Experiment 3: Logic Gates and Applications (2)
Every student has to prepare a preliminary work and also he/she should simulate the circuit, designed for the experimental work - by using a simulation program, such as Logisim.

**Preliminary Work:**

1) Write the Boolean expression for the output Z shown in the figure below. Determine the value of Z for all possible input conditions and list them in a truth table.

![Logic Circuit Diagram](image)

2) Determine the input conditions needed for the current I to be 5 mA.

![Logic Circuit Diagram](image)

3) Let inputs A, B, and C have the following waveforms for the logic circuit given below.

![Waveform Diagram](image)
a) Draw the output waveform Y.
b) Draw the output waveform Y, if the input A is permanently shorted to ground.
c) Draw the output waveform Y, if the input A is permanently shorted to +5 V.

4) Use the K – map to simplify the following equations:

\[ f(A,B,C,D) = A'BC' + ACD + BCD + A'BD + A'BC + AB'C + BC'D \]
\[ f(A,B,C,D) = (A' + B + C)(A + C' + D)(B + C + D)(A' + B + D') \]

5) \[ f(A,B,C,D) = \Sigma (0,2,5,8,12,13) \]
\[ g(A,B,C,D) = \Pi (1,3,4,6,14,15) \]
a) Draw the NAND – NAND gate structure for both functions
b) Draw the NOR – NOR gate structure for both functions

6) Let A and B be 1-bit binary numbers. Design a logic circuit whose output is HIGH whenever both A and B are either LOW or HIGH; otherwise the output is LOW.

7) Design a BCD to 8 4-2-1 encoder. For each decimal digit its corresponding code is found by adding 8, 4, and subtracting 2, 1. For example: 1 can be obtained by adding 4; subtracting 2 and 1 as: 4–2–1. Hence, 8 4-2-1 code for 1: 0111. Similarly, 8 4-2-1 code for 2: 0110.

Each BCD digit is four bits labeled as A, B, C, D (from most significant to least significant). Each 8 4-2-1 is four bits labeled as W, X, Y, Z (from most significant to least significant).

Note that the input BCD can only be in the range of 0 to 9, i.e., 10,11,12,13,14, and 15 will not be used.
Experiment:

Implement the 8 4 -2 -1 encoder that you have designed in the preliminary work of Question 7. Verify its operation.