

# Computer Organization, Spring 2023

## Lab 5: Pipeline CPU

**Due : 2023/06/15 23:59:59**

### 1. Goal

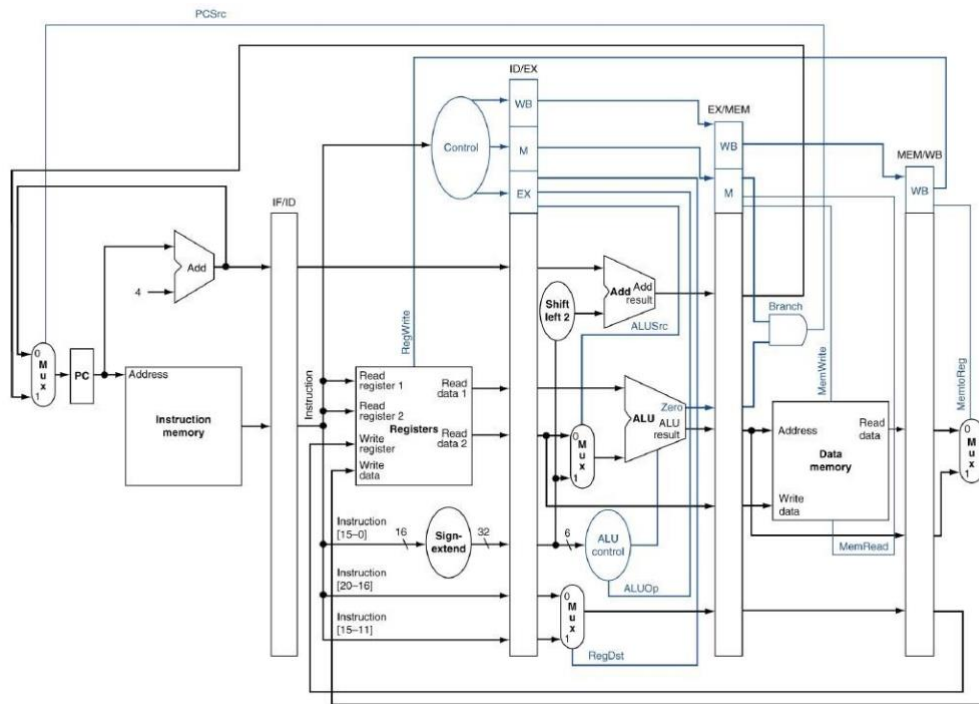
In this lab, please modify the single cycle processor designed in Lab4 to a pipelined processor. You don't have to consider the hazard issue.

### 2. Demands

- A. Please use Vivado as your simulator.
- B. Reg\_file(negative-edge triggered), Program\_Counter, and TestBench are supplied. Please add these modules to accomplish the design of your CPU.
- C. We have also provided template to assist you in completing Lab5.
- D. **You can create additional modules (.v files) for your design. However, it is essential to include an explanation in your report for the inclusion of these modules. Failure to mention any additional modules in your report may result in a deduction of 10 points from your grade.**
- E. Submit all **\*.v** source files and report(pdf) on E3. **Other form of file will get 10%.**

### 3. Requirement description

#### A. Architecture Diagram



According to the above diagram, in this lab you should implement a five stage pipelined processor with IF, ID, EX, MEM, and WB stages. You should insert a pipeline register between each two stages. Each pipeline register should contain the fields for data and control signals. The pipeline registers are written when the positive clock edge occurs.

#### B. The description of pipeline stage

The function of each stage is described as follows:

**IF stage:** In this stage, the processor fetches an instruction from the instruction memory and performs  $PC + 4$ .

**ID stage:** In this stage, the processor decodes the instruction to generate the control signals, reads two source registers, and generates the signextended immediate value.

**EX stage:** In this stage, ALU\_Ctrl generates control signals for function units according to ALUOp. At the same time, Register Write ID and branch target are also determined in this stage.

**MEM stage:** In this stage, the processor accesses data memory according to the control signals. The modification of PC from branch taken instruction is also performed in this stage.

**WB stage:** In this stage, the processor will write the value into register file according to the control signal when negative clock edge occurs.

### C. Description of pipeline register

Please design five pipeline registers. Each pipeline register must be “positive-edge triggered”, has default value 0. Then, insert these pipeline registers into your single-cycle CPU designed in Lab4 to accomplish the pipelined CPU required in this lab.

DO NOT set any delay time for the sequential circuits of the pipelined registers designed by you.

### 4. Test

CO\_P4\_test\_data1.txt tests the basic instructions. There are 2 test patterns, CO\_P5\_test\_data1.txt and CO\_P5\_test\_data2.txt.

Corresponding instructions and output answer are CO\_P5\_test1\_ASM.txt and CO\_P5\_test2\_ASM.

The default pattern is the first one.

### 5. Grade

- a. Total score: 100pts. **COPY WILL GET A 0 POINT!**
- b. Instruction score: Total 20 pts
- c. Report: 20 pts – format is in CO\_document. (up to 2 pages)

### 6. Hand in your assignment

Please upload the assignment to the E3.

Put all of \*.v source files and report into same compressed file.

(Use **Lab5\_student ID** to be the name of your compressed file, **please make sure your files are correct**)

### 7. Q&A

If you have any question, just send email to TAs.