

EXPERIMENT # 5: Universal Capability of NAND and NOR Gates

Name: _____ **Date:** _____

Equipment/Parts Needed:

Digital Trainer (Logic Probe)
Breadboard
7400 NAND gate
7402 NOR gate
7404 Inverter
7408 AND gate
7432 OR gate

Objective:

- The universality of the NAND and NOR gates means that they can be used as an inverter and the combinations of NAND/NOR gates can be used to implement the AND, OR, and all other logic operations.
- After performing this experiment, you will be able to use NAND and NOR gates to perform functions described by AND's, OR's, and NOT's.

Discussion:

- The NAND gate is a universal gate because it can be used to produce the NOT operation, the AND operation, the OR operation, and the NOR operation. An inverter can be made from a NAND gate by connecting all of the inputs together and creating, a single input as shown below.

1.

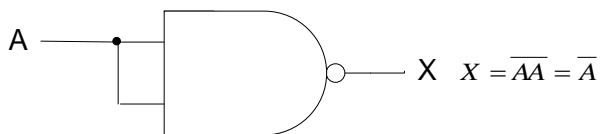


Figure 5-1 An inverter operation generated by the use of NAND gate

2.

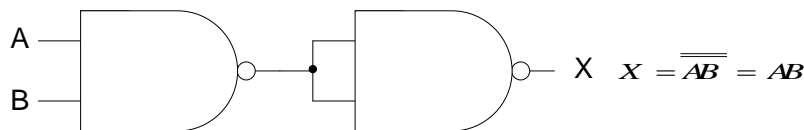


Figure 5-2 An AND operation generated by the use of two NAND gates

EMT1250 LABORATORY EXPERIMENT

3.

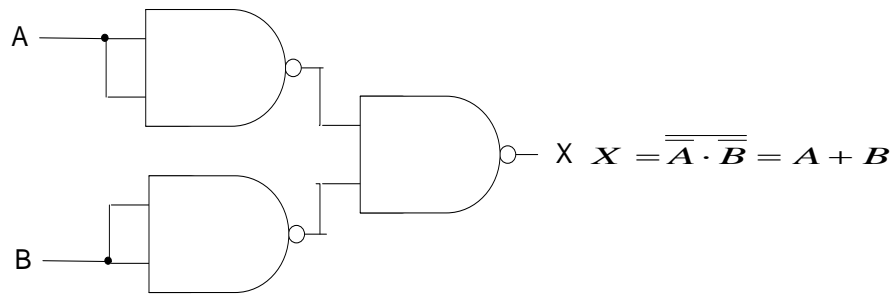


Figure 5-3 An OR operation generated by the use of three NAND gates

- A **Truth Table** defines how a combination of gates will react to all possible input combinations.
- A **Logic Probe** is a piece of test equipment which displays the logic level at a point in the circuit. 0 to 0.8V = Logic 0 and lights the **L** indicator. 2.0V to 5.0V = Logic 1 and lights the **H** indicator. Invalid logic voltage levels light neither indicator.

Part 1:

1) Find the Boolean equation for the logic circuit shown in Figure 5-4.

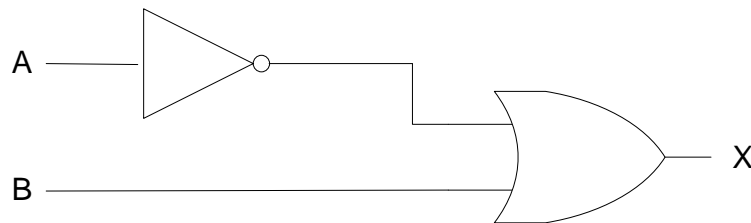


Figure 5-4 Logic Circuit for part 1.

EMT1250 LABORATORY EXPERIMENT

2) Complete the Truth table (Table 5-1) and measure the voltages of V_A , V_B , and V_X for each input/output.

Voltages measured		Truth Table			Output
V_A (V)	V_B (V)	A	B	X	V_X (V)
		0	0		
		0	1		
		1	0		
		1	1		

Table 5-1 Truth table and volts measured for input/output for Figure 5-4

3) Reconstruct the circuit above using only NAND gates. Include Boolean algebra, truth tables, and logic diagrams for the circuit reconstructed with only NAND gates.

3-1) Boolean algebra expression

3-2) Draw the reconstructed circuit and logic diagram here (only NAND gates)

EMT1250 LABORATORY EXPERIMENT

3-3) Built the truth table for the reconstructed circuit and measured the voltage for each input/output

Voltages measured		Truth Table			Output
V_A (V)	V_B (V)	A	B	X	V_X (V)
		0	0		
		0	1		
		1	0		
		1	1		

Table 5-2 Truth table and volts measured for input/output for the reconstructed circuit

Instructor's Signature: _____, Date: _____

Part 2:

1) Find the Boolean equation for the logic circuit shown in Figure 5-5.

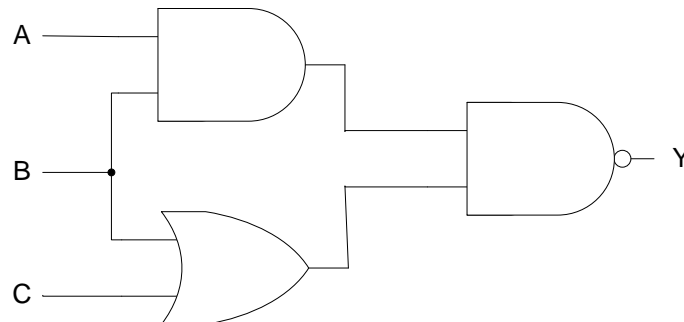


Figure 5-5 Logic Circuit for part 2.

EMT1250 LABORATORY EXPERIMENT

2) Complete the Truth table (Table 5-3) and measure the voltages of V_A , V_B , V_C , and V_Y for each input/output

Voltages measured			Truth Table				Output
V_A (V)	V_B (V)	V_C (V)	A	B	C	Y	V_Y (V)
			0	0	0		
			0	0	1		
			0	1	0		
			0	1	1		
			1	0	0		
			1	0	1		
			1	1	0		
			1	1	1		

Table 5-3 Truth table and volts measured for input/output for Figure 5-5.

3) Then reconstruct the circuit above using only NOR gates. Include Boolean algebra, truth tables, and logic diagrams for the circuit reconstructed with only NOR gates.

3-1) Boolean algebra expression

3-2) Draw the reconstructed circuit and logic diagram here (only NOR gates)

EMT1250 LABORATORY EXPERIMENT

3-3) Built the truth table for the reconstructed circuit and measured the voltage for each input/output

Voltages measured			Truth Table				Output
V _A (V)	V _B (V)	V _C (V)	A	B	C	Y	V _Y (V)
			0	0	0		
			0	0	1		
			0	1	0		
			0	1	1		
			1	0	0		
			1	0	1		
			1	1	0		
			1	1	1		

Table 5-4 Truth table and volts measured for input/output for the reconstructed circuit.

Instructor's Signature: _____, Date: _____

Questions/Report:

1. Why are NAND gates and NOR gates sometimes referred to as *universal gates*?
2. Why would a designer want to form an AND gate from two NAND gates?
3. Using only four NAND gates, draw the logic circuit for NOR gate.
4. How many inverters could be formed using a 7400 NAND IC?