# Lab# 9 COMBINATIONAL LOGIC

**Instructor**: I Putu Danu Raharja.

**Objectives**:
Learn to implement combinational logic circuits.

**Method**:

Complete the circuit for a 32-bit adder and subtractor and verify it's operation using the simulator.

**Preparation**:

Read Appendix B in the textbook.

**File To Use**: add.circ

## 9.1 EXERCISE

1. Download the Logisim into your desktop and run it.

2. From the "Window" menu, select "Combinational Analysis".

   a. Create three inputs named Ci, A, and B.

   b. Create two outputs named Co and S.

   c. Complete the truth table for the adder.

   d. Look at the "Expression" and "Minimized" tabs.

   e. Press the "Build Circuit" button and enter add1 as the name of the new circuit.

   f. Within the newly created add1 circuit, change the orientation of the Ci input so that it is facing south. Change the orientation of the Co output so that it is facing north.

   g. Change the values of the Ci, A, and B inputs and observe the Co and S outputs to verify the correct operation of the circuit.

3. Complete the add8 circuit by combining eight 1-bit adders.

   a. Add three splitters to the circuit. Each splitter should have an input bit width of 8 and a fan out of 8. Attach two east-facing splitters to the 8-bit inputs A and B. Attach a west-facing splitter to the 8-bit output S.

b.  Create eight instances of the add1 circuit.

c.  Connect the S outputs of the eight add1 instances to the splitter for the 8-bit S output.

d.  Connect the carry inputs and outputs of the eight add1 instances so that carries will propagate appropriately from the Ci input, through the 1-bit adders, to the Co output.

e.  Connect the A inputs of the eight add1 instances to the splitter for the A input.

f.  Connect the B inputs of the eight add1 instances to the splitter for the B input.

4.  Complete the add32 circuit by combining four 8-bit adders.

a.  You will find three splitters in the circuit. Each splitter has an input bit width of 32 and a fan out of 4. Thus, each connection to a splitter represents 8 bits.

b.  Create four instances of the add8 circuit.

c.  Connect the 8-bit S outputs of the four add8 instances to the splitter for the 32-bit S output.

d.  Connect the carry inputs and outputs of the four add8 instances so that carries will propagate appropriately from the Ci input, through the 8-bit adders, to the Co output.

e.  Connect the 8-bit A inputs of the four add8 instances to the splitter for the A input.

f.  Connect the 8-bit B inputs of the four add8 instances to the splitter for the B input.

5.  Within the main circuit, you will find a 32-bit adder connected side-by-side with your add32 circuit. Change the values of the Ci, A, and B inputs and observe the Co and S outputs to verify the correct operation of your add32circuit.

6. Add one bit output V to your add32 circuit. The output V is used to detect an overflow.

7. Modify your circuits to accommodate a subtraction operation, A – B, by adding an input M controlling the operation. When M=0 the circuit is an adder, and when M=1 the circuit becomes a subtractor.