

# 2011 Paper 5 Question 1

## Computer Design

Consider the following UltraRISC processor which has just one instruction (so there is no opcode), with one operand (an address).

```
module UltraRISC();
    logic [7:0] mem[31:0]; // memory
    logic [7:0] pc; // program counter
    logic [7:0] ir; // instruction register
    logic [7:0] acc; // accumulator
    logic      step;
    logic      clk;
    logic [7:0] next_pc, next_ir;
    logic [8:0] next_acc;
    logic      borrow;
    parameter Lt=16, Lx=17, Ly=18, Lz=19, Lstop=31;
    initial begin
        clk <= 1; pc <= 0; step <= 0; acc <= 0;
        // Code      Data
        mem[ 0] <= Lt; mem[Lt] <= 13; // holds T
        mem[ 1] <= Lt; mem[Lx] <= 13; // holds X
        mem[ 2] <= Lt; mem[Ly] <= 7; // holds Y
        mem[ 3] <= Lx; mem[Lz] <= 3; // holds Z
        mem[ 4] <= Lx; mem[Lstop] <= 0;
        mem[ 5] <= Ly;
        mem[ 6] <= Lt;
        mem[ 7] <= Lt;
        mem[ 8] <= Lx;
        mem[ 9] <= Lt;
        mem[10] <= Lt;
        mem[11] <= Lt;
        mem[12] <= Lz;
        mem[13] <= Lx;
        mem[14] <= Lstop;
        mem[15] <= 0;
    end // initial begin
    always #5 clk <= !clk;
```

[continued. . .

## 2011 Paper 5 Question 1 (continued)

```
always_comb
  if(step==0) begin
    next_ir = mem[pc];
    next_acc = acc;
    next_pc = pc+1;
  end else begin
    next_ir = ir;
    next_acc = mem[ir]-acc;
    borrow = next_acc[8];
    next_pc = pc+borrow;
  end

always_ff @(posedge clk) begin
  step <= !step;
  ir <= next_ir;
  pc <= next_pc;
  acc <= next_acc;
  if(step) mem[ir] <= next_acc;
  if(ir==Lstop) begin
    $display("result = %d, finished",acc);
    $finish;
  end
end
endmodule
```

- (a) What is the CPI (cycles per instruction) for this processor? [3 marks]
- (b) What function does the one instruction perform? [5 marks]
- (c) What result is produced when the program held in `mem` is executed? Explain your answer. [10 marks]
- (d) How does the code density compare with the MIPS32 ISA? [2 marks]