Experiment 2 **Digital Circuits** **2022**

Combinational Circuits for Binary Addition

You need to perform the experiment on TINKERCAD

Part A. De Morgan's Theorem

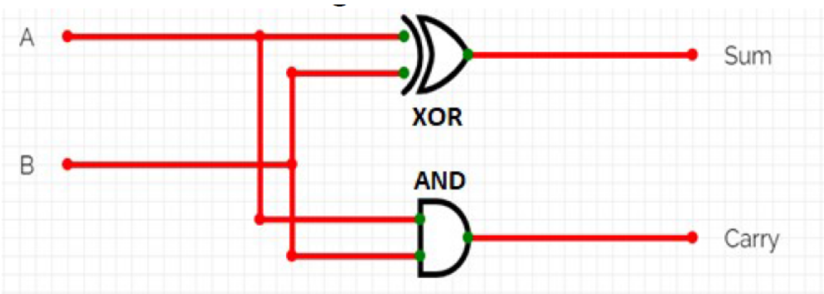
De Morgan's theorem state that $(A + B)' = A' \cdot B'$ and $(A \cdot B)' = A' + B'$. Verify these theorem by proceeding step by step as follows:

1. Set up a circuit consisting of two NOR gates (remember that one IC has 4 gates of same type) and one AND gate to perform the function $Y = A' \cdot B'$, using a NOR gate with its two inputs connected together to perform the NOT function.
2. Obtain the truth table of this circuit and verify that the truth table is the same as that of a NOR gate.
3. Repeat step 1 by replacing NOR with NAND and using an OR gate instead of an AND gate to verify that the truth table of the function $Y = A' + B'$ is the same as that of a NAND gate.

Part B. Binary Half Adder using Gates

A binary Half Adder adds two bits A and B to generate SUM and CARRY bits as the output according to the following Boolean expressions for the outputs:

$SUM = A' \cdot B + A \cdot B' = A \oplus B$ and $CARRY = A \cdot B$.



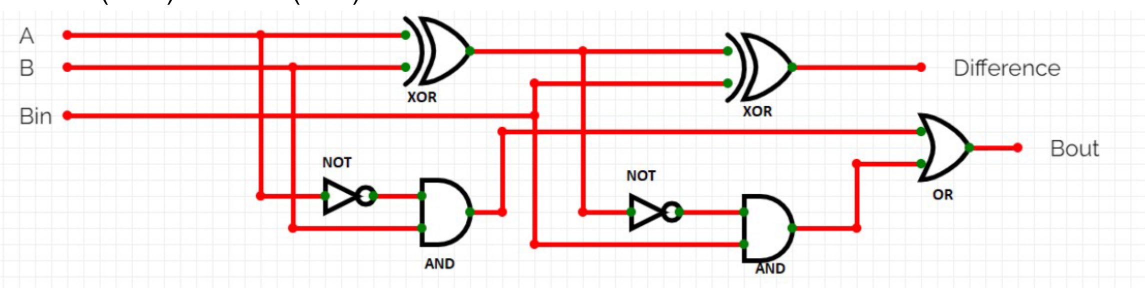
1. Set up the circuit of a Half Adder using an XOR gate and an AND gate. Apply the inputs A and B from two input slide switches and observe the outputs S1 and C1 on two LEDs for all combinations of the inputs. Tabulate these values and verify the operation of the Half Adder.

Part C. Binary Full Subtractor using Gates

A binary Full Subtractor subtracts the Subtrahend bit B and a Borrow-in bit Bin from the Minuend bit A to generate DIFFERENCE and BORROW bits as output. Write down the complete truth table of a Full Subtractor and verify that the DIFFERENCE and BORROW outputs are given by the following logic expressions:

$DIFFERENCE = A \oplus B \oplus Bin$ and

$BORROW\ (Bout) = A'.B + (A \oplus B)'.Bin$.



1. Verify the truth table experimentally by applying the inputs A, B and Bin through three input switches and displaying the DIFFERENCE and BORROW outputs on LEDs.

Problem Statement

1. A private collector has received a valuable gemstone which they wish to put on display. Due to its value, the collector has proposed an idea to prevent thieves from stealing the gemstone or escaping after attempting to steal it.

   The gemstone rests on top of a pressure plate on a pedestal, surrounded by a glass case. If glass is removed with weight intact or weight is removed from pressure plate with glass not removed a warning is issued. If the glass is broken and the gemstone's weight is removed from the pressure plate, the alarm is set on.
   Design the logic circuit required for this trap, modelling the glass case, pressure plate and steel barrier as follows:

   → Glass case (input J): 0 – Glass not removed 1 – Glass removed
   → Pressure plate (input K): 1 – Weight removed 0 – Weight applied
   → Alarm (output X): 0 – Alarm off 1 – Alarm On
   → Warning (output Y): 0 – Warning off 1 - Warning On

Deliverables & Rubrics **(Total-10 marks)**

Deliverables-

1) Aim
2) Components/ICs Used
3) Link of TINKERCAD Workspace (working project): 1 mark
4) Pin Diagram of the IC: 1.5 marks
5) Neat Circuit Diagram (Screenshot of TinkerCAD workspace): 2 marks
6) Truth Table: 1.5 marks
7) Observations/Results: 1 marks
8) Application: 1 marks
9) Problem statement solution, circuit implementation(Design Screenshot): 2 marks

Penalties:- (-ve marking)

1) Circuit not working	0 grade
2) Plag case	0 grade
2) Late submission	
0-10 min:	no penalty
10-30 min:	2 marks
More than 30 min:	5 marks
3) Crosswires or wire crossing a component	2 marks
4) Component out of the board:	1 mark/component
5) Unnecessary use of a component or wires:	1 mark/component