Department of Biomedical Engineering
Digital Electronics / Third stage
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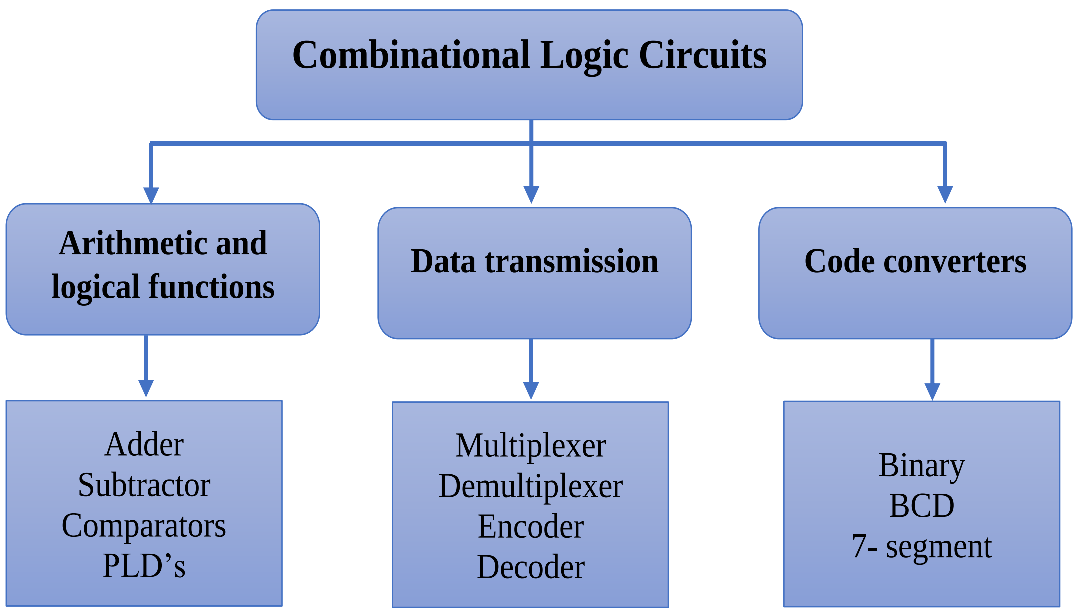
Experiment No. 4

Combinational Logic Circuits

Introduction

Basic combinational logic circuits are digital circuits in which the output depends only on the present input values, without memory or feedback loops. These circuits perform logical operations such as AND, OR, NOT, XOR, etc., and are widely used in arithmetic and data processing applications. In this experiment, the full adder circuit will design



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1.1Objective

This experiment aims to design and analyze a **full adder** circuit that performs binary addition of three input bits and generates the sum and carry outputs. The experiment demonstrates the working principle of digital arithmetic and combinational logic circuits.

A full adder is a combinational logic circuit used for binary addition. Unlike a half adder, which adds only two bits, a full adder adds three binary inputs:

A (First input bit)

B (Second input bit)

$\mathbf{C_{in}}$ (Carry input from a previous addition stage)

1.2 Components

The CircuitMaker software is used to design and simulate logical circuits

1.3 Theory

Digital electronics plays a crucial role in modern computing and communication systems, with arithmetic operations being fundamental to its functioning. One of the most essential circuits in digital arithmetic is the full adder, which performs binary addition. Unlike a half adder, a full adder can handle carry inputs, making it indispensable for multi-bit binary addition. This essay explores the theoretical foundation, design, and implementation of a full adder circuit, highlighting its significance in digital computing.

The outputs are determined by the following Boolean expressions:

- Sum Output (S):
- Carry Output (C_{out}):

These expressions ensure that the circuit correctly computes binary addition with carry propagation.

Truth Table of the Full Adder

A1	A2	A3	Dec	B1	B2	B3	Dec
0	0	0	0	0	0	0	0
0	0	1	1	0	0	1	1
0	1	0	2	0	1	0	2
0	1	1	3	0	1	1	3
1	0	0	4	1	0	0	4
1	0	1	5	1	0	1	5
1	1	0	6	1	1	0	6
1	1	1	7	1	1	1	7

A full adder can be constructed using basic logic gates such as AND, OR, and XOR. The design involves:

- Sum Calculation: Two XOR gates are used to compute.
- Carry Calculation: Three AND gates and one OR gate are used to implement.

Alternatively, a full adder can be implemented using universal gates (NAND or NOR gates), which can optimize hardware design for efficiency.

Experimental Procedure

1. **Components Required:**

Using CircuitMaker software to connect the following circuit

- XOR, AND, and OR gates
- Power supply (5V)
- Hex display indicators for output verification

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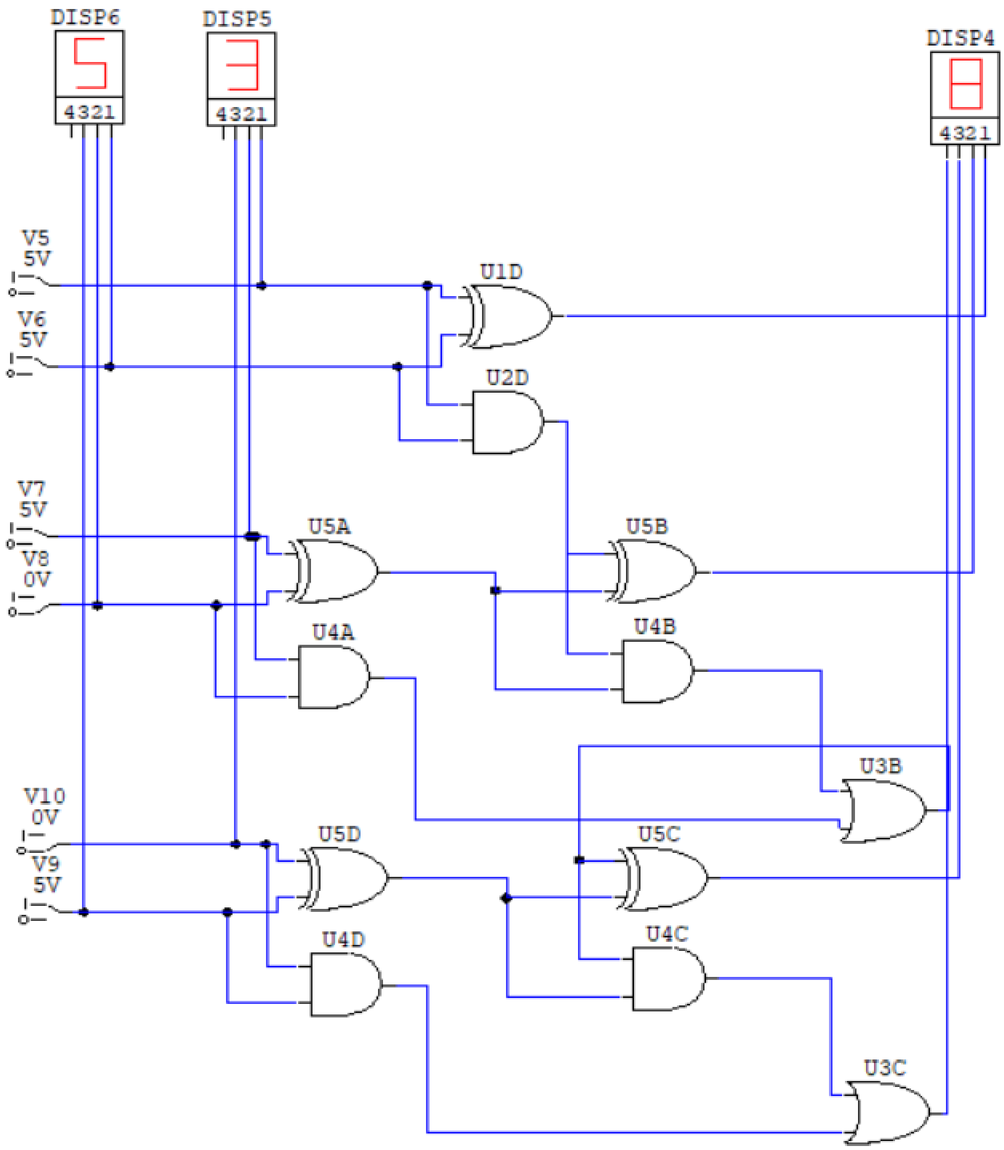

2. Steps to Implement:

- Connect the circuit as shown in the figure.
- Apply different binary combinations of A1, A2, A3, B1, B2, and B3.
- Add the decimal number 5 with 3 and check the result

Observations and Results

Through practical implementation, the circuit successfully computes binary addition, producing expected outputs as per the truth table. The experiment also demonstrates the scalability of full adders in multi-bit addition by cascading multiple units to form Ripple Carry Adders and Carry Look-Ahead Adders.

Discussion:

1. How does the full adder differ from a half adder in terms of functionality and circuit complexity?
2. Why is the XOR gate crucial in the sum calculation of a full adder?
3. Desing the logic circuit to calculate two bits