# Computer Organization
# HKBU-BNU United International College

## Lab3: Combinational Circuits

## Lab Objective

To understand how to analyze and design basic combinational circuits.

## Introduction

Combinational Circuits (CC) are circuits made up of different types of logic gates. The output of the combinational circuit depends only on the current input values. The circuits do not make use of any memory or storage device. Typical combvinational circuits include adders, decoders, multiplexers and ALUs.

A **full adder** adds binary numbers and accounts for values carried in as well as out. A one-bit full-adder adds three one-bit numbers, often written as A, B, and $C_{in}$; A and B are the operands, and $C_{in}$ is a bit carried in from the previous less-significant stage. The circuit produces a two-bit output. Output carry and sum typically represented by the signals $\mathbf{C_{out}}$ and **S**.

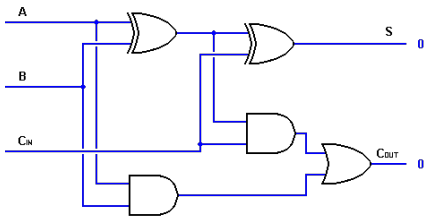


Figure 1 Full Adder

A **Decoder** is a circuit that changes a code into a set of signals. It is called a decoder because it does the reverse of encoding. A decoder has 'n' input lines and maximum of $2^n$ output lines. One of these outputs will be active High based on the combination of inputs present, when the decoder is enabled. Figure 2 shows a 2-to-4 decoder.

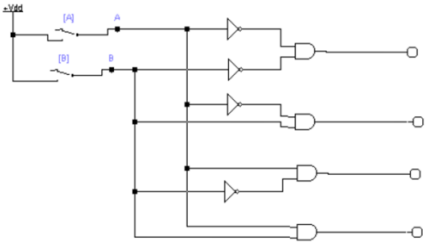

Figure 2 Two-to-Four Decoder

A **Multiplexer** (or mux; spelled sometimes as multiplexor), also known as a data selector, is a device that selects between several analog or digital input signals and forwards it to a single output line. A multiplexer of $2^n$ inputs has *n* select lines, which are used to select which input line to send to the output. Figure 3 is a four inputs MUX.

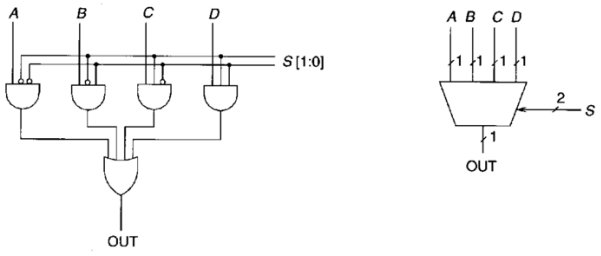


Figure 3 Four-to-One Multiplexer

## Lab Instruction

**Step 1: Download the Electronic Workbench (EWB) ewb5.zip file from ISpace, unzip files, and launch the Electronic Workbench software.**

**Step 2: Implement the Full Adder in Figure 1 and draw its truth table.**

**Step 3: Implement the Decoder in Figure 2 and draw its truth table.**

**Step 4: Implement the Multiplexer in Figure 3 and draw its truth table.**

## Lab Exercise

Design a combinational circuit to implement a **three inputs MAJORITY function**: F(x, y, z) =1 when at least 2 inputs are 1.

**Hints**: The design of combinational circuits starts from a specification of the problem and culminates in a logic diagram or set of Boolean equations from which the logic diagram can be obtained.

The procedure involves the following steps:
1. From the specifications of the circuit, determine the required number of inputs and outputs, and assign a letter symbol to each.
2. Derive the truth table that defines the required relationship between inputs and outputs.
3. Obtain the SOP and simplified Boolean functions of each outputs as function of the input variables. (You can also use the K-Map to obtain the simplest Boolean function.)
4. Draw the logic diagram.
5. Verify the correctness of the design.

**Challenge: 1) Can you implement the same function using a decoder? 2) Implement an ALU.**

## Submission

Zip and submit all the Electronics Workbench model files along with a doc file containing the truth tables and the process of solving the lab exercise.