VIU VANCOUVER ISLAND UNIVERSITY

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CSCI 355
Fall Term
Digital Logic and Computer Organization

Lab #2
Combinational Logic

Date Due: Saturday, September 28, 11:59 pm **Total Marks: 32**

General Instructions

- **This lab assignment is individual work. You may discuss questions and problems with anyone, but the work you hand in for this assignment must be your own work. Put your name, student number and instructor's name on the cover page of your report. Failure to follow these conventions will result in a deduction of grades for you. Do not submit folders, zip documents, even if you think it will help.**
- **Assignments must be submitted to VIULearn.**
- **VIULearn will not let you submit work after the assignment deadline. It is advisable to hand in each answer that you are happy with as you go. You can always revise and resubmit as many times as you like before the deadline; only your most recent submission will be graded.**
- **Partial credit will be given as appropriate, so hand in all attempts.**

1. Objectives

i. Construct NAND equivalent for Sum-of-Products
ii. Construct NOR equivalent for Product-of-Sums
iii. Familiarization with Exclusive OR (XOR) gate
iv. Construct XOR using NAND only logics/ NOR only logics

2. Health and Safety

This section tries to highlight the health and safety concern while conducting lab activities. Any laboratory environment may contain conditions that are potentially hazardous to a person's health if not handled appropriately. The Department of Computer Science laboratory Bld:315/115 obviously has electrical potentials that may be lethal and must be treated with respect. One of our objectives is to educate all laboratory users to be able to handle laboratory materials and situations safely and thereby ensure a safe and healthy experience for all. Watch for posted information in and around the laboratories, and on the class website.
https://adm.viu.ca/sites/default/files/viu_safety_design_for_facilities_standard_draft.pdf

3. Background

3.1 NOR/AND Equivalence

Using DeMorgan's theorem $\overline{x_1 + x_2} = \overline{x_1} \cdot \overline{x_2}$, the equivalence between NORs and ANDs can be seen:

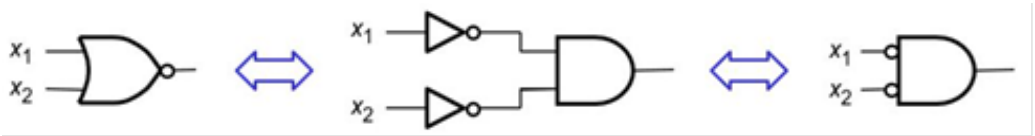


Figure 3-1: NOR/AND Equivalence

3.2 NAND/OR Equivalence

Using DeMorgan's theorem $\overline{x_1 \cdot x_2} = \overline{x_1} + \overline{x_2}$, the equivalence between NANDs and ORs can be seen:

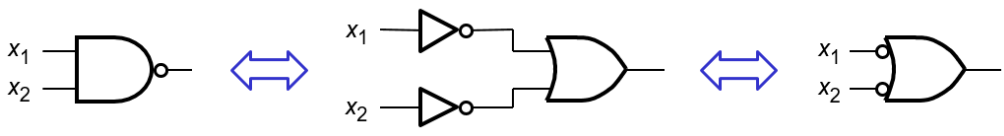
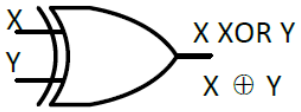


Figure 3-2: NAND/OR Equivalence

3.3 XOR Gate

One function that is quite useful, and while not a fundamental gate (as can be constructed using inverters, ANDs, and ORs), is called the Exclusive-OR (or XOR for short). The XOR gate has two inputs and a single output with the output being true when only ONE input is true. The symbol and truth table for an XOR gate are shown in Figure 3-3.



X	Y	X XOR Y
0	0	0
0	1	1
1	0	1
1	1	0

Figure 3-3: XOR Gate

4. Pre-Lab

4.1 NAND Equivalent for Sum-of-Products

4

Consider the Sums-of-Products circuit shown in Figure 4-1.
Determine the truth table for this circuit (Only include columns for 3 inputs and 1 output).
Determine an equivalent circuit (schematic diagram) which only uses NAND gates (can be done with four NAND gates). Your hand-drawn figure must be clear and legible.

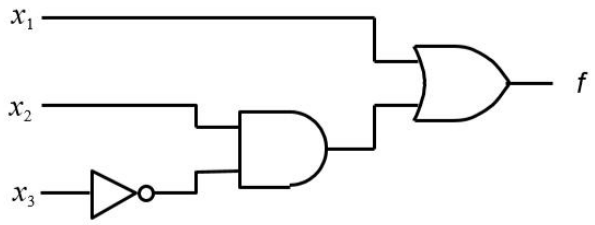


Figure 4-1: Sum-of-Products Circuit

4.2 NOR Equivalent of Product-of-Sums

4

Consider the Products-of-Sums circuit shown in Figure 4-2.
Determine the truth table for the circuit (Only include columns for 3 inputs and 1 output).
Determine an equivalent circuit that only uses NOR gates (can be done with four NOR gates).
Your hand-drawn figure must be clear and legible.

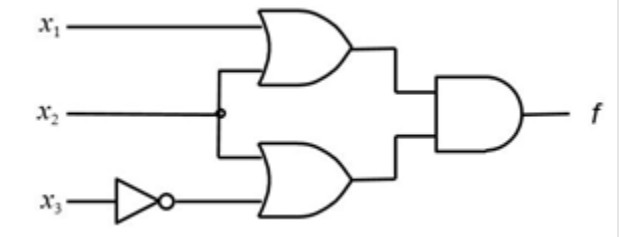


Figure 4-2: Product-of-Sums Circuit

4.3 A 4-input XOR using 2-input XOR Gates

6 Draw the schematic diagram for the circuit (can be done with three 2-input XOR gates) and determine the truth table for the circuit with 16 different input combinations.

x1	x2	x3	x4	f	ODD or Even Number of 1's

In your report, explain how you could tell if the number of logic 1 inputs was odd or even, without knowing exactly how many of the inputs were logic 1 and how many were logic 0.

4.4 XOR Gate using only NAND logic and only NOR logics

4 Construct XOR gate using NAND logics only. Draw the schematic diagram of your circuit (can be done with four NAND gates).

Construct XOR gate using NOR logics only. Draw the schematic diagram of your circuit (can be done with five NOR gates).

5. Equipment Required

Power supply, 1 x 7400 Quad 2-Input NAND Gate, 2 x 7402 Quad 2-Input NOR Gate, 1 X 7486 Quad 2-input XOR, Breadboard, Digital Circuit Evaluator, Wiring Kit

6. Debugging (or What to Try When Things Aren't Working)

There are several things/procedures you should use to debugging circuits when things are not working correctly. These include (but are not limited to):

- Draw a copy of the circuit on paper and label all PINs to aid in debugging.
- Check that all component pins are correctly inserted in the breadboard (sometimes they get bent underneath a component).
- Make sure that components are not "misaligned" in the breadboard (e.g., off by one row).

- Try a different section in the breadboard (in case there is a bad internal connection).
- Measure the source voltages to verify power input.
- Measure key points in the circuit for proper voltage/waveform (i.e., divide-and-conquer).
- Make sure the power and input signals are turned on.

7. Lab Procedure

7.1 NAND Equivalent for Sum-of-Products

3

i. Construct the NAND-only version of the Sum-of-Products circuit developed in Prelab 4.1.
ii. You should include a picture of your breadboard with the completed circuit in your lab report.
iii. Fill in the appropriate Truth Table and comment if the circuit is working as expected.

7.2 NOR Equivalent of Product-of-Sums

3

i. Construct the NOR-only version of the Products-of-Sums circuit developed in Prelab 4.2.
ii. You should include a picture of your breadboard with the completed circuit in your lab report.
iii. Fill in the appropriate Truth Table and comment if the circuit is working as expected.

7.3 XOR using NAND logics only

3

i. Construct the NAND-only version of the XOR equivalent circuit developed in Prelab 4.4.
ii. You should include a picture of your breadboard with the completed circuit in your lab report.
iii. Fill in the appropriate Truth Table and comment if the circuit is working as expected.

7.4 XOR using NOR logics only

3

i. Construct the NOR-only version of the XOR equivalent circuit developed in Prelab 4.4.
ii. You should include a picture of your breadboard with the completed circuit in your lab report.
iii. Fill in the appropriate Truth Table and comment if the circuit is working as expected.

Note: No need to include pin-out sheets for this lab. I want you to include the PINs on the schematic diagrams rather.
Provide the functional diagram/pinning information of ICs in the Appendix.