

## Assignment 4: Digital circuit

**Attention:** Recommend using  $\text{\LaTeX}$  to complete your work. You can use any tool, such as Logisim, Visio, Draw.io, PowerPoint, etc., to create diagrams. However, handwritten or hand-drawn content is not acceptable.

### 1 Combinational logic

Analyze the circuit shown in Fig. 1 and answer the following questions:

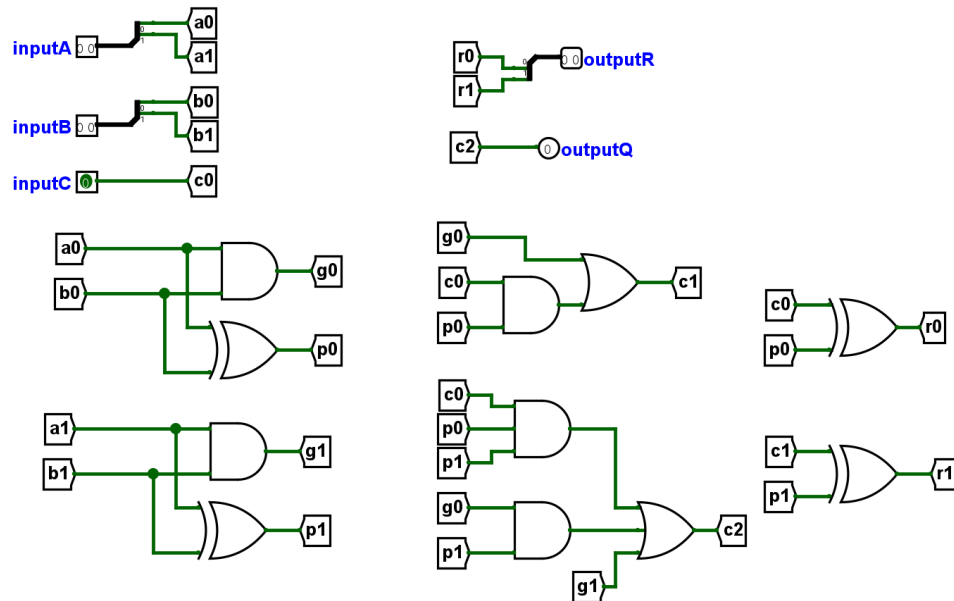


Figure 1: A 2-bit arithmetic circuit

- Draw the truth table of this circuit. [10 pt]
- Which kind of arithmetic operation (addition, subtraction, multiplication, division, shift, or comparison) is performed by this circuit? What are the advantages and disadvantages of the circuit in Fig. 1 compared to the corresponding arithmetic circuit mentioned in Digital circuits I? [10 pt]
- Assume that all 2-input logic gates have 1 ns delay, all 3-input logic gates have 2 ns delay, and other delays are not considered. Calculate the max delay of this circuit. [10 pt]

#### Answer to Question 1

Your answer here.

## 2 SDS

Draw a counter that counts from 0 to 5 using three D flip-flops (each flip-flops represents one output bit) and some 2-input logic gates (AND, OR, NOT). Please use the method taught in class to build a Moore FSM that implements the circular counter. Complete the state transition logic and output logic. **[35 pt]**



Figure 2: The counter cycles through the process of counting from 0 to 5.

### Answer to Question 2

Your answer here.

### 3 Finite state machine

The function of a vending machine which sells bottles of soda is described below:

- Each bottle costs \$1.50.
- The machine only accepts \$0.50 and \$1 coins. If a customer inserts enough coins, the machine will dispense a bottle of soda (FSM will output “1”, otherwise “0”) and returns change if needed , e.g., the output of DISPENSE states may be “1 \$0.5”, other states’ output may be “0 \$0”.
- The process happens one coin at a time, and there is no simultaneous insertion of multiple coins or shipping of multiple bottles. After each transaction, the vending machine enters the IDLE state.
- We don’t need to account for a scenario where a customer inserts coins but decides not to make a purchase.

(a) Draw the FSM (Moore machine) for this vending machine.[15 pt]

(b) Draw the FSM (Mealy machine) for this vending machine.[10 pt]

(c) Could Moore machines and Mealy machines be converted into each other to implement the same function? Compare their difference.[10 pt]

#### Answer to Question 3

Your answer here.
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