EXPERIMENT D10: COMBINATIONAL LOGIC CIRCUITS

Related course: KIE1003 (Digital System)

OBJECTIVES:
To construct digital circuits using combination of basic logic gates.

EQUIPMENT / MATERIALS:
DC power supply; breadboard; wires/jumpers; logic gate ICs: 74XX32, 74XX08, 74XX00, 74XX86, 74XX04 (XX can be HC, LS or AC); LEDs; 470Ω resistors

INSTRUCTIONS:
1. Record all your results and observations in a logbook or on a piece of paper.
2. Follow the demonstrator's instructions throughout the experiment.
3. Make sure that the DC power supply is **switched OFF** before connecting and disconnecting the circuit.
4. **Place/remove every IC on/from the breadboard carefully** to avoid pin damage.
5. Please refer to the datasheets for the pin configuration of the logic gate ICs.

INTRODUCTION:

A logic gate performs a logical operation on one or more logic inputs and produces a single logic output. Logic gates are primarily implemented electronically using diodes or transistors. The input and output are represented by "0" and "1".

In electronic logic, a logic level is represented by a voltage or current, (which depends on the type of electronic logic in use). Each logic gate requires power so that it can source and sink currents to achieve the correct output voltage. In logic circuit diagrams, the power is not shown, but in a fully electronic schematic, power connections are required.

Logic gates can be separated into different logic families, which are differentiated by their different building blocks and different logic levels. Two of the most common logic families are the transistor-transistor logic (TTL) and complementary metal oxide silicon (CMOS).

An adder is an example of digital circuit that can be built through the combination of basic logic gates. In computers and processors, adders are used in the arithmetic logic units, to calculate addresses, table indices, increment and decrement operators, and similar operations. Adders can be divided into "Half-Adder" (HA) and "Full-Adder" (FA). HA follows the rules of binary addition and is limited to the addition of 1-bit numbers. FA can perform additions of numbers greater than 2-bits in length.

PROCEDURE:

TEST 1: Combination of Basic Logic Gates

1. Referring to the circuit in Figure 1 and 2, derive the equation for output Y in terms of inputs A, B, C, D and fill in the "Output based on theory" column in Table 1 and 2.
2. Construct the circuit as shown in Figure 1 using one NOT gate IC (74XX04), one OR gate IC (74XX32) and one AND gate IC (74XX08) on a breadboard. XX can be HC, LS or AC.

Connect V_{CC} (pin 14) of every IC to +5V through a 470Ω resistor and GND (pin 7) to 0V of the DC power supply, as shown in Figure 1. Connect the output Y to LED.

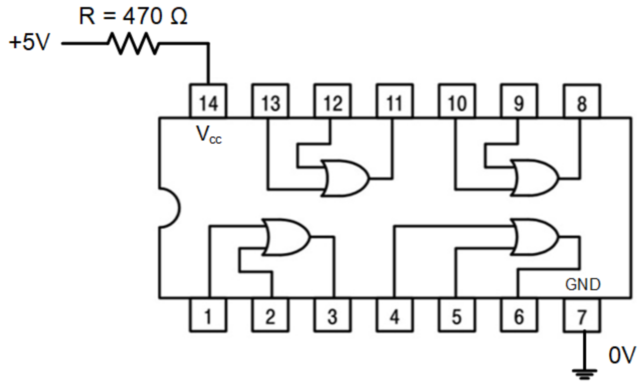

Figure 1

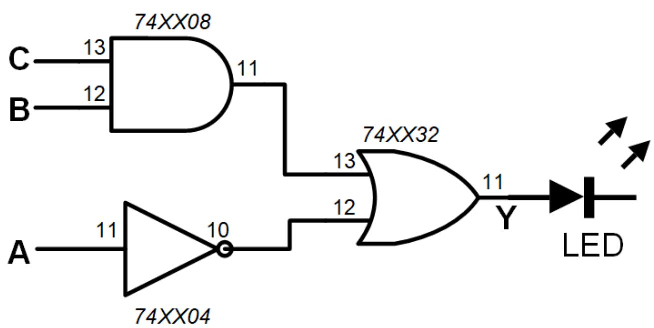

Figure 2

3. Switch ON the DC power supply. Take a photo of your circuit.
4. Connect the input as shown in Table 1. Do not leave the input pins floating (i.e. it must be connected to either +5V or 0V). For example:
   - When A=0, B=0 or C=0, that means they are connected to 0V.
   - When A=1, B=1 or C=1, that means they are connected to +5V.
5. For every input, record the output in Table 1. The output is shown by the LED:
   - When the LED is ON, that means the output Y = 1.
   - When the LED is completely OFF, that means the output Y = 0.

Table 1

Input			Output Y based on theory	Output Y from measurement
A	B	C		
0	0	0		
0	0	1		
0	1	0		
0	1	1		
1	0	0		
1	0	1		
1	1	0		
1	1	1		

6. Switch OFF the DC power supply.
7. Continued from the circuit in Figure 2, construct the circuit as shown in Figure 3. Connect the input A to a pushbutton. Initially, the pushbutton remains in off state or normally open state but when it is pressed, it allows the current to pass through it. For example:
   - When A=0, that means the pushbutton is not pressed.
   - When A=1, that means the pushbutton is pressed.
8. Repeat steps 2 to 5 and fill in Table 2.

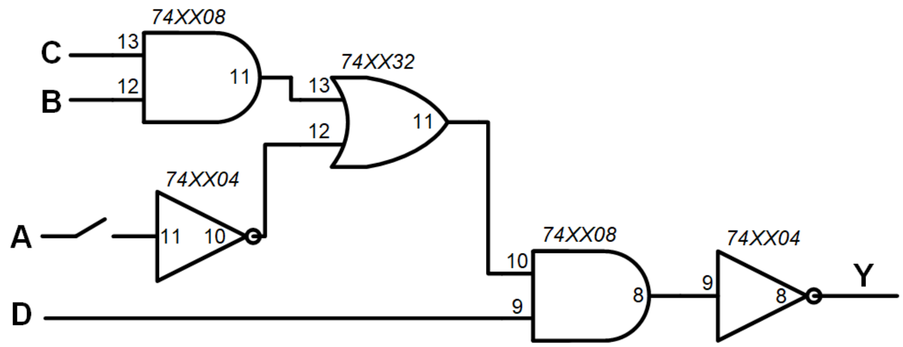

Figure 3

Table 2

Input				Output Y based on theory	Output Y from measurement	Input				Output Y based on theory	Output Y from measurement
A	B	C	D			A	B	C	D		
0	0	0	0			1	0	0	0		
0	0	0	1			1	0	0	1		
0	0	1	0			1	0	1	0		
0	0	1	1			1	0	1	1		
0	1	0	0			1	1	0	0		
0	1	0	1			1	1	0	1		
0	1	1	0			1	1	1	0		
0	1	1	1			1	1	1	1		

TEST 2: Full Adder Circuit

1. Construct a full adder circuit as shown in Figure 4 on the breadboard. Connect V_{CC} (pin 14) of every IC to +5V through a 470Ω resistor and GND (pin 7) to 0V of the DC power supply. Connect the output S and C_{out} to LEDs.

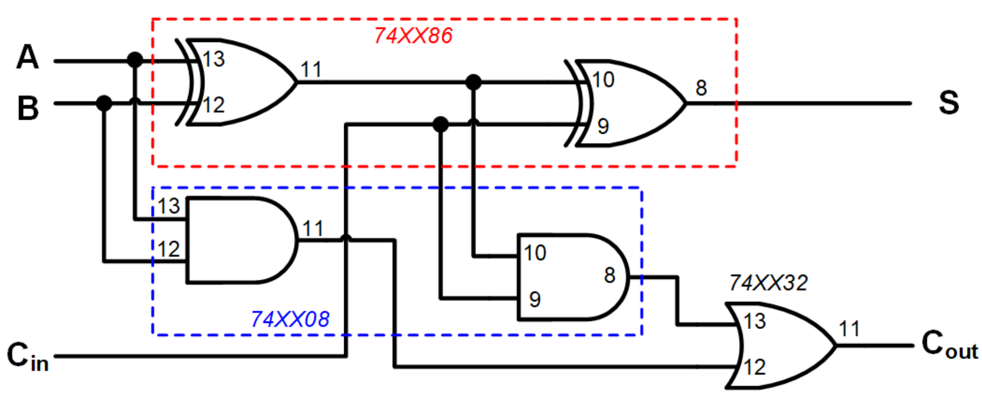

Figure 4

2. Switch ON the DC power supply. Take a photo of your circuit.
3. Connect the input as shown in Table 3. For example:
   - When A=1, B=1 or C_{in}=1, that means the input pin is connected to +5V.
   - When A=0, B=0 or C_{in}=0, that means the input pin is connected to 0V.
4. For every input, record the output in Table 3. The output is shown by the LED:
   - When the LED is ON, that means the output, S = 1 or C_{out} = 1.
   - When the LED is completely OFF, that means the output, S = 0 or C_{out} = 0.
5. Compare your results with the theory and discuss in your report whether they are correct or not.

Table 3

Input			**Output**	
A	**B**	**C_{in}**	**S**	**C_{out}**
0	0	0		
0	0	1		
0	1	0		
0	1	1		

Input			**Output**	
A	**B**	**C_{in}**	**S**	**C_{out}**
1	0	0		
1	0	1		
1	1	0		
1	1	1		

OPEN-ENDED TASK:

Using the inputs and outputs as in Table 4, construct a half adder circuit using only NAND gates on a breadboard. Include the schematic drawing and photo of the logic circuit in your report.

Table 4

Input		**Output**	
A	**B**	**S**	**C**
0	0		
0	1		
1	0		
1	1		

END OF EXPERIMENT