American International University- Bangladesh
Department of Electrical and Electronic Engineering
EEE2104: Digital Logic Design Laboratory

Title: Construction of a combinational circuit from a truth table or a given statement.

Introduction:

This experiment shows the students the practical verification of Construction of a combinational circuit from a given statement.

1) Students implement the logic circuits derived from a given statement in the breadboard using gate ICs and observes whether the output verifies the truth table of the given logic statement.
2) Theoretical work is done by deriving the logic circuit and truth table from the given logic equation/statement.
3) Occasionally, equations are obtained by solving a Kmap for some given conditions.
4) In the end, the circuits are implemented in the breadboard using gate ICs and observed whether the output verifies the truth table and the equations.

A logic circuit can be constructed from a given logic statement by observing the individual logic operations performed in the circuit and matching them with their corresponding logic gates. This can be done by detecting the gates and their logic expression outputs. Then gates required need to be determined from the logic expressions by observing the sequence of the inputs and operations performed on them. Expressions are simplified using Boolean algebra and De Morgan's law or Karnaugh map to reduce the number of gates used. Then the circuit is implemented in the breadboard using gate ICs and observed whether the output verifies the truth table of the given statement.

Theory and Methodology:

Combinational circuits are built with logic gates and other components. It does not include any values to be taken from a previous state of the circuit.

Boolean algebra: In Boolean algebra, a variable is a symbol used to represent an action, a condition, or data. A single variable can only have a value of 1 or 0.

1) **Variable:** A symbol used to represent a logical quantity that can have a value of 1 or 0, usually designated by an italic letter.
2) **Complement:** The inverse or opposite of a number. In Boolean algebra, the inverse function, expressed with a bar over the variable.
3) **Sum term:** The Boolean sum of two or more literals equivalent to an OR operation
4) **Product term:** The Boolean product of two or more literals equivalent to an AND operation.

5) **Sum of Products(SOP):** A form of Boolean expression that is basically the ORing of ANDed terms.
6) **Product of Sums(POS):**A form of Boolean expression that is basically the ANDing of ORed terms.
7) **Karnaugh map:** An arrangement of cells representing combinations of literals in a Boolean expression and used for systematic simplification of the expression.

Boolean expressions can be written in the sum-of-products form (SOP) or in the product-of-sums form (POS). These forms can simplify the implementation of combinational logic, particularly with PLDs. In both forms, an overbar cannot extend over more than one variable.

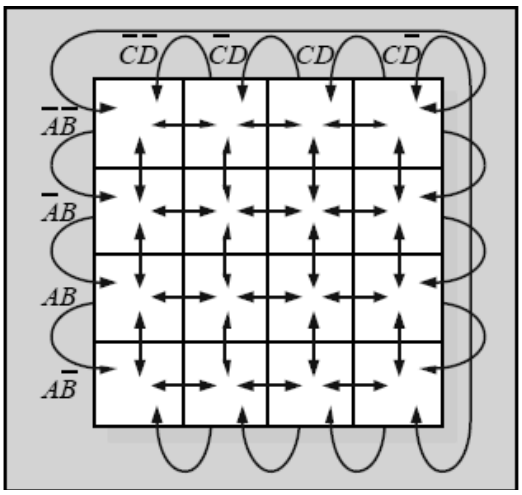

Fig.1: 4-variable Karnaugh map

A 4-variable Karnaugh map has an adjacent cell on each of its four boundaries as shown. Each cell is different only by one variable from an adjacent cell. Grouping follows the rules given in the text. It is a four variable map using binary numbers for the variables.

Pre lab homework:

Students should study

1) All the different types of logic gates and their corresponding output expressions,
2) Different theorems of Boolean algebra including De Morgan's law,
3) How to derive the truth table from logic expressions,
4) Pin diagrams of all the different types of logic gate ICs,
5) How to solve and derive logic equations from Kmap.
6) Students must perform the simulation using Multisim and MUST present the simulation results to the instructor before the start of the experiment.

Equipments:

1) Digital trainer board.
2) Integrated Circuits (ICs):
    a) OR gate (IC 7432) 1[pcs]

b) AND gate (IC 7408) 6[pcs]
c) NOT gate (IC 7404/7406) 4[pcs]

3) Connecting wires.

Precautions:

Students should take the following precautions while conducting the experiment -

1) Check all the outputs of the ICs whether they are working,
2) Be careful while handling the power supplies and to keep them off when they are not needed,
3) Not to directly touch the power terminals with bare hands while they are on,
4) Be careful while handling the multimeter,
5) Carefully connect the ICs according to their pin configuration,
6) Carefully connect the wires with the ICs and to make sure that they are firmly connected,
7) Check whether all the data switches and output showing LEDs are working.

Experimental Procedure:

Problem 1: Construction of a combinational circuit from given statement.

Let A, B, C & D are inputs of a logic circuit and X,Y are the outputs. Now construct a logic circuit in your trainer board where X will be HIGH only when all the logic inputs are equal and Y will be HIGH when B &D are unequal.

Problem 2: Construction of a combinational circuit from a truth table or a given statement.

Inputs			Output
A	B	C	F
0	0	0	1
0	0	1	1
0	1	0	0
0	1	1	0
1	0	0	0
1	0	1	0
1	1	0	1
1	1	1	1

1) Determine the output and the truth tables of the logic circuits mentioned in problem 1 and 2,
2) Determine which gates and how many of them are required,
3) Check and detect all the IC numbers.
4) Carefully place the ICs on the Trainer Board and bias them by connecting them to the +5 volt DC supply and ground.
5) Connect them using wires according to the logic diagram,

6) Connect the outputs to the LEDs using wires,
7) Check and note down the outputs by giving different inputs according to the derived truth table.

Simulation and Measurement:

Compare the simulation results with your experimental data and comment on the differences (if any).

Results/ Findings:

Students will implement the circuit in the Trainer Board and match the theoretically obtained truth table by matching outputs for individual input configurations. If the practically obtained truth table does not match they will also investigate the errors.

Questions for report writing:

1. What is combinational logic circuit.
2. Develop the truth table for a certain three-input logic circuit with the output expression
   $Y=ABC+\overline{A}\overline{B}C+\overline{A}BC+A\overline{B}C+AB\overline{C}$.
3. Implement the following logic expressions
   $Y= ABC+AB+AC$.

Discussion:

Students will summarize the experiment discuss it as a whole. They will observe that the method of constructing logic circuits from logic equations and truth tables is valid and effective. They will also see whether they can make the circuit efficient by reducing the number of gates used. They will also include any limitations of the process.

Reference:

[1] Thomas L. Floyd, "Digital Fundamentals", available Edition, Prentice Hall International Inc.