

Computer Organization

Lab 4: Pipelined CPU

Due: 2019/6/6

1. Goal

Based on your Lab 3 CPU design, implement a pipelined CPU.

2. Homework Requirement

- Please use ModelSim or Xilinx as your HDL simulator.
- Please **attach student IDs as comments** at the top of each file.
- Please zip the Verilog files and the report and **name it as "ID.zip"**.
- You must use the supplied Reg_File.v
- In the top module, please change N to the value which is total lengths of input signal (include data and control) of pipeline register.

Pipe_Reg #(.size(N)) ID_EX

(google → verilog+parameter / parameterized modules / 參數式模組)

- Your CPU needs to support the following instructions: (80%)**

- ADD
- ADDI
- SUB
- AND
- OR
- SLT
- SLTI
- LW
- SW
- BEQ
- MULT

`mult rd, rs, rt; // rd=rs*rt`

0	rs	rt	rd	0	24
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g. Testbench ("C0_P4_test_1.txt"):

Use this testbench to test the basic instructions:

```
begin:
addi    $1,$0,3;           // a = 3
addi    $2,$0,4;           // b = 4
addi    $3,$0,1;           // c = 1
sw      $1,4($0);          // A[1] = 3
add     $4,$1,$1;          // $4 = 2*a
or      $6,$1,$2;          // e = a | b
and     $7,$1,$3;          // f = a & c
sub     $5,$4,$2;          // d = 2*a - b
slt     $8,$1,$2;          // g = a < b
beq     $1,$2,begin
lw      $10,4($0);         // i = A[1]
```

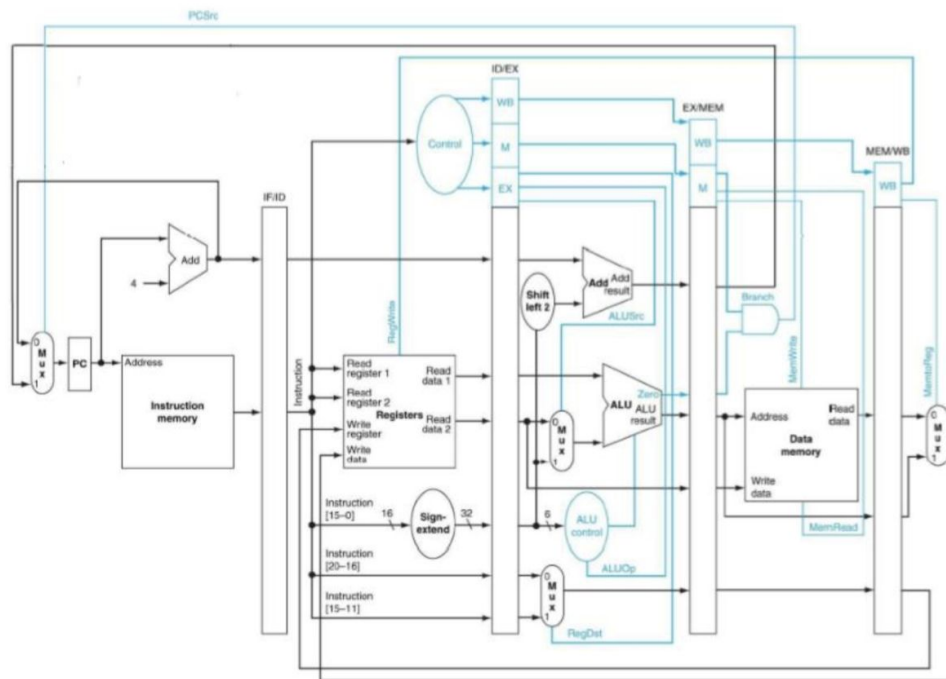
h. Bonus: Answer the question below and write it on your report. (20%)

Consider "C0_P4_test_2.txt", try to solve the data hazard of I1/I2, I5/I6, and I8/I9 data dependency. Just modify the machine code of the testbench and test it on your pipeline CPU. (Write down the machine code and show the execution result in your report.)

```
I1:  addi    $1,$0,16
I2:  addi    $2,$1,4
I3:  addi    $3,$0,8
I4:  sw      $1,4($0)
I5:  lw      $4,4($0)
I6:  sub     $5,$4,$3
I7:  add     $6,$3,$1
I8:  addi    $7,$1,10
I9:  and     $8,$7,$3
I10: addi    $9,$0,100
```

Hint: You may (1) insert NOP or (2) reorder instructions.

3. Architecture Diagram



4. Report

- Your Architecture
- Hardware Module Analysis
- Problems You Met and Solutions
- Result
- Summary

5. Grade

- Total:** 120 points (plagiarism will get 0 point)
- Report:** 20 points (please use **pdf format**)
- Late submission:** Score * 0.8 before 6/13. After 6/13, you will get 0.

6. Q&A

If you have any question, it is recommended to ask in the [facebook discussion forum](#).