boolean expressions that we solved using the other gates.

2. Goal of this exercise: The purpose of this lab is to familiarize students with the functionality of the MUX and DECODER all which are more useful in digital design than the original Boolean functions. We will also use these logic gates in some actual circuits.

3. Theory of experiment: The Combinational Building Blocks MUX and DECODER have been discussed in class. The basic definitions are:

- **MUX:** The output is the selection of a given input based on the selection lines used.
- **DECODER:** It is the opposite of the MUX. It outputs a single line based on its input combination.

4. Experimental Equipment List: The following experimental components are required for this experimental procedure:
- **IDL-800 Digital Lab. Circuits Evaluator ("breadboard" unit with test equipment and power supply built in)**

- **IDL-800 User Manual**
- **SN 74LS04 hex inverter (NOT) gate (digital logic kit)**
- **SN 74LS00 and SN74LS08 quad 2-input NAND and AND gates (digital logic kit)**
- **SN 74LS02 and SN 74LS32 quad 2-input NOR and OR gates (digital logic kit)**

- **SN 74LS86 XOR gate (digital logic kit)**
- **SN 74LS153 4:1 MUX gate (digital logic kit)**
- **SN 74LS154 4:16 DECODER gate (digital logic kit)**
- **Breadboard wire connection kit**
- **Pin assignment diagrams for circuits noted above**

5. Pre-Work: Prior to the laboratory period, study class notes and prepare a truth table for each of the two combinational blocks to be studied (4:1 MUX & 4:16 DECODER). Bring these truth tables to the laboratory.

6. Experimental Procedure:

Equipment Re-Familiarization
1) Take a moment to re-familiarize yourself with the IDL-800 chassis (refer to the manual at any time if additional information is needed). By now, you should be relatively familiar with its features and with the basic functions that you will be using today.

2) Making sure that the master power to the unit is off, connect +5V and 0V to the power busses at the top of the prototype chassis. You will make all +5V and 0 (ground) connections to these busses.

• **Y = (B • C) + [(~ A) • (~B) • (~C)] + [B • (~C)]. You should minimize it and then implement**

• **Exercise 2.27:** An M-bit thermometer code for the number k consists of k 1's in the least significant bit positions and M- k 0's in all the more significant bit positions. For the experiment, a binary-to-thermometer code converter has 3 inputs and 7 outputs. It produces a 7 bit thermometer code for the number specified by the input. For example, if the input is 110, the output should be 0111111. Design a 3:7 binary-to-thermometer code converter. Give a simplified Boolean equation for each output, and sketch a schematic.

• **Question 2.2:** Design a circuit that will tell whether a given month has 31 days in it. The month is specified by a 4-bit input, A3:0. For example, if the inputs are 0001, the month is January, and if the inputs are 1100, the month is December. The circuit output, Y, should be HIGH only when the month specified by the inputs has 31 days in it. Write the simplified equation, and draw the circuit diagram using a minimum number of gates. (Hint: Remember to take advantage of don't care.)

This part will have 3 truth-tables, 3 logic diagrams, 3 circuit diagrams.

2) Understand the functionality of MUX and DECODER.
3) Solve the following questions using MUX

• **Y = (B • C) + [(~ A) • (~B) • (~C)] + [B • (~C)]**

• Question 2.2 – question involving finding months with 31 days (as in part 1).

This part would have just the 2 circuit diagrams. Truth-tables are the same as above and logic and circuit diagrams will be the same.

4) Solve the following questions using DECODER

• Y = [(~A) • (~B) • (~C)] + [A • (~B) • C] + [A • (~B)] using DECODER and other gates.

• Y = (A • B • C) + [A • B • (~C)] using DECODER and other gates.

• Exercise 2.27 – question involving thermometer code (as in part 1) using DECODER and other gates.

This part would have 2 truth-tables, 2 circuit diagrams. Logic and circuit diagrams will be the same.
5) Show how to build a 4:16 decoder, using only 2:4 decoders (no other gates). Just draw the construction.

7. Equipment Disassembly: The experimental procedure is complete. Please disassemble the circuit wiring, replace in the wiring kit box and replace it as you found it in the cabinet. Turn in the logic circuit kit to the TA. Make sure that your work area is clean.

8. Laboratory Report: As before, your laboratory report should follow the form given. In your write-up, discuss the operation of the circuits and the verification of the function of each. Also complete the following:

• **Draw the pin diagrams of the ICs used – MUX, DECODER**

• **Draw the circuit diagram, truth table, and logic diagram for all the questions as required and mentioned in this file as well as for the questions announced in Lab or posted online (if any).**

• **Add minimization steps used (k-map or any other method) in the report.**

• **Discuss your experience in the laboratory and any problems with the procedure.**

• **Discuss any insights gained from the exercises.**

Grading Criteria:

	Points
Y = (B • C) + [(~ A) • (~B) • (~C)] + [B • (~C)]	20
2.27 using gates	20
2.2 using gates	20
Y = (B • C) + [(~ A) • (~B) • (~C)] + [B • (~C)] using mux	10
2.2 using mux	10
Y = [(~A) • (~B) • (~C)] + [A • (~B) • C] + [A • (~B)] using decoder	20
Y = (A • B • C) + [A • B • (~C)] using decoder	20
2.27 using decoder	10
4:16 decoder using 2:4 decoder	20