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

Title: Derive logic equations and truth table from combinational circuits.

Introduction:

This experiment shows the students a practical verification of deriving logic equations and truth table from combinational circuits. Knowing how to derive logic equations and truth table from combinational circuits helps a person with detecting the output logic expressions from any unknown logic circuit. This can be done by detecting the gates and their logic expression outputs. Then truth tables need to be derived from the logic expressions by observing the sequence of the gate connections. Expressions are simplified using Boolean algebra and De Morgan's law 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.

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.

Circuit 1:

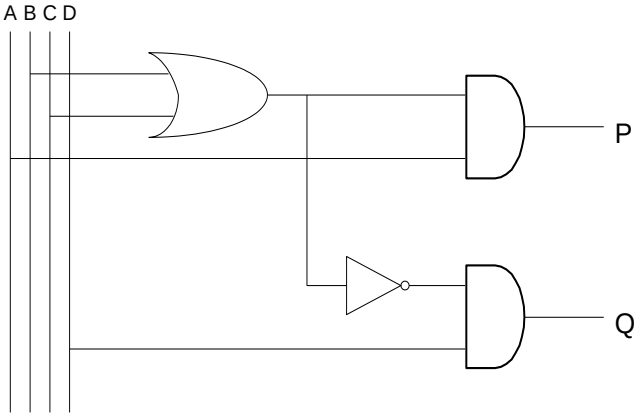

Fig.1:Circuit 1

Truth table is constructed from considering ABCD as a 4 bit input starting from 0000 to 1111.

Inputs are A, B, C and D on the left. Outputs to be derived are P and Q on the right. Inputs B and C are passing through an OR gate resulting in the expression B+C. This output is passed through AND gate with the input A. Output of the AND gate is P.

$$P = A(B+C)$$

Output Q is taken from a second AND gate which receives inputs from an inverted output of the previously mentioned OR gate, ($\overline{B+C}$) and D.

$$Q = (B+C)D$$

Corresponding outputs are calculated from logic expressions of P and Q.

Circuit 2:

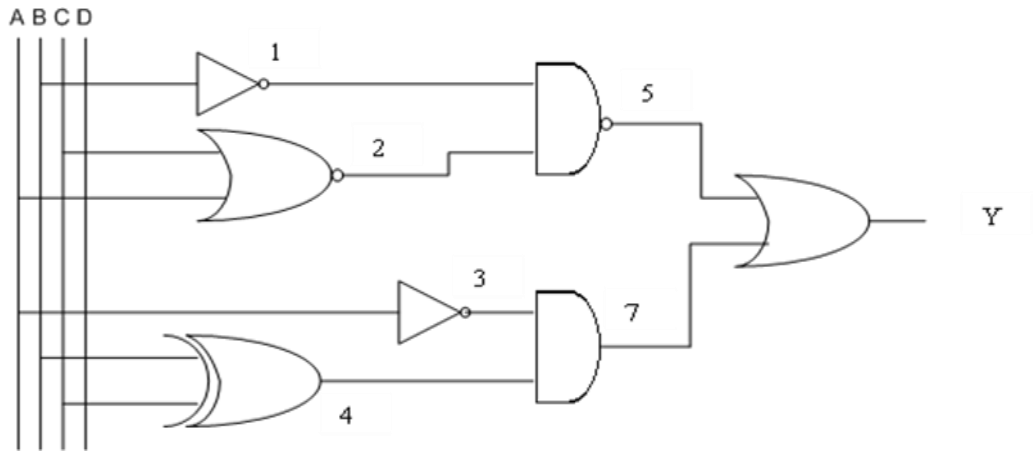

Fig.2: Circuit 2

Inputs are A, B, C and D on the left. The output to be derived is Y on the right. Gates 1 and 3 are NOT gates. Input of gate 1 is B, output is $\overline{B}$. Similarly Input of gate 3 is A, output is $\overline{A}$. Gate 2 is a NOR gate with inputs A and C. Output is $\overline{A+C}$. Gate 5 is a NAND gate and it receives inputs from the output terminals of gates 1 and 2. Which results in an output of

$$\overline{\overline{B}(\overline{A+C})}$$

Gate 4 is an X-OR gate which receives inputs from B and C. Output is $B\overline{C}+\overline{B}C$. Gate 7 is an AND gate and it receives inputs from the output terminals of the gates 3 and 4. Which results in an output of

$$\overline{A}(B\overline{C}+\overline{B}C)$$

Final output Y comes from an OR gate and it receives inputs from the output terminals of the gates 5 and 7.

$$Y= \overline{\overline{B}(\overline{A+C})} + \overline{A}(B\overline{C}+\overline{B}C)$$

Truth table is constructed from considering ABCD as a 4 bit input starting from 0000 to 1111. Corresponding outputs are calculated from logic expression of Y.
At the end of the experiment, students should construct the obtained logic equations with Universal Gates(NAND and NOR).

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) Students should 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) 2[pcs]
    c) NOT gate (IC 7404/7406) 2[pcs]
    d) NOR gate (IC 7402) 1[pcs]
    e) NAND gate (IC 7400) 1[pcs]
    f) XOR gate (IC 7486) 1[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:

1) Determine the output and the truth tables of the logic circuits in Fig 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,
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/ wave shapes 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:

Construct the derived equations by using Universal gates (both NAND and NOR).

Discussion:

Students will summarize the experiment and discuss it as a whole. They will observe that the method of deriving 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:

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