Fall 2018

California State University, Northridge
Department of Electrical & Computer Engineering

Experiment 7
Boolean Laws and DeMorgan's Theorems

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ECE 320L
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Introduction:

The objective of this experiment is to properly build and analyze the inputs and outputs of logical gates to understand the underlying theory of Demorgan's laws and boolean algebra. The experiment covers the utilization of OR, AND, and NOT gates.

Equipment used:

Type	Model	Serial No.	Calibration Date
Oscilloscope	Tektronix 2213A	N/A	N/A
Digital Multimeter	Tektronix CDM250	N/A	N/A
Function Generator	Agilent 33220A	N/A	N/A
Proto Board	Tektronix	N/A	N/A

Parts Used:

QTY	Component	Value	Tolerance	Type
3	Capacitor	0.1 μF	+/- 5%	Carbon
1	Quad 2-input OR Gate	N/A	N/A	N/A
1	Quad 2-input NAND Gate	N/A	N/A	N/A
1	Hex Inverter	N/A	N/A	N/A
1	LED	N/A	N/A	N/A

Software Used:

1. Google Docs
2. Krita
3. Snipping Tool

Theory:

Binary variables can have only a value of 1 or 0

An Overbar is considered to be the “Not or Complement”

The logical addition “+" is read as “OR”

The Logical Multiplication “•” is read as “AND”

Basic rules of Boolean algebra.

1. $A + 0 = A$
2. $A + 1 = 1$
3. $A \cdot 0 = 0$
4. $A \cdot 1 = A$
5. $A + A = A$
6. $A + \overline{A} = 1$
7. $A \cdot A = A$
8. $A \cdot \overline{A} = 0$
9. $\overline{\overline{A}} = A$
10. $A + AB = A$
11. $A + \overline{A}B = A + B$
12. $(A + B)(A + C) = A + BC$

(Table of Basic Rules)

Demorgan’s theorems are used to simplify logical expressions that contain a complement of a formula.

The complement of a two variables operated under AND is equivalent to the the complement of each variable operated under OR.

$$\overline{X \cdot Y} = \overline{X} + \overline{Y}$$

Likewise, the complement of a two variables operated under OR is equivalent to the the complement of each variable operated under AND.

$$\overline{X + Y} = \overline{X} \cdot \overline{Y}$$

Procedure & Results:

Figure 7-1 was constructed with a power supply of 5v, a square wave generated at 1khz, and a 0.1 **μ**F capacitor between the Vcc and ground of the IC. Circuit was tested on the oscilloscope to match the example.

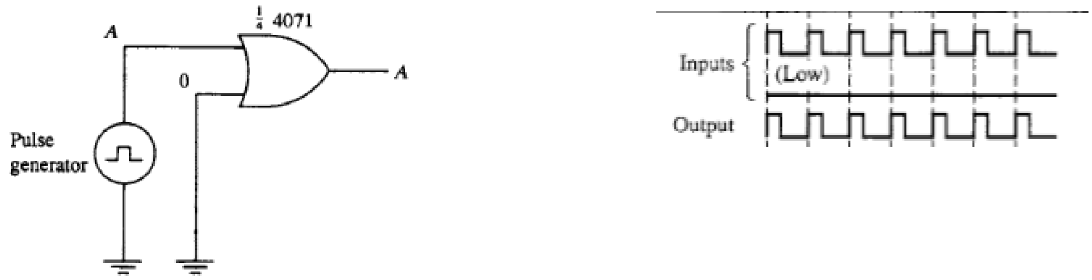


FIGURE 7–1

Figure 7-2 was constructed, with the same function as 7-1. Both inputs are function A. Oscilloscope results were recorded in table 7-2.

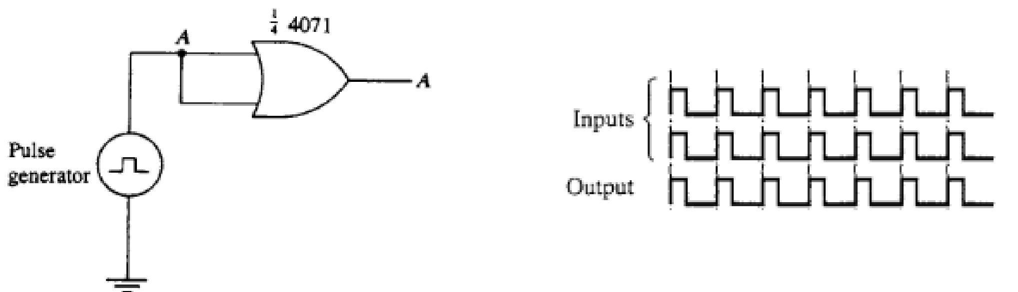


FIGURE 7–2

Figure 7-3 was constructed. The IC was switched to a Quad 2-input NAND Gate.

The inputs and outputs of the circuit were recorded in Table 7-2.

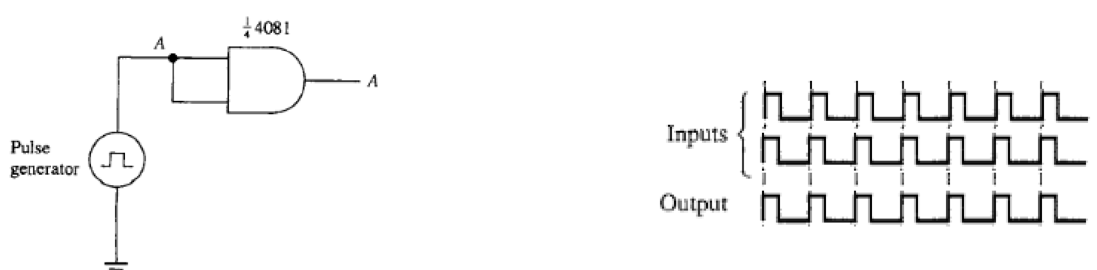


FIGURE 7–3

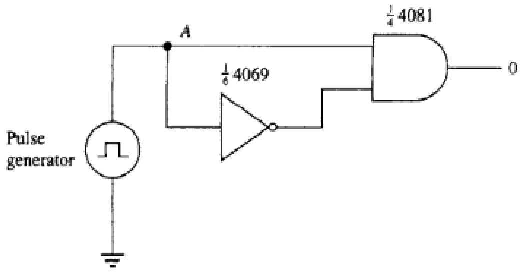
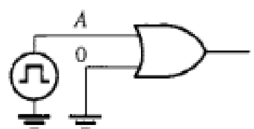
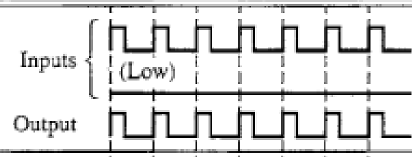
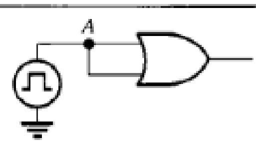
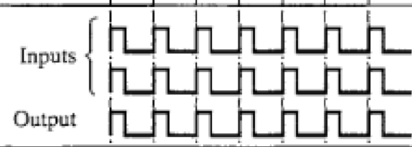
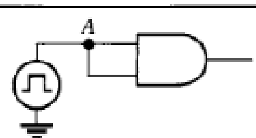
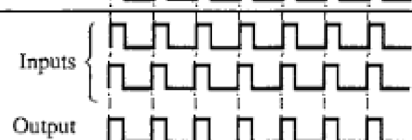
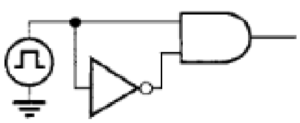
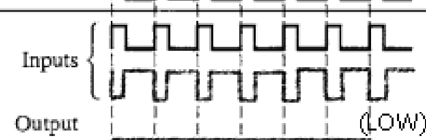


FIGURE 7–4

Figure 7-4 was constructed. The first input was function A and the second was the inverted function A into a NAND Gate. Inputs and outputs were recorded in Table 7-2.

TABLE 7–2

Schematic	Timing Diagram	Boolean Rule
		$A + 0 = A$
		$A + A = A$
		$AA = A$
		$A\bar{A} = 0$

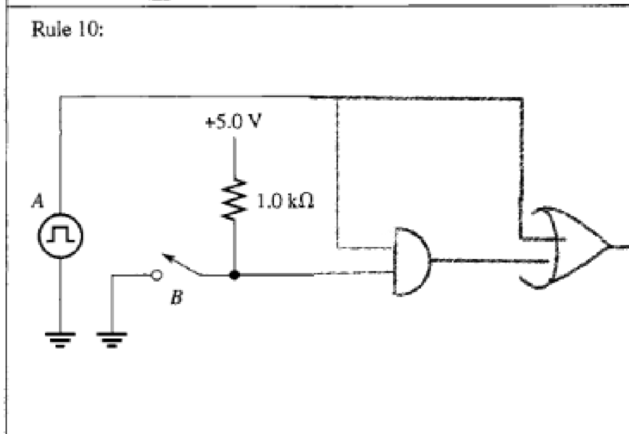
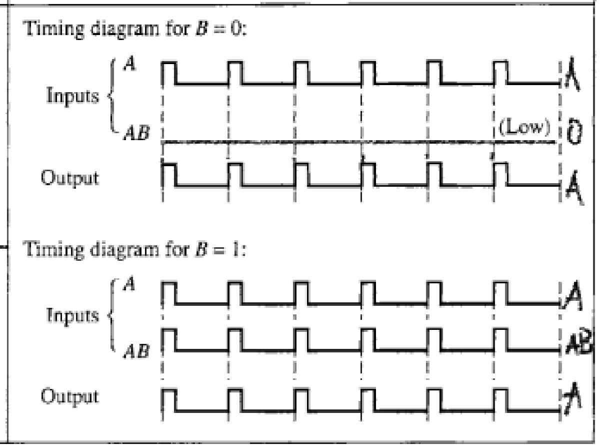
The logic determined by the measurements are consistent with the basic rules of boolean algebra.

A circuit was designed for the logical expression of rule 10.

10. $A + AB = A$

The schematic was drawn for inputs of function A and switch B. The circuit was constructed and the timing diagrams were recorded in Table 7-3.

TABLE 7–3

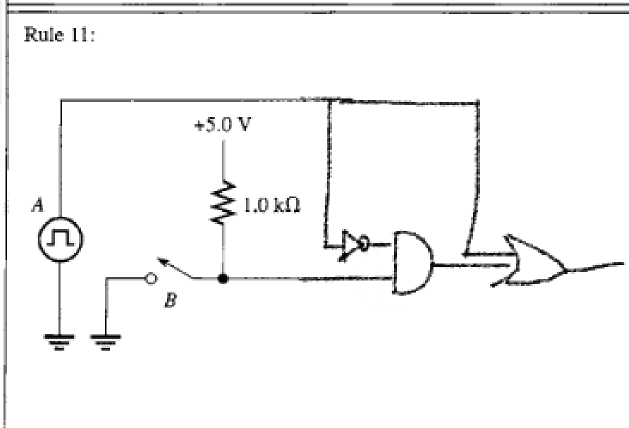
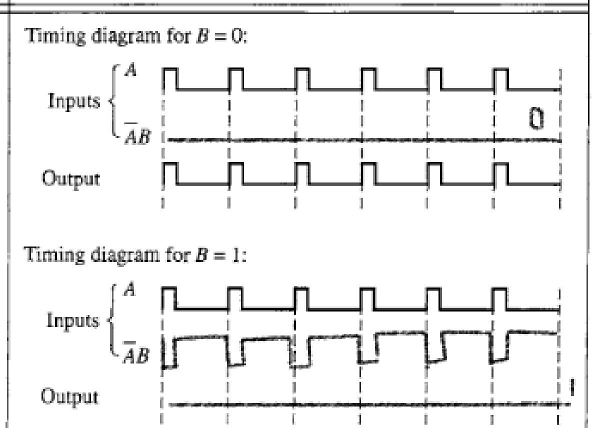
Schematic	Timing Diagram
	

Regardless of the value of B we get output A which is consistent with Rule 10.

A circuit was designed for the logical expression of rule 11.

11. $A + \overline{A}B = A + B$

TABLE 7–4

Schematic	Timing Diagram
	

For further investigation, Figure 7-5 and 7-6 were constructed and compared.

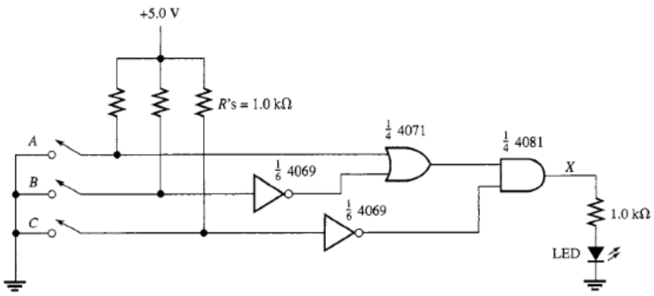


FIGURE 7–5

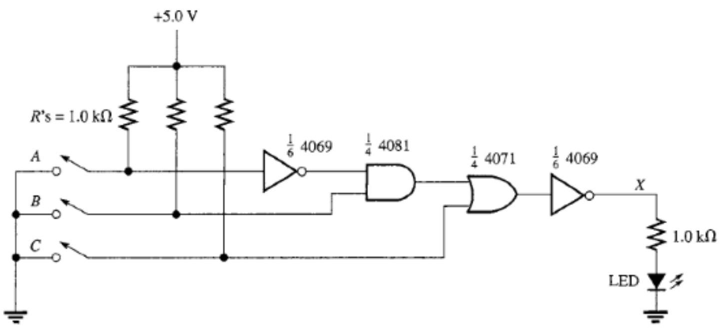


FIGURE 7–6

The outputs were tested with an LED and recorded in truth table 7-5 and 7-6

TABLE 7–5
Truth table for Figure 7–5. $\bar{C}(A+B)$

Inputs			Output
A	*B*	*C*	*X*
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

TABLE 7–6
Truth table for Figure 7–6. $\overline{\bar{A}B + C}$

Inputs			Output
A	*B*	*C*	*X*
0	0	0	1
0	0	1	0
0	1	0	0
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Looking at the truth tables, since they both produce the same outputs for the same inputs, the two logical expressions are equivalent.

Conclusion:

The purpose of this experiment was to analyze and construct logical circuits of basic boolean algebra using integrated chips. The circuits constructed directly represented many of the basic logical rules, and verified their truth. The circuits also verified many other rules such as Demorgan's theorems and the properties of boolean algebra. The experiment also covered the idea of logical equivalence and the many ways an operation can be expressed as a combination of other logical operations. The measurements in the experiment were all accurate and consistent with fundamental theory of boolean algebra.