Name : Digital Logic Gates and Boolean Functions.

Objectives

- We have to study the basic logic gates- AND, OR, NOT, NAND, XOR.

- We have to get acquainted with the representation of Boolean functions using truth tables, logic diagrams and Boolean Algebra.

- We have to prove the extension of inputs of AND and OR gates using the associate law.

- We have to become familiarized with combinational logic circuits.

Theory

Logic Gates: Logic gates are the elementary building blocks of digital circuits. Digital logic gates operate at two discrete voltage levels representing the binary values 0 (logical LOW) and 1 (logical HIGH).

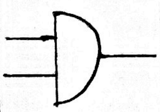
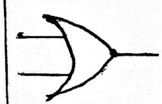
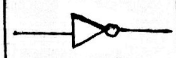
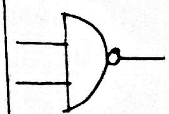
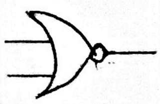
Gate	Description	IC#	Symbol
AND	Multi-input circuit producing an output of 1 if all inputs are 1.	7408	
OR	Multi-input circuit producing an output of 1 when any of its input is 1.	7432	
NOT	Single-input circuit that inverts the input (also called an Inverter) The output is 0 if the input is 1 and vice versa.	7404	
NAND	AND followed by an Inverter.	7400	
NOR	OR followed by an Inverter.	7402	
XOR	The Exclusive-OR or Ex-OR is a two-input circuit that produces an output of 0 is both inputs are same and 1 if the inputs are different.	7486	

Table : Logic gates

Truth Table:

A	B	F = A.B
0	0	0
0	1	0
1	0	0
1	1	1

Table: Truth table for an AND gate.

A truth table shows all output logic levels of a logic circuit for every possible combination of inputs.

Boolean Algebra: Boolean algebra is a branch of mathematical logic that formalizes the relation between variables that take the truth values of true or false, denoted by 1 and 0. respectively. It is fundamental in the development of digital electronics.

Postulates and Theorems		Name
$A+0=A$	$A\cdot 1=A$	Identity
$A+A'=1$	$A\cdot A'=0$	
$A+A=A$	$A\cdot A=A$	
$A+1=1$	$A\cdot 0=0$	
$(A')'=A$		Invalution
$A+B=B+A$	$AB=BA$	Commutative
$A+(B+C)=(A+B)+C$	$A(BC)=(AB)C$	Associative
$A(B+C)=AB+AC$	$A+BC=(A+B)(A+C)$	Distributive
$(A+B)'=A'B'$	$(AB)'=A'+B'$	De Morgan
$A+AB=A$	$A(A+B)=A$	Absorption

Table : Laws of Boolean algebra

Combinational Logic : Combinational logic refers to digital networks where the output is solely dependent on the current input(S) and is not affected by previous states. The analysis of combination logic requires writing the Boolean functions for each element of the circuit, producing their truth tables and subsequently combining each function for the final output and truth table.

<u>Integrated Circuit (IC)</u>: The basic rule for most ICs is that there is polarity mark, such as the half-moon notch shown in the below figure. Another common polarity mark is a small dot, triangle or tab by pin 1. The rule is to move counter-clockwise around the chip from the polarity mark while numbering the pins staring at 1. Sometimes no direct mark may be present in which case the pin numbers can be inferred simply from the orientation of the text inscribed

on the IC.

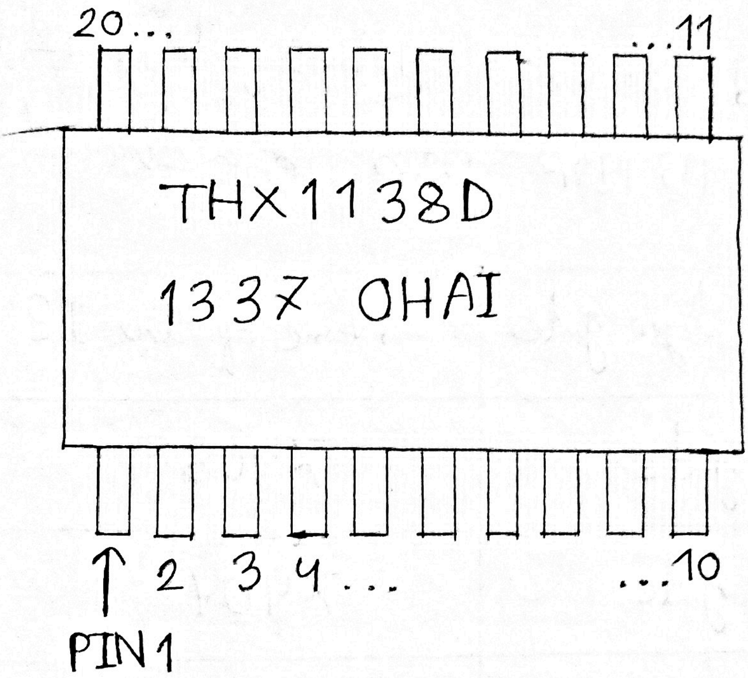


Figure : IC Configuration.

Data Sheet

F.1 Introduction to Basic Logic Gates

Input AB	AND $F = A.B$	OR $F = A+B$	NAND $F = \overline{A.B}$	XOR $F = A \oplus B$	NOR $F = \overline{A+B}$
0 0	0	0	1	0	1
0 1	0	1	1	1	0
1 0	0	1	1	1	0
1 1	1	1	0	0	0

Input A	NOT $F = \overline{A}$
0	1
1	0

Table: Truth Table of Logic Gates

F.2 Constructing 3-input AND & OR gates from 2-input AND & OR gates

ABC	$F = ABC$	$F = A+B+C$
000	0	0
001	0	1
010	0	1
011	0	1
100	0	1
101	0	1
110	0	1
111	1	1

Table: Truth Table for 3-input AND and OR

$F = ABC = A(BC) = (AB)C$
$F = A+B+C = A+(B+C) = (A+B)+C$

Table: Expressing 3-input gates as 2-input gates using associative law.

F.3 Implementation of Boolean Functions

A	B	C	$I_1 = A'C$	$I_2 = AB'$	$I_3 = BC$	$F = I_1 + I_2 + I_3$
0	0	0	0	0	0	0
0	0	1	1	0	0	1
0	1	0	0	0	0	0
0	1	1	1	0	1	1
1	0	0	0	1	0	1
1	0	1	0	1	0	1
1	1	0	0	0	0	0
1	1	1	0	0	1	1

Table: Truth Table for the given Boolean Function

Questions

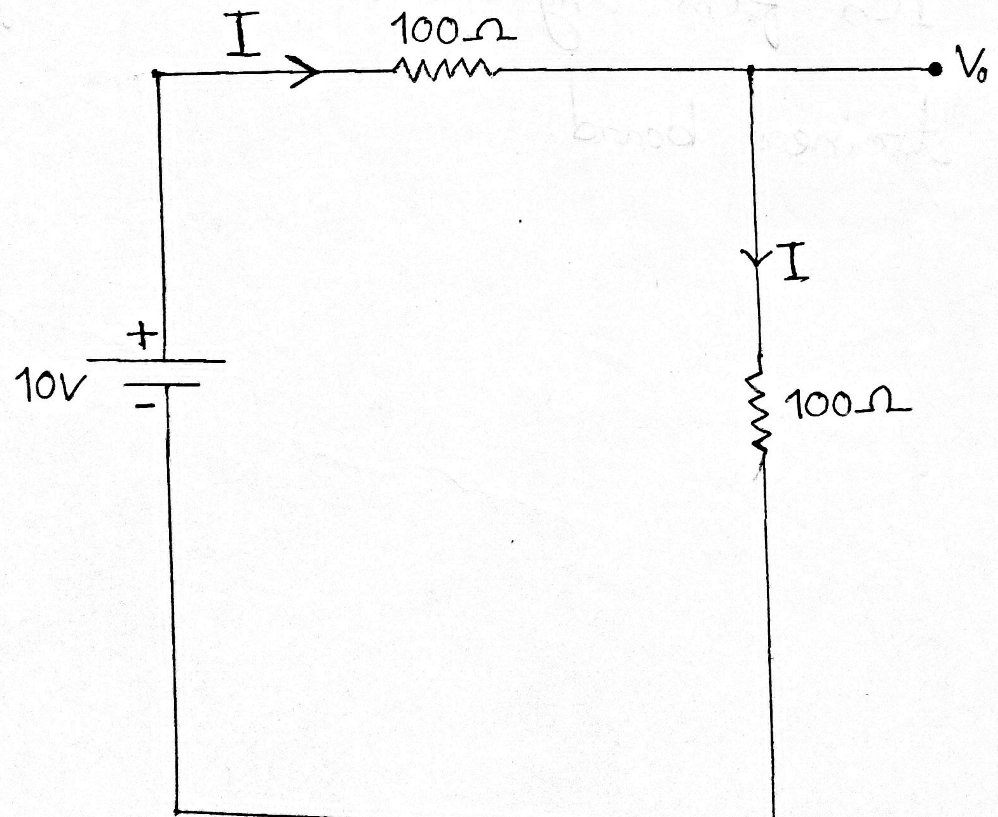
E.1.2(1) The names of the ICs that I would need if I wanted to use 13 AND gates, 12 NOT gates and 15 NOR gates in a circuit are:

Name of logic gate	Name of the IC
AND gate.	7408
NOT gate	7404
NOR gate	7402

The quantity of IC I need:

Name of logic gate	Name of the IC	Calculation	Quantity
13 AND gate	7408	$13/4 = 3.25$	4
12 NOT gate	7404	$12/4 = 3$	3
15 NOR gate	7402	$15/4 = 3.75$	4

(2) If the +5V port is not working, we can design very easily a +5V power supply as below. We only require a 10V battery and two 100Ω resistors so that the output voltage is +5V. By this way, we can design a voltage divider network as shown below.



Clearly the two 100Ω resistors are in series. Hence the current is, 11

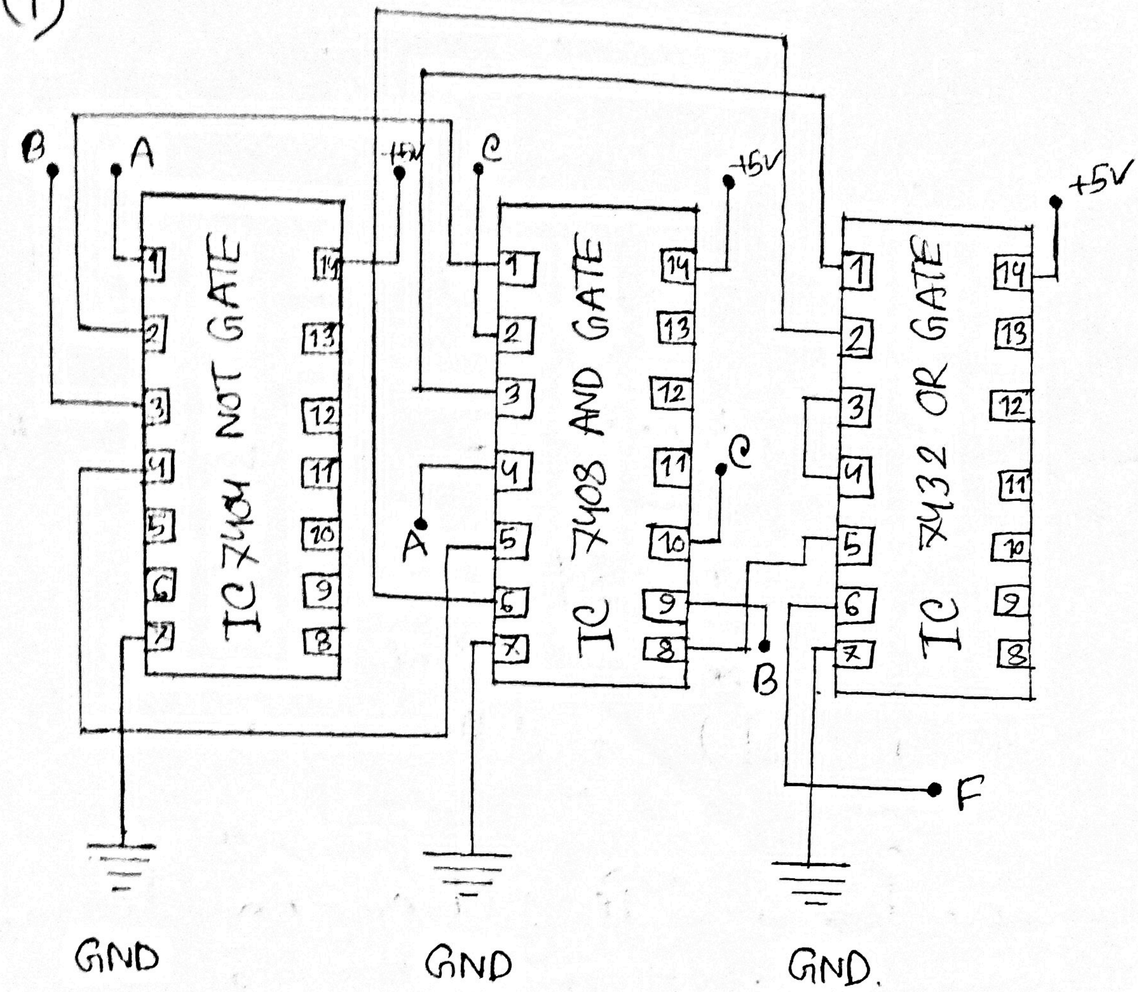
$$I = \frac{10}{100+100} = \frac{10}{200} = 0.05A$$

This current when multiplied with 100Ω resistor (output side) gives 5V.

Output voltage $V_o = 0.05 \times 100 = 5V$.

$\therefore$ We can use this +5V to power the logic IC. Besides that we can power our logic ICs from any of the switches of the trainer board.

E.3.1 (1)



$$F = A'C + AB' + BC.$$

Figure : IC Diagram for the logic circuit.

Source : Chegg Study (www.chegg.com).