

UM-SJTU JOINT INSTITUTE
Introduction to Computer Organization
(VP370)

Project 2 Report

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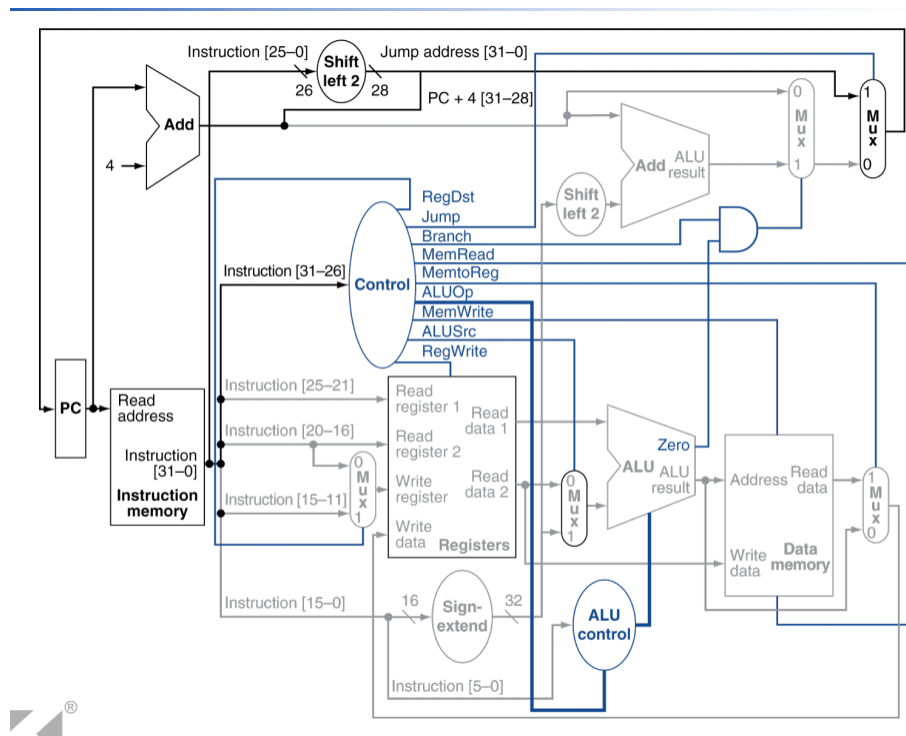
1 Introduction and Objective

Use Vivado and verilog to simulate how MIPS single cycle and pipeline processor works.

- The memory-reference instructions load word (lw) and store word (sw).
- The arithmetic-logical instructions add, addi, sub, and, andi, or, and slt.
- The jumping instructions branch equal (beq), branch not equal (bne), and jump (j).

2 Top Level Block Diagram

2.1 Single cycle



Our design diagram is very similar to the above figure from textbook, but we add a Branch control signal to implement beq and bne.

2.2 PipeLine

3 Design of Components

3.1 IF stage

3.2 Instruction Memory

```
memory[0] = 32' b0010000000001000000000000100000; //addi $t0, $zero, 0x20
memory[1] = 32' b00100000000010010000000000100111; //addi $t1, $zero, 0x27
memory[2] = 32' b00000001000010011000000000100100; //and $s0, $t0, $t1
memory[3] = 32' b00000001000010011000000000100101; //or $s0, $t0, $t1
memory[4] = 32' b10101100000100000000000000000100; //sw $s0, 4($zero)
memory[5] = 32' b10101100000100000000000000000100; //sw $t0, 8($zero)
memory[6] = 32' b00000001000010011000100000100000; //add $s1, $t0, $t1
memory[7] = 32' b00000001000010011001000000100010; //sub $s2, $t0, $t1
memory[8] = 32' b00010010001100100000000000000101; //beq $s1, $s2, error0
memory[9] = 32' b10001100000100010000000000000100; //lw $s1, 4($zero)
memory[10] = 32' b00110010001100100000000000001100; //andi $s2, $s1, 0x18
memory[11] = 32' b00010010001100100000000000000101; //beq $s1, $s2, error1
memory[12] = 32' b10001100000100110000000000000100; //lw $s3, 8($zero)
memory[13] = 32' b00010010001100100000000000000101; //beq $s0, $s3, error2
memory[14] = 32' b00000010010100011010000000101010; //slt $s4, $s2, $s1 (Last)
memory[15] = 32' b00010010100000000000000000000111; //beq $s4, $0, EXIT
memory[16] = 32' b00000010001000001001000000100000; //add $s2, $s1, $0
memory[17] = 32' b00001000000000000000000000000110; //j Last
memory[18] = 32' b00100000000010000000000000000000; //addi $t0, $0, 0(error0)
memory[19] = 32' b00100000000010010000000000000000; //addi $t1, $0, 0
memory[20] = 32' b00001000000000000000000000000111; //j EXIT
memory[21] = 32' b00100000000010000000000000000001; //addi $t0, $0, 1(error1)
memory[22] = 32' b00100000000010010000000000000001; //addi $t1, $0, 1
memory[23] = 32' b00001000000000000000000000000111; //j EXIT
memory[24] = 32' b00100000000010000000000000000010; //addi $t0, $0, 2(error2)
memory[25] = 32' b00100000000010010000000000000010; //addi $t1, $0, 2
memory[26] = 32' b00001000000000000000000000000111; //j EXIT
memory[27] = 32' b00100000000010000000000000000011; //addi $t0, $0, 3(error3)
memory[28] = 32' b00100000000010010000000000000011; //addi $t1, $0, 3
memory[29] = 32' b00001000000000000000000000000111; //j EXIT
```

3.3 ID stage

3.4 EX stage

3.5 MEM stage

3.6 WB stage

4 Control and Data Hazard

4.1 EX stage

This part only contain data hazard.

4.2 ID stage

4.2.1 Control Hazard

4.2.2 Data Hazard

5 Instruction Implementation

6 SSD and Top Module

6.1 Internal Clock Divider

```
module clock500(clock, clk500);
    input clock;
    output clk500;
    reg clk500=0;
    reg [17:0]n;
    always @(posedge clock)begin
        if(n>=18'b110000110100111111)begin
            n<=0;
            clk500<=1;
        end
        else begin
            n<=n+1;
            clk500<=0;
        end
    end
end
endmodule

module ring(clk500, ring);
    input clk500;
    output [3:0]ring;
    reg [3:0]ring=4'b1110;
    reg [8:0]n;
    always @(posedge clk500)begin
        ring[0]<=ring[3];
        ring[1]<=ring[0];
        ring[2]<=ring[1];
        ring[3]<=ring[2];
    end
end
endmodule
```

This module slow down the internal clock of FPGA board to 500 Hz to implement the SSD four digital display.

6.2 SSD Display

```

module Display(ring, PCorReg, currentPC, Data, SSD);
    input [3:0]ring;
    input [31:0]currentPC, Data;
    input PCorReg;
    output [6:0]SSD;
    reg [6:0]SSD=7'b1111111;
    wire [15:0]OUT;
    reg [3:0]code;
    assign OUT=(PCorReg==1) ? currentPC[15:0]:Data[15:0];
    always @(ring)begin
        case(ring)
            4'b1110: code=OUT[3:0];
            4'b1101: code=OUT[7:4];
            4'b1011: code=OUT[11:8];
            4'b0111: code=OUT[15:12];
        endcase
        case(code)
            4'b0000: SSD <= 7'b0000001;
            4'b0001: SSD <= 7'b1001111;
            4'b0010: SSD <= 7'b0010010;
            4'b0011: SSD <= 7'b0000110;
            4'b0100: SSD <= 7'b1001100;
            4'b0101: SSD <= 7'b0100100;
            4'b0110: SSD <= 7'b0100000;
            4'b0111: SSD <= 7'b0001111;
            4'b1000: SSD <= 7'b0000000;
            4'b1001: SSD <= 7'b0000100;

            4'b1000: SSD <= 7'b0000000;
            4'b1001: SSD <= 7'b0000100;
            4'b1010: SSD <= 7'b0001000;
            4'b1011: SSD <= 7'b1100000;
            4'b1100: SSD <= 7'b0110001;
            4'b1101: SSD <= 7'b1000010;
            4'b1110: SSD <= 7'b0110000;
            4'b1111: SSD <= 7'b0111000;
        endcase
    end
endmodule

```

This module directly control the SSD hexadecimal display, including selection for PC value and register value.

6.3 Constrain File

The constrain file shows the connection of the port and signal.

```

1  set_property IOSTANDARD LVCMOS33 [get_ports {ring[3]}]
2  set_property IOSTANDARD LVCMOS33 [get_ports {ring[2]}]
3  set_property IOSTANDARD LVCMOS33 [get_ports {ring[1]}]
4  set_property IOSTANDARD LVCMOS33 [get_ports {ring[0]}]
5  set_property IOSTANDARD LVCMOS33 [get_ports {SSD[6]}]
6  set_property IOSTANDARD LVCMOS33 [get_ports {SSD[5]}]
7  set_property IOSTANDARD LVCMOS33 [get_ports {SSD[4]}]
8  set_property IOSTANDARD LVCMOS33 [get_ports {SSD[3]}]
9  set_property IOSTANDARD LVCMOS33 [get_ports {SSD[2]}]
10 set_property IOSTANDARD LVCMOS33 [get_ports {SSD[1]}]
11 set_property IOSTANDARD LVCMOS33 [get_ports {SSD[0]}]
12 set_property PACKAGE_PIN W4 [get_ports {ring[3]}]
13 set_property PACKAGE_PIN V4 [get_ports {ring[2]}]
14 set_property PACKAGE_PIN U4 [get_ports {ring[1]}]
15 set_property PACKAGE_PIN U2 [get_ports {ring[0]}]
16 set_property PACKAGE_PIN W7 [get_ports {SSD[6]}]
17 set_property PACKAGE_PIN W6 [get_ports {SSD[5]}]
18 set_property PACKAGE_PIN U8 [get_ports {SSD[4]}]
19 set_property PACKAGE_PIN V8 [get_ports {SSD[3]}]
20 set_property PACKAGE_PIN U5 [get_ports {SSD[2]}]
21 set_property PACKAGE_PIN V5 [get_ports {SSD[1]}]
22 set_property PACKAGE_PIN U7 [get_ports {SSD[0]}]
23 set_property IOSTANDARD LVCMOS33 [get_ports clock]
24 set_property IOSTANDARD LVCMOS33 [get_ports clk]
25 set_property PACKAGE_PIN W5 [get_ports clock]
26 set_property PACKAGE_PIN U18 [get_ports clk]
27 set_property IOSTANDARD LVCMOS33 [get_ports PCorReg]
28 set_property IOSTANDARD LVCMOS33 [get_ports SW1]

```



```

29  set_property IOSTANDARD LVCMOS33 [get_ports SW2]
30  set_property IOSTANDARD LVCMOS33 [get_ports SW3]
31  set_property IOSTANDARD LVCMOS33 [get_ports SW4]
32  set_property IOSTANDARD LVCMOS33 [get_ports SW5]
33  set_property PACKAGE_PIN V17 [get_ports PCorReg]
34  set_property PACKAGE_PIN V16 [get_ports SW1]
35  set_property PACKAGE_PIN W16 [get_ports SW2]
36  set_property PACKAGE_PIN W17 [get_ports SW3]
37  set_property PACKAGE_PIN W15 [get_ports SW4]
38  set_property PACKAGE_PIN V15 [get_ports SW5]
39  set_property CLOCK_DEDICATED_ROUTE FALSE [get_nets clk_IBUF]

```

7 Textual Result

By running the instruction memory, we can achieve Textual Result which is contained in Appendix.

8 Conclusion and Discussion

8.1 Single Cycle

For single cycle part, the project asks us to implement both beq and bnq instructions, which is different from Slies. As a result, we increase one bit to ALUOp and add a signal. Since the MIPS processor must implement much more instruction in reality, the ALUOp must have more bits and the controller will generate more signals.

9 Reference

- VE370 Course. Description of Project 4.
- Zheng Gang L6 Single Cycle Processor

10 Appendix

10.1 Textual Result

10.1.1 Single Cycle Textual Result

```
Time:                1000, CLK = 1, PC = 00000000

[$s0] = 00000000, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000000, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                2000, CLK = 0, PC = 00000000

[$s0] = 00000000, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000000, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                3000, CLK = 1, PC = 00000004

[$s0] = 00000000, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000
```

```

Time:                4000, CLK = 0, PC = 00000004

[$s0] = 00000000, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                5000, CLK = 1, PC = 00000008

[$s0] = 00000020, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                6000, CLK = 0, PC = 00000008

[$s0] = 00000020, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                7000, CLK = 1, PC = 0000000c

[$s0] = 00000027, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                8000, CLK = 0, PC = 0000000c

[$s0] = 00000027, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                9000, CLK = 1, PC = 00000010

[$s0] = 00000027, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                10000, CLK = 0, PC = 00000010

[$s0] = 00000027, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                11000, CLK = 1, PC = 00000014

[$s0] = 00000027, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                12000, CLK = 0, PC = 00000014

[$s0] = 00000027, [$s1] = 00000000, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                13000, CLK = 1, PC = 00000018

[$s0] = 00000027, [$s1] = 00000047, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                14000, CLK = 0, PC = 00000018

[$s0] = 00000027, [$s1] = 00000047, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                15000, CLK = 1, PC = 0000001c

[$s0] = 00000027, [$s1] = 00000047, [$s2] = ffffffff9
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                16000, CLK = 0, PC = 0000001c
[$s0] = 00000027, [$s1] = 00000047, [$s2] = ffffffff9
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                17000, CLK = 1, PC = 00000020
[$s0] = 00000027, [$s1] = 00000047, [$s2] = ffffffff9
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                18000, CLK = 0, PC = 00000020
[$s0] = 00000027, [$s1] = 00000047, [$s2] = ffffffff9
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                19000, CLK = 1, PC = 00000024

[$s0] = 00000027, [$s1] = 00000027, [$s2] = ffffffff9
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                20000, CLK = 0, PC = 00000024

[$s0] = 00000027, [$s1] = 00000027, [$s2] = ffffffff9
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                21000, CLK = 1, PC = 00000028

[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```



```

Time:                22000, CLK = 0, PC = 00000028
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                23000, CLK = 1, PC = 0000002c
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                24000, CLK = 0, PC = 0000002c
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000000, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                25000, CLK = 1, PC = 00000030

[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                26000, CLK = 0, PC = 00000030

[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                27000, CLK = 1, PC = 00000034

[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                28000, CLK = 0, PC = 00000034

[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                29000, CLK = 1, PC = 00000038

[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000001, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                30000, CLK = 0, PC = 00000038

[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000001, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

```

Time:                31000, CLK = 1, PC = 0000003c
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000001, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                32000, CLK = 0, PC = 0000003c
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000000
[$s3] = 00000020, [$s4] = 00000001, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

Time:                33000, CLK = 1, PC = 00000040
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000027
[$s3] = 00000020, [$s4] = 00000001, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

Time: 34000, CLK = 0, PC = 00000040

[\$s0] = 00000027, [\$s1] = 00000027, [\$s2] = 00000027
[\$s3] = 00000020, [\$s4] = 00000001, [\$s5] = 00000000
[\$s6] = 00000000, [\$s7] = 00000000, [\$t0] = 00000020
[\$t1] = 00000027, [\$t2] = 00000000, [\$t3] = 00000000
[\$t4] = 00000000, [\$t5] = 00000000, [\$t6] = 00000000
[\$t7] = 00000000, [\$t8] = 00000000, [\$t9] = 00000000

Time: 35000, CLK = 1, PC = 00000044

[\$s0] = 00000027, [\$s1] = 00000027, [\$s2] = 00000027
[\$s3] = 00000020, [\$s4] = 00000001, [\$s5] = 00000000
[\$s6] = 00000000, [\$s7] = 00000000, [\$t0] = 00000020
[\$t1] = 00000027, [\$t2] = 00000000, [\$t3] = 00000000
[\$t4] = 00000000, [\$t5] = 00000000, [\$t6] = 00000000
[\$t7] = 00000000, [\$t8] = 00000000, [\$t9] = 00000000

Time: 36000, CLK = 0, PC = 00000044

[\$s0] = 00000027, [\$s1] = 00000027, [\$s2] = 00000027
[\$s3] = 00000020, [\$s4] = 00000001, [\$s5] = 00000000
[\$s6] = 00000000, [\$s7] = 00000000, [\$t0] = 00000020
[\$t1] = 00000027, [\$t2] = 00000000, [\$t3] = 00000000
[\$t4] = 00000000, [\$t5] = 00000000, [\$t6] = 00000000
[\$t7] = 00000000, [\$t8] = 00000000, [\$t9] = 00000000

```

Time:                37000, CLK = 1, PC = 00000038
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000027
[$s3] = 00000020, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000
Time:                38000, CLK = 0, PC = 00000038
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000027
[$s3] = 00000020, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000
Time:                39000, CLK = 1, PC = 0000003c
[$s0] = 00000027, [$s1] = 00000027, [$s2] = 00000027
[$s3] = 00000020, [$s4] = 00000000, [$s5] = 00000000
[$s6] = 00000000, [$s7] = 00000000, [$t0] = 00000020
[$t1] = 00000027, [$t2] = 00000000, [$t3] = 00000000
[$t4] = 00000000, [$t5] = 00000000, [$t6] = 00000000
[$t7] = 00000000, [$t8] = 00000000, [$t9] = 00000000

```

Time: 40000, CLK = 0, PC = 0000003c

[\$s0] = 00000027, [\$s1] = 00000027, [\$s2] = 00000027

[\$s3] = 00000020, [\$s4] = 00000000, [\$s5] = 00000000

[\$s6] = 00000000, [\$s7] = 00000000, [\$t0] = 00000020

[\$t1] = 00000027, [\$t2] = 00000000, [\$t3] = 00000000

[\$t4] = 00000000, [\$t5] = 00000000, [\$t6] = 00000000

[\$t7] = 00000000, [\$t8] = 00000000, [\$t9] = 00000000